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COMMEMORATION

PHYSIOLOGICAL RESEARCH REGARDING THE INFLUENCE OF THE PATHOGEN ATTACK PRODUCED BY *Elsinoë rosarum* JENKINS & BITANC. IN THE ROSE PLANTS (*Rosa* sp.)

NICOLAE Ion, BUŞE-DRAGOMIR Luminiţa

Abstract. The physiological research regarding influence of the pathogen attack produced by *Elsinoë rosarum* JENKINS & BITANC. has been made on Pascali rose variety cultivated in the Botanical Garden "Al. Buia" from Craiova, Dolj. In the analysed rose leaves it was observed that the diurnal dynamics of the photosynthesis and of transpiration varies depending on the climate conditions, in the morning with lower values, a maximum values after lunch and lower values toward the evening, but the intensity of these processes has lower values in the attacked leaves. The linear regressions performed between the physiological processes (photosynthesis and transpiration) and the photosynthetic active radiation, the temperature leaf and the stomatal conductance show a positive correlation between these, with specific variations in the attacked leaves, in comparison with healthy leaves. In the attacked leaves it was recorded a lower water and chlorophyllian pigment content, which correlates with the decrease of the photosynthesis intensity. Under the damaging action of the pathogens, in the attacked leaves the hydric and metabolic unbalance appear, with negative consequences on the growth of rose plants.

Keywords: attacked leaves, healthy leaves, pathogen, physiological processes, rose variety.

Rezumat. Cercetări fiziologice privind influenţa atacului patogen produs de *Elsinoë rosarum* JENKINS & BITANC. la plantele de trandafiri (*Rosa* sp.). Cercetările fiziologice privind influenţa atacului patogen produs de *Elsinoë rosarum* JENKINS & BITANC. s-au efectuat la soiul de trandafiri Pascali cultivat în Grădina Botanică „Al. Buia" din Craiova, Dolj. La frunzele de trandafiri analizate s-a constatat că dinamica diurnă a fotosintezei şi transpiraţiei variază în funcţie de condiţiile climatice, prezentând valori scăzute dimineaţa, valori maxime după prânz şi valori scăzute spre seară, dar intensitatea acestor procese are valori mai scăzute în frunzele atacate. Regresii liniare efectuate între procesele fiziologice (fotosinteză şi transpiraţie) şi radiaţia fotosintetic activă, temperatura frunzei şi conductanţa stomatală, evidenţiază corelaţii pozitive între acestea, cu variaţii specifice, la frunzele atacate, comparativ cu frunzele sănătoase. În frunzele atacate s-a înregistrat un conţinut mai scăzut de apă şi pigmenţi clorofilieni, fapt corelat cu scăderea intensităţii fotosintezei. Sub acţiunea dăunătoare a patogenului, în frunzele atacate, apar dezechilibre hidrice şi metabolice, cu consecinţe negative asupra creşterii plantelor de trandafiri.

Cuvinte cheie: frunze atacate, frunze sănătoase, patogen, procese fiziologice, soi de trandafiri.

INTRODUCTION

The rose is a plant from the Rosaceae family spread in most regions of the world. Genus *Rosa* includes around 140 species, widely scattered in Europe, Asia, the Middle East and North America (CAIRNS, 2003).

Anthracnose of the rose produced by the *Elsinoë rosarum* (JENKINS & BITANC. 1957) is found on different *Rosa* species and varieties of cultivated roses. In our country it was first reported in 1952, in Cluj Botanical Gardens (NEGRU 1956, cited in SĂVULESCU *et al.*, 1969).

Light intensity and temperature are the main factors with the influence on photosynthesis intensity. In the *Rosa* sp. at a light intensity of 1826 μmol/m^2/s, the intensity of photosynthesis is of 11.21 μmol CO_2/m^2/s. The transpiration intensity of leaf varies according to the characteristics of the species and the environmental conditions. Thus, at a temperature of 35.4°C, the transpiration intensity is of 6.03 μmol H_2O/m^2/s (BURZO *et al.*, 2000).

The development of the pathogen agents on the surface of the organs or in the tissues of the attacked plants reduce the assimilation of the foliar surface, which entail a change in the physiological processes with consequences for the quantity and quality of production by flowers (NICOLAE, 2010).

MATERIAL AND METHODS

The physiological research regarding the influence of the pathogen attack produced by *Elsinoë rosarum* JENKINS & BITANC. has been made on rose plants - **Pascali** variety cultivated in the Botanical Garden "Al. Buia" from Craiova, Dolj.

The variety of **Pascali** rose plants presents a height of 80 cm, white flowers and easy perfume.

The intensity of the physiological processes (photosynthesis intensity and transpiration intensity) and photosynthetic active radiations, leaf temperature and stomatal conductance were established with the analyser LCi (The Ultra Compact Photosynthesis Measurement System) and the obtained results were graphically represented and statistically interpreted.

The total water content and the dry substance content were determined by the help of the drying stove - gravimetric method.

The chlorophyll content was estimates by Minolta SPAD 502 chlorophyll meter.

The estimation of the attack was made using the calculation formulae by SĂVESCU & RAFAILĂ (1978).

RESULTS AND DISCUSSIONS

Anthracnose is found all the over ground organs of the plant, but the first symptoms emerge on the leaves. Light green punctiform spots emerge on the outer leaves, grow bigger and then become surrounded by a brown-purple or crimson ring (Figs. 1; 2).

The tissues corresponding to the spots sometimes get loose and fall and the leaf has empty marks on it. Black dots emerge on the surface of the spots and they are appear in concentric circles made up of conidiophore and conidia. The strongly damaged leaves get yellow, dry out and fall before time.

Similar spots are formed on the leaf, the calyx and even on the petals. Small spots (aprox. 2 mm) are formed on the bark of the twigs and they are circular, deepened into the surface. They may be brown with purple hues and they have a white-grey centre (SĂVULESCU *et. al.*, 1969).

Elsinoë rosarum JENKINS & BITANC. presents intercellular mycelium, they are formed on septate conidiophores, hyaline, with conidia, brown in colour, oval or ellipsoidal, unicellular. Under the pressure of coniophores and conidia, the epidermis is to tear and conidia are issued (MARINESCU *et al.*, 1988).

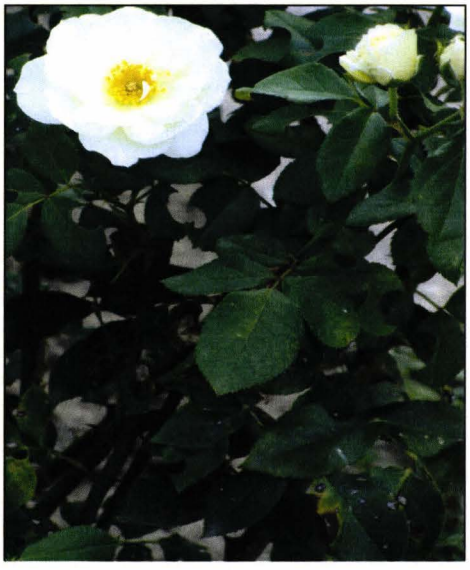

Figure 1. The rose plants - **Pascali** variety attacked by *Elsinoë rosarum* / Figura 1. Plante de trandafiri - soiul **Pascali** atacate de *E. rosarum* (original).

Figure 2. The rose leaves - **Pascali** variety attacked by *Elsinoë rosarum.* / Figura 2. Frunze de trandafiri - soiul **Pascali** atacate de *E. Rosarum* (original).

The estimation of the attack (frequency, intensity and degree of attack) produced by the *Elsinoë rosarum* JENKINS & BITANC. at rose plants - **Pascali** variety is presented in figure 3.

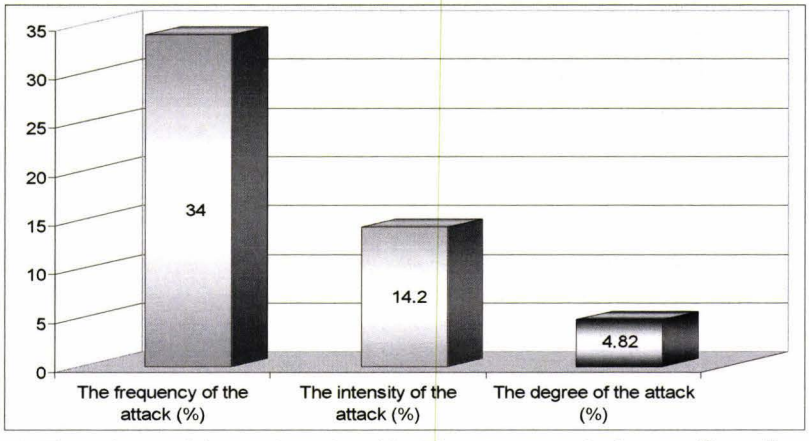

Figure 3. The estimate of the attack produced by *Elsinoë rosarum* in the roses **Pascali** variety.
Figura 3. Estimarea atacului produs de *E. rosarum* la trandafiri - soiul **Pascali**.

The physiological research regarding influence of the pathogen attack produced by *Elsinoë rosarum* JENKINS & BITANC. on roses - **Pascali** variety has been made, according to the climatic conditions, on August 28th 2010.

The photosynthesis intensity increases from early morning due to the increase of light intensity, temperature and the stomata opening level, it maintains itself constant until noon, then gradually decreases due to the decrease of light intensity, the accumulation of organic substances in chloroplasts, the gradual decrease of temperature, as well as the reduction of the opening degree of stomata. The diurnal dynamics of photosynthesis intensity in the attacked leaves is similar to that in healthy leaves but the recorded values are lower as a result of the reduction of the assimilation surface by the appearance of spots and deterioration to chlorophyll pigments, the yellowing of the leaves, and premature drying of the leaves (Fig. 4).

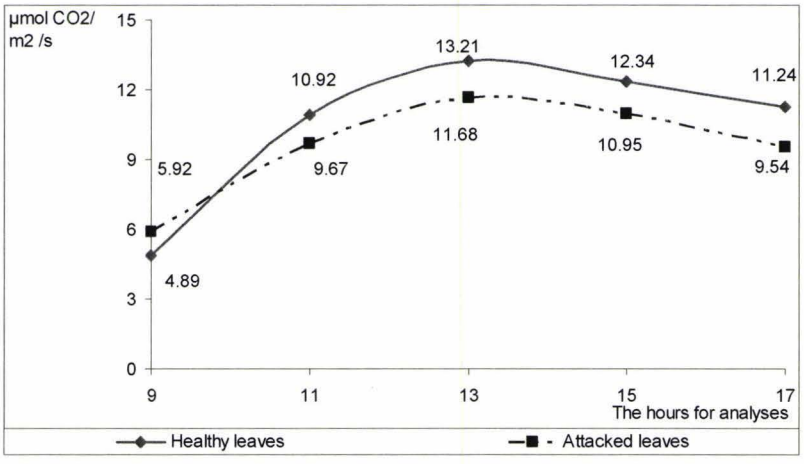

Figure 4. The diurnal dynamics of photosynthesis intensity in the rose leaves - **Pascali** variety.
Figura 4. Dinamica diurnă a intensităţii fotosintezei la frunzele de trandafiri - soiul **Pascali**.

The transpiration intensity increases from dawn when the opening of stomata takes place, presents a maximum value during the afternoon when the temperature is higher and the air relative humidity is lower, and towards evening the reduction of the transpiration process takes place. The dynamics of transpiration intensity in the attacked rose leaves presents lower values, in comparison with healthy leaves, as a result of malfunctioning mechanisms of the stomatic apparatus, of the withering and drying leaves (Fig. 5).

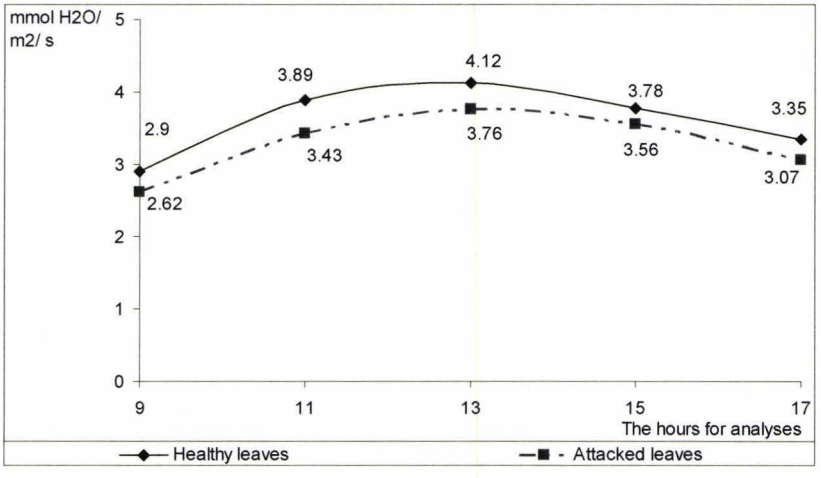

Figure 5. The diurnal dynamics of transpiration intensity in the rose leaves - **Pascali** variety.
Figura 5. Dinamica diurnă a intensităţii transpiraţiei la frunzele de trandafiri - soiul **Pascali**.

The intensity of physiological processes (photosynthesis and transpiration intensity) depend on the photosynthetic active radiation, the temperature leaf and the stomatal conductance and presents specific variations in the attacked leaves, in comparison with healthy leaves.

The rose leaves have an increasing photosynthetic active radiation in the morning (9 a.m.) when the values are of 1020 µmol/m^2/s for the healthy leaves and of 992 µmol/m^2/s for the attacked leaves, they grow until after noon (1 p.m.) when the values are of 1510 µmol/m^2/s for the healthy leaves and of 1468 µmol/m^2/s for the attacked leaves, while towards the evening (5 p.m.) the values decrease gradually to 1365 µmol/m^2/s the healthy leaves and to 1360 µmol/m^2/s for the attacked leaves.

The linear regressions performed between the values of photosynthesis intensity and the photosynthetic active radiation show a good positive correlation, the coefficient of determination (R^2) being of 0.96 for the healthy leaves and 0.93 for the attacked leaves and linear regressions performed between the values of transpiration intensity and the photosynthetic active radiation show a positive correlation, the coefficient of determination (R^2) being of 0.70 for the healthy leaves and 0.73 for the attacked leaves (Figs. 6 and 7).

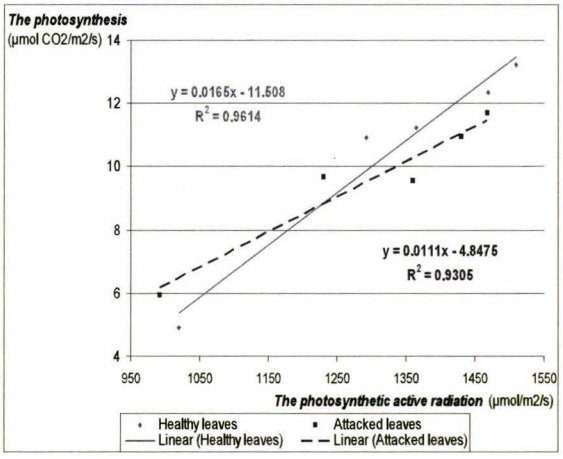

Figure 6. The correlation between the photosynthesis intensity and the photosynthetic active radiation in the rose leaves - **Pascali** variety. / Figura 6. Corelaţii între intensitatea fotosintezei şi **radiaţia** fotosintetic activă la frunzele de trandafiri - soiul **Pascali**.

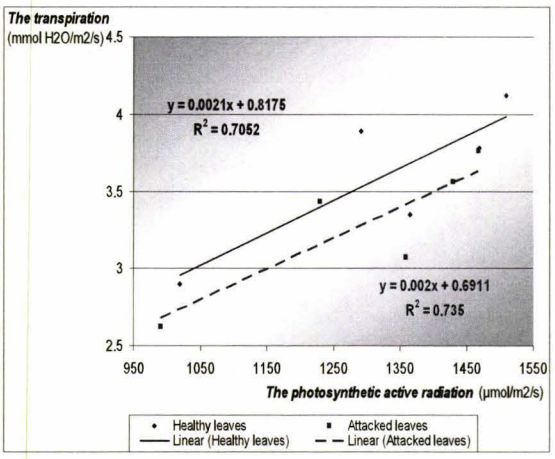

Figure 7. The correlation between the transpiration intensity and the photosynthetic active radiation in the rose leaves - **Pascali** variety. / Figura 6. Corelaţii între intensitatea transpiraţiei şi radiaţia fotosintetic activă la frunzele de trandafiri - soiul **Pascali**.

In the leaves of roses can be seen an increase of the leaf temperature in the morning (9 a.m.), when the values are of 28.4°C in the healthy leaves and 28.5°C in the attacked leaves, the increase of the temperature up until after lunch (1p.m.), when the values are of 34.2°C in the healthy leaves and 34.3°C in the attacked leaves and towards the evening (5 p.m.) the gradual decrease of the temperature, recording values of 32.3°C in the healthy leaves and 32.6°C in the attacked leaves.

The linear regressions performed between the values of photosynthesis intensity and the leaf temperature show a good positive correlation, the coefficient of determination (R^2) being of 0.98 for the healthy leaves and 0.97 for the attacked leaves and linear regressions performed between the values of transpiration intensity and the leaf temperature show a positive correlation, the coefficient of determination (R^2) being of 0.85 for the healthy leaves and 0.89 for the attacked leaves (Figs. 8; 9).

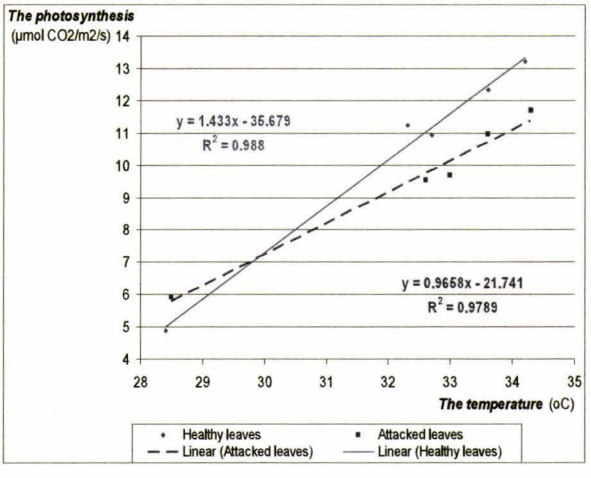

Figure 8. The correlation between the photosynthesis intensity and the temperature in the rose leaves - **Pascali** variety. / Figura 8. Corelaţii între intensitatea fotosintezei şi temperatura frunzelor de trandafiri - soiul **Pascali**.

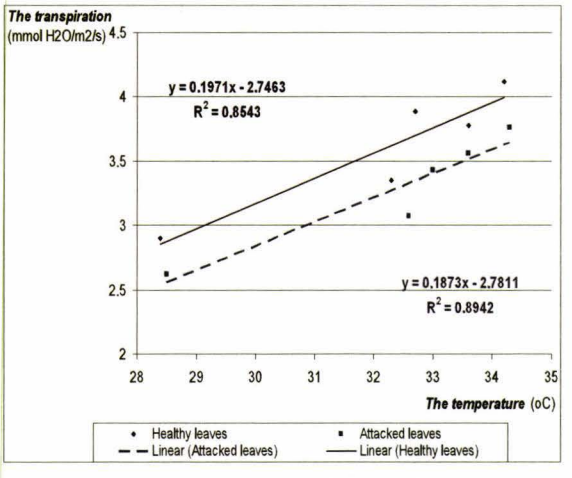

Figure 9. The correlation between the transpiration intensity and the temperature in the rose leaves - **Pascali** variety. / Figura 9. Corelaţii între intensitatea transpiraţiei şi temperatura frunzelor de trandafiri - soiul **Pascali**.

In the leaves of roses it can be seen an increase of the stomatal conductance of CO_2 starting in the morning (9 a.m.), when the recorded values are 0.09 mol/m^2/s in the healthy leaves and 0.07 mol/m^2/s in the attacked leaves, the increase of the stomatal conductance up until after lunch (1 p.m.), when the recorded values are 0.14 mol/m^2/s in the healthy leaves and 0.12 mol/m^2/s in the attacked leaves and towards the evening (5 p.m.) the gradual decrease of the stomatal conductance, when the recorded values are 0.1 mol/m^2/s in the healthy leaves and 0.08 mol/m^2/s in the attacked leaves.

The linear regressions performed between the values of photosynthesis intensity and the stomatal conductance show a positive correlation, the coefficient of determination (R^2) being of 0.80 for the healthy leaves and 0.77 for the attacked leaves and linear regressions performed between the values of transpiration intensity and the stomatal conductance show a positive correlation n, the coefficient of determination (R^2) being of 0.87 for the healthy leaves and 0.78 for the attacked leaves (Figs. 10; 11).

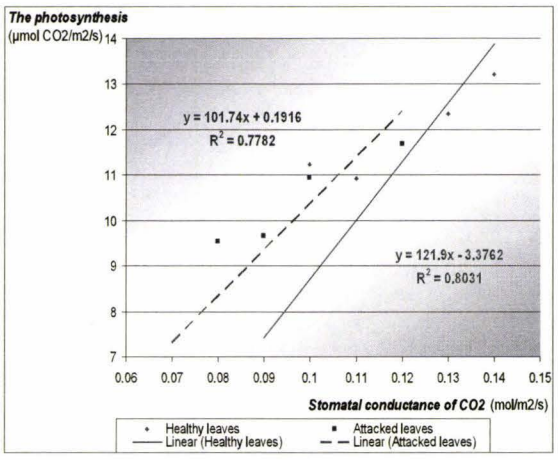

Figure 10. The correlation between the photosynthesis intensity and the stomatal conductance in the rose leaves - **Pascali** variety. / Figura 10. Corelaţii între intensitatea fotosintezei şi conductanţa stomatală la trandafiri - soiul **Pascali**.

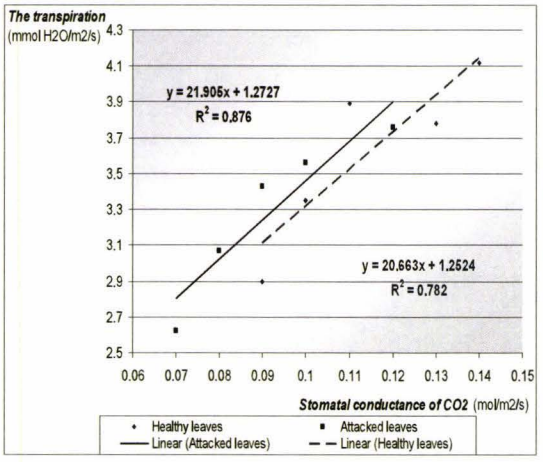

Figure 11. The correlation between the transpiration intensity and the stomatal conductance in the rose leaves - **Pascali** variety. / Figura 11. Corelaţii între intensitatea transpiraţiei şi conductanţa stomatală la trandafiri - soiul **Pascali**.

In the attacked rose leaves it can be seen a decrease of the water content and an increase of the dry substance content, which is manifested by the withering and premature drying of the leaves (Fig. 12).

The attacked leaves present a decrease of the chlorophyll content, manifested by their yellowing as a result of the deterioration of the chlorophyllian pigments; this correlates with the decrease of the intensity of photosynthesis (Fig. 13).

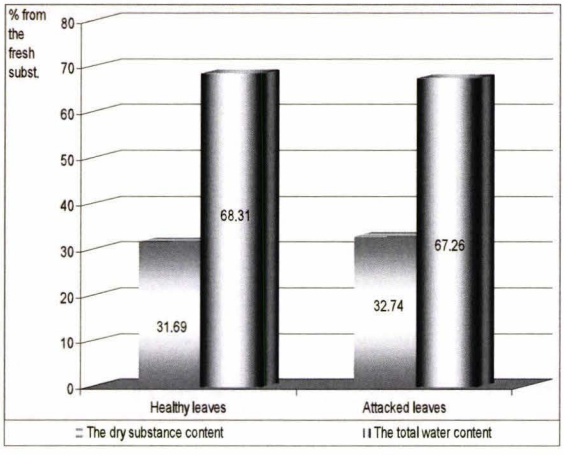

Figure 12. The water contents and the dry substance content in the rose leaves - **Pascali** variety. / Figura 12. Conţinutul de apă şi conţinutul de substanţă uscată la frunzele de trandafiri - soiul **Pascali**.

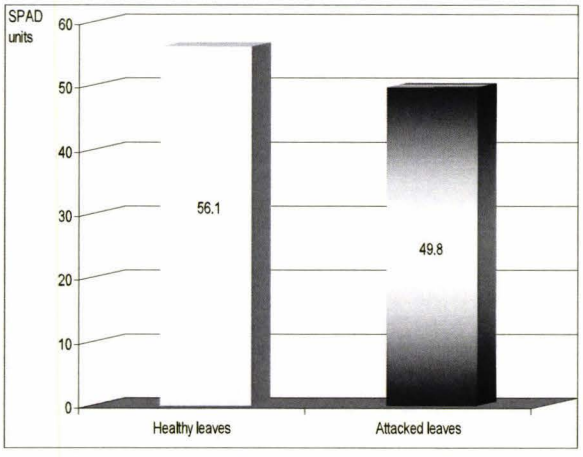

Figure 13. The chlorophyll content in the rose leaves - **Pascali** variety. / Figura 13. Conţinutul de clorofilă la frunzele de trandafiri - soiul **Pascali**.

CONCLUSIONS

In the rose leaves, *Pascali* variety, it was observed that the diurnal dynamics of the photosynthesis and transpiration present a minimum in the morning, a maximum after lunch and a minimum toward the evening, but it presents lower values in the leaves attacked by *Elsinoë rosarum* JENKINS & BITANC, compared with the healthy leaves.

The linear regressions performed between the physiological processes (photosynthesis and transpiration intensity) and the photosynthetic active radiation, the temperature leaf and the stomatal conductance show a positive correlation between them, with specific variations in the attacked leaves.

In the leaves attacked by the pathogen, lower water content and higher dry substance content was recorded, manifested by the withering and drying leaves under the damaging action of the pathogens.

In the attacked leaves a lower chlorophyllian pigments content was recorded, and this correlates with the decrease of the photosynthesis intensity, with implications on the growth and development of the plants.

REFERENCES

BURZO I., TOMA S., VOICAN VIORICA, AMĂRIUŢEI ALEXANDRINA, ŞELARU ELENA, POPESCU V., CRĂCIUN C. 2000. *Fiziologia plantelor de cultură.* Întreprinderea Editorial Poligrafică „Ştiinţa", Chişinău. **4**. 401 pp.

CAIRNS T. 2003. *Horticultural Classification Schemes.* In: Roberts A. V., Debener T., Gudin S. (Eds.) Encyclopedia of Rose Science. Elsevier Science Publishing Co Inc. Academic Press. **1**: 117-124.

MARINESCU G., COSTACHE M., STOENESCU A. 1988. *Bolile plantelor floricole.* Edit. Ceres. Bucureşti. 216 pp.

NICOLAE I. 2010. *Fiziologia plantelor horticole.* Edit. „Sitech", Craiova. 262 pp.

SĂVESCU A. & RAFAILĂ C. 1978. *Prognoza în protectia plantelor.* Edit. „Ceres", Bucureşti. 354 pp.

SĂVULESCU OLGA, BARBU VALERIA, ELIADE EUGENIA, NĂGLER M., TUDOSESCU-BĂNESCU VERONICA. 1969. *Bolile plantelor ornamentale din România.* Edit. Academiei R.S.R. Bucureşti. 604 pp.

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RESEARCH ON BRYOPHYTES FROM OCHIU LAKE

DOBRESCU Codruţa Mihaela, SOARE Liliana Cristina

Abstract. Located in Argeş County, Ochiu Lake is part of a chain of swampy depressions, all formed by the landslides triggered by the deepening of the Valsan Valley. It was first referred to by GH. TURCU (1960) who indicated the presence of this crossing swamp with a central oligotrophic nest, the only one known in the Southern Carpathians areas at the time. In terms of hydrology, chemistry and flora, the features of the area vary considerably from the data known 50 years ago, the work showing especially the changes on bryophytes.

Keywords: Ochiu Lake, swamps, *Sphagnum*, bryoflora.

Rezumat. Cercetări privind brioflora de la Lacul cu Ochiu. Lacul cu Ochiu a fost semnalat pentru prima dată de GH. TURCU în anul 1960 ca fiind singura mlaştină de trecere cu un cuib central oligotrof, cunoscută în regiunile extracarpatice din sudul Carpaţilor Meridionali. Este situat în cadrul platformei gruiurilor argeşene şi face parte dintr-o salbă de depresiuni înmlăştinite, formate toate prin alunecările de teren care s-au declanşat după adâncirea văii Vâlsanului. În ceea ce privesc aspectele hidrologice, chimice şi floristice, fizionomia zonei variază considerabil faţă de datele cunoscute de acum 50 de ani, lucrarea prezentând modificările survenite în special în ceea ce priveşte briofitele.

Cuvinte cheie: Lacul cu Ochiu, mlaştină, *Sphagnum*, brioflora.

INTRODUCTION

The wetlands are remarkable ecologic sites, recognized today as biodiversity reserves.

Wetlands is a collective term for water units classified as swamps, bogs, ponds and rush-beds found along the coasts or marine and ocean shores, within the river basin perimeters, along the major water-courses, especially in the lower sectors of the grasslands, as well as in other flat areas (VANDERPOORTEN & GOFFINET, 2009; GOFFINET & SHAW, 2009).

Ochiu Lake is situated on the left side of the Valsan river, about 3 km away from Stroeşti village, Argeş county. It was first referred to by TURCU (1961) who indicated the presence of this crossing swamp with a central oligotrophic nest, the only one known in the Southern Carpathians areas at the time (TURCU, 1961).

Located in the platform of Arges hills, Ochiu Lake is part of a chain of swampy depressions, all formed by the landslides triggered by the deepening of the Valsan Valley (Fig. 1). The examination of the physical and geographical conditions, as well as the positioning factors, showed that the development of oligotrophic central area was due to topographic conditions and accumulation of large amounts of oligotrophic water coming from streams and infiltrated through crystalline, siliceous gravel, poor in nutrients (TURCU, 1970).

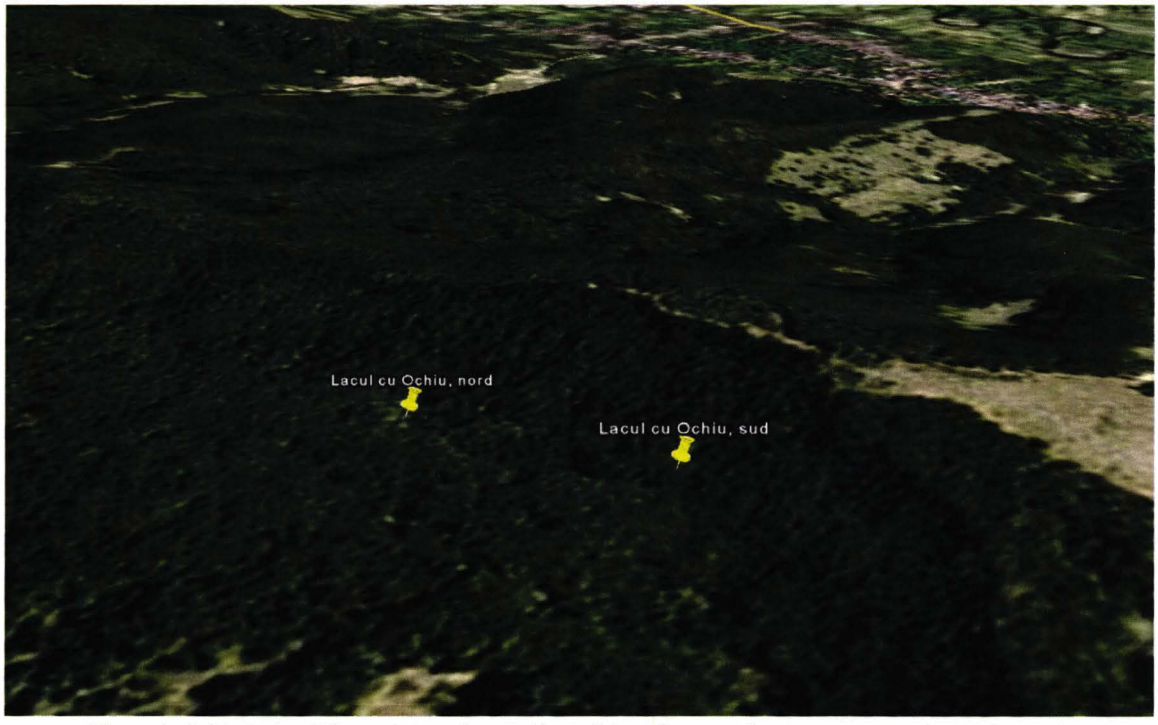


Figure 1. Ochiu Lake. / Figura 1. Lacul cu Ochiu (original, hartă realizată cu programul *Google Earth*).

Ochiu Lake occupied an area of about 5 000 m², completely covered with vegetation, and 1.5 – 2 m thick sublayer of *Sphagnum*, which contained species specific to bogs (*Eriophorum vaginatum, Drosera rotundifolia, Betula pubescens* and *B. hybrida*).

Sphagnum species was determined by Tr. Ştefureac as *Sphagnum recurvum* var. *amblyphyllum* and *S. magellanicum* var. *roseum* (sometimes passing into var. *purpurascens*) (TURCU, 1961).

MATERIAL AND METHODS

In our research we made trips to "Ochiu Lake" in the months September-November 2009 and April 2010, we collected bryophytes, we made pH measurements and marked more GPS points (100-112) on which we drew the map of the area and measured the lake surface.

Of some species of bryophytes analysed, numerous original colour photographs were made that were intended to highlight features of morphology, to complete descriptions and to ease of identifying species.

Identification was done using relevant bryological literature. Nomenclature was actualized according to Hill (HILL *et al.*, 2006).

RESULTS AND DISCUSSIONS

The description of the collecting sites is determined by the following geographic coordinates: Lake Ochiu - N - 45°07'00.0"- 45°07'06.6"; E - 24°49'02.2"- 24°49'05.5"

The data in the field show a lake altitude ranging from 587 m (point 102: N 45° 07,033', E 024° 49,077') to 615 m (point 110: N 45° 07,062', E 024° 49,040') and a pH value of 4.

Compared with the data published by Turcu 50 years ago, the current situation in the field is highly different, in that the lake has a water band whose width varies between 1.5 (in point 104: N 45° 07.065 'E 024° 49.072') and 3 m (in point 111: N 45° 07.042 'E 024° 49.056') (Fig. 2), while the inside is a heavily forested area with *Betula pubescens*, *Betula hybrida, Alnus glutinosa* and *Salix cinerea* (Fig. 3), interrupted here and there by waterholes.

By adding this water band around the lake, its surface has doubled (approx. 10,000 m²).

The northern end of Ochiu Lake develops groups of *Carex vesicaria, C. pseudocyperus, Juncus effusus* and *Sparganium erectum*.

Figure 2. Ochiu Lake surrounded by a band of water. / Figura 2. Lacul cu Ochiu înconjurat de o bandă de apă (original).

Figure 3. Ochiu Lake - Aspect of forest area. / Figura 3. Aspect din zona împădurită a Lacului cu Ochiu (original).

The vertical structure of the lake has a 30 cm soil layer, below which it lies a water layer with plant debris, 2 m deep, and a mud layer on the bottom. The waterbed is responsible for the movement of the superficial layer under the weight of each step. *Sphagnum* species were not found in vegetative state, but were identified microscopically in the soil samples (Figs. 4, 5).

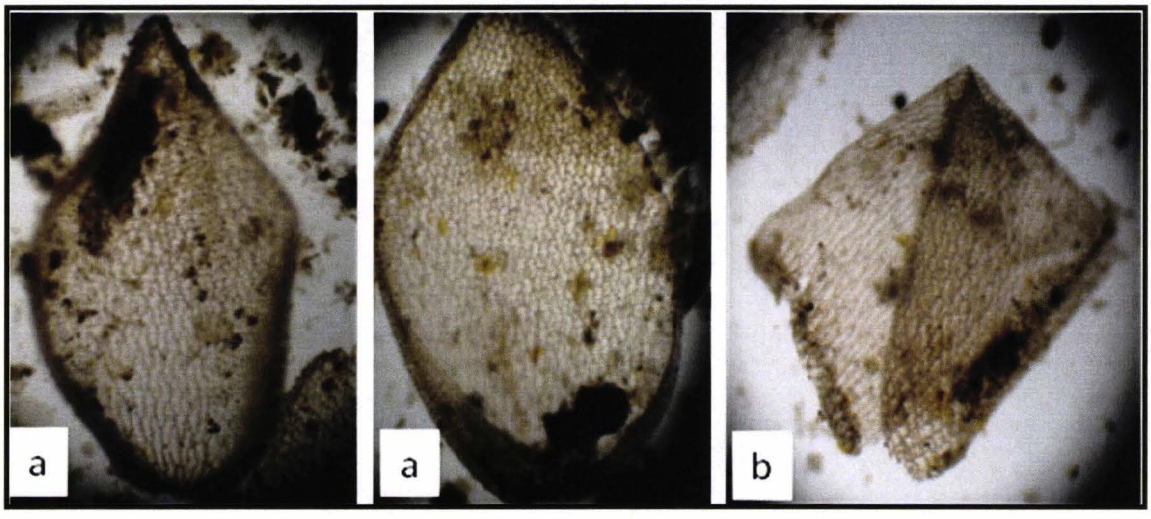


Figure 4. *Sphagnum magellanicum*: Leaf frames (a) and Leaf stems (b)./ Figura 4. *S. magellanicum*: Frunze rameale (a) şi tulpinale (b) (10X4X4) (original).

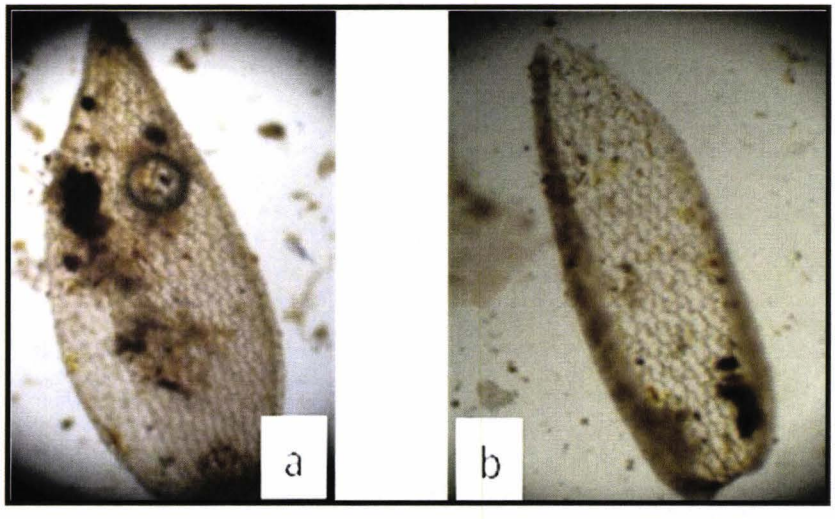


Figure 5. *Sphagnum recurvum* var. *amblyphyllum*: Leaf frames (a) and Leaf stems (b). / Figura 5. *S. recurvum* var. *amblyphyllum*: Frunze rameale (a) şi tulpinale (b) (10X4X4) (original).

At Lake Ochiu the following species of bryophytes were identified: *Riccia fluitans* L., *Lophocolea heterophylla* (SCHRAD.) DUMORT., *Sphagnum magellanicum* BRID. var. *roseum* WARNST., *S. recurvum* P. BEAUV. var. *amblyphyllum* (RUSS.) WARNST., *Atrichum undulatum* (HEDW.) P. BEAUV., *Polytrichastrum formosum* (HEDW.) G. L. SM., *Orthotrichum affine* SCHRAD. EX BRID., *Rhizomnium punctatum* (HEDW.) T. J. KOP., *Hypnum cupressiforme* var. *cupressiforme* HEDW., *H. cupressiforme* var. *lacunosum* BRID., *H. cupressiforme* var. *resupinatum* (TAYLOR) SCHIMP., *H. jutlandicum* HOLMEN & E. WARNCKE, *Leucodon sciuroides* (HEDW.) SCHWÄEGR.

With regard to the number of taxa, the best represented is *Hypnum* species (Fig. 6), while the largest populations belong to *Atrichum undulatum* and *Polytrichastrum formosum* species.

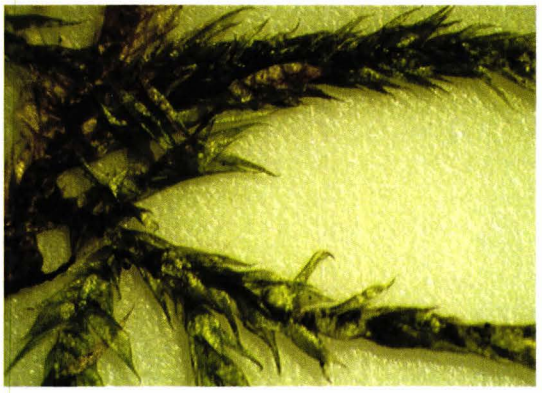
The anthropogenic pressure exerted on these habitats (drainage, deforestation, peat extraction) in the course of time, caused significant, sometimes irreversible changes, resulting in the reduction of peat bogs areas and restricting habitats of vascular plants species and specific bryophytes.

For the current state of *Sphagnum* species, we took into account the over-collection hypothesis founded by CHURCH *et al.*, 2001, and learned from the discussions with the locals that the peat moss was extensively mined and used for building wells (CHURCH *et. al.*, 2001).

Ochiu Lake has evolved in its dynamics, consisting of a mosaic of units in various stages of development, in other words, parts of different origin, thus observing both plants specific to wetlands, and some interesting plants, specific to eutrophic swamps.

Although we have chosen to study only bryophytes, Ochiu Lake is an oligotrophic swamp, with mesotrophic and eutrophic areas requiring further research in terms of flora and vegetation.

Hypnum cupressiforme var. ***cupressiforme***



Hypnum cupressiforme var. ***resupinatum***

Figure 6. Differentiation of the genus *Hypnum* taxa according to the leaf appearance and mode of insertion on the stem.
Figura 6. Diferenţierea taxonilor genului *Hypnum* după aspectul frunzelor şi modul de inserare pe tulpină (original).

REFERENCES

CHURCH J. M., HODGETTS N. G., PRESTON C. D., STEWART, N. F. 2001. *British Red Data Books. 2. Mosses and Liverworts*. Joint Nature Conservation Committee. Peterborough, UK.

GOFFINET B. & SHAW A. J. 2009. *Bryophyte Biology, Second Edition*. Cambridge University Press. Cambridge. 565 pp.

HILL M. O., BELL N., BRUGGEMAN-NANNENGA M. A., BRUGUÉS M., CANO M. J., ENROTH J., FLATBERG K. I., FRAHM J. P., GALLEGO M. T., GARILLETI R., GUERRA J., HEDENÄS L., HOLYOAK D. T., HYVÖNEN J., IGNATOV M. S., LARA F., MAZIMPAKA V., MUÑOY J., SÖDERSTRÖM L. 2006. *Bryological Monograph. An annotated checklist of the mosses of Europe and Macaronesia*. Journal of Bryology. Maney Publishing. London. **28**: 198-267.

TURCU GH. L. 1961. *Sfagnetul de la Lacul cu Ochiu (reg. Argeş)*. Comunicările Academiei Republicii Populare Române. Edit. Academiei Române. Bucureşti. **11**(6): 665-673.

TURCU GH. 1970. *Flora şi vegetaţia regiunii deluroase dintre Argeş şi Rîul Doamnei*. Rezumatul tezei de doctorat. Centrul de multiplicare al Universităţii din Bucureşti. Bucureşti. 55 pp.

VANDERPOORTEN A. & GOFFINET B. 2009. *Introduction to Bryophytes*. Cambridge University Press. Cambridge. 303 pp.

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AREAL LIMITS IN THE ROMANIAN TERRITORY: *Aphanes australis* RYDBERG 1908

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Abstract. The taxonomy and chorology of some species belonging to the *Aphanes* genus in Europe, including Romania, is still unclear. This paper continues the series of the type of papers started by the great botanist Dihoru, works regarding the chorology of the species with their limits within Romania. There are included the localities where the species was found within Romania and also some ecological considerations.

Keywords: *Aphanes australis*, taxonomy, chorology, Romania.

Rezumat. Limita arealului pe teritoriul României: *Aphanes australis* RYDBERG 1908. Taxonomia şi corologia unor specii aparţinând genului *Aphanes* din Europa, inclusiv România este încă neclară. Lucrarea de faţă continuă seria lucrărilor de acest gen începute de marele botanist Dihoru, lucrări ce vizează corologia speciilor cu limita arealului pe teritoriul României. Sunt incluse localităţile în care a fost găsită specia pe teritoriul României şi unele consideraţii ecologice.

Cuvinte cheie: *Aphanes australis*, taxonomie, corologie, România.

INTRODUCTION

The *Aphanes* genus species of the Romanian flora were initially included in the *Alchemilla* genus (BUIA, 1956). Subsequently there were separated from this genus to the *Aphanes* one in the different determinators of the country (BELDIE, 1977, 1979; CIOCÂRLAN, 2000, 2009) based on obvious characteristics: they are annual plants, the flowers are grouped in side fascicles opposite to the leaves and they have only a stamen.

Initially only *Aphanes arvensis* LINNAEUS 1753 was known from the flora of our country (BUIA, 1956). Subsequently, NYÁRADY (1957) mentions a second species of this genus in Romania: *Aphanes microcarpa* (BOISS. & REUT.) ROTHM. 1937 with the following synonyms: *Alchemilla microcarpa* BOISS. & REUT. 1842; *A. pusilla* POMEL. ex BATT. & TRAB. 1888; *A. minutiflora* AZN. 1899. The discussions regarding this species made by A. NYÁRADY refers to the *Aphanes microcarpa s.l.* aggregate species, as it results from the synonyms inserted and as it was also considered by ROTHMALER in 1937.

By 2006, only the two species under the name listed above were known for this genus. DIHORU & RĂDUŢOIU (2006) were the first ones that mention *Aphanes australis* RYBD. under this name in the flora of our country. It is in fact the so-called *A. microcarpa* sensu A. NYÁRADY.

MATERIAL AND METHODS

The collected material was analysed according to the Romanian and foreign literature (BRITTON & BROWN, 1913; CARRASCO & MONGE, 1991; CIOCÂRLAN, 2000, 2009; DIHORU & RĂDUŢOIU, 2006; HOLUB, 1970; LIPPERT, 1984; WALTERS 1968).

The authors' abbreviations were done after BRUMMITT & POWELL (1992).

The resorts where the species was found are presented together with the GPS coordinates, and we used LEHRER & LEHRER (1990) coordinates (Rugetu - GR20 and Moi - FQ77) for mapping the distribution of this species in Romania.

RESULTS AND DISCUSSIONS

The collected material from the two localities mentioned at the chorology belongs to: *Aphanes australis* RYDB. 1908, (*A. microcarpa* auct. roman., non (BOISS. & REUT.) ROTHM., (NYÁRADY, 1957), *A. inexspectata* LIPPERT 1984, (CIOCÂRLAN, 2000)), species characterized by divided stipule in elongated and hypanthium lobes of 1.4 mm (Figs. 1-4).

It is worth mentioning that: it is a small, low-growing plant, with leaves having 3-5 lobes, 2-10 mm long, and usually appearing green. Insignificant flowers are produced in the leaf axils, and have no petals.

When it is briefly analysed, it may be confused with *Aphanes arvensis* L. from which it may be differentiated by several characteristics:

1a. Flowers 1.5-2 mm long with sepals slightly divergent. Fructiferous Hypanthium larger than 2 mm. Palmate-lobate stipules with triangular lobes ..... *Aphanes arvensis* L.

1b. Flowers up to 1 mm long with conivent sepals. Fructiferous Hypanthium of 1.4-1.9 mm. Palmate thin stipules with oblong lobes ..... *Aphanes australis* RYDB.

Ecology and cenology: It is an heliophilous, thermophile plant and grows in grassed areas, on textured soils more or less sandy. It cohabits with *Cerastium glomeratum* THUILL., *Montia fontana* L. subsp. *chondrosperma* (FENZL) WALTERS (Fig. 5).

Status: Critically Endangered (CR).

Chorology from Romania: Arad County: Zarand Mountains, Debela Gora Hill, September 25, 1970, leg. I. Pop (as *A. arvensis* [CL 593286], rev. G. Negrean 31.I.2004); Vâlcea County: between Slătioara and Milostea (NYÁRADY, 1957); Mehedinţi County: the Dubova Depression, July 25, 1966, leg. ?, det. G. Negrean [BUCM 71216] (DIHORU & NEGREAN, 2009). The new locations (Fig. 6): Moi village, Gorj county- N 44°54'094 "and E 23°13'358" at heights of 244 m and Rugetu locality N 45°08'290 "and E 23°520'210" at heights of 531 m.

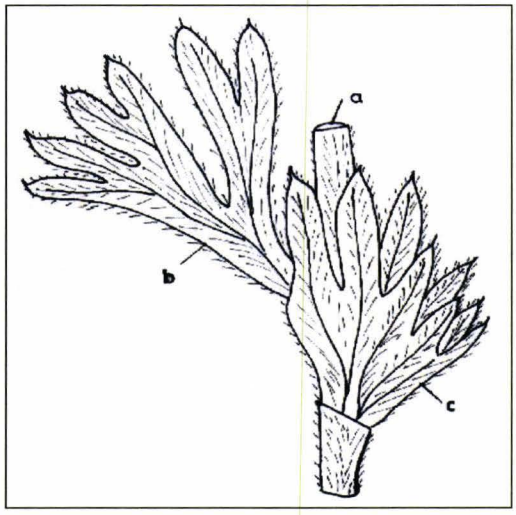

Figure 1. *Aphanes australis* - upper leave: a. ax; b. lamina; c. stipules (6x).
Figura 1. *A. australis* - frunză superioară: a. ax; b. lamină; c. stipele (6x) (original).

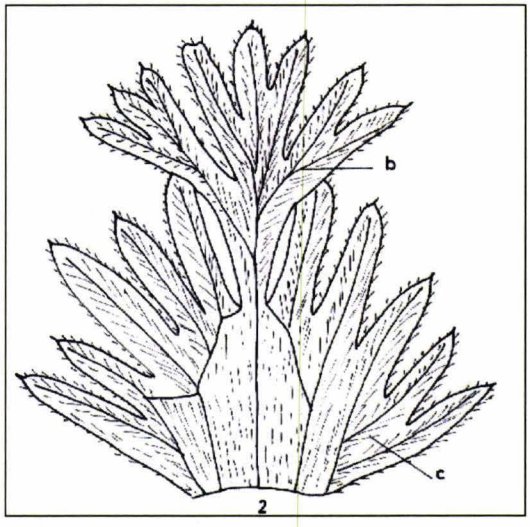

Figure 2. *Aphanes australis* - middle leave with split and wide stipules: b. lamina; c. stipules (6x).
Figura 2. *A. australis* - frunză mijlocie cu stipulele despicate şi întinse - b. lamină; c. stipele (6x) (original).

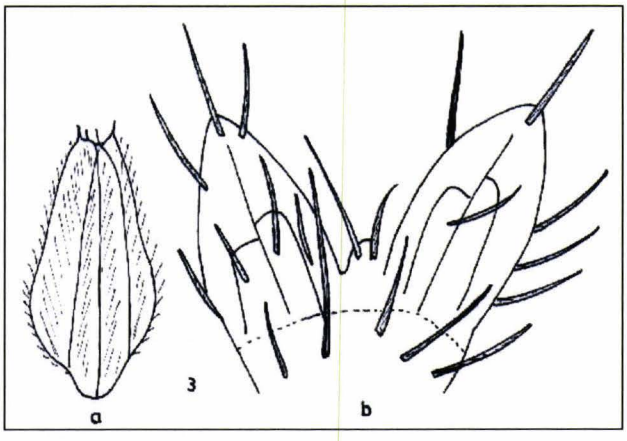

Figure 3. *Aphanes australis* - hypanthium: adaxial seen (15x) b. two lobes from calyx (it can be observed a lobe from calyx) (50x).
Figura 3. *Aphanes australis* - hipantiu: vedere adaxială (15 x); b. 2 lobi ai caliciului (se observă un lob din caliciu) (50x) (original).

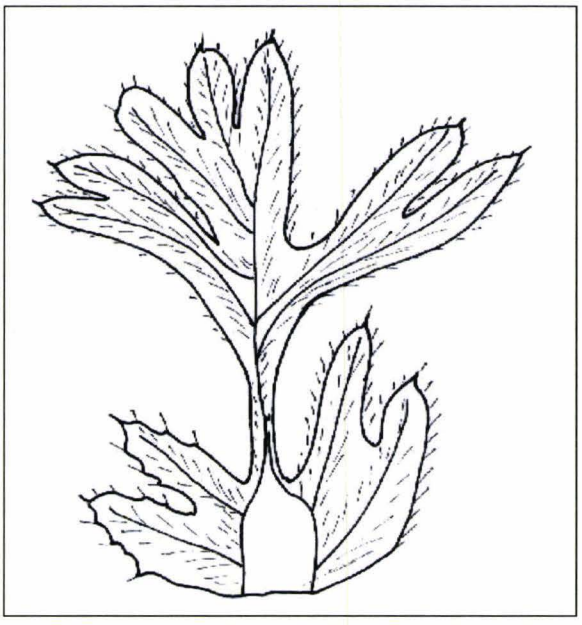

Figure 4. *Aphanes australis* - inferior leave.
Figura 4. *A. australis* - frunză inferioară (6x) (original).

Figure 5. *Aphanes australis* RYDB. alongside *Montia fontana* L. subsp. *chondrosperma* (FENZL) WALTERS in meadow from Moi locality.
Figura 5. *Aphanes australis* RYDB. alături de *Montia fontana* L. subsp. *chondrosperma* (FENZL) WALTERS în pajişti din localitatea Moi (original).

CONCLUSIONS

The paper represents a timid attempt to clarify the *Aphanes australis* RYDB. species in Romania.

In addition to the information from nomenclature, ecology and taxonomy there are also presented in this paper the chorology information from literature, collections and personal observations that are also included in a map.

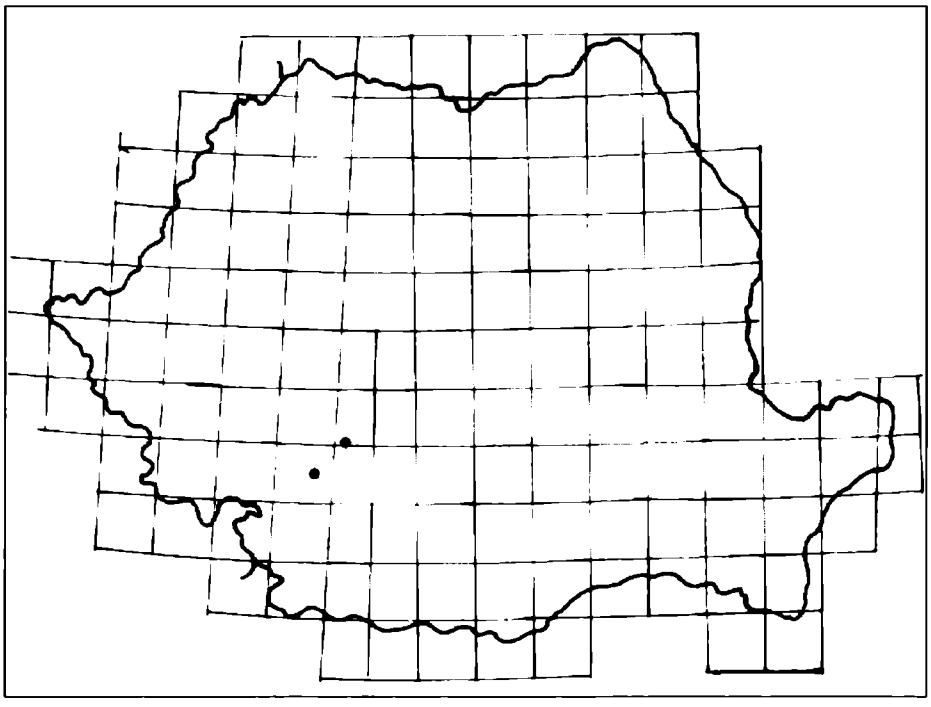

Figure 6. The map with new locations for *Aphanes australis* RYDB. from Romania.
Figura 6. Harta cu noile locaţii pentru *Aphanes australis* RYDB. din România (original).

REFERENCES

BELDIE AL. 1977, 1979. *Flora României. Determinator ilustrat al plantelor vasculare.* Edit. Academiei Române. Bucureşti. **1, 2**: 406, 412.

BRITTON N. L. & BROWN H. A. 1913. *An illustrated flora of the Northen United States Canada and the British Possessions.* Charles Scribner's Sons. New York. 2-735.

BRUMMITT R. K. & POWELL C. E. 1992. *Authors of plant names.* Royal Botanic Gardens. Kew. (EDS.). 732 pp.

BUIA AL. 1956. *Fam. Rosaceae.* In: Flora României. Edit. Academiei Române. Bucureşti: **4**: 161-883.

CARRASCO M. A. & MONGE C. 1991. *Precisiones sobre el grupo Aphanes microcarpa en la Peninsula Iberica.* Candollea, Genneve. **46**: 101-110.

CIOCÂRLAN V. 2000. *Flora ilustrată a României. Pteridophyta et Spermatophyta.* Edit. Ceres. Bucureşti. 1038 pp.

CIOCÂRLAN V. 2009. *Flora ilustrată a României. Pteridophyta et Spermatophyta.* Edit. Ceres. Bucureşti. 1041 pp.

DIHORU G. & RĂDUŢOIU D. 2006. *Aphanes microcarpa s.l. in Romania.* Croatian Symposium on Agriculture. Opatia. Croaţia. **40**: 769-770.

DIHORU G. & NEGREAN G. 2009. *Cartea roşie a plantelor vasculare din România.* Edit. Academiei Române. Bucureşti. 630 pp.

HOLUB J. 1970. *Brief Comments on the second volume of "Flora Europaea".* Preslia (Praha). **42**: 90-95.

LEHRER A. Z. & LEHRER MARIA 1990. *Cartografierea faunei şi florei României (coordonate arealografice).* Edit. Ceres, Bucureşti. 290 pp.

LIPPERT W. 1984. *Zur Kenntnis Aphanes microcarpa - Komplexes.* Mitteilungen der Botanischen Munchen. **20**: 451-464.

NYÁRADY A. 1957. *Aphanes microcarpa (Boiss. & Reut.) Rothm., o specie nouă pentru flora Romaniei din Fam. Rosaceae.* Studii şi Cercetări de Biologie. Bucureşti. **8**(3-4): 285-289.

ROTHMALER W. 1937. *Systematische Vorarbeiten zu einer Monographie der Alchemilla* (L.) Scopoli emendat VII. *Aufteilung der Gattung und Nomenclatur.* Feddes Repert. Berlin. **42**: 164-173.

WALTERS S. N. 1968. *Aphanes* L. In: TUTIN T. G., HEYWOOD V. H., BURGES N. A., MOORE D. M., VALENTINE D. H., WALTERS S. M. & WEBB D. A. *Flora Europaea.* At the University Press. Cambridge. **2**: 64.

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CHOROLOGICAL STUDIES OF SOME MEDICINAL PLANTS FROM SOZOLOGICAL CATEGORIES OF THE MOUNTAIN FLORA OF ARGEŞ COUNTY

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Abstract. Reported to the number of higher plants of the Romanian flora, in Argeş County, there grow a significant number of plants with medicinal properties. The flora of Arges County is represented by 2009 species; 411 species are included in different sozological categories, 23 of the species with medicinal properties being grouped in five categories of the Red List: Vulnerable (7), Near Threatened (12), Least Concern (1), Critically Endangered (1) and Data Deficient (1).

Keywords: chorological, sozological, Argeş county.

Rezumat. Studiu corologic al unor plante medicinale din categorii sozologice în flora munţilor judeţului Argeş. Raportat la numărul speciilor de plante superioare din flora Romaniei, în judeţul Argeş există un număr semnificativ de plante cu proprietăţi medicinale. Flora judeţului Argeş numără 2009 specii superioare, 411 sunt incluse în diferite categorii sozologice, iar dintre acestea, 23 specii cu proprietăţi oficinale sunt distribuite în cinci categorii sozologice: vulnerabile (7), aproape ameninţate (12), cu risc scăzut de dispariţie (1), critic periclitate (1) şi insuficient cunoscute (1).

Cuvinte cheie: corologic, sozologic, judeţul Argeş.

INTRODUCTION

Based on the estimated number of the Romanian Flora - 3759 species and subspecies of higher plants (CIOCÂRLAN, 2009), a significant amount of medicinal plants grows in Argeş County. The information from the literature and personal researches in the field has shown the existence of 2009 species and subspecies in the Făgăraş Mountains in Argeş County. All these taxonomic categories belong to 584 genera and 144 botanical families. Among these species and subspecies, 411 are included in the following categories of the Red List: rare, vulnerable, endemic to Romania, endemic to Romania but not endangered, species having rare European specific spreading area, species having endangered European specific spreading area (IUCN Red List, Habitats Directive Annex IIb, IVb and Bern Convention - App I). The results of this paper regarding chorology, ecology and medicinal proprieties of the studied species offer useful information concerning the biodiversity, conservation and possibilities for economic and medicinal exploitation.

MATERIAL AND METHODS

The establishment of the protected plants was made by: BOŞCAIU *et al.*, 1994; DIHORU & DIHORU, 1994, OLTEAN *et al.*, 1994; OPREA, 2005; ALEXIU, 2008 and DIHORU & NEGREAN, 2009.

The **IUCN Red List of Threatened Species** (also known as the **IUCN Red List** or **Red Data List**) is the world's most comprehensive inventory of the global conservation status of plant and animal species. The International Union for the Conservation of Nature and Natural Resources (IUCN) is the world's main authority on the conservation status of species. A series of Regional Red Lists are produced by countries or organizations, which assess the risk of extinction to species within a political management unit.

Species are classified in nine groups, set through criteria such as rate of decline, population size, area of geographic distribution, and degree of population and distribution fragmentation.

1. Extinct (EX) - No individuals remaining.
2. Extinct in the Wild (EW) - Known only to survive in captivity, or as a naturalized population outside its historic range.
3. Critically Endangered (CR) - Extremely high risk of extinction in the wild.
4. Endangered (EN) - High risk of extinction in the wild.
5. Vulnerable (VU) - High risk of endangerment in the wild.
6. Near Threatened (NT) - Likely to become endangered in the near future.
7. Least Concern (LC) - Lowest risk. Does not qualify for a more at risk category. Widespread and abundant taxa are included in this category.
8. Data Deficient (DD) - Not enough data to make an assessment of its risk of extinction.
9. Not Evaluated (NE) - Has not yet been evaluated against the criteria

RESULTS AND DISCUSSIONS

Categories of vulnerable (VU) and critically endangered plants (CR) are represented, in Argeş, by the following species: *Angelica archangelica* L., *Arnica montana* L., *Galanthus nivalis* L., *Gentiana lutea* L., *Gentiana*

punctata L., *Leontopodium alpinum* CASS., *Narcissus poëticus* L. ssp. *radiiflorus* (SALISB.) BAKER and *Rhododendron myrtifolium* SCHOTT ET KOTSCHY. IUCN category, the family, frequency in Arges county, therapeutic properties are presented in Table 1. For conservation, it is recommended banning their collection.

Table 1. IUCN categories of medicinal flora in Argeş County and their therapeutic properties.
Tabel 1. Categoriile IUCN de floră medicinală în judeţul Argeş şi proprietăţile lor terapeutice.

Family	Species	Frequency in Argeş county	IUCN Category	Phytotherapy
Apiaceae	*Angelica archangelica* L.	Occasionally	VU	Angelica contains a variety of chemicals which have been shown to have medicinal properties. Chewing on angelica or drinking tea brewed from it will cause local anaesthesia, but it will heighten the consumer's immune system. It has been shown to be effective against various bacteria, fungal infections and even viral infections (NĂDĂŞAN, 2003)
	Syn.: *Archangelica officinalis* HOFFM. Family: Asteraceae Vernacular: Angelică; Anghelică; Anghelină; Buceniş; Buciniş; Cucută mare. Geographical Distribution: Eua-bor IUCN Category: VU Located in Argeş: Râiosu-Buda Massif: Buda Valley, Iezer-Păpuşa Massif: Bătrâna Valley, Iezer Valley, Leaota Mountains: Marginea Domnească (The edge of the Royal), Bădenilor Valley, Făgăraş Massif: Zârna Valley.			
Ericaceae	*Rhododendron myrtifolium* SCHOTT ET KOTSCHY	Occasionally	VU	Anti-inflammatory and hepatoprotective functions against related diseases, which is probably due to its anti-oxidant efficacy sourced from flavonoids, saponins and phenolic compounds (BOJOR, 2003)
	Syn.: *Rhododendron kotschyi* SIMONK.; *Rhododendron ferrugineum* L. subsp. *kotschyi* (SIMONK.) HAYEK Family: Ericaceae Vernacular: Bujor de munte; Smârdar; Perişoare; Popdele; Tulpin, Vase munte. Geographical Distribution: Carp-Balc IUCN Category: VU Located in Argeş: Massif Râiosu-Buda, Massif Piatra Craiului, Massif Iezer-Păpuşa: Păpuşa, Portăreasa, Şeţu, Ţefeleica, Mâra Mică, Tărâţoasa Mountains, Huluba Peak, Curmătura Groapelor, Iezerul Mare, Iezer Valley, Bătrâna Peak, Lespezi, Căţunu Valley, Andrew's teeth, Bătrâna by Colţi, Leaota Mountains: Tâncava, Românescu, Leaota Peak.			
Gentianaceae	*Gentiana lutea* L.	Occasionally	CR	The root is anthelmintic, anti-inflammatory, antiseptic, biter tonic, emmenagogue, cholagogue, febrifuge, refrigerant and stomachic. It is taken internally in the treatment of liver complaints, indigestion, gastric infections and anorexia (CHIEJ, 1984)
	Family: Gentianaceae Vernacular: Ghinţură galbenă Geographical Distribution: Alp-Carp IUCN Category: VU Located in Argeş: Făgăraş Massif, Ghimbav Massif, Piatra Craiului Massif: Dâmbovicioara Gorges.			
	Gentiana punctata L.	Occasionally	VU	Anthelmintic, stimulates gastric secretion, stimulates bile secretion, tonic, anti-pyretic, stimulating appetite (BOJOR, 2003)
	Family: Gentianaceae Vernacular: Enţură, Ghinţură pătată, Ochincea. Geographical Distribution: Alp-Carp IUCN Category: VU Located in Argeş: Râiosu-Buda Massif, Iezer-Păpuşa Massif: M. Căţunu, Valley Iezer, Făgăraş Massif: Negoiu Peak, "Capra Budei".			
Asteraceae	*Arnica montana* L.	Relativ Occasionally	VU	An antiseptic ointment is used to treat wounds, bruises and inflammation. It contains the toxin helenalin, which can be poisonous if large amounts of the plant are eaten. The roots contain derivatives of thymol, which are used as fungicides and preservatives and may have some anti-inflammatory effect (BOJOR, 2003).

	Family: Asteraceae Geographical Distribution: Eur Frequency in Romania: Relatively Occasionally IUCN Category: VU Located in Argeş: Piatra Craiului Massif: Dâmbovicioarei Gorges, Brusturetului Gorges, Ghimbav Mountains: Cheii Gorges, Great Gorge of the Dambovita, Iezer-Păpuşa Massif: Andrew's teeth			
	Leontopodium alpinum CASS.	Occasionally	VU	In the scientific literature one can find evidence for pharmacological and cosmetic properties: anti-inflammatory properties, anti-bacterial properties, Anti-inflammatory and analgesic and anti-swelling properties in vivo (animal experiments), sun protection (DOBNER et al., 2004).
	Syn.: *Antennaria leontopodium* (L.) GAERTN. Family: Asteraceae Vernacular: Albumeală; Albumiţă; Floare de colţ; Floare de coţi; Floare de stâncă; Floare domească; Floarea reginei; Flocoşele; Linărică; Mucezea; Prescurele; Semenic; Studeliţe; Talpa mâţei. Geographical Distribution: Eua IUCN Category: VU Located in Argeş: Râiosu-Buda Massif, Ghimbav Mountains: Cheiţei Gorges, Great Gorges of the Dambovita, Piatra Craiului Massif: Dâmbovicioarei Gorges, Brusturetului Gorges, Marele Grohotiş (Grand detritus), Făgăraş Massif: "Capra Budei", Piciorul Caprei, Negoiu.			
Amaryllidaceae	*Galanthus nivalis* L.	Frequent	VU	An active substance in snowdrop is called galantamine, which, as anticholinesterase, can act as an antidote to poisons. Galantamine (or galanthamine) can be helpful in the treatment of Alzheimer's disease, though it is not a cure (PÂRVU, 2000).
	Family: Amaryllidaceae Vernacular: Ghiocei, Aişoare, Cloconei, Clocoţei de omăt, Ghiorele, Luşte, Primăvăruţă. Geographical Distribution: Eur IUCN Category: VU Located in Argeş: Râiosu-Buda Massif, Budei Valley, Piatra Craiului Massif: Dâmbovicioarei Gorges, Brusturetului Gorges, Dragoslovenilor Valley, Ghimbav Mountains: Great Gorges of the Dâmboviţa.			
	Narcissus poëticus L. ssp. *radiiflorus* (SALISB.) BAKER	Occasionally	VU	Pharmaceutical action: flowers have soothing properties, soothing, emollient, disinfectant, antiseptic lung. You can use it for the following disorders: anxiety, asthma, diarrhea, cardiac neurosis, agitation or nervousness, tachycardia, cough (BOIT & STENDER, 1954).
	Syn.: Narcissus radiiflorus SALISB.; *Narcissus angustifolius* CURTIS EX HAW.; *Narcissus poëticus* L. subsp. *angustifolius* HEGI). Family: Amaryllidaceae Geographical Distribution: Euc IUCN Category: VU Located in Argeş: Poiana Narciselor Negraşi			

CONCLUSIONS

In Argeş county, a relatively large number of plant species are in different endangered categories. Some of these have medicinal properties. The paper highlights chorology, distribution, vernacular name, vulnerability, their major phototherapeutic effects.

Endangered species from different categories that have medicinal properties will be multiplied by various traditional breeding methods or by biotechnological breeding methods to protect natural species.

REFERENCES

ALEXIU V. 2011. *Categorii sozologice din cormoflora judeţului Argeş*. Edit. Paralela 45. Piteşti. 234 pp.

ALEXIU V. 2008. *Cormoflora judeţului Argeş*. Edit. Ceres, Bucureşti. 323 pp.

BOIT H. G. & STENDER W. 1954. *Uber die alkaloide Narcissus poëticus. I. Mitteil. Uber Amaryllidaceen-alkaloide*. Chem Berichte. **87**: 624-627.

BOJOR O. 2003. *Ghidul plantelor medicinale şi aromatice de la A la Z*. Edit. Fiat Lux, Bucureşti. 266 pp.

BOŞCAIU N., COLDEA GH., HOREANU CL. 1994. *Lista Roşie a plantelor vasculare dispărute, periclitate, vulnerabile şi rare din flora României*. Ocrotirea Naturii şi a Mediului înconjurător. Edit. Academiei, Bucureşti. **38**(1): 45-56.

CHIEJ R. 1984. *The Macdonald Encyclopedia of Medicinal Plants*. Macdonald & Co. London. 274 pp.
CIOCÂRLAN V. 2009. *Flora ilustrată a României. Pteridophyta et Spermatophyta*. Edit. Ceres, Bucureşti. Ed. a III-a. 1141 pp.
DIHORU GH. & DIHORU ALEXANDRINA. 1994. *Plante rare, periclitate şi endemice în Flora României – Lista Roşie*. Acta Horti. Botanici, Bucureşti: 173-197.
DIHORU GH. & NEGREAN G. 2009. *Cartea Roşie a plantelor vasculare din România*. Edit. Academiei Române, Bucureşti. 630 pp.
DOBNER M. J., SOSA S., SCHWAIGER S., ALTINIER G., DELLA LOGGIA R., KANEIDER N. C., STUPPNER H. 2004. *Anti-inflammatory activity of Leontopodium alpinum and its constituents*. Planta medica. **70**(6): 502.
NĂDĂŞAN V. 2003. *Incursiune în fitoterapie*. Edit. Viaţă şi Sănătate, Bucureşti. 288 pp.
OLTEAN M., NEGREAN G., POPESCU A., ROMAN N., DIHORU G., SANDA V., MIHĂILESCU SIMONA. 1994. *Lista roşie a plantelor superioare din România*. Academia Română, Bucureşti: 1-52.
OPREA A. 2005. *Lista critică a plantelor vasculare din România*. Edit. Universităţii „Alexandru Ioan Cuza", Iaşi. 668 pp.
PÂRVU C. 2000. *Universul plantelor*. Mică Enciclopedie. Ed. a III-a, revăzută şi completată. Edit. Enciclopedică, Bucureşti. 871 pp.
***. http://en.wikipedia.org/wiki/IUCN_Red_List (accessed March 11, 2012).

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CONSIDERATIONS REGARDING THE ASSOCIATION *Veratretum albi* PUŞCARU et al., 1956

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Abstract. In this paper are presented the results of the study research that I performed in the Southern Carpathians in the period 2004-2009 regarding the association *Veratretum albi* PUŞCARU *et al.*, 1956. Although groups of *Veratrum album* LINNÉ were met in almost all the massifs of the Southern Carpathians, well united phytocoenosis were identified only in the Retezat Mountains. The variation of the rather big floristic composition of the phytocoenosis determined a lot of opinions regarding the syntaxonomic position. Although the field observation suggest to include the association among the megaforbs, in the Class Mulgedio-Aconitetea HADAČ & KLIKA in KLIKA 1948 because when the nitrates finish from the soil the characteristic species of the Order Adenostyletalia became predominant. The surveyings from the Hăşmaş Mountains and Cibin Mountains described by other authors – besides of my own surveyings – have been presented in the phytosociological table of this association.

Keywords: megaforbs, *Veratretum albi*, Southern Carpathians.

Rezumat. Consideraţii privind asociaţia *Veratretum albi* PUŞCARU et al., 1956. În această lucrare sunt prezentate rezultatele cercetărilor personale referitoare la asociaţia *Veratretum albi* PUŞCARU *et al.*, 1956 efectuate în Carpaţii Meridionali în perioada 2004-2009. Deşi pâlcuri de *Veratrum album* LINNÉ au fost întâlnite în aproape toate masivele muntoase din Carpaţii Meridionali, fitocenoze bine închegate au fost identificate numai în Munţii Retezat. Variaţia compoziţiei floristice destul de largi a fitocenozelor a determinat o multitudine de păreri în privinţa poziţiei sintaxonomice. Totuşi, observaţiile din teren pledează pentru încadrarea asociaţiei printre megaforbiete, în clasa Mulgedio-Aconitetea HADAČ & KLIKA in KLIKA 1948 datorită faptului că odată cu epuizarea nitraţilor din sol devin predominante speciile caracteristice ordinului Adenostyletalia. În tabelul fitosociologic al acestei asociaţii sunt prezentate, alături de releveele proprii şi releveele descrise de alţi autori din Masivul Hăşmaş şi Munţii Cibin.

Cuvinte cheie: megaforbiete, *Veratretum albi*, Carpaţii Meridionali.

INTRODUCTION

Physical and geographical setting

The Southern Carpathians are the highest area of our country. These mountains are situated in central Romania, south to the Transylvanian Depression. Prahova Valley (East), Timiş-Cerna Passage (West) and hilly regions (North & South) are framing these mountains. The following groups are forming the Southern Carpathians: Bucegi Group, Făgăraş Group, Parâng Group, Retezat-Godeanu Group.

The Eastern Carpathians lie from the northern border of the country up to Prahova Valley. They are formed by several mountainous groups: the northern group (Maramureş and Bucovina Carpathians), the central group (Moldo-Transilvanian Carpathians) and the sourthen group (the Curvature Carpathians) (POSEA, 2006).

Unlike in the Eastern Carpathians, in Southern Carpathians the metamorphic rocks and the magmatic ones are prevalent, which control the massiveness of these mountains, being more resistant to erosion (PELIN *et al.*, 1969).

The climate is a typically mountain one (1,000 and 1,800 – 2,000 m), even with alpine influences (over 1,800 - 2,000 m). The annual average temperature decreases as the height increases, from 6^0C (at 1,000 m) and 2^0C (1,800 m); the average temperature of the warmest and the coldest months decreases proportionally. The rainfalls increase from 800 mm to 1,200 mm-1,400 mm / year. The winds are on western domination, in Haţeg, Petroşani and Loviştea depressions such phenomena of thermo inversion had been reported (CRISTEA & DIMITRIU, 1961; VELCEA & SAVU, 1982).

MATERIAL AND METHODS

For the study or the vegetal carpet we have used methods of phyto-sociologic research characteristic to the Central European phytosociologic School, wich was based on the principles and methods elaborated by BRAUN-BLANQUET (1926).

The names of the species are conformable to Flora României (CIOCÂRLAN, 2009).

The syntaxonomic nomenclature was adopted according to the stipulations of the International Code of the Phytosociological Nomenclature elaborated by WEBER *et al.* (2000).

RESULTS AND DISCUSSIONS

The Association *Veratretum albi* PUŞCARU *et al.*, 1956 (Syn: *Poëto-Veratretum lobeliani* BORZA 1933 n.n.) was identified in the large area of the Southern Carpathians in the Parâng Mountains (SANDA, 2002), in the Sadu Valley Basin (DRĂGULESCU, 1995), in the Făgăraş Mountains (PUŞCARU *et al.*, 1981; POPESCU & SANDA, 1995), in the Lotru Mountains (NICULESCU *et al.*, 2008) and the area of the Eastern Carpathians (Hăşmaş Mountain, NECHITA, 2003).

The correspondent of this association in Europe is *Poo chaixii-Veratretum lobeliani* KORNAŠ & MEDWECKA-KORNAŠ 1967. Like the Romanian association, it is included in the Alliance Rumicion alpini RUBEL ex KLIKA in KLIKA & HADAČ 1944 and the Rumicetalia alpini RUBEL ex KLIKA in KLIKA & HADAČ 1944 Order. Both associations present phytocoenosis which grow in similar climatic conditions (LÁNÍKOVÁ, 2009).

Its phytocoenosis are not always clearly individualized, the only differential criteria being the abundance of the species *Veratrum album* (LINNÉ). The syntaxonomic position of the association is disputable; there are different opinions. Thus, some phytocoenologists include it together with the Association Rumicetum alpini BERGER 1922 in the Class Galio-Urticetea PASSARGE 1967 em. KOPECKÝ 1969 (SANDA *et al.*, 2008), while other include it in the Class Artemisietea vulgaris LOHMEYER et al. in R. TÜXEN 1950 (OBERDORFER 1978, COLDEA 1991) or Mulgedio-Aconitetea (MUCINA *et al.*, 1993). The field researches shown that the last variant is better, as long as after the nitrates (resulted from the animals' dejections) from the soil are finished, species of the Order Adenostyletalia become predominant and this justify the decision to include it in this order of the Aliance Rumicion alpini (SĂMĂRGHIŢAN, 2005).

Because *V. album* appears in the edificated meadows of *Festuca rubra* (LINNÉ) and *F. airoides* (LAMARCK), DRĂGULESCU (1995) consider that it is more appropriate to treat *V. album* coenosis as facieses of the association they grow up inside.

The phytocoenosis grow up very well on high altitudes, on northern slopes which are wetter, at the end of the meadow, and next to forests. In the floristic composition are included: *Veratrum album, Festuca rubra* (LINNÉ), *Nardus stricta* (LINNÉ), *Deschampsia caespitosa* (LINNÉ) BEAUV., *Trifolium repens* (LINNÉ), *Plantago media* (LINNÉ), *Stellaria graminea* (LINNÉ), *Urtica dioica* (LINNÉ) etc. (Table 1).

The spectre of the bioforms highlights a high percentage of the hemicryptophytes (77%), followed by the therophytes (13%) and chamephytes (4%), while the other cathegories of bioforms are less represented in these phytocoenosis (Fig. 1).

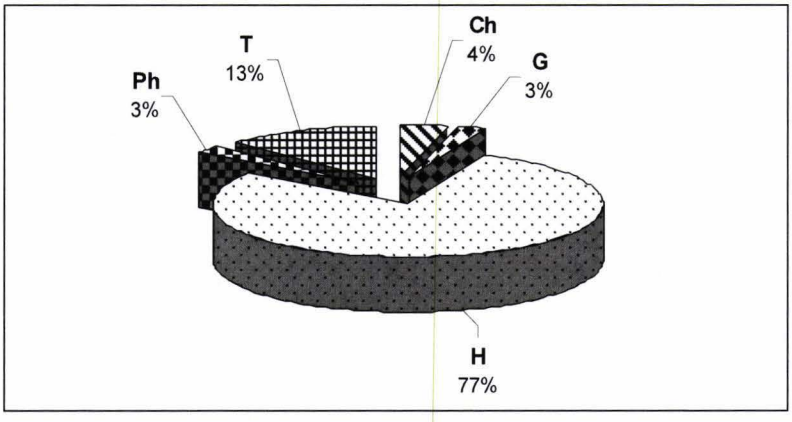

Figure 1. The spectrum of the bioforms (percentages) of the *Veratretum albi* association.
Figura 1. Spectrul bioformelor (procente) asociaţiei *V. albi.*

The floristic elements that form the basic substance of chormoflora are Eurasiatic (37.97%), European (25.31%) and Central-Europaen (6.32%). The presence of the Alps elements (8.86%) stresses the florogenetical links with the Alps' flora (Fig. 2).

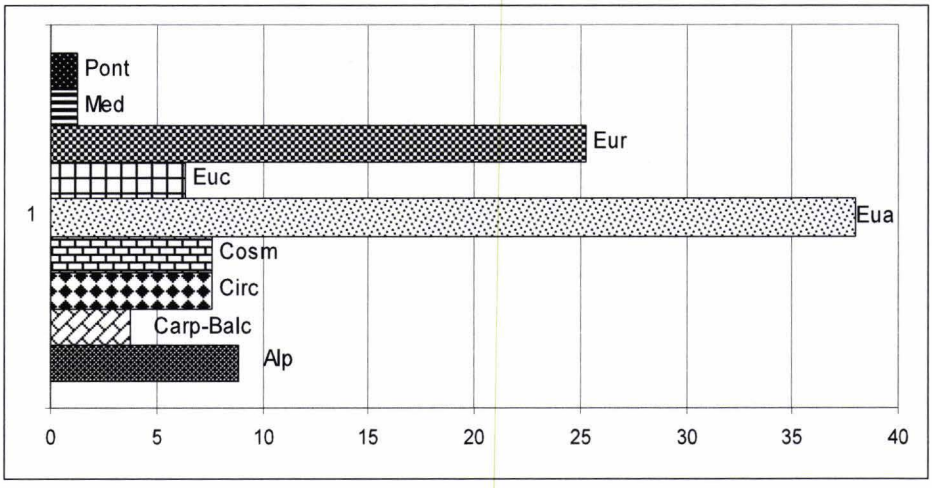

Figure 2. The spectrum of the floristics elements (percentages) of the *Veratretum albi* association.
Figura 2. Spectrul elementelor floristice (procente) pentru asociaţia *V. albi.*

Table 1. *Veratretum albi* PUSCARU *et al.*, 1956. / Tabel 1. *V. albi* PUSCARU *et al.*, 1956.

Biof.	Geoelem.	Cyt.	The relevé Altitude (m x 10) Exposure Inclination (in grades) Area (m^2) Coverage (%)	1 200 V 10 100 75	2 180 NV 45 100 75	3 170 - - - 90	4 160 NV 25 25 80	5 165 SV 20 25 80	6 150 SV 20 25 80	7 160 NE 25 25 80	8 160 NV 20 25 90	K
			Ass.									
G	Eua	D	*Veratrum album*	4	4	4	4	4	4	4	4-5	V
			Rumicion et Rumicetalia									
H	Alp-Eur	D	*Rumex alpinus*	+	+	-	+	-	+	+	+	IV
TH-H	Eur (Mont)		*Senecio squalidus*	-	-	-	-	+	+	+	-	II
H	Circ (Arct-Alp)	D-P	*Poa alpina*	-	-	-	+	-	-	-	+	II
H	Eur	P	*Rumex obtusifolius*	-	+	-	-	+	+	-	-	II
H	Cosm	D	*Veronica serpyllifolia*	-	-	-	-	-	-	+	-	I
			Adenostylion et Adenostyletalia									
H	Eua	P	*Senecio germanicus*	+	+	-	+	-	-	+	+	IV
H	Eur	P	*Valeriana sambucifolia*	-	-	-	-	+	+	-	+	II
H	Euc (Mont)	P	*Gentiana asclepiadea*	-	-	-	-	+	+	-	-	II
TH-H	Eua	D	*Angelica archangelica*	+	-	-	-	-	-	-	-	I
H	Eua	D	*Rumex arifolius*	1	1	-	-	-	-	-	-	II
			Mulgedio-Aconitetea									
H	Circ	D	*Viola biflora*	-	-	-	+	-	+	+	+	III
H	Alp-Carp	D	*Knautia longifolia*	-	-	-	+	+	+	-	-	II
mPh	Eur (Alp)	D	*Ribes petraeum*	-	-	-	-	+	-	+	-	II
H	Eur (Mont)	D	*Cicerbita alpina*	-	-	-	-	-	-	-	+	I
H	Eua (Mont)	P	*Geranium sylvaticum*	-	+	-	-	-	-	+	-	II
H	Eur (Mont)	D	*Ranunculus platanifolius*	+	-	-	-	-	-	-	+	II
H	Alp-Eur	P	*Gentiana punctata*	+	-	-	-	-	-	-	-	I
			Variae Syntaxa									
H	Circ	P	*Festuca rubra*	-	-	1	1	+	+	+	+	IV
H	Eur	D	*Anthyllis vulneraria*	-	-	-	+	+	+	-	+	III
H-G	Eua	P	*Euphorbia cyparissias*	-	-	-	+	-	+	+	+	III
H	Eua (Arct-Alp)	P	*Hieracium aurantiacum*	-	-	-	-	+	+	+	+	III
H	Eua	P	*Lotus corniculatus*	-	-	-	+	-	+	+	+	III
H-TH	Eua	D	*Trifolium pratense*	-	-	-	-	+	+	+	+	III
H (G)	Circ	P	*Agrostis capillaris*	-	-	+	+	+	+	-	-	III
H	Eur	P	*Alchemilla subcrenata*	-	-	-	+	-	-	+	+	II
H (Ch)	Eua	P	*Antennaria dioica*	-	+	-	+	+	+	-	-	III
TH	Eua	D	*Carum carvi*	-	-	-	+	-	+	+	-	I
TH	Eur	P	*Crepis biennis*	-	-	-	+	+	-	-	+	I
Th	Eur		*Euphrasia stricta*	-	-	+	-	-	+	+	+	III
TH	Alp-Carp-Balc	P	*Gentianella austriaca*	-	-	-	+	-	+	+	-	II
Ch	Euc (Mont)	D	*Helianthemum rupifragum*	-	-	-	+	+	-	+	-	II
Th-H	Eua	D-P	*Medicago lupulina*	-	-	-	-	+	-	+	+	II
H	Circ (Arct-Alp)	P	*Phleum alpinum*	-	-	-	+	-	+	-	+	II
H	Eua	P	*Taraxacum oficinale*	-	-	-	-	+	+	-	+	II
Ch	Med-Euc	P	*Teucrium chamaedrys*	-	-	-	+	+	+	-	-	II
H	Eua	P	*Trifolium repens*	-	+	+	-	+	+	+	-	IV
H	Eua	D-P	*Briza media*	-	-	-	-	+	-	-	+	II
H	Eua (Med)	P	*Carex distans*	-	-	-	+	-	+	-		II
H	Eua	P	*Dactylis glomerata*	-	-	-	-	-	-	+	+	II
H	Eua		*Leucanthemum vulgare*	-	-	+	-	-	+	+	-	II
H	Eua (Circ)	D	*Nardus stricta*	-	+	1	+	-	+	-	-	III
H	Eur	D	*Pimpinella major*	-	-	-	-	+	-	+	-	II
H	Alp (Eur)	D	*Poa molinerii*	-	-	-	-	+	-	-	+	II
H	Alp-Eur	D-P	*Potentilla aurea*	-	-	-	-	-	-	+	+	II
H	Pont-Balc		*Potentilla chrysantha*	-	-	-	+	-	+	-	-	II
H	Eua (Med)	D	*Ranunculus acris*	-	-	-	+	-	-	-	+	II
H	Eur	D-P	*Trifolium alpestre*	-	-	-	-	+	-	+	-	II
H	Atl-Eur		*Trifolium hybridum*	-	-	-	-	-	+	+	-	II
H	Eua	P	*Achillea millefolium*	-	-	+	-	-	-	+	-	II
H	Eua	P	*Anthoxanthum odoratum*	-	-	+	-	-	-	-	+	II
H	Eur	D	*Bellis perennis*	-	-	-	-	-	-	+	-	I
G	Eur	D-P	*Dacthylorhiza maculata*	-	-	-	-	+	-	-	-	I
TH-H	Eur	P	*Gentianella ciliata*	-	-	-	-	+	-	-	-	I
H	Cosm		*Juncus effusus*	-	-	-	-	-	+	-	-	I
H	Cosm	D	*Lolium perenne*	-	-	-	-	-	-	-	+	I
H	Eua	D-P	*Plantago media*	-	+	+	-	-	-	-	+	II
H	Cosm	P	*Prunella vulgaris*	-	+	-	-	-	-	-	+	II
H	Cosm	P	*Urtica dioica*	+	-	+	+	-	-	-	-	II
H	Cosm	D-P	*Deschampsia caespitosa*	+	+	1	-	-	-	-	-	II

MPh	Euc	D	*Pinus mugo*	+	-	-	-	-	-	-	-	I
H	Eua	D	*Silene vulgaris*	+	-	-	-	-	-	-	-	I
H	Eua	D	*Selinum carvifolium*	+	-	-	-	-	-	-	-	I
H	Euc	D	*Luzula sylvatica*	-	+	-	-	-	-	-	-	I
H	Eua	P	*Epilobium montanum*	-	+	-	-	-	-	-	-	I
H(Ch)	Eua	D	*Lamium maculatum*	-	+	-	-	-	-	-	-	I
H	Eur	D	*Cynosurus cristatus*	-	-	+	-	-	-	-	-	I
Th (TH)	Eur	P	*Trifolium dubium*	-	-	+	-	-	-	-	-	I
H	Euc	D	*Centaurea phrygia*	-	-	+	-	-	-	-	-	I
H	Eur	P	*Polygala vulgaris*	-	-	+	-	-	-	-	-	I
Ch	Eua	P	*Veronica officinalis*	-	-	+	-	-	-	-	-	I
H	Eua	D	*Stellaria graminea*	-	+	+	-	-	-	-	-	II
H	Eua	P	*Potentilla erecta*	-	-	+	-	-	-	-	-	I
H	Carp-Balc		*Potentilla ternata*	-	-	+	-	-	-	-	-	I
H	Eur	P	*Geum montanum*	-	-	+	-	-	-	-	-	I
H	Eur	P	*Alchemilla vulgaris*	-	-	+	-	-	-	-	-	I
TH	Carp-Balc	P	*Campanula* abietina*	-	-	+	-	-	-	-	-	I
H	Carp-Balc	D-P	*Viola declinata*	-	-	+	-	-	-	-	-	I
H	Circ	D-P	*Carex ovalis*	-	-	+	-	-	-	-	-	I

Data and place of relevés:
1 – Retezat Mountain, Tăul Negru (11.08.2005); 2 – Retezat Mountain, Tăul Negru (11.08.2005); 3 – Cibin Mountain, Onceşti (17.07.1979), ap. DRĂGULESCU, 1995; 4 – Hăşmaş Mountain, Poiana Albă (6.08.1993), ap. NECHITA, 2003; 5 – Hăşmaş Mountain, Poiana Albă (6.08.1993)), ap. NECHITA, 2003; 6 – Hăşmaş Mountain, Poiana Albă (6.08.1993)), ap. NECHITA, 2003; 7 – Hăşmaş Mountain, Curmătura Hăşmaşului (1.08.1996)), ap. NECHITA, 2003; 8 – Hăşmaş Mountain, Curmătura Hăşmaşului (1.08.1996)), ap. NECHITA, 2003.

By analyzing the ecologic indexes we found out that regarding the humidity (U), the majority of the studied megaforbs are mesophytes ($U_{3-3.5}$=54.54%). Regarding the temperature factor (T): the microthermic ($T_{2-2.5}$=37.66%) and micro-mesothermic ($T_{3-3.5}$=23.37%) are the best represented, that indicating a cold climate specific for the superior mountain and subalpine floors. The criophytes species ($T_{1-1.5}$=9.09%) and the moderate-thermophytes ($T_{4-4.5}$=2.59%) are poorely represented, while the thermophytes ($T_{5-5.5}$) are not present. The index that regards the soil reaction (R), highlights the presence of the acid-neutrophilous ($R_{3-3.5}$=18.18%) and low-acid-neutrophilous ($R_{4-4.5}$=25.97%), joined by the euriionic species (R_0=40.25%). The acidopyhilous species are found in big percentage ($R_{2-2.5}$=2.59%), to the edification of the mountain high weed, while the neutro-basiphilous ($R_{5-5.5}$=1.29%) and the strong-acidophilous ones ($R_{1-1.5}$=2.59%) are poorely represented (Fig. 3).

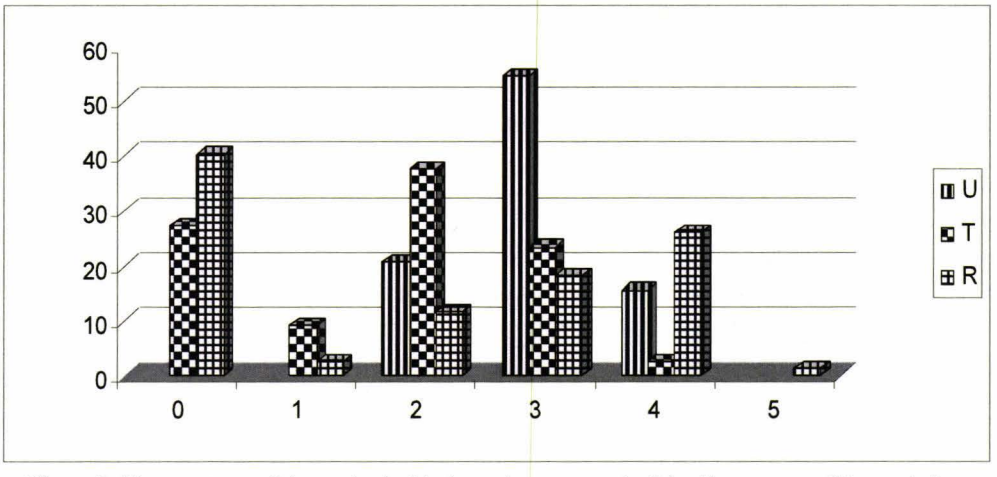

Figure 3. The spectrum of the ecological indexes (percentages) of the *Veratretum albi* association.
Figura 3. Spectrul indicilor ecologici (procente) pentru asociaţia *V. albi.*

The polyploides species (43.03%) dominate the floristic composition of this coenosis, while the diploid represent only 35.44% from the total amount of the species (Fig. 4).

We found it in the Retezat Mountains (August 08, 2005), while groups of *Veratrum album* which did not form well united phytocoenosis, we also identified in the Făgăraş & Bucegi Massifs, in the ex sheep breeding places.

The coenosis from the Retezat Mountains of this association have been found by us too on the old places of a sheepfold near Tăul Negru at a 2000 m altitude, Western exposure, 10^0 inclination.

Depending on the intensity of the shepards activity, the floristic composition of the coenosis in which the white veratrum is predominant varies between distant values, fact that explains the diversity of opinions regarding the syntaxonomic wage-class. Despite this the groups from the Retezat Mountains which were related to this association show a certain belonging to the Class Mulgedio-Aconitetea (*Ranunculus platanifolius* (LINNÉ), *Geranium sylvaticum* (LINNÉ), *Gentiana punctata* (LINNÉ), *Viola biflora* (LINNÉ), *Cicerbita alpina* (LINNÉ) WALLR.).

The personal surveyings made in Retezat Mountains (rel. 1, 2) together with the described surveyings from Cibin Mountains (rel. 3, DRĂGULESCU, 1995) and Hăşmaş Mountains (rel. 4-8, NECHITA, 2003) will be presented in table 1.

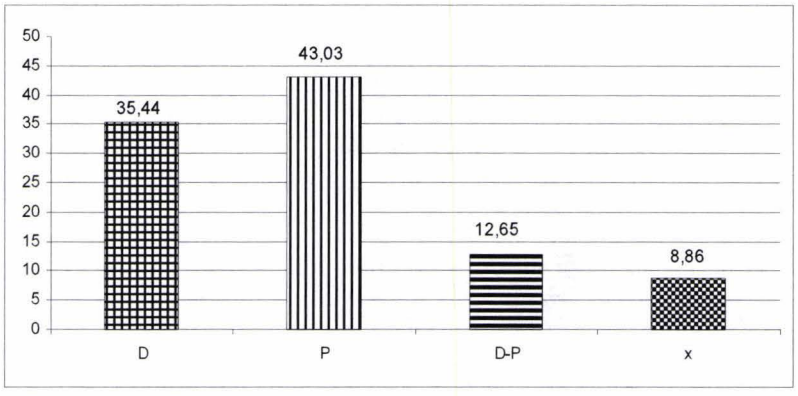

Figure 4. The spectrum of the karyological index (percentages) of the *Veratretum albi* association.
Figura 4. Spectrul cariologic (procente) al asociaţiei *V. albi.*

CONCLUSIONS

Veratretum albi association was reported to Rumicetalia alpini order and integrated in different phytosociological classes by some authors.

From the floristic analysis it can be recorded that the species that form the floristic composition of the association are mainly Eurasiatic and European hemicryptophyte.

From the point of view of the ecological factors there are mesophytes, microtherme, micro-mesotherme, acido-neutrophilous and low-acido-neutrophilous.

All these data obtained after the research are in concordance with the features of the other associations of megaforbs and this thing is a proof for the correct recording of the *Veratretum albi* association in Mulgedio-Aconitetea class.

REFERENCES

BRAUN-BLANQUET J. 1926. *Études phytosociologiques en Auvergnes.* C. Mont-Louis, Clerrmont-Ferrand. 94 pp.

CIOCARLAN V. 2009. *Flora ilustrată a României. Pteridophyta et Spermatophyta.* Edit. Ceres. Bucureşti. 1139 pp.

COLDEA GH. 1991. *Prodrome des associations vegetales des Carpates du Sud-Est. (Carpates Roumaines). Documents Phytosociologiques.* Camerino. **13**: 439-452.

CRISTEA E. & DIMITRIU N. 1961. *Bucegii.* Edit. Uniunii de Cultură fizică şi Sport. Bucureşti: 11-86.

DRĂGULESCU C. 1995. *Flora şi vegetaţia Văii Sadului.* Editura Constant. Sibiu: 271-272.

LANIKOVA DEANA. 2009. *Diverzita vytrvalé ruderální a sešlapávané vegetace České republiky.* Disertační práce. Masarykova Univerzita v Brně: 154-155 Available on line at:http://is.muni.cz/th/42935/prif_d/DisP_text_Lanikova_2009.pdf (accesed: December 20, 2011).

MUCINA L., GRABHERR G., ELLMAUER TH. 1993. *Die Pflanzengesellschaften Österreichs.* VEB Gustav Fischer Verlag Jena. Stuttgart. New York. **2:** 468-505.

NECHITA NICOLETA. 2003. *Flora şi vegetaţia cormofitelor din Masivul Hăşmaş, Cheile Bicazului şi Lacul Roşu.* Edit. Piatra-Neamţ: 294-296.

NICULESCU MARIANA, IMBREA ILINCA, NICOLIN ALMA ALIOARA. 2008. *Contribution regarding the study of the Rumicion alpinii RÜBEL 1933 alliance in the Lotru Mountains.* Research Journal of Agricultural Science. **40**(3): 71-76. Available on line at: http://agricultura.usabtm.ro/Simpo2008pdf/Volumul%203/Sectiunea%208/15%20Niculescu%20Mariana%202.pdf (accesed: July 02, 2011).

OBERDORFER E. 1978. *Stüddeutsche Pflanzengesellschaften.* Veb Gustav Fischer Verlag Jena. Stuttgart. **2**: 329-341

PELIN M., PAULIUC S., TODIRIŢĂ-MIHĂILESCU V. 1969. *Geologia României.* Edit. Didactică şi Pedagogică. Bucureşti: 135-169.

POPESCU A. & SANDA V. 1995. *Caracterizarea unităţilor de vegetaţie din Masivul Făgăraş* (I-III). Naturalia. Ştiinţă şi cercetare, Piteşti. **7**: 91-99, 102-113.

POSEA GRIGORE. 2006. *Geografia fizică a României.* Edit. Fundaţiei România de Mâine. Bucureşti: 132-155.

PUŞCARU-SOROCEANU EVDOCHIA, CSŰRÖS ŞT., PUŞCARU D., POPOVA CUCU ANA. 1981. *Die Vegetation der Wiesen und Weiden des Făgăraş-Gebirges in den SüdKarpaten.* Phytocoenologia. **9** (2): 257-309.

SĂMĂRGHIŢAN MIHAELA. 2005. *Flora şi vegetaţia Văii Gurghiului.* Edit. University Press. Târgu-Mureş: 363-375.

SANDA V. 2002. *Vademecum ceno-structural privind covorul vegetal din România.* Edit.Vergiliu. Bucureşti: 221-227.

SANDA V., KINGA ÖLLERER, BURESCU P. 2008. *Fitocenozele din România. Syntaxonomie, structură, dinamică şi evoluţie.* Universitatea din Bucureşti. Edit. Ars Docendi. Bucureşti: 217-345.

VELCEA VALERIA & SAVU AL. 1982. *Geografia Carpaţilor şi a Subcarpaţilor Româneşti*. Edit. Didactică şi Pedagogică, Bucureşti: 111-124.

WEBER H. E., MORAVEC J., THEURILLAT J. P. 2000. *International Code of Phytosociological Nomenclature*. Journal of Vegetation Science. 3rd edition. Opulus Press Uppsala. Sweden. **11**: 739-768.

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THE ANTHROPOGENIC POTENTIAL IMPACT ON FLORA IN GHIŢU-MOLIVIŞ AREA (ARGEŞ COUNTY)

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Abstract. This paper is an analysis of the vascular flora based on personal observations and data from botanical literature of Ghiţu-Moliviş area. In Arefu village program there is a planned tourism development regarding the infrastructure (ski slope, hotel, motel, hostel, restaurant, cottages), the construction of holiday homes and apartments with complementary functions related to technical infrastructure and access roads, the creation of a hydroelectric power generation, service, storage spaces with adjacent investment (sport equipment rental centres), the recreation areas, sports fields and green spaces.

Keywords: potential impact, flora, Ghiţu-Moliviş.

Rezumat. Potenţialul impactului antropic asupra florei în zona Ghiţu-Moliviş (judeţul Argeş). Lucrarea face o analiză a florei vasculare pe baza observaţiilor personale şi a datelor din literatura botanică a zonei Ghiţu-Moliviş, întrucât în programul de dezvoltare al comunei Arefu se prevăd, în special, dezvoltarea infrastructurii specifice turismului (pârtie de schi, hotel, motel, pensiuni, restaurant, cabană), construcţiilor de case de vacanţă şi de locuinţe, cu funcţiunile complementare aferente, infrastructurii tehnico-edilitare şi a căilor de acces, înfiinţarea unei zone de generare de energie hidroelectrică, de prestări servicii, spaţii de depozitare cu investiţii adiacente (centre de închiriere echipament sportiv), zona de recreere, terenuri de sport, spaţii verzi.

Cuvinte cheie: potenţial impact, flora, Ghiţu-Moliviş.

INTRODUCTION

Arefu village is situated in the north-west of Argeş county and includes the Upper Argeş Valley and Vidraru Lake, Frunţii and Ghiţu Mountains.

According to its geographical location, the territory administrated by the municipality is:

- In the bio-geographical alpine region,
- In the Southern Carpathians,
- In the European Central Region including its floristic Carpathian type,
- In specific regions for high mountain pastures and mountain forests (DONIŢĂ *et al.*, 2005).

The area covered by this Urban Plan of Mount Ghiţu includes most of the northern side and lower portions of the slopes from north-west and north-east and it is covered by deciduous forests mixed with resin forests and pastures. Over Ghiţu-Moliviş territory there is Natura 2000 ROSCI0122 - site of Community importance in Fagaraş Mountains, as it was declared by the Order of the Ministry of Environment and Sustainable Development no. 1964/2007. In this site, the analysed area occupies a reduced part (PUZ Environmental Report on the "Creation of general infrastructure and tourism activities in the specific climatic area - Moliviş Ghiţu", Arefu village, Argeş County, 2007).

The site ROSCI0122 from Făgăraş Mountains was declared of Community interest - for the habitats mentioned in the Law 92/43/EEC on the conservation of natural habitats, plants and animal species - and the conservation requires the designation of special areas of habitat, those that require strict protection and those whose removal from the wild and exploitation are likely to be subject to management measures. In Argeş county, the site area covers the following locations: Arefu (89%), Berevoieşti (<1%), Brăduleţ (7%), Lereşti (38%), Nucşoara (85%), Rucăr (55%), Sălătrucu (62%), Valea Mare-Pravăţ (4%). On the above mentioned territory there is also a very important reserve of Argeş County: "Moliviş" Peaty, with an area of about 82.50 hectares, less studied and unused from the touristic point of view. The suggested site includes the highest and wildest sector of the Romanian Carpathians, with one of the largest glacial and periglacial relief extensions, with an extensive suite of unique landscapes, with specific environmental conditions due to the geological diversity, to the pedological and climate diversity reflected in very high biodiversity of the area (Standard Sheet from Piedmont Făgăraş ROSPA0098). Habitats are very varied, starting from the meadow ones (alders, old willow thickets - with largely continuous and compact areas), shrubs, forest ecosystems, both alpine and subalpine. In this massif there are also representative fragments of virgin and natural forests -now practically inexistent in Europe - which polarize a special land biodiversity, providing a priceless national wealth. Within the site there are nowadays more protected areas among which we mention the nature reserves of Alpine meadow in Făgăraş Mountains between Suru and Podragu, Moldoveanu - Capra Alpine meadow, Bâlii Valley, Vâlsan Valley, Arpăsel, etc. Among flora species of European interest, on Ghiţu Moliviş territory we mention: *Eleocharis carniolica, Liparis loeselii, Campanula serrata.*

MATERIAL AND METHODS

The analysis of vascular flora of Făgăraş Mountains was compiled from personal and laboratory research and from the study of botanical literature. The taxonomic nomenclature was adopted in accordance with the CIOCÂRLAN (2009). A large proportion is represented by the cormophytes identified and published by ALEXIU, 2008 and STANCU, 2005. The vascular flora is analysed in this paper taking into account the systematic categories, the bioforms, the

geoelements, the ecological indices (the soil moisture, the temperature and the soil reaction) and the sozological categories.

RESULTS

The systematic analysis: In the Ghiţu-Moliviş area there have been identified 479 species, grouped into 70 families. The families with the greatest number of species (347 species in total), are: Asteraceae, Poaceae, Caryophyllaceae, Cyperaceae, Orchidaceae, Ranunculaceae, Brassicaceae, Fabaceae, Rosaceae, Scrophulariaceae, Apiaceae, Lamiaceae, Salicaceae, Primulaceae, Campanulaceae, Saxifragaceae, Juncaceae. Other 132 species are grouped in 53 families (Fig. 1).

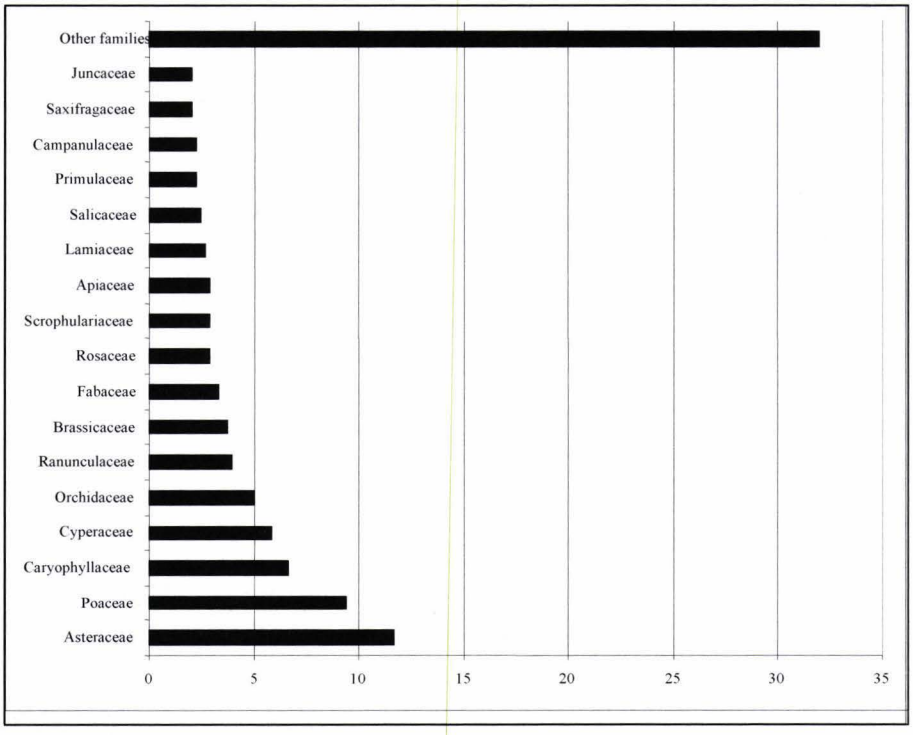

Figure 1. Taxonomic analysis of Ghiţu-Moliviş flora.
Figura 1. Analiza taxonomică a florei din zona Ghiţu-Moliviş.

Bioforms analysis: The largest group of plants in the studied area is formed by the hemicryptophytes (308 species / 64%), followed by geophytes (59 species / 13%) and phanerophytes (43 species / 9%). High percentage of hemicryptophytes indicates that the researched territory belongs to temperate climate regions. The therophytes presence shows the existence of anthropogenic activities in the investigated area. Camephytes (44 species / 9%) highlights the extent of territory to the subalpine floor of Ghiţu Mountains (Fig. 2).

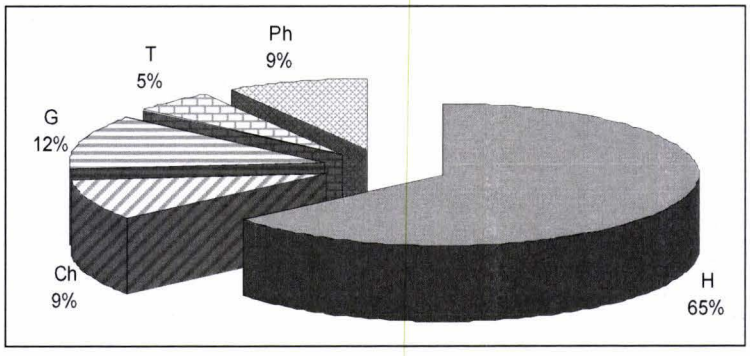

Figure 2. Bioforms percentage on Ghiţu-Moliviş territory.
Figura 2. Ponderea bioformelor în teritoriul Ghiţu-Moliviş.

Geoelements analysis: Amid flowers Eurasian origin (27%), interferes European species (17%), circumpolar (14%) and Central Europe (9%). A significant proportion of species is of a Carpathian origin (9%) with representatives such as *Aconitum lycoctonum* ssp. *moldavicum, Aquilegia transsilvanica* (threatened endemic taxa), *Achillea oxyloba*

ssp. *schurii* (European taxon threatened), *Hepatica transsilvanica* (threatened endemic), *Ranunculus carpaticus, Papaver alpinum* ssp. *corona-sancti-stephani* (European taxon threatened), *Dianthus glacialis* ssp. *gelidus* (threatened endemic), *D. henteri* (threatened endemic), *D. spiculifolius* (threatened endemic taxa), *D. tenuifolius* (threatened endemic taxa), *Silene dinarica* (threatened endemic), *Sempervivum montanum* ssp. *carpaticum* (globally threatened taxa), *Chrysosplenium alpinum*. Carpatho-Balkan species (8%) are represented by *Tozzia alpina* ssp. *carpatica* (a threatened European taxon), *Campanula patula* ssp. *abietina* (European taxon threatened), *Silene lerchenfeldiana, Saxifraga carpatica* (Red List vulnerable taxon Romania), *Potentilla aurea, Rhododendron myrtifolium* (Red List vulnerable taxon Romania), *Pulmonaria rubra, Symphytum cordatum, Festuca drymeia.* Alpical species of the Carpathians (5%), remember, *Minuartia austriaca, Viola alpina, Draba kotschyi, Cardamine resedifolia* etc., few items are included in other categories (11%), which have a low share of representation (Fig. 3).

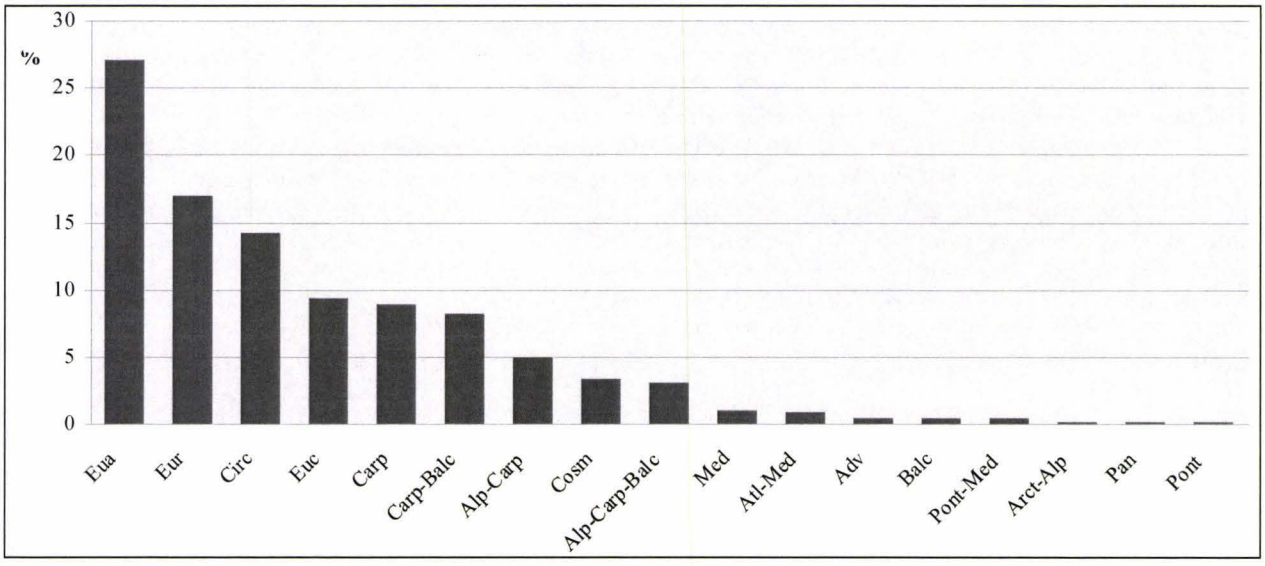

Figure 3. Spectrum of geoelements in the area Ghiţu-Moliviş.
Figura 3. Spectrul geoelementelor în arealul Ghiţu-Moliviş.

Sozological analysis: In the mentioned area there are some species classified as Vulnerable (V): *Lycopodium complanatum, Dianthus henteri, Draba kotschyi, Phyteuma confusum, Primula farinosa, Ranunculus glacialis, Androsace chamaejasme*. There are also quoted taxa threatened even at European level (*Achillea oxyloba* ssp. *schurii, Papaver alpinum* ssp. *corona-sancti-stephani, Tozzia alpina* ssp. *carpatica, Campanula patula* ssp. *abietina*) or even at a global level like *Sempervivum montanum* ssp. *carpaticum.*

Ecological analysis: In order to characterize the flora there were taken into account three edafo-climatic factors: humidity (U), temperature (T) and soil reaction (R). In the investigated area, the flora is characterized by preference for mesophilic environment, mesothermal, low-acid-neutrophilia (Fig. 4).

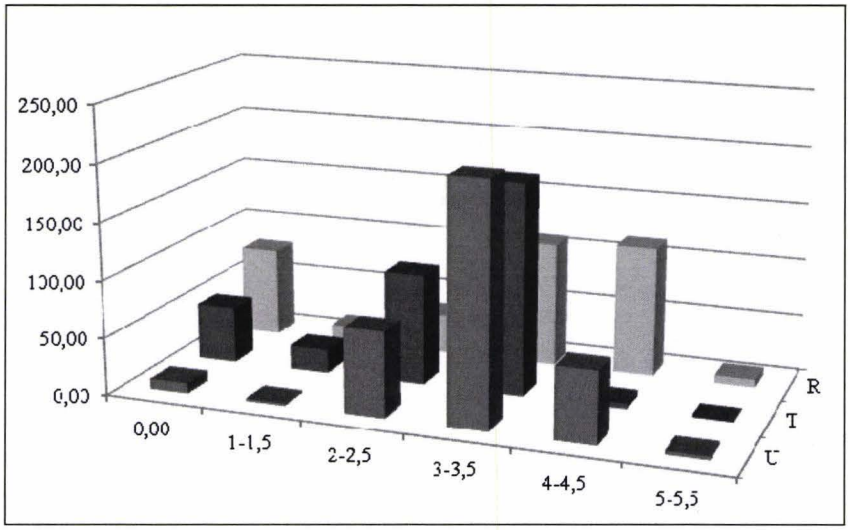

Figure 4. The number of environmental groups in the area Ghiţu-Moliviş.
Figura 4. Ponderea categoriilor ecologice în arealul Ghiţu-Moliviş.

DISCUSSIONS

To minimize the risks on the flora, it is necessary to observe the period of execution of the objectives that led to the AUP (Area Urban Plan) and an accurate compliance with the subsequent projects that will underpin the execution. Measures proposed to prevent, reduce and offset any adverse environmental effects of implementing the AUP (Area Urban Plan):

- The protected vegetation in locations where construction work will be carried out will be identified before the construction works, and there will be solutions - given by authorized personnel - to protect it; it is recommended that monitoring be done by working with a biologist / botanist;
- It will be necessary to restore vegetation through ecological reconstruction, by covering with characteristic humus to allow specific vegetation restoration; complete ban of planting on green areas some allochthonous species with invasive features;
- In areas where total or partial soil removal is inevitable, it is recommended a rehabilitation of the area with a mixture of native species like: *Festuca, Trifolium* - in any case with no unknown or allochthonous species; there should be lawn mowing and anthropogenic impact will be limited.

Given the fact that AUP (Area Urban Plan) has as a final destination the organization of tourism in ecological conditions, with the enhancement of the biodiversity in the area, with measures of environmental protection through specific infrastructure (water networks, establishment of sewerage, sewage treatment, waste management with selective collection), we consider that, after the implementation of Area Urban Plan, which will take into account the environmental report measures proposed by the **Environment Report** of reducing the impact and compensation for adverse effects, there will be a reduced anthropogenic pressure on the environment factors like: air, water and soil / subsoil, biodiversity, so that the effective implementation of specific objectives of AUP will be higher than the negative effect on soil and biodiversity by occupying with buildings.

CONCLUSIONS

Although many ecological studies are needed for knowledge of flora, we can say that it was taken the first step in this direction. The analysis provides an overview of the studied area, which can provide basic data for future projects. In the investigated area there have been identified 479 species, grouped in 233 genera and 70 families. Plant species diversity is high, hemicryptophytes being predominant, followed by geophytes, phanerophytes and camephytes.

The particular note of the study is the presence of Carpathian endemic species such as *Silene zawadzkii, Dentaria glandulosa, Thymus bihoriensis, Melampyrum saxosum, Pedicularis baumgarteni, Festuca nitida* ssp. *flaccida.* It is remarked the presence of threatened taxa in Europe (*Achillea oxyloba* ssp. *schurii, Papaver alpinum* ssp. *corona-sancti-stephani, Tozzia alpina* ssp. *carpatica, Campanula patula* ssp. *abietina*) or even at global level as for *Sempervivum montanum* ssp. *carpaticum.*

REFERENCES

ALEXIU V. 2008. *Cormoflora judeţului Argeş.* Edit. Ceres. Bucureşti. 323 pp.

CIOCÂRLAN V. 2009. *Flora ilustrată a României. Pteridophyta et Spermatophyta.* 3rd edition, revised and added, Edit. Ceres, Bucureşti. 1141 pp.

DONIŢĂ N., POPESCU A., PAUCĂ-COMĂNESCU MIHAELA, MIHĂILESCU SIMONA, BIRIŞ I. A. 2005. *Habitatele din România.* Edit. Silvică Bucureşti. 496 pp. Available online at: http://www.scribd.com/doc/36283048/Habitatele-Din-Romania-Donita-Et-All (accesed: February 10, 2012)

STANCU ILEANA DANIELA. 2005. *Flora şi vegetaţia Munţilor Râiosu şi Buda, Masivul Făgăraş.* Edit. Universităţii din Piteşti. 226 pp.

***. *Formularul standard al sitului ROSPA0098 Piemontul Făgăraş.* Available online at: http://ebookbrowse.com/rosci0122-muntii-fagaras-formular-standard-pdf-d269410666 (accesed: February 10, 2012)

***. *Raport de Mediu pentru PUZ privind „Crearea infrastructurii generale şi specifice activităţilor de turism din arealul climatic Ghiţu-Moliviş", comuna Arefu, jud. Argeş.* Available online at: http://arpmag.anpm.ro/upload/20695_Raport%20de%20mediu%20Consiliul%20Local%20al%20comunei%20Arefu.pdf (accessed: February 10, 2012).

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SPECIES DIVERSITY AND DISTRIBUTION OF FREE-LIVING AND PLANT PARASITIC NEMATODES FROM ORDER DORYLAIMIDA (NEMATODA) IN DIFFERENT HABITATS OF THE REPUBLIC OF MOLDOVA

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Abstract. Species and trophic diversity of free-living and plant parasitic nematodes from order Dorylaimida and their distribution in different natural and agricultural habitats of the Republic of Moldova were studied. One hundred thirteen species of nematodes belonging to 43 genera and 13 families were identified. The highest species diversity (61 species) of nematodes were revealed in different types of forests and multiannual plantations such as grape, fruit and berry (47 - 54 species), followed by annual plantations of sugar beet and oil plants (14 - 32 species) and 23 - 43 species were found in river sediment and riverbanks. Most species of omnivores with cp 4 and 5 (Om4, Om5) were dominant in all observed habitats, while herbivores (He5) Longidoridae and Xiphinematidae were numerous in multiannual plantations including potential vectors of nepoviruses. Predatory Nematodes (Pr5) Nygolaimidae, Discolaimidae and partly fungivores (Fu4) Leptonchidae, Tylencholaimidae were present in all studied habitats with high species diversity, mostly in forests.

Keywords: free-living and plant parasitic nematodes, order Dorylaimida, species, trophic composition, distribution.

Rezumat. Diversitatea speciilor şi distribuţia nematodelor libere şi fitoparazite din ordinul Dorylaimida (Nematoda) în diferite habitate ale Republicii Moldova. Studiul diversităţii speciilor şi al spectrului trofic al nematodelor libere şi fitoparazite din ordinul Dorylaimida din Republica Moldova, conform distribuţiei lor în ecosistemele naturale şi antropizate, precizează 113 specii de fitonematode din 43 genuri, incluse în 13 familii. Variaţia numărului de specii de fitonematode, repartizate conform tipului de cenoze, a fost: 61 specii depistate în diverse ecosisteme forestiere, 47 - 54 specii în plantaţii horticole multianuale, urmate apoi de culturile plantelor anuale tehnice (sfeclă de zahăr şi plante oleaginoase), 14 - 32 specii şi 23 - 43 specii în sedimentele râurilor şi sectoarelor palustre. Conform clasificării după spectrul trofic, predomină speciile de fitonematode omnivore polifage cu cp 4 şi 5 (Om4, Om5) colectate în toate sectoarele investigate din cenoze naturale şi antropizate. Speciile de nematode fitofage (He5) din familiile Longidoridae şi Xiphinematidae sunt mai frecvente în plantaţii perene, inclusiv şi potenţialii vectori ai nepo-virusurilor. Concomitent, s-au depistat şi formele de nematode prădătoare (Pr5) Nygolaimidae, Discolaimidae şi parţial micofagele (Fu4) Leptonchidae, Tylencholaimidae semnalate în toate cenozele investigate, o diversitate specifică majoră preponderent în cenozele ecotipice forestiere.

Cuvinte cheie: nematode libere şi fitoparazite, ordinul Dorylaimida, specii, spectrul trofic, distribuţie.

INTRODUCTION

Order Dorylaimida is one of the major taxonomic group of free-living and plant parasitic nematodes having an universal distribution (spread) in terrestrial (soil and moss) and freshwater habitats (DE LEY & BLAXTER, 2002). Order Dorylaimida includes about 2,000 species belonging to 250 genera (JAIRAJPURI & AHMAD, 1992) that are numerous and distributed from tropical soils and deciduous forests (LOOF & ZULLINI, 2000) to Dry Valleys of Antarctica (ANDRASSY, 2008). The average body size is a little over 1 mm, but certain species may be as small as 0.3-0.4 mm (*Dorylaimellus*) or larger, reaching even 12 mm (*Paralongidorus*) (JAIRAJPURI & AHMAD, 1992; LOOF, 1999). They form a very diverse, not only taxonomically, but also environmentally group, since there is almost no such habitats, which were not detected nematodes of this order; due to trophic diversity, they feed on plant and animal materials. Most of them are predators, feeding on Protozoa, small invertebrates and their eggs by piercing the veil of its victims by a special spear and sucking out their contents (ELIAVA, 1983). Some of dorylaimids eat the mycelium of fungi, algae or affect the tissues of healthy plants as parasites, while some families as Longidoridae are able to transmit the virus diseases of agricultural plants. Apparently, the ancient dorylaimids formed on the ground among mosses and lichens. Some of dorylaimids occupy the freshwater habitats and involve in nematode communities of meiobenthos. According to food specialization, they are plant parasites, fungivores, predators and omnivores. The stoma of dorylaimids is equipped with body piercing - a spear, which is within the unit features of a large structural diversity (JAIRAJPURI & AHMAD, 1992; GAGARIN, 2001; EYUALEM-ABEBE *et al.*, 2006).

Modern taxonomic system for nematodes in situation of lack of paleontological data is offset by a comparative analysis of morphological characters, ecological data and molecular phylogeny studies. The implication of SSUrDNA sequences into the classification by DE LEY & BLAXTER (2002) proposed that the class Enoplea appeared first, and it is even possible that subclass Dorylaimia could have originated within subclass Enoplia as they obtain the main morphological characters such as cylindrical pharynx, three glands opening close to stoma and amphidal fovea pocket-like. On other hand, SSU data allow for the possibility that Dorylaimia diverged first, because all known Dorylaimia are absent from marine habitats (DE LEY, 2006).

Order Dorylaimida sharply separated from the rest of Enoplea by some structural features: the cuticle is smooth, devoid of setae; tangoreceptors of the head are always in the form of papillae, amphids are like pocket-holes, mouth is reduced and always armed with a cuticle tube formation (spear), esophagus is cylindrical along the entire

length with very rarely basal thickening, female mostly with pair of tubes, antidromic reflexed ovaries, caudal glands and spinneret always available (LOOF, 1999, ANDRASSY, 2009). Within the Order Dorylaimida the typical plant parasitic species, omnivores and predators have been developed on the ways to improve the perforating apparatus (ELIAVA, 1983; ANDRASSY, 2009). In parallel, within the two suborders Dorylaimina and Nygolaimina, the typical development of plant parasitic species and predators on ways to improve the punching machine apparatus such as "a spear-top box" with greatly elongate odontostyle and odontophore with basal flanges (Longidoridae), axial spear and spear prefix sometimes with heads (Leptonchoidea) and a spear wall (tooth) (Nygolaimoidea) have occurred (ELIAVA, 1983; PENA-SANTIAGO *et al.*, 2000; ANDRASSY, 2009).

Species of Dorylaimida have a permeable cuticle, permitting them to respond with a range of reactions to pollutants and reflect the restorative capacity of soil and freshwater ecosystems. On the scale colonizer-persister (*cp* 1 to 5) (BONGERS & FERRIS, 1999) dorylaimids are generally assigned a rank of 4 to 5, emphasizing their potential utility as bioindicators of ecosystem health. Using the functional guilds as combinations of feeding groups (YEATES *et al.*, 1993, YEATES, 2003) and life strategy with *cp* values from extremely *r*-strategy to *K*-strategy (BONGERS, 1990, 1999) supports the understanding of the position of dorylaimids as bioindicators in nematode communities (BONGERS & FERRIS, 1999; FERRIS *et al.*, 2001).

The general goal of the present study is the analysis of long-term accumulated taxonomic and ecological data on plant parasitic and free-living nematodes of the order Dorylaimida from different terrestrial and freshwater habitats of the Republic of Moldova and their importance in natural and agricultural ecosystems.

MATERIAL AND METHODS

Site description

The deciduous forests including "Codrii" Scientific Forest Reserve based on oak and beech, middle-European type, are formed by different types of forests such as beech (*Fagus sylvatica* L. with *Quercus* spp.), lime – ash (*Tilia tomentosa* MOENCH., *T. cordata* MILL., *Fraxinus excelsior* L.), maple – hornbeam (*Acer campestre* L., *A. platanoides* L., *Carpinus betulus* L.) and other mixed forests in Republic of Moldova. The sediment and soil samples of the river and riverbanks along the Prut River and the Dniester River were studied. Multiannual (grape, fruits and berries) and annual crops (sugar beet, corn, sunflower and wheat) were observed.

Sampling and processing

Taxonomic and ecological data on dorylaimids from different natural ecosystems such as forests, meadows, the Prut and the Dniester rivers and agricultural crops (vineyards, fruit and berry plantations and fields of sugar beet, corn and cereals) of the Republic of Moldova were accumulated during more than half of a century by the Moldavian nematologists: Nesterov P. I., Dementieva S. P., Lisetskya L. F., Stegarescu Olga P., Poiras Larisa N.

Most soil samples were collected from the depth of 15 - 30 cm, but in the case of nematodes belonging to the family Longidoridae, the samples were deeper than 50 cm; maximum 5 replications were included in each sample.

The Nematodes were extracted by sieving and decanting standard methods of brass screens and Baermann funnels and then fixed in 4% hot formaldehyde solution (VAN BEZOOIJEN, 2006).

Data analysis

The nematode specimens were identified on mass-slides to species, using the keys and species description by NESTEROV (1979), NICKLE (1991), JAIRAJPURI & AHMAD (1992), ANDRASSY (2009), etc. The species of nematodes were listed according to the taxonomic classification from "Fauna Europaea".

The nematodes were assigned to the following feeding groups according to YEATS *et al.* (1993) characterized by feeding habitats: fungivores (Fu), bacterivores (Ba), omnivores (Om), predators (Pr) and herbivores (He). The functional guilds are defined as combination of feeding groups and life strategy using *cp* values (1-5) from extremely *r*-strategy to *K*-strategy (BONGERS, 1990, 1999; BONGERS & BONGERS, 1998; FERRIS *et al.*, 2001).

RESULTS AND DISCUSSIONS

As a result of long-term studies of free-living and plant parasitic nematodes from order Dorylaimida about 113 species were registered. The species belong to 43 genera and 13 families, collected from different natural and agricultural ecosystems of Republic of Moldova, which represent about a quarter of all the identified species (POIRAS, 2008b, POIRAS, *et al.*, 2008b). The species diversity according to families is Qudsianematidae (28 species), Dorylaimidae (27), Longidoridae (14) and Aporcelaimidae (10), Tylencholaimidae (8) and genera *Mesodorylaimus* (13 species), *Xiphinema* (11), *Eudorylaimus* (9), *Tylencholaimus* (8), *Aporcelaimellus* (7) and *Crassolabium* (4) (Table 1).

The highest species diversity of nematodes (61 species) from order *Dorylaimida* was found in different types of forests, especially with plant formations, such as *Fageto-Quercetum, Tilio-Fraxinetum* and mixed (*Populus* spp., *Salix* spp., *Ulmus* spp., *Sorbus* spp., *Malus* spp., *Cerasum* spp., *Prunus* spp. etc.). Thus, only in the "Scientific Forest Reserve "Codri" 38 species of dorylaimids have been identified with large populations of some species belonging to genera: *Aporcelaimus*, *Aporcelaimellus*, *Eudorylaimus*, *Mesodorylaimus*, *Tylencholaimus* and others (POIRAS, 2008a; POIRAS *et al.*, 2008b). Most of these species are long-lived nematodes with medium body length, about 2 - 4 mm, to large body length, up to 12 mm (Longidoridae), the lowest gonad/body ratio and low reproductive rate, with few large

eggs and low motility. The dorylaimids revealed in forests belong to different functional guilds such as: omnivores (Om4, Om5), predators (Pr5), herbivores (He4, He5) and bacterivores (Ba3) with greater sensitivity to disturbance, preferring the highest food web structure and undisturbed conditions. The Bacterivores (Ba3) are represented by a single species *Auloilaimoides elegans* found only in the deciduous forest.

Table 1. Species diversity of nematodes from order Dorylaimida and their distribution in different natural and agricultural ecosystems of Republic of Moldova. / Tabel 1. Diversitatea speciilor de nematode din ordinul Dorylaimida şi distribuţia lor în diverse ecosisteme naturale şi agricole din Republica Moldova.

No.	Order / Suborder / Family	Natural ecosystems				Agricultural ecosystems				
						Multiann. crops		Annual crops		
		Forest	Meadow	River	Riverbank	Grape	Fruit/ berry	Sugar beet	Oil	Grain
I. Suborder Nygolaimina, Superfam. Nygolaimoidea, Fam. Nygolaimidae										
1	*Aquatides aquaticus* (THORNE 1930)	■		■	■		■			
2	*Clavicaudoides clavicaudatus* (ALTHER 1953)	■					■			
3	*Nygolaimus bisexualis* (THORNE 1930)	■	■				■			
4	*N. brachyuris* (DE MAN, 1880) THORNA 1930	■	■		■	■	■		■	
5	*N. ferox* THORNE 1939	■								
6	*Solididens bisexualis* (THORNE 1930)	■			■					
II. Suborder Dorylaimina, Superfam. Belondiroidea, Fam. Belondiridae										
7	*Belondira moldavica* NESTEROV 1976	■								
8	*Laurophragus lauri* NESTEROV 1976	■								
9	*Dorylaimellus cataracticus* ANDRASSY 1968		■		■	■	■		■	
10	*Oxydirus oxycephalus* (DE MAN,1885) THORNE 1939	■								
11	*O. terramoldavicus* GHEBRE, NESTEROV 1994	■				■				
Superfamily Dorylaimoidea, Fam. Actinolaimidae										
12	*Paractinolaimus macrolaimus* (DE MAN 1880)			■	■					
Family Aporcelaimidae										
13	*Aporcelaimellus amplexor* (NESTEROV, LISETZKAJA 1965) HEYNS, 1965	■			■					
14	*A. krygeri* (DITLEVSEN, 1928) HEYNS 1965	■			■		■	■	■	
15	*A. obscurus* (THORNE, SWANGER 1936)			■	■	■	■	■		
16	*A. obtusicaudatus* (BASTIAN 1865) HEYNS 1965	■	■		■	■	■	■	■	■
17	*A. papillatus* (BASTIAN 1865)		■					■	■	■
18	*A. paraobtusicaudatus* (MICOLETZKY 1922)	■				■		■	■	
19	*A. simus* (ANDRÁSSY 1958)					■			■	
20	*Aporcelaimus regius* (DE MAN 1876)	■					■		■	
21	*A. superbus* (DE MAN 1880)	■	■		■	■		■	■	
22	*Paraxonchium laetificans* (ANDRASSY 1956)	■			■	■	■			
Family Dorylaimidae										
23	*Crocodorylaimus flavomaculatus* (LINSTOW 1876)			■						
24	*C. fusus* ANDRÁSSY 1993			■						
25	*Dorylaimus helveticus* STEINER 1919			■						
26	*D. montanus* STEFANSKI 1923			■						
27	*D. stagnalis* DUJARDIN 1845			■						
28	*Laimydorus filiformis* (BASTIAN 1865)	■	■			■	■			
29	*Mesodorylaimus arvensis* COBB, THORNE, SWANGER1936								■	■
30	*M. bastiani* (BÜTSCHLI 1873)	■	■	■	■	■	■	■	■	
31	*M. centrocercus* (DE MAN 1880)	■			■	■	■	■	■	■
32	*M. intermedius* DASSONVILLE & HEYNS 1984		■			■			■	
33	*M. litoralis* LOOF 1969			■	■					

34	*M. luci* BRZESKI, SZCZYGEI 1961									
35	*M. mesonyctius* (KREIS 1930)									
36	*M. meyli* (ANDRÁSSY 1958)									
37	*M. orientalis* (KREIS 1930)									
38	*M. pendschikenticus* (TULAGANOV 1949)									
39	*M. potus* HEYNS 1963									
40	*M. pseudobastiani* LOOF 1969									
41	*M. recurvus* ANDRÁSSY 1964									
42	*Opisthodorylaimus sylphoides* (WILLIAMS 1959)									
43	*Prodorylaimus acris*									
44	*Prodorylaimus dolichurus* (LOOF 1946)									
45	*P. longicaudatoides* ALTHERR 1968									
46	*P. vixamictus* (ANDRÁSSY 1962)									
47	*Thornenema baldum* (THORNE 1939)									
48	*T. lissum* (THORNE 1939)									
49	*T. mauritianum* (WILLIAMS 1959)									
	Family Longidoridae THORNE 1935									
50	*Longidorus elongatus* (DE MAN 1876) THORNE, SWANGER 1936									
51	*L. euonymus* MALI & HOOPER 1974									
52	*L. macrosoma* HOOPER 1961									
53	*Xiphinema brevicolle* LORDELLO & DA COSTA 1961									
54	*X. dentatum* STURHAN 1978									
55	*X. diversicaudatum* (MICOLETZKY 1927)									
56	*X. index* THORNE & ALLEN 1950									
57	*X. italiae* MEYL 1953									
58	*X. pachtaicum* (TULAGANOV 1938)									
59	*X. rivesi* DALMASSO 1969									
60	*X. rotundatum* STEKHOVEN & TEUNISSEN 1938									
61	*X. simile* LAMBERTI & al. 1983									
62	*X. turcicum* LUC & DALMASSO 1964									
63	*X. vuittenezi* LUC & al.,1964									
	Family Nordiidae JAIRAJPURI & SIDDIQI 1964									
64	*Enchodelus macrodorus* (DE MAN 1880)									
65	*E. microdorus* SCHIEMER 1965									
66	*Longidorella microdora* (DE MAN 1880)									
67	*L. parva* THORNE 1939									
68	*Pungentus marietani* ALTHERR 1950									
	Family Qudsianematidae JAIRAJPURI 1963, **Subfamily Qudsianematinae** JAIRAJPURI 1969									
69	*Allodorylaimus bokori* (ANDRÁSSY 1959)									
70	*A. diadematus* (COBB 1936)									
71	*A. granuliferus* (COBB 1893)									
72	*Dorydorella bryophila* (DE MAN 1880)									
73	*D. pratensis* (DE MAN 1880)									
74	*Ecumenicus monohystera* (DE MAN 1880)									
75	*Epidorylaimus humilior* (ANDRÁSSY 1960)									
76	*E. lugdunensis* (DE MAN 1880)									
77	*E. muscorum* (SKWARRA 1921)									
78	*Eudorylaimus acuticauda* (DE MAN 1880)									
79	*E. balticus* (SCHULTZ 1934)									
80	*E. brunetti* (MEYL 1953) ANDRASSY 1959									

81	*E. bureshi* (ANDRASSY 1958) ANDRASSY 1959	■			■			■		
82	*E. carteri* (BASTIAN 1865)				■		■			■
83	*E. curvatus* (THORNE, SWANGER1938) ANDRASSY 1959	■	■				■			
84	*E. iners* (BASTIAN 1865)				■		■			
85	*E. maritus* ANDRÁSSY 1959	■	■			■	■	■		
86	*E. similis* (DE MAN 1876)	■					■		■	
87	*Labronema vulvapapillatum* (MEYL 1954)	■	■						■	
88	*Microdorylaimus miser* (THORNE & SWANGER 1936)			■				■		
89	*M. modestus* (ALTHERR 1952)	■								
90	*M. parvus* (DE MAN 1880)	■				■	■		■	
91	*Nygolaimoides gubernaculifer* (ANDRÁSSY 1957)	■								
92	*Crassolabium ettersbergensis* (DE MAN 1885)	■	■		■	■	■	■	■	■
93	*C. laticollis* (DE MAN 1906)						■			■
94	*C. minutus* (BÜTSCHLI 1873)	■				■	■		■	
95	*C. solus* (ANDRÁSSY 1962)				■					
96	*Thornia steatopyga* (THORNE & SWANGER 1936)			■	■					
Subfamily Discolaiminae SIDDIQI 1969										
97	*Discolaimium cylindricum* THORNE 1939	■	■			■	■			■
98	*Discolaimoides bulbiferus* (COBB 1906)	■								
99	*Discolaimus major* THORNE 1939	■	■		■	■	■	■		■
Superfamily Tylencholaimoidea FILIPJEV 1934**; Family Aulolaimoididae** JAIRAJPURI 1964										
100	*Aulolaimoides elegans* MICOLETZKY 1915	■								
Family *Leptonchidae* THORNE 1935										
101	*Leptonchus granulosus* COBB 1920	■					■		■	
102	*Proleptonchus amphidius* JAIRAJPURI 1964					■	■			
Family Tylencholaimidae FILIPJEV 1934										
103	*Tylencholaimus maritus* LOOF et JAIRAJPURI 1968	■	■							
104	*T. mirabilis* (BÜTSCHLI 1873) DE MAN 1876				■					
105	*T. nanus* THORNE 1939	■	■				■			
106	*T. paradoxus* LOOF et JAIRAJPURI 1968	■	■				■			
107	*T. pacificus* NESTEROV 1979	■				■				
108	*T. pusillus* LOOF et JAIRAJPURI 1968						■			
109	*T. stecki* STEINER 1914	■	■		■	■				
110	*T. teres* THORNE 1939						■		■	■
Family Tylencholaimellidae JAIRAJPURI 1964										
111	*Doryllium uniforme* COBB 1920				■					
112	*Tylencholaimellus affinis* (BRAKENHOFF 1914)	■	■			■	■	■		
113	*T. coronatus* THORNE 1939	■	■		■	■	■		■	

Multiannual plantations create favorable conditions for nematodes. 47 species from order Dorylaimida were registered in vineyards; 54 species in orchards and berry plantations (POIRAS, 2008b; POIRAS *et al.*, 2008a). Most of the species belonging to omnivores with long life span (Om5), genera *Aporcelaimellus, Aporcelaimus* and omnivores (Om4), genera *Epidorylaimus, Eudorylaimus* were diverse and numerous. Among plant parasitic nematodes, the ectoparasites (He5) from genera *Longidorus* and *Xiphinema* are able to be a vector of nepo-viruses (TAYLOR & BROWN, 1997), such as *Xiphinema diversicaudatum* associate with yellow dwarf disease of raspberry, also mosaic and yellow crinkle of strawberry (arabis mosaic virus ArMV), *X. index* – grapevine fanleaf virus (GFLV), *X. rivesi* – tomato ringspot virus (ToRSV), peach rosette mosaic virus (PRMV), cherry rasp leaf virus (CLRV), tobacco ringspot virus (TRSV), *X. vuittenezi* – (CLRV), *Longodorus macrosoma* and *L. elongates* – raspberry ringspot virus (RRSV). In addition to virus transmission, these nematodes cause the formation of galls, necrotic areas of growth of plant roots; they can remain viable for a long time after the uprooting of vineyards and berry bushes, even when the content of the soil under fallow or in crop rotation with is unfavorable for their development on host plants (POIRAS, 2005; POIRAS *et al.*, 2008a). Populations of vector virus nematodes are able to create the foci of viral diseases directly at perennials such as grapes, fruit and berry crops.

The dorylaimid families composed of small-sized species with body length less than 1cm (guilds Om4, Fu4 and He4) such as *Longidorella parva* (Nordiidae), *Microdorylaimus parvus, Dorydorella bryophila, Crassolabium ettersbergense* (Qudsinematidae) are able to colonize rapidly poor habitats (YEATES, 2003), probably in some cases by migration over soil surface covered with unicellular algae.

The species composition of nematode communities of meiobenthos depends on the structure of the river channel, flow velocity and type of benthic sediments. The range of power of some major freshwater dorylaimids vary widely, they are often predatory, feeding on small protozoa, being feeders of bacteria and fungi. In the meiobentos of both studied rivers, the Dniester and the Prut, the large freshwater species (Om4, Om5) dominate – *Dorylaimus stagnalis* (this species prefers waste water), *D. montanus*, *Mesodorylaimus litoralis*, *M. mesonyctius*, *Crocodorylaimus fusus* and others.

The riverbanks of the Prut and the Dniester, sporadically flooded, affect the freshwater nematode communities increasing the number of amphibionts such as: *Mesodorylaimus bastiani*, *Aporcelaimellus krygeri*, *A. obtusicaudatus, Dorydorella pratensis, Ecumenicus monhystera, Thornia steatopyga*, various species of the genera *Eudorylaimus* and *Crassolabium* (POIRAS, 2010) and some species vectors of nepo-viruses such as *Xiphinema rivesi* and the *X. index*. Most of these species are typical for the terrestrial habitats; however, they have the ability to survive on the terrestrial sites covered with water or on the real aquatic habitats.

According to the ratio of trophic groups of nematodes from order Dorylaimida, the omnivorous species (Om4, Om5) were dominant in all studied habitats; however, they are numerous in natural ecosystems. Nematode herbivores (He4, He5) are more diverse as species and sometimes they form numerous populations in the root system of agricultural plants. Nematode predators (Pr5) and fungivores (Fu4) are present in all studied habitats; however, they are diverse and numerous mostly in forests.

Table 2. Functional guilds and families of Nematodes of the order Dorylaimida in different habitats of the Republic of Moldova. / Tabel 2. Ghildiile functionale şi familiile de nematode ale ordinului Dorylaimida în diferite habitate ale Republicii Moldova.

Functional guilds	Families
Ba3 (bacterivorous family with *cp* value 2)	Aulolaimoididae
Fu4 (fungivorous families with *cp* value 4)	Leptonchidae, Tylencholaimidae, Tylencholaimellidae
Om4 (omnivorous family with *cp* value 4)	Qudsianematidae (*Allodorylaimus, Dorydorella, Epidorylaimua, Eudorylaimus, Microdorylaimus, Crassolabium*), Nordiidae (*Enchodelus, Pungentus*), Dorylaimidae (*Dorylaimus, Crocodorylaimus, Thornenema*)
Om5 (omnivorous family with *cp* value 5)	Qudsianematidae (*Mesodorylaimus, Laimydorus*), Aporcelaimidae, Thornenematidae, Dorylaimidae (*Laimydorus, Mesodorylaimus, Opishodorylaimus, Prodorylaimus*), Paraxonchidae
Pr5 (predatory family with *cp* value 5)	Nygolaimidae, Discolaimidae, Swangeriidae, Belondiridae (*Oxydirus*)
He4 (herbivorous family with *c-p* value 4)	Nordiidae (*Longidorella*)
He5 (herbivorous family with *c-p* value 5)	Longidoridae, Xiphinematidae, Belondiridae (*Belondira, Dorylaimellus*)

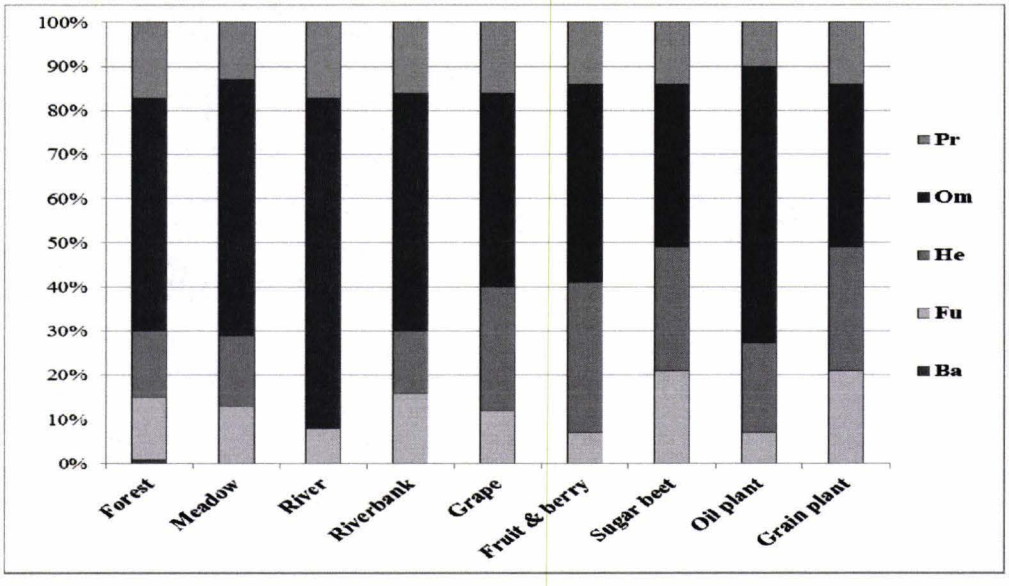
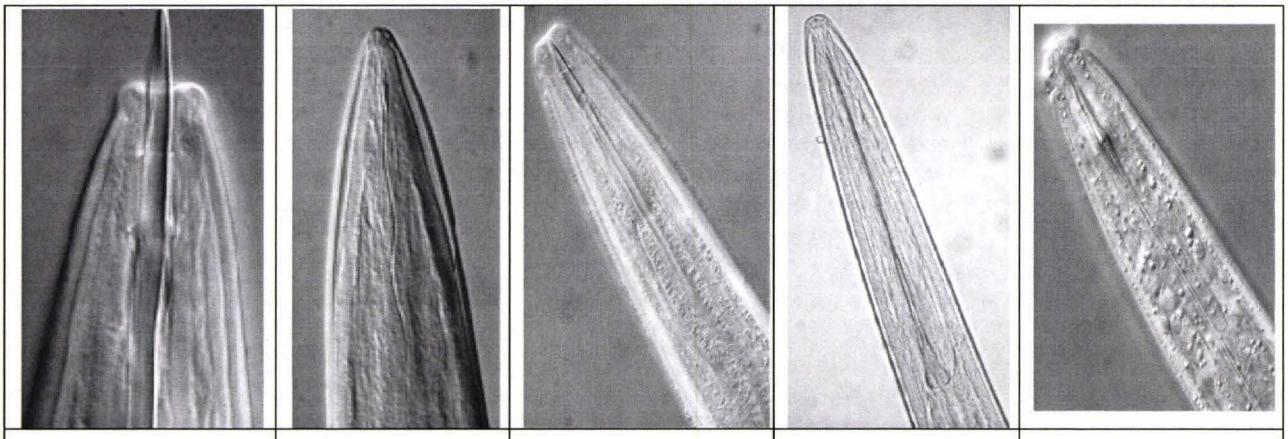


Figure 1. Percentages (Ratio) (%) of trophic groups of nematodes (Ba – bacterivores, Fu – fungivores, He – herbivores, Om – omnivores, Pr – predators) from order Dorylaimida collected from different ecosystems (forest, meadow, river sediment, riverbank, grape, fruit and berry, sugar beet, oil plants and grain plants). / Figura 1. Procentele (%) grupelor trofice ale nematodelor (Ba – bacterifage, Fu – micofage, He – fitofage, Om – polifage, Pr – prădătoare) din ordinul Dorylaimida, colectate din diverse ecosisteme naturale şi antropizate (pădure, pajişte, sediment de râu, mal de râu Nistru şi Prut, sfeclă de zahăr, plante oleaginoase, plante cerealiere (horticole multianuale, plante anuale tehnice – sfeclă de zahăr, plante oleaginoase şi sedimentul rîurilor, sectoare palustre).



Dorylaimus montanus	*Oxydirus*	*Mesodorylaimus*	*Xiphinema*	*Tyelencholaimus*

Photo 1. The structure of the head of nematodes from order Dorylaimida with different feeding types.
Foto 1. Structura părţii anterioare a cavităţii bucale a nematodelor din ordinul Dorylaimida, cu diferite tipuri de hrănire (original).

CONCLUSIONS

The free-living and plant parasitic nematodes from order Dorylaimida are represented (presented) by 113 species belonging to 43 genera and 13 families with wide distribution within different natural and agricultural habitats in the Republic of Moldova. The highest species diversity of dorylaimids has been revealed in different types of forests. Thus, in the Nature Forest Reserve "Codrii" the large populations of nematodes were formed by the genera: *Aporcelaimus*, *Aporcelaimellus*, *Eudorylaimus* and *Tylencholaimus*. Most predatory species belonging to the families Nygolaimidae and Discolaimidae were diverse mostly in forests. In the meiobenthos of the rivers Dniester and the Prut the large dorylaimids such as: *Dorylaimus stagnalis*, *D. montanus*, *Mesodorylaimus litoralis*, *M. mesonyctius*, *Crocodorylaimus fusus* were dominant. In the sporadically flooded riverbanks, the amphibionts such *Mesodorylaimus bastiani*, *M. mesonyctius, Aporcelaimellus krygeri*, *A. obtusicaudatus* and various species from genera *Mesodorylaimus, Eudorylaimus* and *Crassolabium* were common. Multiannual plantations of grape and fruit trees create favorable conditions for dorylaimids. Thus, 47 species were registered in vineyards and 54 species - in orchards and berry plantations. Some of ectoparasites with long life span from the genera *Longidorus* and *Xiphinema* are able to be vectors of nepo-viruses for multi-annual plants such as: grape, fruit trees and berries. Some specimens of *Xiphinema dentatum, X. index and X. rivesi* were found in the riverbanks. Most species of dorylaimids are sensitive to environmental changes and can serve as good bioindicators using (of) functional guilds as combination of trophic groups and life strategy.

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REFERENCES

ANDRASSY I. 2008. *Eudodorylaimus species (Nematoda: Dorylaimida) of continental Antarctica.* Journal of Nematode Morphology and Systematics. Ed. Departament of Animal Biology and Plant Ecology, University of Jaen, Spain, Edit. "Las Lagunillas" **11**(1): 49-66.

ANDRASSY I. 2009. *Free-living nematodes of Hungary*. Hungarian Natural History Museum. Budapest. 608 pp.

BEZOOIJEN J. V. 2006. *Methods and techniques for nematology.* Publisher, Wageningen University. Netherlands. 112 pp.

BONGERS T. 1990. *The Maturity Index: an ecological measure of environmental disturbance based on nematode species composition.* Oecologia. Springer-Verlag. **83**: 14-19.

BONGERS T. 1999. *The Maturity Index, the evolution of nematode life history trails, adaptive radiation and cp-scaling.* Plant and Soil. Springer Link. **212**: 13-22.

BONGERS T. & BONGERS M. 1998. *Functional diversity of nematodes*. Applied Soil Ecology. Elsevier. **10**: 239-251.

BONGERS T. & FERRIS H. 1999. *Nematode community structure as a bioindicator in environmental monitoring.* Trends in Ecology and Evolution. Elsevier. **14**(6): 224-228.

DE LEY P. & BLAXTER M. 2002. *Systematic position and phylogeny.* In: Lee D.L. (Ed.) The biology of nematodes, London, UK, Taylor & Francis: 1-30.

DE LEY P. 2006. *A quick tour of nematode diversity and the backbone of nematode phylogeny.* WormBook . Eds: The *C. elegans* Research Community. WormBook. p.1-12. http://www.wormbook.org.

ELIAVA I. 1983. *Systematic, phylogeny and ecology of nematodes from order Dorylaimida.* PhD thesis Institute of Zoology AS SSSR. Tbilisi. 43 pp.

EYUALEM-ABEBE, TRAUNSPURGER W., ANDRASSY I. 2006. *Freshwater nematodes: ecology and taxonomy.* CABI Publishing. Wallingford UK, Cambridge, USA. 752 pp.

FERRIS H., BONGERS T., GOEDE R. G. M. 2001. *A framework for soil food web diagnostics: Extension of the nematode faunal analysis concept.* Applied Soil Ecology. Imprint Elsevier. **18**: 13-29.

GAGARIN V. G. 2001. *Free-living nematodes of freshwater of Russia and adjacent countries.* "Nauka" Moscow. 169 pp. [In Russian].

JAIRAJPURI M. S. & AHMAD W. 1992. *Dorylaimida: free-living, predaceous and plant-parasitic nematodes.* E. J. Brill Publishing, the Netherlands. 458 pp.

LOOF P. A. A. 1999. *Nematoda, Adenophorea (Dorylaimida).* Suesswasserfauna Von Mitteleuropa. (Eds. J. Schwoerbel and A. Brauer). Spektrum Akademischer-Verlag. Heidelberg. **4**(2-2). 263 pp.

LOOF P. A. A. & ZULLINI A. 2000. *Free-living nematodesfrom nature reserves in Costa Rica.I. Dorylaimina.* Nematology 2, E. J. Brill Publishing: 605-633.

NESTEROV P. I. 1979. *Plant parasitic and free-living nematodes of South-West of USSR.* Edit. Stiinta. Chisinau: 312 pp. [In Russian].

NICKLE W. R. ED. 1991. *Manual of agricultural nematology.* Marcel Dekker. Inc. New York. 1035 pp.

PENA-SANTIAGO R., ABOLAFIA J., LOOF P. A. A. 2000. *Nematodes of the order Dorylaimida from Andalucia Oriental, Spain. The genus Mesodorylaimus.* Nematology. Ed. Brill Publishing, the Netherlands. **2**(4): 365-379.

POIRAS LARISA. 2005. *Taxonomical study of nematodes of grape in Moldova with emphases economically dangerous species.* Universitatea Agrară de Stat. Lucrări Ştiinţifice, **13**. Horticultură, viticultură, silvicultură şi protecţia plantelor. Chisinau: 229-235.

POIRAS LARISA. 2008a. *Species and trophic diversity of soil nematodes in the "Codrii" Forest Reserve.* Oltenia. Studii şi comunicării. Ştiinţele Naturii. Muzeul Olteniei Craiova. **24**: 42-47.

POIRAS LARISA. 2008b. *Nematodes from order Dorylaimida in Moldova: species diversity, systematic position and ecology.* Buletinul Academiei de Ştiinţe a Moldovei. Ştiinţele Vieţii. **2**(305): 104 -109.

POIRAS LARISA, CHERNETS A., POIRAS N. 2008a. *Species diversity of plant parasitic nematodes of perennial plants in Republic of Moldova.* Buletinul Academiei de Ştiinţe a Moldovei. Ştiinţele Vieţii. Chişinău. **3**(306): 87-91.

POIRAS LARISA, BALDWIN J.G., TODERAS I. 2008b. *Terrestrial and freshwater nematodes of order Dorylaimida: current research and perspective.* Simpozium internaţional consacrat jubileului de 60 ani al acad. Ion Toderaş. IEP Ştiinţa. Chişinău: 115-120.

POIRAS LARISA. 2010. *Nematodes of the sediment/soil interface in the Lower Prut.* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **26**: 73-80.

TAYLOR C. E. & BROWN D. J. F. 1997. *Nematode vectors of plant viruses.* CABI Publishing. Wallingford UK, Cambridge. USA. 286 pp.

YEATES G. W., BONGERS R. G., GOEDE R. G. M., FRECKMAN D. W., GEORGIEVA S. S. 1993. *Feeding habits in soil nematode families and genera – an outline for soil ecologists.* Journal of Nematology (SON Executive Board). **25**(3): 315-331.

YEATES G. W. 2003. *Nematodes as soil indicators: functional and biodiversity aspects.* Biology and Fertility of soils. Springer. **37**: 199-210.

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SPECIES DIVERSITY OF NEMATODE COMMUNITES OF THE RAPESEED (*Brassica napus*) AND THEIR ECONOMIC IMPORTANCE IN THE REPUBLIC OF MOLDOVA

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Abstract. Species and trophic composition of nematode communities of the rapeseed (*Brassica napus*), their abundance and distribution have been studied in eight administrative regions of the Republic of Moldova. Forty two species of free-living and plant parasitic nematodes with density 730 - 1.350 ind./100 g soil were revealed in rapeseed fields. Plant parasitic species were predominant (37 - 58%) followed by bacterivores (15 - 30%), omnivore-carnivores (11 - 27%) and fungivores (8 - 15%). Among plant parasitic species with pathogenic effects there were identified the endoparasites *Pratylenchus pratensis, P. penetrans, P. thornei, Ditylenchus dipsaci*, migratory ectoparasites *Rotylenchus robustus, Helicotylenchus dihystera, H. multicinctus* and the sedentary ectoparasite *Paratylenchus hamatus*. Most bacterivores were represented by species from the families Cephalobidae, Panagrolaimidae and fungivores – families Aphelenchidae, Aphelenchoididae. Maturity index values were varied 2.2 - 3.02 due to the predominance *cp*2 bacterivores, fungivores, plant parasites and partly *cp* 4, 5 omnivores - carnivores.

Keywords: Nematode community of rapeseed, species diversity, abundance, trophic groups, functional guilds, Maturity index.

Rezumat. Diversitatea specifică a comunităţilor de fitonematode la cultura rapiţei de toamnă (*Brassica napus*) şi importanţa lor economică în Republica Moldova. S-a cercetat diversitatea specifică şi compoziţia trofică a comunităţilor de fitonematode la cultura rapiţei de toamnă (*Brassica napus l.v. oleracea*) 2009 - 2010, cu răspândire şi frecvenţă majoră, cercetate în opt raioane administrative pe întreg teritoriul Republicii Moldova. S-au găsit 42 de specii de nematode fitoparazite şi libere cu o densitate de 730 - 1350 ind./100 g sol. Conform spectrului trofic, s-a constatat predominanţa speciilor de nematode fitoparazite (37 - 58%), urmate de speciile bacteriofage (15 - 30%), omnivore-carnivore (11 - 27%) şi micofage (8 - 15%), în raport cu numărul total de specii. În structura trofică a asociaţiilor de fitonematode, s-au evidenţiat frecvenţa speciilor endoparazite *Pratylen*chus *pratensis, P. penetrans, P. thornei, Ditylenchus dipsaci*, migratoare ectoparazite *Rotylenchus robustus, Helicotylenchus dihystera, H. multicinctus* şi sedentare ectoparazite *Paratylenchus hamatus*. Grupa speciilor bacteriofage a fost reprezentată mai frecvent de specii din familiile Cephalobidae şi Panagrolaimidae, iar micofagele din familiile Aphelenchidae şi Aphelenchoididae. Indicele de Maturitate (MI) relevă o variaţie de 2.2 - 3.02 cu predominanţa grupei (colonizare-persistentă) *cp*2 fitoparazite, bacteriofage, micofage şi parţial grupa persistentă *cp* 4, 5 omnivore - carnivore.

Cuvinte cheie: comunităţi de fitonematode, rapiţa de toamnă, diversitate de specii, abundenţă, grupe trofice, indice de maturitate.

INTRODUCTION

Most popular in many countries is the gained rape - oilseed crops, the seeds of which are used to obtain vegetable oil for technical and food needs. Winter rapeseed (*Brassica napus* L.) is grown for oil extracted from the seed with the high content of erucic acid (>40%) that is widely used for industrial purposes; the oil content of the low erucic acid seed (<2%) is suitable for human consumption as well (BERNARD *et al.*, 1993). The program of expansion and cultivation of winter rapeseed in R. Moldova has progressively developed since 2005 and area cultivated with this plant is about 21.000 ha. There are mostly cultivated new varieties and hybrids imported from European countries (MORARU & PUNTEA, 2001; CERTAN *et al.*, 2007). This culture grows during the cold period and has a relatively short growing season compared to sunflower, well feed and honey plant. During a short period, the rapeseed creates a strong vegetative mass, rich in mineral elements, so that the ploughing it into the soil as green manure, increases fertility and improves the physical properties of soil (MICU *et al.*, 2005). The nematode communities of rapeseed have drawn attention of nematologists starting with 2009 (POIRAS *et al.*, 2009).

Few data on the nematode communities are available; there were studied more attentively especially plant parasitic species in plant Brassicaceae. However, studying the structure of nematode communities could be important to set up a database for the soil quality assesses the effects of future disturbance. This is particularly important considering that the diffusion of the rapeseed crop in the world is increasing because of its use as a bio-diesel source (CERTAN *et al.*, 2007).

In this research, the nematode communities as bioindicators of the soil condition have been analysed. The nematode community of the rapeseed (*Brassica napus* var. *oleifera*) fields was studied, considering its abundance, species composition, trophic structure and ecological indexes.

MATERIAL AND METHODS

The rapeseed *Brassica napus* L. var. *oleifera* was investigated in the farmer fields of different districts of the Republic of Moldova such as north district – Glodeni (**Gl**), center – Ialoveni (**Ial**), Criuleni (**Cr**), Orhei (**Orh**), south east – Causeni (**Cau**) and south – Cantemir (**Cant**) (this abbreviation is used for locality index in tables 1, 2 and Fig 1).

Soil samples were collected from the depth up to 30 - 50 cm, near the plant roots. Nematodes were extracted by modified Baermann funnels and fixed in 4% formaldehyde at 60° C (BEZOOIJEN, 2006). Nematodes were counted

per 100 mg soil, transferred to glycerine by the modified method of Seinhorst and prepared the mass slide collection. About hundred nematodes from each sample were identified by taxonomic keys (NESTEROV, 1979; RYSS, 1988; NICKLE, 1991; JAIRAJPURI & AHMAD, 1992; SIDDIQI, 2000; ANDRASSY, 2005, 2007; PERRY & MOENS, 2006) and arranged by nematode classification based on the SSU DNA data (DE LEY & BLAXTER, 2002).

The nematodes were assigned to the following feeding groups (YEATS *et al.*, 1991) characterized by feeding habits: bacterivores (Ba); fungivores (Fu); omnivore-carnivores (Om-Ca) and plant parasites (PP). To analyse the community structures, the nematode families were allocated to functional guilds (FERRIS *et al.*, 2001).

The functional guilds are defined as combinations of feeding groups and life strategy using *cp* values from extremely r-strategy to K-strategy (BONGERS, 1990, 1999; BONGERS & BONGERS, 1999). Nematode community indices were used such as (1) Maturity index MI=$\sum v(i)$ x $f(i)$, where $v(i)$ is c-p value of taxon i according to their r and K characteristics; $f(i)$ is the frequency of taxon i in a sample; (2) Plant parasitic index (PPI) which was determined in a manner for plant parasitic genera and ratio PPI/MI (BONGERS & FERRIS, 1999).

RESULTS AND DISCUSSIONS

Forty two species of free-living and plant parasitic nematodes with density 730 - 1,350 ind./100 g soil were revealed in rapeseed fields from eight administrative regions of the Republic of Moldova during 2009 - 2010 (Table 1, 2; Fig. 1). Thus, 20 - 24 species of nematodes were collected with density of 850 - 1,250 ind./100 g soil in rapeseed plantations in central administrative regions, 16 - 23 species with density of 730 - 1,250 ind./100 g soil in the south and 21 - 28 species with density of 1,180 - 1,350 ind./100 g soil in the north. Among all the studied nematode communities, the plant parasitic species were dominant by the number of species and their densities especially in Donduseni, Drochia and Orhei regions.

Plant parasitic nematodes were predominant by the number of species and their densities; they represented 37% (Ialoveni) to 58% (Donduseni) of all the trophic groups (Fig. 1). Among plant parasitic nematodes, the species belonging to functional guild PP3 such as migratory endoparasite species *Pratylenchus penetrants, P. pratensis, P. thornei, Rotylenchus robustus,* species (guild PP2) *Ditylenchus dipsaci* and ectoparasite *Paratylenchus hamatus,* migratory ectoparasites *Merlinius dubius, Helicotylenchus dihystera, H. multicinctus* formed sometimes numerous populations in the root system of rapeseed plants. Plant parasitic species (PP2) without the pathogenic effects such as *Deladenus aridus, Filenchus filiformis, Aglenchus agricola, A. briophilus, Tylenchus davainei, Ditylenchus miceliophagus* are usually numerous in the rhizosphere of plants.

The species from the genus *Pratylenchus* are more dangerous for agricultural annual plants like the oilseed rape (*Brassica napus* L.) as they are mobile endoparasites mostly living in roots; sometimes they are found in above-ground parts like stems. They may multiply to very large numbers (10 - 35 x 10^3 specimens per 10 g of roots) after penetrating the root. All stages from the J2 may enter and live in the soil for some time and attack a new host root. Usually, they infected roots are dark red or brown, caused by the necrosis of the invaded cells and invasion of secondary pathogens like fungi or bacteria. Several "sickness symptoms", slowly expanding patches with poor growth plants and yellowing, are due to *Pratylenchus* species (NICKLE, 1991).

Also, in the rhizosphere of the oilseed rape, the species were numerous, *Ditylenchus dipsaci* as obligatory plant parasitic nematode which feeds on the tissues of higher plants and has an extensive intraspecific variation (many biological races) in host range. Some species of nematodes from the genera *Helicotylenchus, Rotylenchus* (Hoplolaiminae) are obligatory plant parasites, associated with plant roots.

Often infestation predisposes the plants to other diseases or it opens up opportunities for the spreading of fungal (by Aphelenchoidea) and bacterial (by Panagrolaimoidea, Cephaloboidea) decomposition (NICKLE, 1991).

The most important nematode as worldwide pathogen of agriculture is the cyst nematode from the genus *Heterodera.* In the Republic of Moldova, *Heterodera schahtii* is the most marked. The typical symptoms are the outer yellow leaves and finally death, the shortened and deformed roots with the presence of the pinhead-sized white females and brown cysts. The typical field symptoms of the nematode infestations are small patches of poorly growing plants and yield; losses may be higher than 50% (BERNARD & MONTGOMERY-DEE, 1993). At the present study we did not find the cyst nematode *Heterodera schahtii* in the rapeseed plantations; however, in case of using this culture in crop rotation together with sugar beet it may be a risk of appearance of this pathogenic nematode.

Mostly, the assemblages of the bacterivorous nematodes were not very diverse by species, but their populations were numerous. However, in rapeseed fields from Causeni and Orhei, the bacterivores (Ba2) such as the *Eucephalobus elongates, Heterocephalobus teres, Acrobeloides buetschlii* were numerous by species and their densities. The Bacterivores (Ba1), present only by genera *Mesorhabditis* and *Panagrolaimus,* were not often found in the rapeseed fields; however, their populations could be numerous. In comparison with different trophic groups, the bacterivores were 15-30% among all the trophic groups; the species from the genera *Cephalobus, Eucephalobus, Heterocephalobus* and *Acrobeloides* were the most numerous. In the rapeseed fields, the fungivorous nematodes (8 - 15%) were present by species from the genera *Aphelenchus, Aphelenchoides, Paraphelenchus.* However, the most common species (Fu2) were *Aphelenchus avenae* and *Aphelenchoides parietinus.*

Table 1. Specific biodiversity and the trophic spectrum of communities of the free-living and parasitic phytonematodes in the *Brassica napus* crop from different administrative regions of the Republic of Moldova. / Tabel 1. Diversitatea specifică şi spectrul trofic al comunităţilor de fitonematode parazite şi libere la cultura rapiţei de toamnă (*Brassica napus*) în diferite zone ale Republicii Moldova.

Species of nematodes	Guild	Rapeseed fields of administrative regions of R. Moldova							
		North		Centre			South and South-East		
		Don	Dr	Ial	Orh	Cr	Cimis	Cant	Caus
PP									
Deladenus aridus	PP2	+	+	-	+	-	-	-	+
Filenchus filiformis	PP2	+	+	-	+	-	+	+	-
Aglenchus agricola	PP2	+	+	+	+	+	-	+	+
A. briophilus	PP2	-	-	-	-	+	-	+	-
Tylenchus davainei	PP2	+	+	+	+	+	+	-	+
Helicotylenchus dihystera	PP2	-	+	+	-	+	+	+	+
H. multicinctus	PP2	+	+	-	+	+	+	-	+
Ditylenchus dipsaci	PP3	-	-	+	+	+	-	+	-
D. miceliophagus	PP2	+	+	+	-	+	-	+	-
Merlinius dubius	PP2	+	+	+	+	-	+	+	+
Pratylenchus penetrans	PP3	+	-	+	-	-	+	+	-
P. pratensis	PP3	+	+	-	+	+	-	-	+
P. thornei	PP3	-	+	-	+	-	-	-	-
Rotylenchus robustus	PP3	+	+	-	-	+	+	+	+
Nothotylenchus acris	PP2	+	-	+	-	-	-	-	+
Paratylenchus hamatus	PP2	-	+	+	+	-	+	+	-
Longidorella parva	PP2	+	-	-	+	+	-	+	+
Fu									
Aphelenchus avenae	Fu2	+	+	-	+	+	+	+	+
Aphelenchoides parietinus	Fu2	+	-	+	-	+	+	+	-
A. subtenuis	Fu2	+	+	-	-	-	+	-	+
A. composticola	Fu2	-	+	+	-	-	-	-	-
Paraphelenchus tritici	Fu2	-	+	+	-	-	+	+	+
P. ambliurus	Fu2	+	-	+	+	+	-	-	-
Om-Ca									
Aporcelaimus regius	Om5	-	+	+	-	+	-	-	+
A. obtusicaudatus	Om5	+	-	+	+	+	-	+	+
Eudorylaimus brunetti	Om4	-	+	-	-	+	-	-	+
Mesodorylaimus arvensis	Om4	+	+	+	-	-	+	+	-
M. meyli	Om4	-	-	-	+	+	-	+	-
Ecumenicus monohystera	Om4	+	-	-	+	-	+		-
Pungetus marietani	Om4	-	-	+	-	-	+		+
Clarcus papillatus	Ca5	-	-	-	+	+	-		-
Mylonchulus brachyuris	Ca4	-	-	+	-	-	-		-
Ba									
Mesorhabditis signifiera	Ba1	-	-	-	-	-	+		+
Cephalobus mucronatus	Ba2	-	-	+	-	+	+		-
C. thermophilus	Ba2	+	-	+	-	+	+		-
Eucephalobus elongatus	Ba2	+	+	-	-	-	+		+
Heterocephalobus teres	Ba2	-	+	-	+	-	+		+
Acrobeloides buetschlii	Ba2	-	+	+	-	+	-		-
Stegelletina insubricus	Ba2	-	-	-	-	+	-		-
Chiloplacus symmetricus	Ba2	+	-	-	+	-	+		-
Panagrolaimus rigius	Ba1	-	+	+	-	-	-		-
Wilsonema agrarum	Ba2	+	-	-	-	+	+		+

Table 2. Number of species of nematodes and their abundance, trophic groups (ratio %) and ecological indexes in rapeseed fields from different administrative regions of Republic Moldova. / Tabel 2. Efectivul numeric al speciilor de fitonematode, spectrul trofic (rata %) şi indicele ecologic la cultura rapiţei de toamnă în diverse zone ale Republicii Moldova.

Trophic groups and ecological indexes	Rapeseed fields of administrative regions R. Moldova						
	Don	Dr	Ial	Cr	Orh	Cau	Cant
Trophic groups (%):							
Plant parasites (PP)	58	47	37	42	48	40	44
Bacterivores (Ba)	17	26	24	27	23	30	15
Fungivores (Fu)	14	13	15	8	8	10	14
Omnivore-carnivores (Om-Ca)	11	14	24	23	21	20	27
Total (%)	100	100	100	100	100	100	100
Maturity index (MI)	2.67	2.65	2.55	3.02	2.2	2.47	2.33
Ratio indexes PPI/MI	0.8	0.86	0.84	0.63	0.95	1.1	0.68
Number of species	21	28	24	20	21	23	16
Average number of ind./100 g soil	1180	1350	1250	850	998	1250	730

The trophic group of carnivores (11 - 27%) is present by *Clarcus papillatus* (Ca5) and *Mylonchulus brachyuris* (Ca4) which were found only in the rapeseed plantation of the central administrative region. The omnivores were

present by species (Om4, Om5) from families *Aporcelaimidae, Quidsinematidae* and *Dorylaimidae.* The diversity and the number of the omnivorous and carnivorous species depend on the soil structure and their humidity.

The Maturity index (MI) varied between 2.2 and 3.02; the rate is higher than 2.0 because the *cp*1 taxa is represented by few species, *Mesorhabditis signifiera* and *Panagrolaimus rigius*, with no numerous populations. Most nematode communities of the rapeseed consist of plant parasitic nematodes with *cp* 2 and 3, also, the bacterivores *cp*2 and fungivores *cp* 2. The omnivorous Nematodes with *cp* 4, *cp*5 and the carnivores with *cp* 4, *cp*5 were present in the all studied fields. The MI value is low in the situation when *cp*1 taxa have a high proportion of species and decreasing number of *cp* 3-5 taxa. The Ratio PPI/MI (Plant Parasitic Index and the Maturity Index) is between 0.63 - 1.1. A value of Ratio PPI/MI less than 0.9 means plants make optimal use of natural sources, a value of 0.9 - 1.2 - slight nutrient disturbance (BONGERS, 1999; FERRIS *et al.*, 2001). Plant parasitic nematodes are potentially more responsive to host plants than to soil amendment and crop species may have influenced the nematode community structure more than management practices (NEHER, 2001).

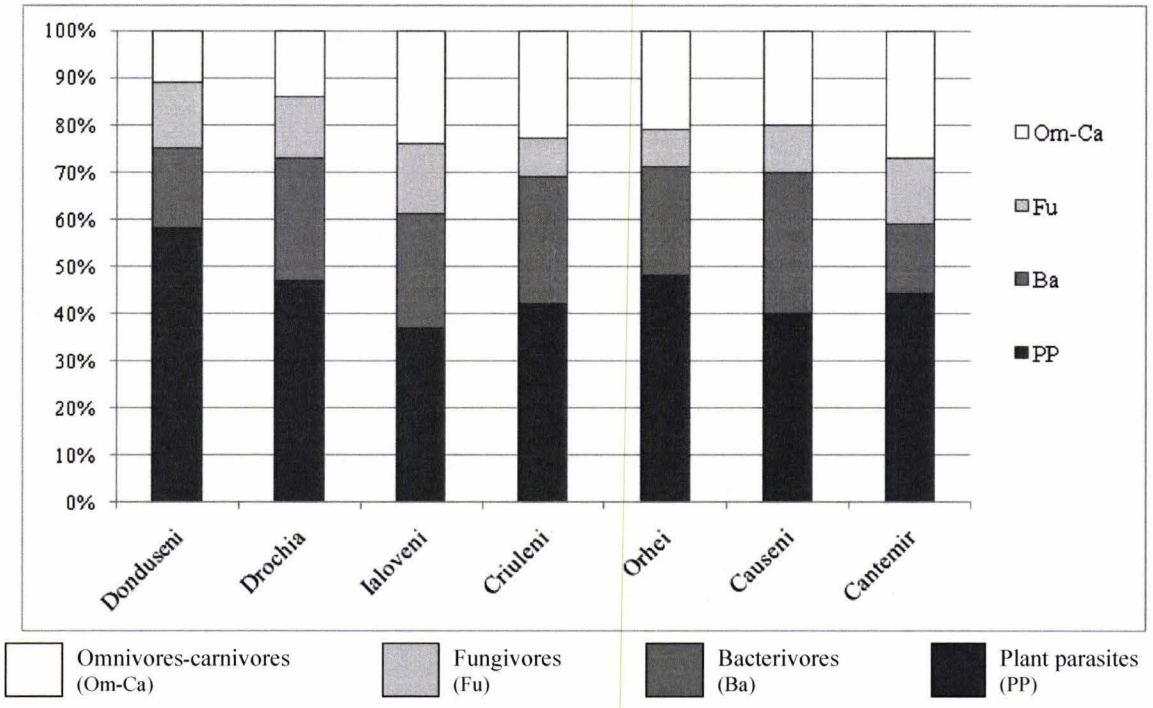

Figure 1. The variation of percentages of the trophic groups of nematode communities from different administrative regions of the Republic of Moldova. / Figura 1. Variaţia procentajelor grupelor trofice ale comunităţilor de nematode în diferite zone ale Republicii Moldova.

CONCLUSIONS

The species and trophic composition of nematode communities of rapeseed (*Brassica napus l. v. oleracea*) were studied in eight administrative regions in the Republic of Moldova during 2009 - 2010. During the studied years, the conditions for growing of rapeseed were favourable, namely enough precipitations and sunny days. According to the taxonomic identifications, forty two species of free-living and plant parasitic nematodes with density 730 – 1,350 ind./100 g soil were revealed in rapeseed fields. Thus, there were identified 20 - 24 species of nematodes with density 850 - 1,250 ind./100 g soil in rapeseed plantations in central administrative regions, 16 - 23 species with density 730 - 1,250 ind./100 g soil in south regions and 21 - 28 species with density 1,180 - 1,350 ind./100 g soil in north regions. The plant parasitic species were predominant (37 - 58%) followed by bacterivores (15 - 30%), omnivore-carnivores (11 - 27%) and fungivores (8 -15%). Among the plant parasitic species with pathogenic effects we mention the following species: endoparasites: *Pratylen*chus *pratensis*, *P. penetrans*, *P. thornei*, *Ditylenchus dipsaci,* migratory ectoparasites: *Rotylenchus robustus, Helicotylenchus dihystera, H. multicinctus* and sedentary ectoparasites: *Paratylenchus hamatus.* Mostly, bacterivores were represented by species from the families: Cephalobidae, Panagrolaimidae, fungivores from the families: Aphelenchidae, Aphelenchoididae. Maturity index values varied from 2.2 to 3.02, due to the predominance of *cp*2 bacterivores, fungivores, plant parasites and partly *cp* 4, 5 omnivores - carnivores. The development of lateral roots of the rapeseed and the volume of root hairs contribute to increasing the trophic and species diversity of plant parasitic nematodes. The species diversity of nematode communities of rapeseed depends on agriculture management and microclimate (humidity, temperature, soil type and topography).

REFERENCES

ANDRASSY I. 2005. *Free-living nematodes of Hungary*. Hungarian Natural History Museum. Budapest. **5**(1). 497 pp.

ANDRASSY I. 2007. *Free-living nematodes of Hungary*. Hungarian Natural History Museum. Budapest. **5**(2). 475 pp.

BERNARD E. C. & MONTGOMERY-DEE M. E. 1993. *Reproduction of plant-parasitic nematodes on winter rapeseed (Brassica napus ssp. oliifera)*. Supplement to Journal of Nematology. Publisher Society of Nematologists, Marceline, MO, ETATS UNIS. **25**(4S): 863-868.

BEZOOIJEN J. V. 2006. *Methods and techniques for nematology*. Publisher, Wageningen University. Netherlands: 112 pp.

BONGERS T. 1990. *The maturity index: an ecological measure of enviromental disturbance based on nematode species composition*. Oecologia. Springer-Verlag. **83**: 14-19.

BONGERS T. 1999. *The Maturity Index, the evolution of nematode life history trails, adaptive radiation and cp-scaling*. Plant and Soil. Springer Link. **212**: 13-22.

BONGERS T. & BONGERS M. 1998. *Functional diversity of nematodes*. Applied Soil Ecology. Elsevier. **10**: 239-251.

BONGERS T. & FERRIS H. 1999. *Nematode community structure as a bioindicator in environmental monitoring*. Trends in Ecology and Evolution. Elsevier. **14**(6): 224-228.

CERTAN A., SOLI N., SOH G. 2007. *Rapiţa de toamnă*. Tipografia Centrala. Chisinau. 28 pp.

DE LEY P. & BLAXTER M. 2002. *Systematic position and phylogeny*. Chapter In: Lee D.L. (Ed.) The biology of nematodes. UK, Taylor & Francis. London: 1-30.

FERRIS H., BONGERS T., GOEDE R. G. M. 2001. *A framework for soil food web diagnostics: Extension of the nematode faunal analysis concept*. Applied Soil Ecology. Elvesiver. **18**: 13-29.

JAIRAJPURI M. S. & AHMAD W. 1992. *Dorylaimida: free-living, predaceous and plant-parasitic nematodes*. E. J. Brill. New York. 458 pp.

MICU V. E., CARASTAN D. I., CHISNICEAN V. I. 2005. *Recomendaţii tehnologice în cultivarea rapiţei de toamnă in R. Moldova*. Chisinau. 65 pp.

MORARU G. & PUNTEA A. 2001. *Tehnologia modernă de cultivare în investigarea soiurilor şi hibrizilor de rapiţă de toamnă în Moldova*. Edit. Ştiinţa, Chisinau. 48 pp.

NESTEROV P. I. 1979. *Plant parasitic and free-living nematodes of South-West of USSR*. Edit. Ştiinţa. Chisinau. 312 pp. [In Russian].

NEHER D. 2001. *Role of nematodes in soil health and their use as indicators*. Journal of Nematology (SON Executive Board). **33**: 161-168.

NICKLE W. R. (Ed.) 1991. *Manual of agricultural nematology*. Marcel Dekker. Inc. New York. 1035 pp.

POIRAS LARISA., IURCU ELENA, BIVOL A., MELNIC MARIA, ANTOFICA A. 2009. *Biodiversity of phytonematode communities of rapeseed in cenral and south regions of R. Moldova*. Plant Protection: Achivments and prospectives. Intern. Scientific symposium, Institute of Plant Protection ASM. Chisinau: 77-79. [In Romanian].

PERRY R. N. & MOENS M. 2006. *Plant nematology*. CAB International. Oxfordshire UK, Cambridge USA. 438 pp.

RYSS A. Y. 1988. *Parasitic nematodes of roots of fam. Pratylenchidae (Tylenchida) world fauna*. Nauka. Leningrad. 350 pp. [In Russian].

SIDDIQI M. T. 2000. *Tylenchida. Parasites of plants and insects*. CABI Publishing. 833 pp.

YEATES G. W., BONGERS R. G., GOEDE R. G. M., FRECKMAN D. W., GEORGIEVA S. S. 1993. *Feeding habits in soil nematode families and genera – an outline for soil ecologists*. Journal of Nematology (SON Executive Board). **25**(3): 315-331.

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CONTRIBUTIONS TO THE KNOWLEDGE OF THE SPIDER FAUNA FROM THE NATIONAL PARK BUILA VÂNTURARIŢA, COUNTY VÂLCEA (ROMANIA)

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Abstract. The article presents the results of the research carried out on the spider fauna of the National Park Buila Vânturariţa, County Vâlcea, during April-October 2011. There were identified 84 species of spider belonging to 17 families, of which only four species can be considered relatively rare for the Romanian fauna. The families Lycosidae, as number of specimens and Linyphiidae, as number of species and genera, were the dominant families. There are presented data on: sex ratio, the biogeographical features of the spider fauna and grouping of the investigated habitats depending on the species identified.

Keywords: spiders, fauna, National Park Buila Vânturariţa, sex ratio, similarity, zoogeographical distribution.

Rezumat. Contribuţii la cunoaşterea faunei de aranee din Parcul Naţional Buila Vânturariţa, judeţul Vâlcea (România). Articolul prezintă rezultatele cercetărilor întreprinse asupra faunei de aranee din Parcul Naţional Buila Vânturariţa, judeţul Vâlcea, în perioada aprilie-octombrie 2011. Au fost identificate 84 de specii de aranee încadrate în 17 familii, dintre care doar patru specii pot fi considerate relative rare pentru fauna României. Familiile Lycosidae, ca număr de exemplare şi Linyphiidae, ca număr de specii şi genuri, au fost familiile dominante. Sunt prezentate date cu privire la: raportul numeric al sexelor, caracteristicile biogeografice ale faunei de aranee şi gruparea habitatelor investigate în funcţie de speciile identificate.

Cuvinte cheie: aranee, faună, Parcul Naţional Buila Vânturariţa, raportul sexelor, similaritate, distribuţie zoogeografică.

INTRODUCTION

Until the achievement of the present the study, which renders data collected in the field, in the literature, there were no data on the spider fauna from the National Park Buila Vânturariţa. There could have been made some extrapolations, related to the spider species present in the park area, starting from the data on the spider fauna from adjacent areas.

Cleopatra Sterghiu counts 69 species of spider from 18 families, collected from several types of habitats located in Cozia Massif (STERGHIU, 1993). Of these, 26 species were identified in the National Park Buila Vânturariţa, as well. All Cleopatra Sterghiu mentions the species *Clubiona terrestris* WESTRING 1851 and *Liocranum rupicola* (WALCKENAER 1830) as being collected at 5-10 km upstream of Căciulata-Vâlcea (STERGHIU, 1985).

I. E. Fhun and Floriana Niculescu-Burlacu cites several species of the family Lycosidae, collected in Vâlcea County, from habitats located relatively close to the National Park Buila Vânturariţia: *Pardosa hortensis* (THORELL 1872) collected from Băile Govora, *Arctosa cinerea* (FABRICIUS 1777) collected from the Brezoi-Cornetu, *Lycosa radiata* (LATREILLE 1817) collected from Racoviţa, Cozia, Teiuş and *Pirata knorii* (SCOPOLI 1763) collected from Vaideeni (FHUN & NICULESCU-BURLACU, 1971).

In the fauna fascicle dedicated to the family Salticidae, I. E. Fhun and V. F. Gherasim (FHUN & GHERASIM, 1995) mentions two species, collected from areas relatively close to National Park Buila Vânturariţa: *Phelgra fasciata* (HAHN 1826) and *Heliophanus cupreus* (WALCKENAER 1802) collected on the Olt Valley, at Cornetu. These were, in the year 2011, the available data on the spider fauna of an area large enough that included the National Park Buila Vânturariţa, very vague information, which practically represented the starting point in studying the park area, in terms of the spider fauna.

MATERIAL AND METHODS

Buila-Vânturariţa Massif is located in central-northern part of Vâlcea County and makes part of Căpăţânii Mountains (Fig. 1). It is a calcareous massif that extends from west of Bistriţa Gorge and up to the east of the Olăneşti Gorge. The ridge of the massif has a linear spatial extension, on SW-NE direction, with a length of about 14 km and a width between 0.5 and 2.5 km. The altitude varies between 1,885 m (the peak Vânturariţa Mare) and 550 m (at the output the Bistriţa River from gorges). The climate varies on vertical, due to the relief altitude. The beech floor is characterized by precipitation between 600 and 900 mm/year, peaking even 1,000 mm/year, humidity between 68% and 70% and annual average temperatures between 6°C and 9°C. The spruce belt is characterized by rainfall ranging between 700 and 900 mm/year, humidity between 67% and 70%, annual average temperatures between 2°C and 5°C and predominant winds from NW-SE. The top of the mountain is characterized by precipitation higher than 900 mm/year and annual average temperatures between 1°C and 2°C. It was recorded a relatively large difference between the climate of slopes with southeastern exposure and those with northwestern exposure. In the first case, we have a mild climate, due to strong insolation and storage of heat by limestone and the influence of the mild climate of Oltenia.

The material was collected during April-October 2011, in four types of habitats (10 collection stations): forest (beech, mixed, coniferous), riparian, meadow and bog, located on both sides of the mountain: riverside coppice (RC), river Prislop; riparian 1 (R1), creek Izvorul Larg; mixed forest, beech and spruce (MF1), creek Izvorul Larg; riparian 2 (R2), the hut Cheia; beech forest (B), the hut Cheia; mixed forest, beech and spruce (MF2); bog (Bog); spruce forest (S); mountain meadow (MM); gorges of the Cheia River (CH).

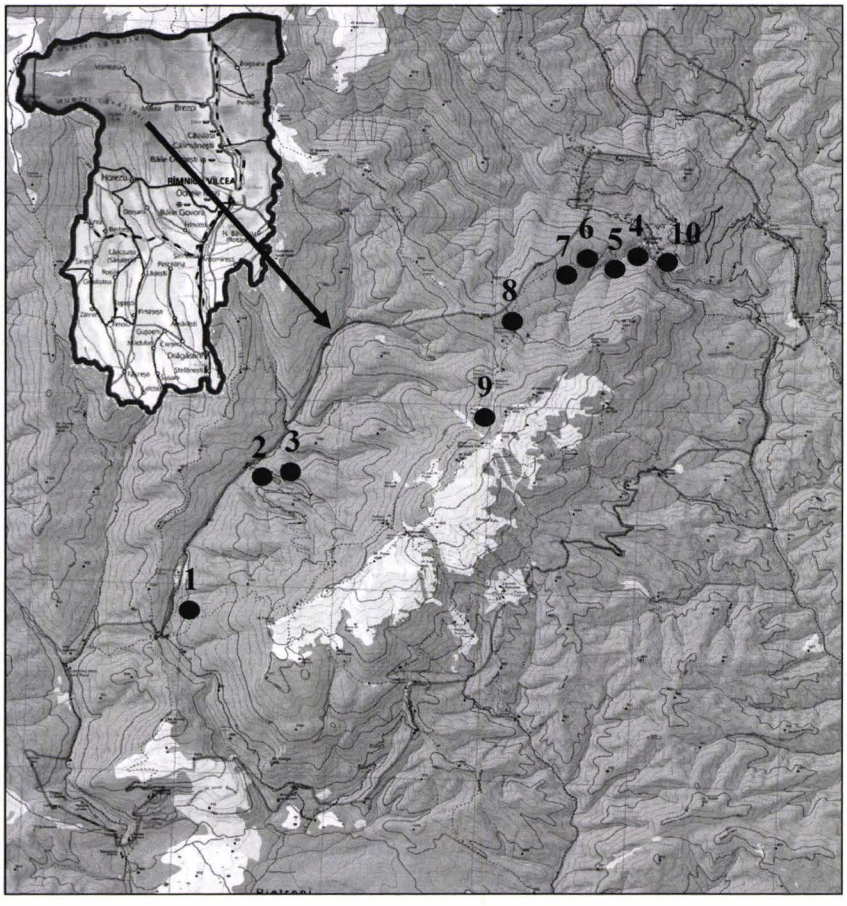

Figure 1. Locating the 10 collection stations in the National Park Buila Vanturariţa: 1 - riverside coppice (RC), creek Prislop; 2 - riparian 1 (R1), creek Izvorul Larg; 3 - mixed forest, beech and spruce (MF1), creek Izvorul Larg; 4 - riparian 2 (R2), the hut Cheia; 5 - beech forest (B), the hut Cheia; 6 - mixed forest, beech and spruce (MF2); 7 - bog (Bog); 8 - spruce forest (S); 9 - mountain meadow (MM); 10 - gorges of the Cheia River (CH). / Figura 1. Localizarea celor 10 staţii de colectare din Parcul Naţional Buila Vânturariţa: 1 - zăvoi (RC), pârâul Prislop; 2 - riparian 1 (R1), pârâul Izvorul Larg; 3 - pădure de amestec, fag şi molid (MF1), pârâul Izvorul Larg; 4 - riparian 2 (R2), cabana Cheia; 5 - pădure de fag (B), cabana Cheia; 6 - pădure de amestec, fag şi molid (MF2); 7 - mlaştină (Bog); 8 - pădure de molid (S); 9 - pajişte montană (MM); 10 - Cheile Cheii (CH).

To capture spiders from different habitat types, there were used the following collection techniques: pitfall traps (Barber traps) used to collect invertebrates with high activity at ground level; in each collection station we placed five traps, arranged in line, to a distance of five meters apart; the traps have worked in the field 184 days; the sampling have been made in average to 46 days; manual collection, direct or with tweezers from the substrate: under logs, on and under the bark of trees, on plants, etc.; sweeping with an entomological net for herbaceous and shrub layer species.

The biological material collected by the pitfall traps represented 96.32% of all captured individuals and 76.2% of all identified species; the other two collection methods have played a secondary role, being used in areas where it was too difficult to use traps (gorges of Cheia River) or to complete the faunal data from some habitats. Manual collection and sweeping were made in summer, in August (August 3-4, 2011), in the gorges of the Cheia River, riparian (R2) and mixed forest (MF2).

RESULTS AND DISCUSSIONS

There were collected 1,819 specimens, of whom 1,804 specimens were determined until species level; the remaining 15 specimens were identified until genus or family, due to the inability to establish exactly the species for juvenile specimens.

Of the 1,804 specimens identified to species level: 1,021 were males, 644 females and 139 immature specimens. In terms of systematics, the material was classified in: 17 families, 57 genera and 84 species. The full list of the spider species collected in the National Park Buila Vânturariţa, with data on the number of males, females, immature and juveniles collected from each stationary, is presented in table 1.

From the fauna point of view, spider species collected from the National Park Buila Vânturariţa are generally common species, not cited in any of the categories: species of community interest, IUCN species, endemic species and species mentioned in the Annex OUG 57/2007 or species present on red lists in Romania. However, we want to draw attention on some species of spider we can consider relatively rare for the Romanian fauna:

Robertus scoticus JACKSON 1914 from the family Theridiidae, is a relatively rare species, that prefers wet areas from the coniferous forests (pine, spruce) and the wetlands, with peat, at ground level, in the moss and plant debris, in open, partially shaded or shaded areas. On altitude, the species can be found from 300 m to over 1,300 m altitude. Adults are active from May to September. In Slovakia it is considered an endangered species, vulnerable in North Rhine and Westphalia (Germany), in Austria near-threatened and in Belgium, it belongs to the category of rare species.

Evansia merens O. P. CAMBRIDGE 1900, from the family Linyphiidae, is a relatively rare species found in forests, with moderate humidity, in open or partially shaded places, between 600 m and 1,400 m altitude. It is active at the ground level, under rocks, logs, rarely found in the litter, but and in the galleries of some species of ants: *Lasius niger* (LINNAEUS 1758), *L. fuliginosus* (LATREILLE 1798), *Formica fusca* LINNAEUS 1758, *F. sanguinea* LATREILLE 1798. Adults are present all year. It is an endangered species in Poland and vulnerable in Slovakia.

Pelecopsis elongate (WIDER 1834), from the family Linyphiidae. It is a relatively rare species, found in coniferous forests, at altitudes between 300 m and 1,000 m, in the litter, more rarely on rocks, in moss or shrub branches, near the ground. It prefers wetlands, partly shaded, semi-open or open. Adults are found from June to December. It is considered an endangered species in Germany and rare in England.

Walckenaeria mitrata (MENGE 1868), from the family Linyphiidae. It is a relatively rare species, present in different types of forests, with moderate humidity, in the litter and moss, at altitudes between 200 and 800 m. It prefers shady places. Adults are present from March until June/July, according to altitude. The species is considered threatened in Belgium and vulnerable in Poland.

Table 1. List of spider species identified in the National Park Buila Vânturariţa.
Tabel 1. Lista speciilor de aranee identificate în Parcul Naţional Buila Vânturariţa.

No.	Taxon	Stationary										F
		RC	R1	MF1	R2	B	MF2	Bog	S	MM	CH	
	Fam. DYSDERIDAE											
1	***Dysdera crocata*** C. L. KOCH 1838			13♂,12♀, 1im.	5♀, 4im	6♀	15♀				4♀	50%
2	***Harpactea rubicunda*** (C. L. KOCH 1838)			1♀	1♀	1♀	2♀					40%
3	***Harpactea saeva*** (HERMAN 1879)				1♂, 1♀							10%
	***Dysdera* sp.**				1j							
	***Harpactea* sp.**			1j								
	Fam. THERIDIIDAE											
4	***Asagena phalerata*** (PANZER 1801)									1♂		10%
5	***Robertus scoticus*** JACKSON 1914							1♂				10%
	Fam. LINYPHIIDAE											
6	***Bathyphantes nigrinus*** (WESTRING 1851)	15♂, 6♀						2♂, 1♀				20%
7	***Centromerus cavernarum*** (L. KOCH 1872)					1♂						10%
8	***Centromerus pabulator*** (O. P. CAMBRIDGE 1875)								1♂			10%
9	***Centromerus sellarius*** (SIMON 1884)				2♀	3♂, 2♀	2♂					30%
10	***Centromerus silvicola*** (KULCZYNSKI 1887)	1♂, 1♀		14♂, 3♀		1♀						30%
11	***Centromerus sylvaticus*** (BLACKWALL 1841)	1♀			1♂, 1♀			20♂, 1♀	1♀			40%
12	***Ceratinella brevipes*** (WESTRING 1851)	1♂										10%
13	***Dicymbium tibiale*** (BLACKWALL 1836)	9♂, 5♀		1♀				1♂, 1♀				30%
14	***Diplocephalus latifrons*** (O. P. CAMBRIDGE 1863)	5♂, 1♀	13♂, 4♀, 2im		4♂, 2♀			7♂, 2♀				40%
15	***Diplostyla concolor*** (WIDER 1834)	16♂, 3♀, 4im	1♀	1♂, 1♀			1♂					40%
16	***Drapetisca socialis*** (SUNDEVALL 1833)		2♂									10%
17	***Evansia merens*** O. P. CAMBRIDGE 1900			1♂								10%
18	***Gonatium rubellum*** (BLACKWALL 1841)			1♂			1♀				1♂, ♀	30%
19	***Gongylidiellum latebricola*** (O. P. CAMBRIDGE 1871)	1♂						15♂				20%
20	***Lepthyphantes minutus*** (BLACKWALL 1833)								3♂, 1♀			10%
21	***Linyphia hortensis*** SUNDEVALL 1830						1♂, 1♀					10%
22	***Megalepthyphantes nebulosus*** (SUNDEVALL 1830)								2♀			10%
23	***Micrargus apertus*** (O. P. CAMBRIDGE 1871)			2♂		1♂						20%

No.	Taxon	Stationary										F
		RC	R1	MF1	R2	B	MF2	Bog	S	MM	CH	
24	***Mughiphantes mughi*** (FICKERT 1875)								4♂			10%
25	***Neriene emphana*** (WALCKENAER 1841)		2♂, 2♀, 1im	1♀	1♂, 3♀, 13im	1♀	4♂, 3♀				1♀	60%
26	***Neriene peltata*** WIDER 1834										1♂, 2♀	10%
27	***Oedothorax agrestis*** (BLACKWALL 1853)							1♂, 2♀				10%
28	***Palliduphantes pallidus*** (O. P. CAMBRIDGE 1871)	3♂	8♂, 1♀	2♂, 2♀	1♂	1♂	2♂, 1♀			1♂		70%
29	***Pelecopsis elongate*** (WIDER 1834)								2♂			10%
30	***Pelecopsis radicicola*** (L. KOCH 1872)	1♂										10%
31	***Tenuiphantes alacris*** (BLACKWALL 1853)		6♂, 6♀, 4im			1♂, 1♀						20%
32	***Tenuiphantes tenebricola*** (WIDER 1834)	1♂	4♂, 12♀, 2im	2♂, 2♀	5♂, 11♀	6♂, 10♀, 3im	4♂, 9♀	1♂, 2♀	12♂, 12♀, 3im			80%
33	***Tenuiphantes tenuis*** (BLACKWALL 1852)					1♂, 6♀						10%
34	***Tiso vagans*** (BLACKWALL 1834)									52♂, 39♀		10%
35	***Walckenaeria antica*** (WIDER 1834)	1♂										10%
36	***Walckenaeria atrotibialis*** (O. P. CAMBRIDGE 1878)									1♂		10%
37	***Walckenaeria mitrata*** (MENGE 1868)			2♂								10%
38	***Walckenaeria vigilax*** (BLACKWALL 1853)							2♂, 1♀		3♂		20%
	Fam. TETRAGNATHIDAE											
39	***Pachygnatha degeeri*** SUNDEVALL 1830	1♂								1♂, 2♀, 21im		20%
40	***Pachygnatha listeri*** SUNDEVALL 1830	10♂, 13♀										10%
41	***Tetragnatha extensa*** (LINNAEUS 1758)				3♀						4♀	20%
	Fam. ARANEIDAE											
42	***Araneus diadematus*** CLERCK 1758										3♀, 1c	10%
43	***Araniella cucurbitina*** (CLERCK 1757)										1♀	10%
44	***Mangora acalypha*** (WALCKENAER 1802)										1♀, 2im	10%
45	***Zygiella x-notata*** (CLERCK 1757)										4♀, 1im	10%
	Fam. LYCOSIDAE											
46	***Alopecosa aculeata*** (CLERCK 1757)									1♀		10%
47	***Alopecosa cuneata*** (CLERCK 1757)	1♂										10%
48	***Alopecosa trabalis*** (CLERCK 1757)									7♂, 2♀		10%
49	***Aulonia albimana*** (WALCKENAER 1805)	3♀										10%
50	***Pardosa alacris*** (C. L. KOCH 1833)	1♂		1♂, 1♀				1♂, 3♀				30%
51	***Pardosa amentata*** (CLERCK 1757)	4♂, 1♀						1♂, 2♀, 1im			1♂, 2♀	30%
52	***Pardosa morosa*** (L. KOCH 1870)										1♀	10%
53	***Pardosa palustris*** (LINNAEUS 1758)									109♂, 165♀, 38im, 87c		10%
54	***Pardosa riparia*** (C. L. KOCH 1833)	2♂, 7♀										10%
55	***Pardosa saltuaria*** (L. KOCH 1870)									3♂, 1♀		10%
	Pardosa sp.	3j										
56	***Piratula hygrophila*** (THORELL 1872)							89♂, 67♀, 14im, 1c				10%
57	***Trochosa terricola*** THORELL 1856	22♂, 7♀								3♂, 1♀		20%
	Fam. ZORIDAE											
58	***Zora spinimana*** (SUNDEVALL 1833)	1♂, 1♀										10%

No.	Taxon	Stationary										F
		RC	R1	MF1	R2	B	MF2	Bog	S	MM	CH	
	Fam. AGELENIDAE											
59	***Coelotes terrestris*** (WIDER 1834)		2♀		14♂, 1im	5♂, 4♀, 2im	9♂, 1♀	35♂, 4♀	72♂, 7♀, 4im	2♂		70%
60	***Histopona torpida*** (C. L. KOCH 1837)			2♀	1♂		3♂, 1♀					30%
61	***Inermocoelotes inermis*** (L. KOCH 1855)	10♂, 1♀	43♂, 10♀,3im	12♂	18♂, 1♀	17♂, 4♀	11♂		1im			70%
62	***Malthonica ferruginea*** (PANZER 1804)		1♂									10%
63	***Malthonica silvestris*** (L. KOCH 1872)										1♂, 2♀	10%
	Coelotes sp./*Inermocoelotes* sp.			3j	1j		1j		1j			
	Fam. CYBAEIDAE											
64	***Cybaeus angustiarum*** L. KOCH 1868	13♂, 5♀	10♂, 7♀, 4im	1♀	7♂, 1im	16♂, 6♀, 1im	18♂, 8♀, 2im	5♂, 1♀	4♂, 3♀			80%
	Fam. HAHNIIDAE											
65	***Cryphoeca silvicola*** (C. L. KOCH 1834)				1♂	2♂			5♂, 1♀			30%
	Fam. DICTYNIDAE											
66	***Cicurina cicur*** (FABRICIUS 1793)	2♂	3♂	4♂, 3♀	9♂, 1♀	15♂						50%
	Fam. AMAUROBIIDAE											
67	***Callobius claustrarius*** (HAHN 1833)		3♂, 1♀	31♂, 2♀	7♂, 5♀	1♂, 1♀	6♂, 2♀		5♂		3♂	70%
	Amaurobius sp.										1j	
	Fam. LIOCRANIDAE											
68	***Apostenus fuscus*** WESTRING 1851			11♂, 13♀, 3im								10%
	Fam. CLUBIONIDAE											
69	***Clubiona comta*** C. L. KOCH 1839						1♀				1♂, 1♀	20%
70	***Clubiona corticalis*** (WALCKENAER 1802)						1♀					10%
71	***Clubiona reclusa*** O. P. CAMBRIDGE 1863							1♀				10%
	Fam. GNAPHOSIDAE											
72	***Drassyllus lutetianus*** (L. KOCH 1866)									2♂		10%
73	***Drassyllus pusillus*** (C. L. KOCH 1833)	1♂								6♂, 3♀		20%
74	***Haplodrassus signifer*** (C. L. KOCH 1839)									4♂, 5♀, 2im		10%
75	***Haplodrassus silvestris*** (BLACKWALL 1833)			4♀								10%
76	***Zelotes latreille*** (SIMON 1878)	1♂								1♂, 1♀		20%
	Fam. THOMISIDAE											
77	***Ozyptila atomaria*** (PANZER 1801)										1♂, 1♀	10%
78	***Ozyptila claveata*** (WALCKENAER 1837)	1♂										10%
79	***Xysticus audax*** (SCHRANK 1803)	2♂, 1♀			1♂							20%
80	***Xysticus erraticus*** (BLACKWALL 1834)									4♂, 1♀		10%
81	***Xysticus kochi*** THORELL 1872										1♂, 2♀	10%
	Xysticus sp.									3j		
	Fam. SALTICIDAE											
82	***Evarcha falcata*** (CLERCK 1757)						1♂				1♂	20%
83	***Heliophanus aeneus*** (HAHN 1832)										1♂, 1♀	10%
84	***Pseudeuophrys erratica*** (WALCKENAER 1826)										1♀	10%

No.	Taxon	Stationary									F
		RC	R1	MF1	R2	B	MF2	Bog	S	MM	CH	
	Sum (number of specimen, male, female, immature and juvenile per site)	**189 spe.** 127♂, 55♀, 4im, 3j	**157 spe.** 95♂, 46♀, 16im	**154 spe.** 98♂, 48♀, 4im, 4j	**128 spe.** 71♂, 36♀, 19im, 2j	**119 spe.** 70♂, 43♀, 6im	**111 spe.** 62♂, 46♀, 2im, 1j	**284 spe.** 181♂, 88♀, 15im	**144 spe.** 108♂, 27♀, 8im, 1j	**485 spe.** 200♂, 221♀, 61im, 3j	**48 spe.** 12♂, 32♀, 3im, 1j	

Legend: ♂-male, ♀-female, im-immature (from the appearance of the primary genitalia to the stage in which genitals are almost fully developed, but non-functional, last moult; j - juvenile (after leaving the cocoon from the appearance of primary genitalia; c - cocoon); sp. - species; spe. - specimens; F - frequency calculated by the number of sites where the species was identified.

For Romania, due to incomplete data, the criterion which was the basis for the classification of the aforementioned species as relatively rare is the small number of collected specimens or specimens present in different collections and the reduced number of citations in the specialized literature in our country. Thus, we mention four works for *Robertus scoticus* (FHUN & OLTEAN, 1970; WEISS & PETRIŞOR, 1999; WEISS & URÁK, 2000; URÁK *et al.*, 2010); a work for *Evansia merens* (WEISS & PETRIŞOR, 1999); four works for *Pelecopsis elongate* (FHUN & OLTEAN, 1970; NAE, 2008; WEISS & PETRIŞOR, 1999; WEISS & URÁK, 2000); four citations for *Walckenaeria mitrata* (WEISS & PETRIŞOR, 1999; LOTREAN, 2008; URÁK, 2008; URÁK *et al.*, 2010).

From the quantitative point of view, most of the collected specimens belonged to the family Lycosidae (31.06%), followed by the families: Linyphiidae (27.10%), Agelenidae (17.04%), and Cybaeidae (6.16%). The rest of the spider families had weights less than 5% (Fig. 2). There were large variations from one resort to another; for example, in the case of family Lycosidae the weight of specimens of this family ranged from zero (MF2, S, B, R1, R2) to 59.85% (Bog) or 64.73% (MM).

The hierarchy changes if we consider the number of genera and species. From this point of view, most genera and species belonged to the family Linyphiidae (38.60%, respectively 39.29%), followed by the families: Lycosidae (8.77% for genera and 14.29% for species), Agelenidae (7.02% for genera, 5.95% for species), Araneidae (7.02% for genera and 4.76% for species), Gnaphosidae (5.26% for genera and 5.95% for species) and Salticidae (5.26%, respectively 3.57%). The rest of the spider families had weights below 5%, as well as the number of genera and the number of species (Fig. 3).

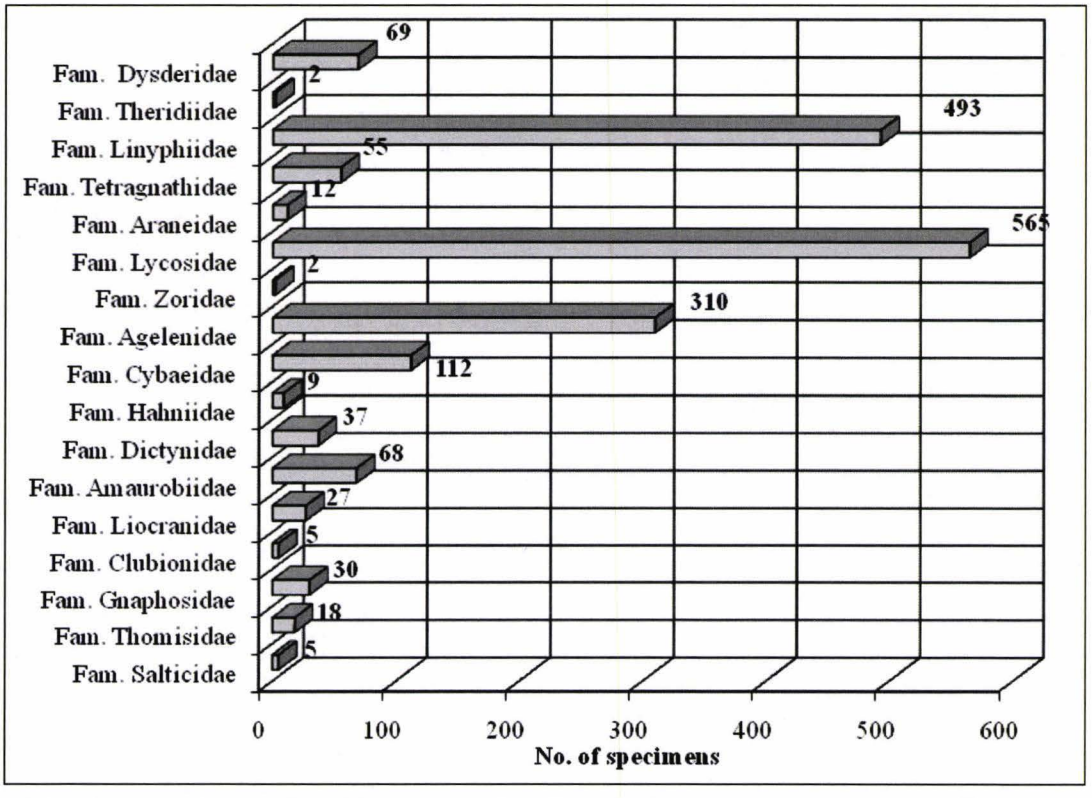

Figure 2. Number of specimens collected from each family. / Figura 2. Numărul de exemplare colectate din fiecare familie.

The "frequencies" of the collected species, depending on the number of habitats in which they were found, varied between 10% and 80%. 75 species (89.28%), of the 84 identified in the National Park Buila Vânturariţa, had frequencies below 50% being identified in a small number of habitats. Most species, 50 species (59.52% of all species collected), were found in one habitat of the 10 studied, their weight, reported to the number of species from the respectively habitat, being higher in: riverside coppice (32.14%), gorges of the Cheia River (57.89%) and mountain

meadow (58.82%). Only four species: *Palliduphantes pallidus* (O. P. CAMBRIDGE 1871), *Coelotes terrestris* (WIDER 1834), *Inermocoelotes inermis* (L. KOCH 1855) and *Callobius claustrarius* (HAHN 1833), respectively two species, *Cybaeus angustiarum* L. KOCH 1868 and *Tenuiphantes tenebricola* (WIDER 1834) had frequencies of 70%, respectively 80%. For the riparian and forest habitats I found a decrease of the weight of species with frequency less than 50% and an increase of the weight of species with frequency above 50%, which shows a grouping of these habitats according to their structure (their nature) and their neighbourhood.

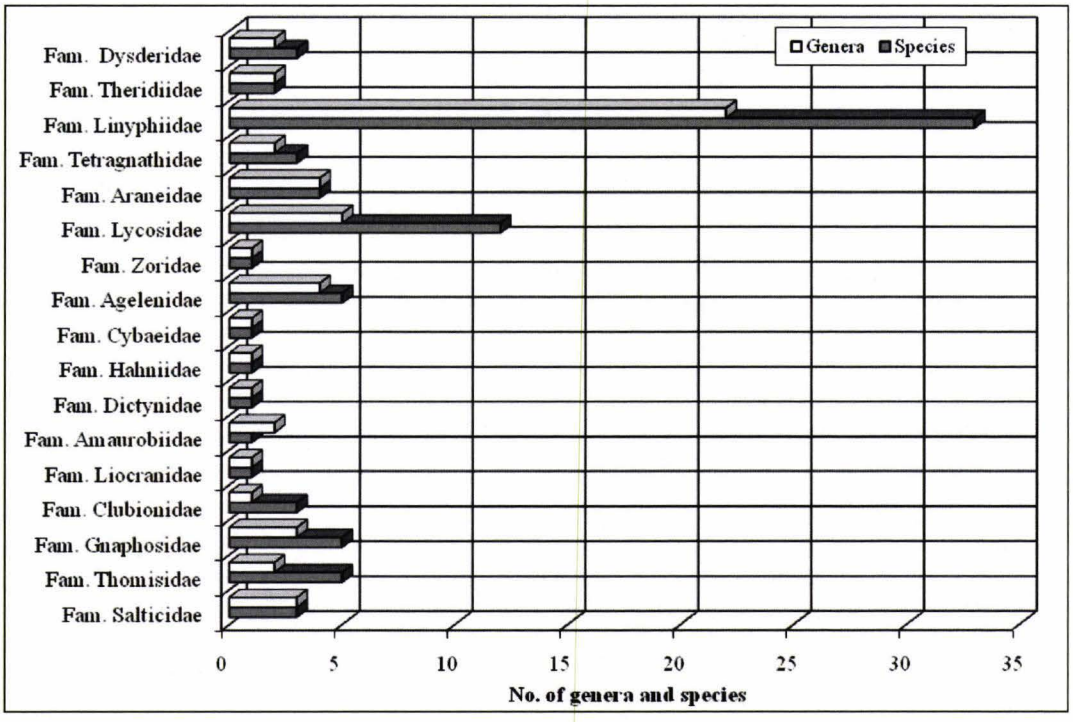

Figure 3. Number of genera and species identified for each family. / Figura 3. Numărul de genuri şi specii identificate din fiecare familie.

In terms of the sex ratio, in the collected material, 61.32% were male and 38.68% were females, the sex ratio being approximately 2:1 in favour of males. The sex ratio, for the 50 spider species for which both sexes were collected, in 20 cases, it was favourable for males, for 6 species it was favourable to females and for 24 species it was relatively balanced, being very close to the theoretical value of 1:1. For the rest of the species (34 species), there were collected either males, in most cases, or females. If we consider juvenile individuals, the sex ratio changes very little, the weight of immature and juvenile specimens being small, only 8.47% of the total collected specimens, of which the juveniles were less than 1% (Fig. 4).

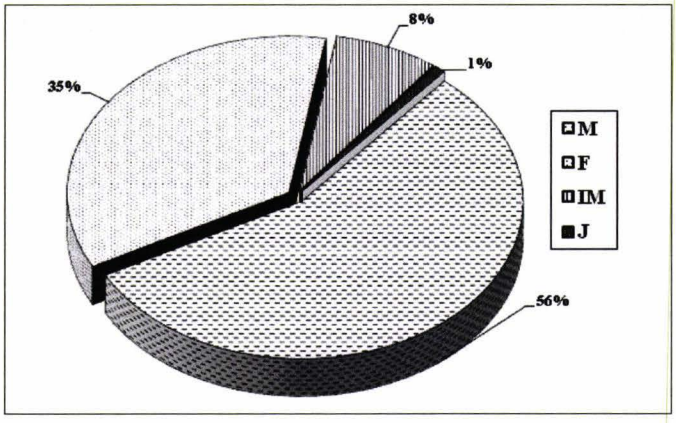

Figure 4. The report between: males, females, immature and juvenile individuals (M-male, F-female, IM-immature, J-juveniles). / Figura 4. Raportul dintre: masculi, femele, imaturi şi juvenili (M-masculi, F-femele, IM-imaturi, J-juvenili).

In accordance with their current spreading, the 84 species of spider identified in the National Park Buila Vânturariţa, were classified into 9 zoogeographical groups (DELTSHEV, 2005). In terms of number of spider species for each zoogeographical groups, I found the presence of large numbers of Palearctic species, almost half (48.81%) of the identified species belonging to this category. These were followed by: the Holarctic species (16.67%), European-Siberian species (13.10%), European species (7.14%) and European Central-Asian species (5.95%). The rest of the zoogeographical elements had weights less than 5% (Fig. 5).

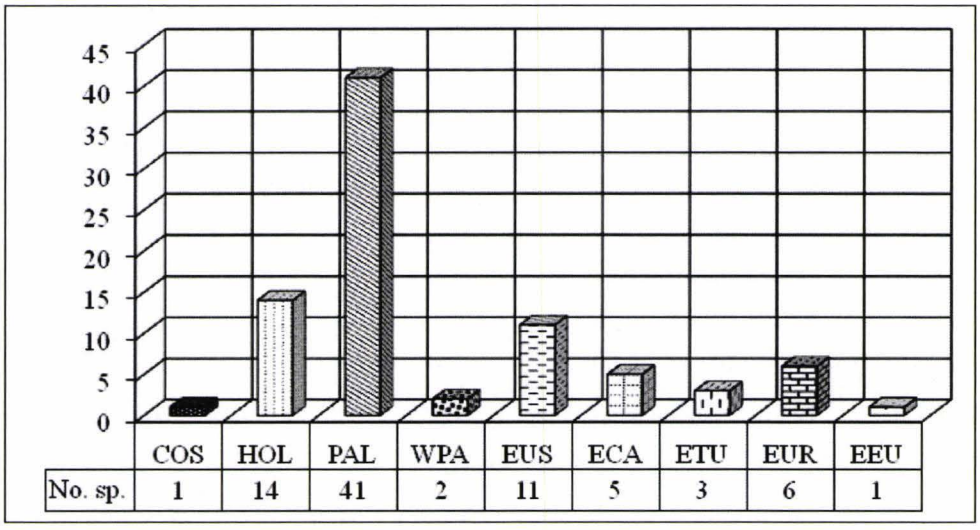

Figure. 5. Distribution of the identified species on zoogeographical groups (COS - Cosmopolitan, HOL - Holarctic, PAL - Palearctic, WPA - Western Palearctic, EUS - European-Siberian, ECA - European Central-Asian, ETU - European-Turanian, EUR - European, EEU - Eastern European). / Figura 5. Distribuţia speciilor identificate pe grupe zoogeografice (COS - Cosmopolit, HOL - Holarctic, PAL - Palearctic, WPA - Vest-Palearctic, EUS - European-Siberian, ECA - European Central-Asiatic, ETU - European-Turanian, EUR - European, EEU - Est European).

Leaving aside the zoogeographical elements with low discriminating power, the Holarctic and Palearctic species, we believe that, the European-Siberian, European-Central Asian, European-Turanian and European zoogeographical elements, totalling 29.76%, are those that allow a more accurate location of the spider fauna of the National Park Buila Vânturariţa. The European-Central Asian, European-Turanian and European elements are located in nemoral belt (mainly in the beech forest), and the European-Siberian ones in the boreal belt (spruce forest). They indicate the appurtenance to Dacian province, the most extensive zoogeographical unit in Romania, including mountainous and hilly areas (DRUGESCU, 1994).

For grouping the habitats, according to the spider fauna, I used the Jaccard index, based on the presence/absence of the species (Fig. 6).

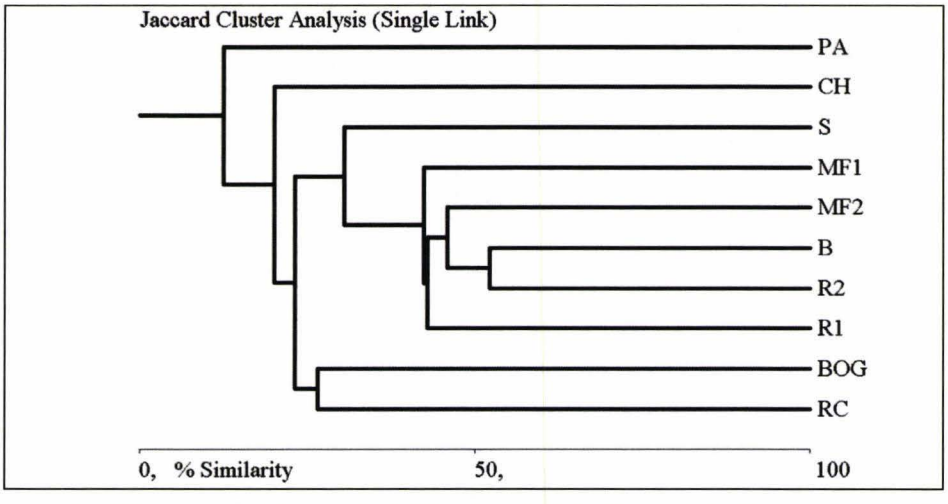

Figure 6. The similarity of studied habitats according to the composition of spider fauna. / Figura 6. Similaritatea habitatelor studiate în funcţie de compoziţia faunei de aranee.

From this viewpoint the mountain meadow clearly detaches from the other investigated habitats, due to particular conditions from this habitat (the similarity is only 12.50%); stationary Cheile Cheii, in terms of specific composition of spider fauna, represents a special habitat, which had a similarity of only 20.00% with other habitats; compared with the mountain meadow, greater similarity with the rest of habitats, was induced by the presence of patches of trees and shrubs; bog and riverside coppice, two wetlands, clearly differs from the forest ecosystems (similarity with these is only 26.30%) and from this group, it emerges the coniferous forest, which shows a low similarity (30.36%) with the other forest ecosystems, being more darker, more uniform, as a monoculture, with a small number of microhabitats.

It is observed the existence of a group of habitats (box with solid line) with higher similarity (over 46.87% and 54.67%); the cluster corresponds to the spatial groups of those three collection stations, their order in the field, starting

from Cheia hut being: R2 → B → MF2. Even if it is part of the cluster which groups deciduous and mixed forests (box with dashed), the habitat MF1 shows a similarity of only 42.14% with the previous group.

The explanation might be that this habitat is represented by a mixed, young forest, probably the result of natural regeneration, located on a slope with southern exposition that means it is warmer, drier and brighter compared to the other forest habitats, which is reflected in the structure of the spider fauna as well. A relatively close similarity (43.48%) was calculated for the stationary R1, located in a mixed forest with a higher percentage of coniferous, wetter and colder compared to MF1.

CONCLUSIONS

This is the first study of the spider fauna of the National Park Buila Vânturariţa; the study led to the identification of 84 species of spider, grouped in 57 genera and 17 families. All species are at the first citation for this area.

From the point of view of fauna only four species: *Robertus scoticus*, *Evansia merens*, *Pelecopsis elongata* and *Walckenaeria mitrata* can be considered relatively rare for the Romanian fauna.

From the point of view of number of species per dominant families we mention Linyphiidae (39.29%) and Lycosidae (14.29%). In terms of number of individuals, the hierarchy is reversed ascertaining the numerical dominance of the species from the family Lycosidae (31.06%), followed by family Linyphiidae (27.10%).

The frequency the spider species, calculated according to the number of habitats in which they were identified, showed that the spider fauna from the National Park Buila Vânturariţa includes a large number of species that have a low continuity in the investigated area, their share being higher in isolated habitats, characterized by a relatively small surface.

The analysis of data on sex ratio showed that it is not balanced, most of the times being in favour of males; overall ratio is to 2:1 in favour of males. Out of the 50 spider species for which there were collected both sexes, in 20 cases, it was favourable for males, for 6 species for females and for 24 species, it was relatively balanced.

Grouping species of spiders according to their distribution area showed the net dominance of widely spread elements, Palearctic and Holarctic species, which totalized nearly 66% of the identified species. In terms of zoogeographical structure of the spider fauna, it is confirmed the affiliation of the investigated area at the Palearctic region, European-Siberian subregion, Central European over-province, Dacian province, with a little Turanian influence.

The values of Jaccard similarity index, less than 55%, reflect a relatively low similarity of the studied habitats through the spider fauna, which indicates a high heterogeneity of the studied area.

REFERENCES

DELTSHEV C. 2005. *Fauna and zoogeography of spiders (Araneae) of Bulgaria.* Journal of Arachnology. **33**: 306-312. http://www.americanarachnology.org/JoA_tocs/JOA_contents_v33n2.html (accessed: January 11, 2012).

DRUGESCU C. 1994. *Zoogeografia României.* Edit. All. Bucureşti. 140 pp.

FIIUN I. E. & OLTEAN CLEOPATRA. 1970. *Lista Araneelor din R. S. România.* Studii şi comunicări. Muzeul de Ştiinţele Naturii Bacău: 157-196.

FUHN I. E. & NICULESCU-BURLACU FLORINA. 1971. *Fauna R. S. România. Fam. Lycosidae.* Edit. Academiei R. S. România. Bucureşti. **5**(3). 256 pp.

FUHN I. E. & GHERASIM V. 1995. *Fauna României. Fam. Salticidae.* Edit. Academiei Române. Bucureşti. **5**(5). 296 pp.

LOTREAN N. 2008. *Observations about arachnid fauna from Micești forest (Argeș District).* Drobeta. Seria Ştiinţele Naturii. Muzeul Regiunii Porţilor de Fier. Edit. Universitaria, Craiova. **18**: 111-123.

NAE A. 2008. *Data concerning the araneae fauna from the Aninei Mountains karstic area (Banat, Romania).* Travaux de l'Institute de Speólogie "Émil Racovitza". Bucharest. **47**: 53-63.

STERGHIU CLEOPATRA. 1985. *Fauna R. S. România. Fam. Clubionidae.* Edit. Academiei R. S. România. Bucureşti. **5**(4). 168 pp.

STERGHIU CLEOPATRA. 1993. *Aranee din Masivul Cozia.* Ocrotirea Naturii şi a Mediului Înconjurător. Edit. Academiei Române. Bucureşti. **37**(2): 99-108.

URÁK I., 2008. *Date despre arahnofauna din bazinul superior al Oltului.* Edit. Scientia. Cluj-Napoca. 240 pp.

URÁK I., SAMU F., MÁTHÉ I., BALOG A. 2010. *Arachnológiai (Arachnida: Araneae) kutatások a Mohos Tőzeglápban.* Acta Siculica. Muzeul Naţional Secuiesc. Edit. Sepsiszentgyörgy. Sfântu Gheorghe. **5**: 127-144.

WEISS I. & PETRIŞOR ANGELA. 1999. *List of the spiders (Arachnida: Araneae) from Romania.* Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa". Bucureşti. **41**: 79-107.

WEISS I. & URÁK I. 2000. *Faunenlisten der Spinnen Rumäniens (Arachnida: Araneae).* http://www.arachnologie.info/fauna.htm (accessed: March 14, 2012).

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THE SPATIAL STRUCTURE OF ORTHOPTERAN COMMUNITIES FROM THE SCIENTIFIC RESERVE "CODRII" FROM THE REPUBLIC OF MOLDOVA

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Abstract. The present work is designed to study diversity and abundance of Orthoptera in the Scientific Reserve "Codrii" from the Republic of Moldova. During this study, a total of 48 species belonging to eight families were collected. There were identified the following families: Bradyporidae, Conocephalidae, Meconematidae, Phaneropteridae, Tettigoniidae, Gryllidae, Gryllotalpinae, Tetrigidae and Acrididae. Acridoidea was the most abundant family found in this study area with 24 species.

Keywords: Orthoptera, fauna, life form, scientific reserve "Codrii".

Rezumat. Structura spaţială a cenozelor de ortoptere în Rezervaţia Ştiinţifică "Codrii" din Republica Moldova. Lucrarea de faţă este concepută pentru a studia diversitatea şi abundenţa ortopterelor în Rezervaţia Ştiinţifică "Codrii" din Republica Moldova. Pe parcursul acestui studiu, au fost colectate 48 de specii care aparţin la opt familii: Bradyporidae, Conocephalidae, Meconematidae, Phaneropteridae, Tettigoniidae, Gryllidae, Gryllotalpinae, Tetrigidae şi Acrididae. Acridoidea a fost suprafamilia cea mai abundentă – cu 24 specii de insecte ortoptere.

Cuvine cheie: Orthoptera, fauna, formă vitală, Rezervaţia Ştiinţifică „Codrii".

INTRODUCTION

The conservation of biodiversity throughout the world is of critical importance to the human population and indeed to the constancy of the whole world. Biological and anthropogenic factors and their intensification have more and more fragmented natural and semi-natural elements. Because of these factors, the number of a lot of flora and fauna species is in decline. Even if Orthoptera insects are one of the diverse and numerous orders from the class Insecta, notwithstanding, these species are highly sensitive to environmental changes such as grazing and abandonment (MARINI *et al.*, 2010; SCHIRMEL *et al.*, 2010).

In woods, grassland ecosystems and not only, faunal surveys revealed that Orthoptera are among the most conspicuous insects. These insects often constitute one of the dominant groups of arthropods and key organisms for diversity, abundance and biomass as they are the main arthropod consumers (CURRY, 1994) and food source for vertebrates (e.g. birds or lizards) (STAHI & ANGHELOVA, 2009; BELOVSSKY & SLADE, 1993).

MATERIAL AND METHODS

Field work

The Scientific Reserve "Codrii" was founded in 1971 for conservation of some representative sectors of old woods from the centre of the Republic situated on the "Moldavian Central Plateau" or "Podişul Central Moldovenesc" (in Romanian). So, the reserve is located in the Centre of the Republic of Moldova, Strasheni district, 49 km away from Kishinev city (geographical coordinates: 47°04', 47°01', latitude; and 28°20', 28°30', longitude; the altitude ranges between 130 and 382.5 m in the region with moderate continental climate). The reserve includes different zones: the protective zone, the buffer and transit zone. The total surface of the reserve is 5,177 ha, of which 5,073 ha are occupied by wooden plants (POPUŞOI, 2008; Ariile Protejate din Republica Moldova, 2012).

The flora of the study area is characterised by "Codrii" and is represented by more than 1,000 species of plants, of which about 60 have the statute of rare species and 23 are included in the Red Book of the Republic of Moldova. The wooden vegetation is composed by species belonging to genera: *Fraxinus* L., *Carpinus* L., *Sorbus* L., *Quercus* L., *Carex* L., *Aegopodium* L., *Stellaria* L. and other genera (POSTOLACHE, 1995).

About its fauna, we can say that here prevail species belonging to Central and West Europe – 52 species of mammals, 151 species of birds, 8 species of reptiles, 10 species of amphibians and more than 8,000 species of insects (MANIC *et al.*, 2006).

Methods of collecting

The study was conducted in the third part of July and in the first ten days of September months of 2009 in the Scientific Reserve „Codrii".

The grasshoppers were collected by sweep net or by hand, additional faunal data were also obtained by using pitfall traps.

The pitfall traps (glass jar, opening diameter 8 cm, filled with 4% solution of formaldehyde with addition of ethylene glycol and few drops of detergent) were used to study fissurobiont and burrowing geobiont species. The pitfall traps were arranged on three transects parallel in-between (interval between them was 10 m) and the distance between traps was 2 m. The exposition period lasted by 10 days in July and September, but the traps were checked every day.

Data analysis: The specimen identification was made according to external morphology and genitalia using different identification keys (KIS, 1976, 1978; KNECHTEL & POPOVICI-BÂZNOŞEANU, 1959; IORGU & IORGU, 2008; HARZ, 1975; BEI-BIENKO, 1964).

The species nomenclature and classification were made according to the site Orthoptera of Europe (http://www.ortheur.org/orthoptera/orthoptera /i000241.html).

The zoogeographical elements were established according to the work of BEI-BIENKO (1950, 1952, 1964) and IORGU & IORGU (2008). For the mathematical and statistical analysis of the orthopteran entomological material we have applied to the work of ANDREEV (2002).

RESULTS AND DISCUSSIONS

The first research of Orthoptera fauna from the Scientific Reserve "Codrii" were done in 2001, from where 20 species were published, but the presence of some species like *Podismopsis poppiusi* and others is doubtful (NICOLAESCU & DERJANSCHI, 2001). Nine new species from this reserve were published by STAHI (2007a) in another paper about the ecology of grasshoppers collected from the "Codrii" Reserve (STAHI, 2007a, b).

We have investigated the Orthoptera communities of the Scientific Reserve "Codrii" from the Republic of Moldova. This research suggests that the Orthoptera were more diverse in the inner forest while they were more abundant at the forest margin. Among the factors affecting the diversity and abundance of Orthoptera there are included: Microclimate variable (temperature, humidity and light intensity), availability of food, structural qualities, oviposition sites, suitable hiding places and the presence of predators.

As a result of the investigation during the third part of July till September of 2009 in the Scientific Reserve "Codrii" there were collected 1,102 orthopteran individuals. These orthopterans belong to 48 species that constitute 45.13% of the fauna of this order from the Republic of Moldova (STAHI & DERJANSCHI, 2010). These species belong to 28 genera and 10 families: Bradyporidae, Meconematidae and Gryllotalpinae with one species; Conocephalidae, Gryllidae and Tetrigidae – three; Phaneropteridae – five; Tettigoniidae – seven and Acrididae respectively with 24 species. The most representative superfamily is Acridoidea with 24 species and the least is Tetrigoidea – 3 species (Table 1).

Concerning the spectrum of feeding groups of Orthoptera insects from the Scientific Reserve "Codrii" just 2% (1 species) are insectivorous (I) (*Meconema thalasinum*); other species from Ensifera suborder and Grylloidea superfamily (except for those belonging to Phaneropterinae family) – 29% are omnivorous (II). All the remaining species from Caelifera suborder and Phaneropterinae family, which represent 69%, are phytophagous (III) (Fig. 1).

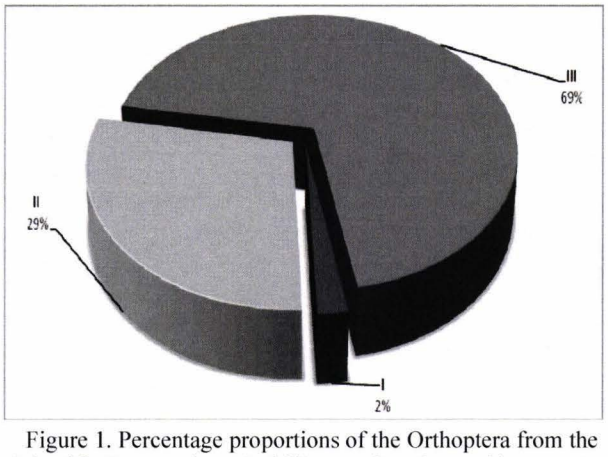

Figure 1. Percentage proportions of the Orthoptera from the Scientific Reservation "Codrii" regarding the trophic spectrum.
Figura 1. Proporţiile procentuale ale ortopterelor din Rezervaţia Ştiinţifică "Codrii" privind spectrul trofic.

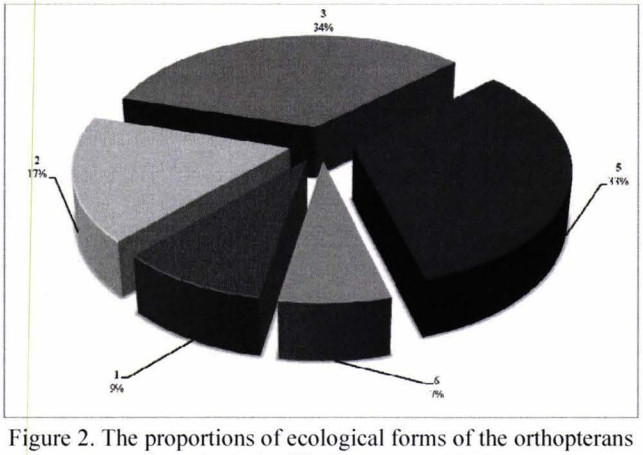

Figure 2. The proportions of ecological forms of the orthopterans from the Scientific Reserve "Codrii".
Figura 2. Proporţia formelor ecologice ale ortopterelor din Rezervaţia Ştiinţifică "Codrii".

The presence and assemblage of orthopteran species are distinctly different depending on the habitat types. This depends on the orthopteran habitat preference, which is determined by the species adaptation to habitat structure, microclimate and disturbance intensity (SAMWAYS, 1997; SZOVENYI, 2002). The samplings of orthopteran specimens were carried out on dry and humid meadows, in wood, groves and glades; we have also studied the plains in the immediate proximity, which have been abandoned for more than 15 years. As a result, in this reserve, there was observed that, regarding the eco-forms of grasshoppers, there prevailed mesophilous and mesoxerophilous species with 31%, after these xerophilous with 17% and hygro mesophilous – 14%, while the last 7% are hygrophilous (Fig. 2).

The majority of grasshopper species are not specialised in food plants and constantly feed on a variety of grasses (PICAUD *et al.*, 2003). Nevertheless, the orthopterans may differ in their preference for different grass species (INGRISCH & KÖHLER, 1998). Most (43%) of Orthoptera species from the reserve are chortobiont, especially those from *Stenobothrus*, *Chorthippus* and *Omocestus* genera. This species can be found in meadows and pastures, where

spontaneous Gramineae prevailed. Also, a lot of the collected species, 17% and 16%, are geo-chortobiont and respectively chorto-geobiont (Fig. 3). Also, in this reserve, there are present fissurobiont and burrowing geobiont species which represent 4% (*Gryllus campestris* and *Melanogryllus desertus*) and 2% (*Gryllotalpa gryllotalpa*) (Fig. 3). These three species were collected by pitfall traps.

Table 1.The diversity, ecology and sinecologycal analyses of Orthoptera species from the Scientific Reserve "Codrii".
Tabel 1. Diversitatea, ecologia şi analiza sinecologică a ortopterelor din Rezervaţia Ştiinţifică "Codrii".

	Species	N ♀/♂	N-1	N (N-1)	Log10N	N_{log10N}	Domination %	Domination Class	Biotope	Vital form	Geographical distribution
	Suborder **ENSIFERA** Superfamily **TETTIGONIOIDEA** KRAUSS, 1902 Family **BRADYPORIDAE**										
1.	*Ephippiger ephippiger*	1/1	1	2	0,30	0,60	0,18	D_1	4-5	B	Central-South-European
	Family **CONOCEPHALIDAE**										
2.	*Conocephalus dorsalis*	5/8	12	156	1,11	14,48	1,18	D_2	1	A	Eurosiberian
3.	*Conocephalus fuscus*	4/6	9	90	1,00	10,00	0,91	D_1	1-3	A	Holopalearctic
4.	*Ruspolia nitidula*	2/1	2	6	0,48	1,43	0,27	D_1	1-3	A	Mediterranean-African
	Family **MECONEMATINAE**										
5.	*Meconema thalassinum*	2/4	5	30	0,78	4,67	0,54	D_1	3-4	C	Holoeuropean
	Family **PHANEROPTERINAE**										
6.	*Leptophyes albovittata*	30/22	51	2652	1,72	89,23	4,71	D_3	3-4	D	Central Asian-Mediterranean
7.	*L. boscii*	21/16	36	1332	1,57	58,02	3,35	D_3	3-4	D	South-East-European
8.	*L. punctatissima*	29/32	60	3660	1,79	108,91	5,53	D_4	3-4	D	North-European
9.	*Phaneroptera falcata*	12/19	30	930	1,49	46,23	2,81	D_3	2-4	C	Eurosiberian
10.	*Ph. nana*	2/4	5	30	0,78	4,67	0,54	D_1	5	C	Circum-Mediterranean
	Family **TETTIGONIIDAE** KRAUSS, 1902										
11.	*Decticus albifrons*	2/1	2	6	0,48	1,43	0,27	D_1	5	F	Circum-Mediterranean
12.	*Metrioptera bicolor*	8/15	22	506	1,36	31,32	2,09	D_2	2-4	A	Eurosiberian
13.	*M. roeselii*	10/5	14	210	1,18	17,64	1,36	D_2	1-2	A	Eurosiberian
14.	*Pholidoptera griseoaptera*	8/6	13	182	1,15	16,05	1,27	D_2	2	C	Holoeuropean
15.	*Platycleis tessellata*	6/2	7	56	0,90	7,22	0,73	D_1	4	A	Holoeuropean
16.	*Pterolepis germanica*	2/3	4	20	0,70	3,49	0,45	D_1	4-5	E	Ponto-Mediterranean
17.	*Tettigonia viridissima*	5/4	8	72	0,95	8,59	0,82	D_1	2-5	C	Holopalearctic
	Superfamily **GRYLLOIDEA** LAICHARTING, 1781 Family **GRYLLIDAE** LAICHARTING, 1781										
18.	*Gryllus campestris*	13/23	35	1260	1,56	56,03	3,26	D_3	3-4	H	Holopalearctic
19.	*Melanogryllus desertus*	21/15	35	1260	1,56	56,03	3,26	D_3	4-5	H	Central Asian-Mediterranean
20.	*Oecanthus pellucens*	19/23	41	1722	1,62	68,18	3,81	D_3	3-4	B	Central Asian-Mediterranean
	Family **GRYLLOTALPIDAE** LEACH, 1815										
21.	*Gryllotalpa gryllotalpa*	3/0	2	6	0,48	1,43	0,27	D_1	1-2	I	Holopalearctic
	Suborder **CAELIFERA** Superfamily **TETRIGOIDEA** SERVILLE, 1838 Family **TETRIGIDAE** SERVILLE, 1838										
22.	*Tetrix bipunctata*	5/4	8	72	0,95	8,59	0,82	D_1	1-3	F	Eurosiberian
23.	*T. subulata*	14/10	23	552	1,38	33,13	2,18	D_3	1	G	Holarctic
24.	*T. tenuicornis*	2/3	4	20	0,70	3,49	0,45	D_1	2-3	F	Holopalearctic
	Superfamily **ACRIDOIDEA** MACLEAY, 1821 Family **ACRIDIDAE** MACLEAY, 1821										
25.	*Acrida ungarica*	12/8	19	380	1,30	26,02	1,81	D_2	3-4	A	Mediterranean-African
26.	*Calliptamus italicus*	9/10	18	342	1,28	24,30	1,72	D_2	4-5	E	Central Asian-Mediterranean
27.	*C. barbarus*	1/1	1	2	0,30	0,60	0,18	D_1	4-5	E	Holopalearctic
28.	*Euthystira bracyptera*	2/1	2	6	0,48	1,43	0,27	D_1	4-5	E	Central Asian-Mediterranean
29.	*Dociostaurus maroccanus*	12/8	19	380	1,30	26,02	1,81	D_2	1-3	A	Eurosiberian
30.	*Chorthippus albomarginatus*	60/32	91	8372	1,96	180,67	8,34	D_4	2-4	A	Central-North-European
31.	*Ch. apicarius*	4/0	3	12	0,60	2,41	0,36	D_1	3	A	Eurosiberian
32.	*Ch. brunneus*	32/45	76	5852	1,89	145,26	6,98	D_4	3-5	G	Central Asian-Mediterranean
33.	*Ch. biguttulus*	26/35	60	3660	1,79	108,91	5,53	D_4	3-5	G	Holopalearctic
34.	*Ch. dichorus*	2/1	2	6	0,48	1,43	0,27	D_1	4-5	A	Central Asian-Pontic
35.	*Ch. dorsatus*	2/4	5	30	0,78	4,67	0,54	D_1	2-3	A	Eurosiberian
36.	*Ch. loratus*	15/9	23	552	1,38	33,13	2,18	D_3	5	A	Ponto-Mediterranean
37.	*Ch. mollis*	7/12	18	342	1,28	24,3	1,72	D_2	4-5	A	Euro-Asiatic-Palearctic
38.	*Ch. parallelus*	19/26	44	1980	1,65	74,39	4,08	D_3	2-4	A	Euro-Asiatic-Palearctic
39.	*Ch. pullus*	13/7	19	380	1,30	26,02	1,81	D_2	3	A	Central-European
40.	*Ch. vagans*	9/14	22	506	1,36	31,32	2,09	D_2	3-4	A	Pontic
41.	*Omocestus haemorhoidalis*	19/16	34	1190	1,54	54,04	3,17	D_3	3-4	E	Euro-Asiatic-Palearctic
42.	*O. minutus*	5/9	13	182	1,15	16,05	1,27	D_2	4	A	Pontic

43.	***O. rufipes***	14/23	36	1332	1,57	58,02	3,35	$\mathbf{D_3}$	4-5	A	Holopalearctic
44.	*O. viridulus*	13/22	34	1190	1,54	54,04	3,17	$\mathbf{D_3}$	3	A	Eurosiberian
45.	*Stauroderus scalaris*	26/12	37	1406	1,58	60,03	3,45	$\mathbf{D_3}$	3-4	E	Euro-Asiatic-Palearctic
46.	*Stenobothrus lineatus*	4/8	11	132	1,08	12,95	1,09	$\mathbf{D_1}$	3	A	Eurosiberian
47.	*S. stigmaticus*	0/2	1	2	0,30	0,60	0,18	$\mathbf{D_1}$	2-4	G	Central-South-European
48.	*Oedipoda caerulescens*	14/18	31	992	1,51	48,16	2,90	$\mathbf{D_3}$	5	F	Holopalearctic
TOTAL		**1102**	**1051**	**44068**	**1,71**	**1667,67**	**100**				

Legend. Life forms: A – chortobiont, B – chorto-thamnobiont, C – thamnobiont, D – thamno-chortobiont, E – geo-chortobiont, F – chorto-geobiont, G – geobiont, H – fissurobiont, I – burrowing geobiont. **Ecological forms:** 1 – hygrophilous, 2 – hygromesophilous, 3 – mesophilous, 4 – mesoxerophilous, 5 – xerophilous.

Legendă. Formă vitală: A – hortobiont, B – horto-tamnobiont, C – tamnobiont, D – tamno-hortobiont, E – geo-hortobiont, F – horto-geobiont, G – geobiont, H – fissurobiont, I – geobiont subteran. **Formă ecologică:** 1 – higrofil, 2 – higro-mezofil, 3 – mezofil, 4 – mezo-xerofil, 5 – xerofil.

The great majority of grasshoppers were collected in the meadows and forest margins, but directly in woods there were observed just the species *Ephippiger ephippiger* and *Meconema thalassinum* and also, individuals of the genera *Leptophyes* and *Phaneroptera*.

The Republic of Moldova occupies 33,700 km^2 and is situated in the southeastern part of Europe, at the junction of the great geobotanical regions: Euro-Asiatic, European, and Mediterranean (GHEIDEMAN, 1986). In accordance with the territorial surface, the Republic of Moldova is one of the smallest countries of Europe, but its fauna diversity is higher than in other big countries, owing to some particularities like: diversity and structure of the soils, varied relief, climates, thermal regime, rainfall amounts, hydrology and others. From these 48 species of Orthoptera order collected in the Scientific Reserve "Codrii" 24 species have Palaearctic distribution, 9 – European, 8 – Mediterranean and the last 7 – Central-Asian (Fig. 4).

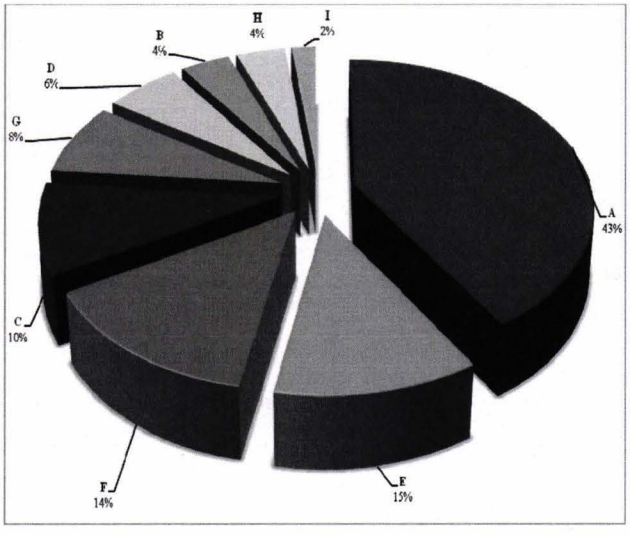

Figure 3. Proportions among life forms of orthopterans from the Scientific Reserve "Codrii".
Figura 3. Proporţia între formele vitale ale ortopterelor din Rezervaţia Ştiinţifică „Codrii".

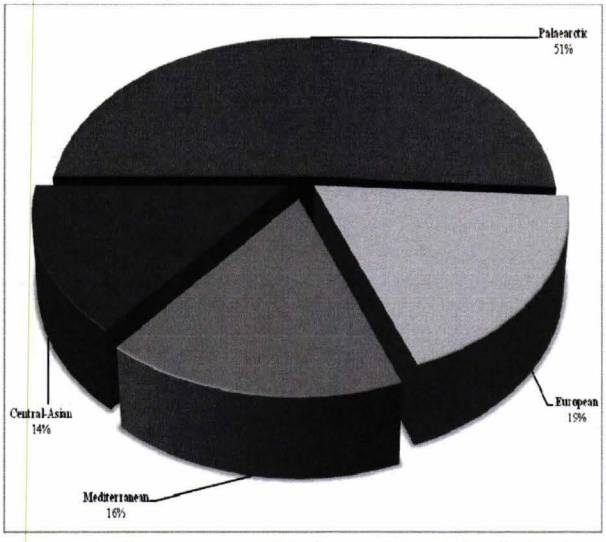

Figure 4. The zoo-geographical repartition of the Orthoptera species from the Scientific Reserve "Codrii".
Figura 4. Repartiţia zoogeografică a ortopterelor din Rezervaţia Ştiinţifică „Codrii".

Following the sinecologycal analysis of the fauna of Orthoptera order registered in the "Codrii" the dominant species are: *Ephippiger ephippiger*, *Conocephalus fuscus*, *Ruspolia nitidula*, *Meconema thalassinum*, *Phaneroptera nana*, *Decticus albifrons*, *Platycleis tessellata*, *Pterolepis germanica*, *Tettigonia viridissima*, *Gryllotalpa gryllotalpa*, *Tetrix bipunctata*, *T. tenuicornis*, *Calliptamus barbarus*, *Euthystira bracyptera*, *Chorthippus apicarius*, *Ch. dichorus*, *Ch. dorsatus*, *Stenobothrus lineatus* and *S. stigmaticus*. These 22 species constituted 9.71% (107 specimens) from the all collected specimens (1,102 specimens).

The species *Conocephalus dorsalis*, *Metrioptera bicolor*, *M. roeselii*, *Pholidoptera griseoaptera*, *Acrida ungarica*, *Calliptamus italicus*, *Dociostaurus maroccanus*, *Chorthippus loratus*, *Ch. mollis*, *Ch. pullus* and *Ch. vagans* are recedent, holding 18.49%, (200 specimens). Also, we want to underline that *Pholidoptera griseoaptera* species was observed just in this reserve during 7 years.

The species *Leptophyes albovittata*, *L. boscii*, *Phaneroptera falcata*, *Gryllus campestris*, *Melanogryllus desertus*, *Oecanthus pellucens*, *Tetrix subulata*, *Chorthippus loratus*, *Omocestus haemorhoidalis*, *O. rufipes*, *O. viridulus*, *Stauroderus scalaris* and *Oedipoda caerulescens* are subdominants, holding 45.74% (504 specimens).

The species *Leptophyes punctatissima*, *Chorthippus albomarginatus*, *Ch. brunneus* and *Ch. biguttulus* are dominant, representing 26.41% (291 specimens).

Besides the diversity of Orthoptera insects from the Scientific Reserve "Codrii" we established that Simpson I_S index had a value of 0.06, the other index – Shannon I_{SH} had the value of 1.39 and the last one – the equitability index had the value of 0.24%.

CONCLUSIONS

In the Scientific Reserve "Codrii", there were collected 48 species of Orthoptera which belong to 28 genera, ten families and four superfamilies: Tettigonioidea, Grylloidea, Tetrigoidea, Acridoidea, the last one being the most representative – 24 species.

The dominant species are: *Leptophyes punctatissima*, *Chorthippus albomarginatus*, *Ch. brunneus* and *Ch. biguttulus*.

Of those 48 species of Orthoptera, 24 species have a Palaearctic distribution, 9 – European, 8 – Mediterranean and the last 7 – Central-Asian distribution.

During the seven years of my research the *Pholidoptera griseoaptera* species was observed just in this reserve.

REFERENCES

ANDREEV A. 2002. *Otsenka bioraznoobraziza, monitoring i ecoseti.* Kishinev: Biotica. 166 pp. [In Russian].

BEI-BIENKO G. 1950. *Pryamokrylyie Orthoptera i cojistokrylyie Dermaptera.* In: Zhivotnyi mir SSSR. Moskva-Leningrad. 3: 379-424. [In Russian].

BEI-BIENKO G. 1952. *Pryamokrylyie.* In: Fauna SSSR. Moskva-Leningrad: AN SSSR. **2** (2): 385 pp. [In Russian].

BEI-BIENKO G. 1964. *Pryamokrylyie.* In: Opredeliteli nasekomykh evropeyskoi chiasti SSSR. Moscka-Leningrad: Nauka. 1: 205-285. [In Russian].

BELOVSSKY G. & SLADE J. 1993. *The role of vertebrate and invertebrate predators in a grasshopper community.* Oikos. Blackwell Publishing. **68**: 193-201.

CURRY J. 1994. *Grassland invertebrates: ecology, influence on soil fertility, and effects on plant growth.* Chapman and Hall, London. 437 pp.

GHEIDEMAN T. 1986. *Opredeliteli visshih rastenii Moldavskoi SSSR.* Ştiinţa. Kishiniov 637 pp. [In Russian].

HARZ K. 1975. *Die Orthopteren Europas.* II. Seria Entomologia. Dr. W. Junk, B. V., Publ. The Hague. 939 pp.

INGRISCH S. & KÖHLER G. 1998. *Die Heuschrecken Mitteleuropas.* Die neue Brehm Bücherei, Bd. 629. Westarp Wissenschaften, Magdeburg. 460 pp.

IORGU I. & IORGU ELENA 2008. *Bush-crickets, crickets and grasshoppers from Moldavia (Romania).* Edit. Iaşi: PIM. 294 pp.

KIS B. 1976. *Cheie pentru determinarea ortopterelor din România. Partea I. Subord. Ensifera.* Studii şi comunicări. Ştiinţele Naturii. Muzeul Brukenthal. Sibiu. **20**: 123-166.

KIS B. 1978. *Cheie pentru determinarea ortopterelor din România. Partea II. Subord. Caelifera.* Studii şi comunicări. Ştiinţele Naturii. Muzeul Brukenthal, Sibiu. **22**: 233-276.

KNECHTEL W. & POPOVICI-BÂZNOŞEANU A. 1959. *Orthoptera: ordinele Saltatoria, Dermaptera, Blattodea, Mantodea.* In: Fauna Romaniei. Insecta. Bucureşti. Edit. Academiei. **7**(4). 265 pp.

MANIC Ş., NEGRU A., COZARI T. 2006. *"Rezervaţia „Codrii": Diversitatea biologică. Agenţia pentru silvicultură „Moldsilva"*, Chişinău, Edit. „Ştiinţa". 92 pp.

MARINI L., BOMMARCO R., FONTANA P., BATTISTI A. 2010. *Disentangling effects of habitat diversity and area on orthopteran species with contrasting mobility.* Biological conservation. Elsevier Ltd. **143**: 2164-2171.

NICOLAESCU V.& DERJANSCHI V. 2001. *Contribuţii la cunoaşterea faunei şi ecologiei ortopterelor (Orthoptera) din rezervaţia „Codrii".* Diversitatea, valorificarea raţională şi protecţia lumii animale. Chişinău: CE USM. 146.

POPUŞOI A. 2008. *60000 ha plantări forestiere Moldsilva, perioada 2002-2008.* Ştiinţa. Chişinău. 60 pp.

POSTOLACHE GH. 1995. *Vegetaţia Republicii Moldova.* Chişinău, Ştiinţa. 340 pp.

SANWAYS M. 1997. *Conservation biology of Orthoptera.* In: Gangwere S.K., Muralirangan M. C. & Muralirangan M. (Eds.): The Bionomics of Grasshoppers, Katydids and their Kin. CAB International, Wallingford: 481-496.

SCHIRMEL J., MANTILLA-CONTRERAS J., BLINDOW I., FARTMANN T. 2010. *Impact of succession and grass encroachment on heathland Orthoptera.* Journal Insect Conservation. Springer Netherlands. **15**: 633-642.

STAHI NADEJDA. 2007a. *Faunistic and synecological research of grasshoppers (Insecta, Orthoptera) from scientific reservations from the Republic of Moldova.* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **23**: 111-114.

STAHI NADEJDA. 2007b. *Fauna ortopterelor din rezervaţia ştiinţifică "Codrii".* International Conference of Young researchers **V** edition. Chisinau. 56 pp.

STAHI NADEJDA. & ANGHELOVA G. 2009. *Păsările ca consumatori ai ortopterelor (Insecta: Orthoptera) din Republica Moldova.* International Conference of Young researchers **VII** edition. Chisinau: 57.

STAHI NADEJDA & DERJANSCHI V. 2009. *The diversity and ecology of Orthoptera species (Insecta, Orthoptera) from the Republic of Moldova.* In: Buletin ştiinţific. Revistă de Etnografie, Ştiinţele Naturii şi Muzeologie. Chişinău. Muzeul de Etnografie şi Ştiinţele Naturii. Chişinău. **10**(23): 109-121.

SZOVENYI G. 2002. *Qualification of grassland habitats based on their Orthoptera assemblages in the Kőszeg Mountains (W-Hungary)*. Entomological Experimentalis et Applicata. Menken. **104**: 159-163.

***. The Orthoptera of Europe http://www.ortheur.org/orthoptera/orthoptera /i000241.html (accessed on February 2, 2012).

***. Ariile protejate din Republica Moldova, 2012. http://www.iatp.md/arii/text/ro/Peisagistice/castel.htm (accesed: March 20, 2012).

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DATA REGARDING THE PRESENCE OF *Cybister (Scaphinectes) lateralimarginalis* (DEGEER 1774) (INSECTA: COLEOPTERA: DYTISCIDAE) IN THE ENTOMOLOGICAL FAUNA OF DOLJ COUNTY (ROMANIA)

LILA Gima

Abstract. This paper introduces in the scientific informational circuit new data regarding the presence of the species *Cybister (Scaphinectes) lateralimarginalis* (DEGEER 1774) (Insecta: Coleoptera: Dytiscidae) in the entomological fauna of Dolj county, Oltenia area (Romania). It al so provides new data on food regime of captive-bred species. We studied 24 specimenes collected from April to June 2012 in Pond Obedin (village Obedin, Breasta village, Dolj county). The 24 specimenes (20 males and 4 females) were kept for observation in aquarium. The specimens analyzed in this material and those that will be collected in the fall will be investigated in order to identify potential parasites.

Keywords: new data, spreading, *Cybister (Scaphinectes) lateralimarginalis*, Obedin, Romania, dimensions, food.

Rezumat. Date preliminare privind prezenţa speciei *Cybister (Scaphinectes) lateralimarginalis* (DEGEER 1774) (Insecta: Coleoptera: Dytiscidae) în fauna entomologică a judeţului Dolj (România). Lucrarea de faţă introduce în circuitul informaţional date noi privind prezenţa speciei *Cybister (Scaphinectes) lateralimarginalis* în fauna entomologică a judeţului Dolj. De asemenea, aduce noi date privind regimul trofic al speciei crescută în captivitate. Au fost studiaţi 24 indivizi colectaţi în perioada aprilie – iunie, 2012 din Balta Obedin (satul Obedin, comuna Breasta, judeţul Dolj). Cei 24 de indivizi (20 masculi şi 4 femele) au fost ţinuţi în acvariu pentru observaţii. Exemplarele analizate în prezentul material şi cele care vor fi colectate în toamnă (2012) vor fi investigate în vederea depistării eventualilor paraziţi.

Cuvinte cheie: date noi, răspândire, *Cybister (Scaphinectes) lateralimarginalis*, Obedin, România, dimensiuni, hrană.

INTRODUCTION

This paper aims at introducing the scientific information new data on the presence of species *Cybister (Scaphinectes) lateralimarginalis* in Dolj county fauna. The species belongs to the family Dytiscidae, superfamily Dytiscoidea. The work aims at bringing new data regarding the trophic regime of the species grown in captivity.

The species *C. (Scaphinectes) lateralimarginalis* is one of water beetles, which is an important part of aquatic food chains and it is a significant bioindicator of the quality of water and quality of the ecosystem (ŠŤASTNÝ & TRÁVNÍČEK, 2000).

Cybister (Scaphinectes) lateralimarginalis beetle is a native Palearctic species (including Europe), Middle Eastand North Africa (Table 1). In Europe, it is found only in Austria, Balearic Islands, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Corsica, Crete, Croatia, Cyprus, Czech Republic, Denmark continental Dodecanese Islands, mainland France, Germany, Greek mainland, Hungary, Italy mainland, Kaliningrad, Latvia, Luxembourg, Macedonia, Poland, mainland Portugal, Romania, Russia (excluding Northand North-West), Sardinia, Sicily, Slovakia, Slovenia, mainland Spain, Sweden, Switzerland, Netherlands, Ukraine, and Yugoslavia (ŠŤASTNÝ & TRÁVNÍČEK, 2000).

Table 1. The worldwide distribution of *Cybister (Scaphinectes) lateralimarginalis*. / Tabel 1. Răspândirea speciei *C. (Scaphinectes) lateralimarginalis* la nivel mondial.

No.	Absent
1	Afro-tropical region
2	Australian region
3	Nearctic region
4	Neotropical region
5	Oriental region

The analysed specimens were collected from Obedin pool situated in the village Obedin, Breasta commune, Dolj County, Romania. Obedin village is located 20 kilometres from Craiova and the geographical coordinates are 44°21'55"N 23°41'23" E. The aquatic ecosystem from which specimens were collected is outside the village an dislocated on the right of the road to the village. On the right side of pond, there is located the farmland and forest Geanovu, and on the left, it is Obedin Hill covered by a forest of *Quercus* species (*Quercus robur, Q. cerris, Q. frainetto*). The pond is covered with floating vegetation and has flooded the depression areas with fixed hydrophilic vegetation (*Typha angustifolia*) with reduced waterflow partially covered with fixed vegetation and plant species, such as *Iris pseudacocus, Potamogeton nutans, Spyrogyra*, etc. (Fig. 2).

So far, the distribution (occurrence) of this species within Dolj has not been studied. The species was first mentioned in Dolj county fauna in 1928 (MARCU, 1928). Subsequently, it was mentioned sporadically in specialty papers (FIRU, 1982; BOBÎRNAC *et al.*, 1999; CHIMIŞLIU, 2008).

Figure 1. Obedin Pond (Google Earth). / Figura 1. Balta Obedin (Google Earth).

Figure 2. Obedin Pond. / Figura 2. Balta Obedin (original).

The first work of synthesis on the family that centralized Dytiscide references in the literature and data processing the heritage preserved in the Department of Natural Sciences Museum of Oltenia Craiova MOGOŞEANU was published (2010). The Heritage Section of Natural Sciences identified 25 specimens that were collected between 1951 and 2001 from five collecting sites in Dolj County – Bistreţ, Ciuperceni, Craiova, Desa and Rast.

MATERIAL AND METHODS

The material was collected from Obedin Pond in the period March-June 2012. Collectings began in the second half of March 2012, during which the average water temperature reached 9^0C and air temperature ranged between 17 and 23^0C. The water temperature in the four months had different values (Table 2).

In the month swith lower temperatures (March), individuals were active throughout the day, while in the months with higher temperatures, they were more active in the morning and evening; they came to feed (~ 5.30-9.00 am and ~5.00-8.00 pm). The pond water temperature ranged between 9 and 23^0C. Since July, the vegetation has greatly increased which made it very difficult to detectand collect specimens, as adult swere hiding under the leaves of cattail (*Typha angustifolia*).

Samples were collected using fishing netand by hand (rare); most of the samples were collected in April as the water front vegetation was less developed and specimens could be easily observed (Table 3).

Table 2. Water temperature in the months of sampling months. / Tabel 2. Temperatura apei în lunile de colectare.

No.	Month	Temperature
1	March	9^0C
2	April	16^0C
3	May	18^0C
4	June	23^0C

Table 3. Numerical variation of specimens during March-June 2012. / Tabel 3.Variaţia numerică a exemplarelor în perioada lunilor martie-iunie 2012.

No.	Months (2012)	Frequency
1	March	2
2	April	12
3	May	6
4	June	4
	Total	**24**

Samples collected were transported in plastic containers with water and transferred into the aquarium with water from Obedin Pond. The water was changed twice a week during the colder period and every two days during the warmer period. In the last period (June 11-30) I used tap water, bugs adapting easily. Tap water temperature is between 24 and 26^0C.

The determination was made according to REITTER (1908). The used nomenclature and the systematics are according to Fauna Europea.

To observe the feeding behaviour of the individuals, the collected adults and brought to the aquariums were fed with aquatic gastropods (*Lymnaea stagnalis*, *Cepaea* sp., *Viviparus* sp.), a species of terrestrial gastropods (*Helix pomatia*) and bits of pork sausage.

RESULTS

A total of 24 individuals were collected in spring 2012, mostly in April. A few specimens were collected in March and most in April (Fig. 3). In total 24 specimens were collected, of which twenty males and four females (Fig. 4).

From measurements made from the collected material, we found that male body length is between 3.0 and 3.4 cm, while females are smaller with body length ranging from 2.9 to 3.0 cm (Tables 3 and 4, Fig. 5). In the consulted literature (IONESCU & LĂCĂTUŞU, 1964) general dimensions of specimens are between 3 and 4 cm.

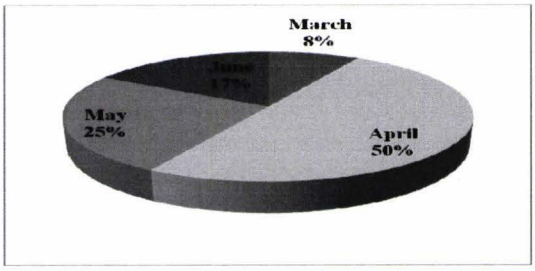

Figure 3. Variation of the number of individuals collected in 2012. / Figura 3. Variaţia numărului de indivizi colectaţi în 2012.

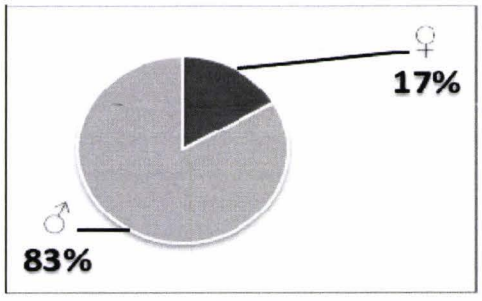

Figure 4. Percentage ratio between *C. lateralimarginalis* ♀ and ♂. / Figura 4. Raport procentual între *C. lateralimarginalis* ♀ şi ♂.

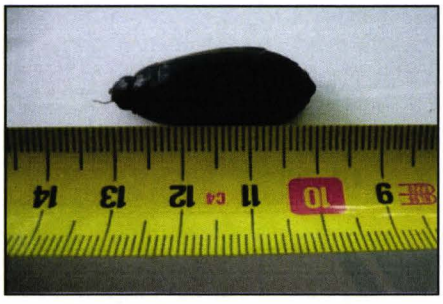

Figure 5. The body length in *C. lateralimarginalis* ♂. / Figura 5. Lungimea corpului la *C. lateralimarginalis* ♂ (original).

Table 3. Variation of the body length of specimens of *C. lateralimarginalis*-♂. / Tabel 3. Variaţia lungimii corpului a exemplarelor de *C. lateralimarginalis*-♂.

No.	*C. lateralimarginalis* - male	Body size	*C. lateralimarginalis* - male	Body size
1	♂1	3.1 cm	♂11	3.3 cm
2	♂2	3.0 cm	♂12	3.1 cm
3	♂3	3.2 cm	♂13	3.2 cm
4	♂4	3.4 cm	♂14	3.1 cm
5	♂5	3.3 cm	♂15	3.3 cm
6	♂6	3.1 cm	♂16	3.1 cm
7	♂7	3.2 cm	♂17	3.3 cm
8	♂8	3.0 cm	♂18	3.0 cm
9	♂9	3.1 cm	♂19	3.0 cm
10	♂10	3.0 cm	♂20	3.2 cm
Average size ♀: 3.0 – 3.4 cm				

Table 4. Variation of the body length of specimens of *C. lateralimarginalis*-♀. / Tabel 4. Variaţia lungimii corpului la exemplarele de *C. lateralimarginalis*-♀.

No.	*C. lateralimarginalis* - female	Body size
1	♀1	3.0 cm
2	♀2	2.9 cm
3	♀3	2.9 cm
4	♀4	3.0 cm
Average size ♀: 2.9 – 3.0 cm		

In terms of food regime, beetles have consumed both aquatic (*Lymnaea stagnalis*, *Cepaea* sp., *Viviparus* sp.) and terrestrial snails (*Helix pomatia*) (Fig. 5). Interestingly, although the species *Helix pomatia* is not an aquatic species, it represented the food for C. *lateralimarginalis* for a week. During four days, *C. lateralimarginalis* was fed on pieces of pork sausages and they accepted it without any problem (Fig. 6).

Figure 5. *C. lateralimarginalis* feeding on snails, *Viviparus* sp. / Figura 5. *C. lateralimarginalis* hrănindu-se cu melc acvatic (*Viviparus* sp.) (original).

Figure 6. *C. lateralimarginalis* feeding on pig sausages. / Figura 6. *C. lateralimarginalis* hrănindu-se cu o bucată de cârnat de porc (original).

CONCLUSIONS

A total of 24 individuals were collected in spring 2012, mostly in April, when aquatic vegetation is dry and less developed, and the individuals are easier to detect. A few specimens were collected in March and most in April.

The number of collecting sites known in Dolj rises to 5-6, our research bringing new data on the species occurrence in Dolj county, by signalling a new collecting site.

It also brings new data on the trophic regime of the species grown in captivity.

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REFERENCES

BOBÎRNAC B., MARCU O., CHIMIŞLIU CORNELIA. 1999. *Cu privire la systematica şi ecologia coleopterofaunei din zona subcarpatică a Olteniei în ultimii 70 de ani (1928-1998).* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **15**: 83-95.

CHIMIŞLIU CORNELIA. 2008.*Coleopterans from the Ciuperceni Reserve Area (Dolj County) conserved in the Entomological Collections of the Section of Natural Sciences of the Museum of Oltenia Craiova.* Studia Universitatis. Revistă ştiinţifică: Ştiinţe ale Naturii: Biologie, Chimie, Fizică. Universitatea de Stat din Moldova. Chişinău. **2**(12): 100-107.

FIRU I. 1982. *Entomofauna terenurilor nisipoase din imprejurimile Craiovei.* Teză de doctorat. Universitatea „Babeş - Bolyai". Facultatea de Biologie şi Geografie. Cluj Napoca.

MARCU O. 1928. *Contribuţiuni la cunoaşterea coleopterelor Olteniei.* Buletinul Asociaţiei Naturaliştilor din Oltenia. **1**(2-3).

MOGOŞEANU GIMA. 2010. *Data regarding the presence of the families Dytiscidae and Hydrophilidae (Insecta: Coleoptera) in the entomological fauna of Oltenia (Romania) (I).* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **26**(2): 133-136.

ŠŤASTNÝ J. & TRÁVNÍČEK D. 2000. *Water beetles of the Danube delta, Romania (Coleoptera: Gyrinidae, Haliplidae, Noteridae, Dytiscidae, Hydrophilidae, Hydraenidae, Dryopidae, Heteroceridae).* Klapalekiana,č.36http://www.mzp.cz/ris/ais-ris-info-copy.nsf/da28f37425da72f7c12569e600723950/7077771a4eb01756c1256c360068da18?OpenDocument (accesed March 8, 2012).

***. http://www.faunaeur.org/ Fauna Europaea (accessed March 22, 2012).

***. EDMUND REITTER.1908. *Germanic fauna.* http://www.zum.de/stueber/reitter1/index.html (accesed: March 12).

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DIVERSITY OF COLEOPTERANS (COLEOPTERA: CARABIDAE, RHYSODIDAE, SILPHIDAE, SCARABAEIDAE, CUCUJIDAE, CERAMBYCIDAE) FROM THE "CODRII" SCIENTIFIC RESERVE OF THE REPUBLIC OF MOLDOVA

BABAN Elena

Abstract. The present paper is dedicated to the research of the actual state of the diversity of species of coleopterans from the forest ecosystems of the scientific reserve "Codrii", the trophic spectrum and rare and endangered species. As a result of the collectings made during 2004-2011, on the area of the scientific reserve "Codrii", there were identified 103 species belonging to 52 genera and 7 families (Carabidae, Rhysodidae, Silphidae, Scarabaeidae, Lucanidae, Cucujidae, Cerambycidae): 8 species are rare and menaced with extinction, of which 2 species are included in the 2nd edition of the Red Book of the Republic of Moldova. According to the preferable trophic system, the majority of coleopterans represents the zoophagous group, which constitutes 36% of the total number of the known species, followed by the phytophagous species (24%). The coprophagous species represent 14%, the xylophagous – 10%, the necrophagous – 9 and the mixophagous – 7%. At the same time there was studied the structure and the dynamics of the coleopterans coenoses from 3 types of forests of "Codrii" scientific reserve. There was shown how the ecological indexes (the index of diversity Shannon, Simpson, equitability) change within the whole period of vegetation of 2004-2011.

Keywords: coleopterans, diversity, trophic spectrum, zoogeography, ecology, entomophages.

Rezumat. Diversitatea coleopterelor (Coleoptera: Carabidae, Rhysodidae, Silphidae, Scarabaeidae, Cucujidae, Cerambycidae) din rezervaţia ştiinţifică „Codrii". Lucrarea de faţă prezintă fauna şi diversitatea speciilor de coleoptere din ecosistemele forestiere ale rezervaţiei ştiinţifice „Codrii". Ca rezultat al colectărilor în perioada anilor 2004-2011, în ecosistemele forestiere ale rezervaţiei ştiinţifice „Codrii" au fost identificate 103 specii de coleoptere ce aparţin la 52 genuri şi 7 familii (Carabidae, Rhysodidae, Silphidae, Scarabaeidae, Lucanidae, Cucujidae, Cerambycidae), dintre care 8 specii sunt rare şi ameninţate cu extincţia, două dintre ele fiind incluse în ediţia II a Cărţii Roşii a Moldovei. După preferinţele trofice, majoritatea speciilor de coleoptere identificate aparţin grupului zoofagilor – 36%, urmat de grupul fitofagilor – 24%. Coprofagii constituie 14%, xilofagii – 10%, necrofagii – 9%, iar mixofagii – 7%. De asemenea, se arată structura şi dinamica cenozelor de coleoptere din 3 tipuri de păduri ale rezervaţiei ştiinţifice „Codrii". Astfel, valorile indicelui de diversitate Shanon, indicelui Simpson şi echitabilitatea variază pe întreaga perioadă a anilor 2005-2011.

Cuvinte cheie: Coleoptera, diversitate, spectru trofic, zoogeografie, ecologie, entomofagi.

INTRODUCTION

"Codrii" forests of Moldova include various objects and natural complexes with undeniable value for the conservation of biodiversity and of natural habitats. The results of investigations in this area will allow to obtain more detailed information on coleopteran diversity of forest ecosystems, species structure and to substantiate some ways of their protection and conservation. We have to mention that special investigations of coleopterans in the scientific reserve "Codrii" have not been performed so far.

The first studies of insect fauna in the area were accomplished by MILLER and ZUBOVSKI at the beginning of the 20th century (1917). In 30's-40's of the past century new data on some carabid coleopterans from this zone were presented in the papers of ARION & PANIN (1928), IENIŞTEA (1938), KNECTEL & PANIN (1944), etc.

In the second half of the 20th century various taxonomic, faunistic works were published completed with new ecological and biological data provided by foreign and local specialists (MEDVEDEV & SHAPIRO, 1957; ADASHKEVICI, 1970; NECULISEANU, 1991, 2004, etc.). Scientific papers were also published, where new species for the fauna of R. Moldova were described, species collected in forests of "Codrii" scientific reserve (ADASHKEVICI, 1970; NECULISEANU & MATALIN, 1995, 2000; BABAN, 2005, 2006, 2009).

In the last years several studies of entomofauna from some types of deciduous woods were performed. As a result of these investigations rare and threatened species were emphasized as well (NECULISEANU *et al.*, 1992a, 1992b, 2004; BABAN & CALESTRU, 2011).

MATERIAL AND METHODS

The studies were performed in vegetation period of 2005-2011 in 3 wood types from "Codrii" scientific reserve, which present different peculiarities of soil and vegetation: mixed oak and hornbeam forest, oak and beech forest, mixed forest of oak and lime-ash.

Wood coleopterans were collected by soil Barber pitfalls, using dished with the volume of 700 ml and collection with entomological net, the manual of the various plants, shrubs, ground, etc. As fixative-preserving liquid served the concentrated solution of sodium chloride (NaCl) and acetic acid (CH_3COOH).

In total, during the three years, there were collected and analysed about 7,500 individuals.

Synecological analysis was based on the estimation of ecological synthetic indices: index of ecological diversity using Shannon function, modified by Mac Arthur corrected by Lloyd and Ghelardi, equitability according to STAN (1994), ANDREEV (2002) and SIMIONESCU (1983). Coleopteran identification was made based on the works of KRYŽANOVSKIJ (1965), PANIN (1955), FREUDE *et al.* (1976).

RESULTS AND DISCUSSION

"Codrii" scientific reserve is characterized by high faunistic heterogeneity. Coleopteran fauna found in these forest ecosystems is represented by 103 species belonging to 52 genera and 7 families, of which 8 species are rare and endangered in Moldova (*Carabus intricatus* L., *C. ullrichi* GERM. *Aptinus bombarda* ILL., *Gnorimus nobilis* L., *Cetonischema aeruginosa* DR., *Lucanus cervus* L., *Cucujus cinnaberinus* SCOP., *Morimus funereus* MULS.).

The collected species belong to the following families: Carabidae, Rhysodidae, Silphidae, Scarabaeidae, Lucanidae, Cucujidae and Cerambycidae (Table 1).

During the research period, more representative from the diversity point of view proved to be the families: Carabidae with 60 species belonging to 22 genera and Scarabaeidae with 21 species from 7 genera. Other families were represented by a smaller number of species, as it follows: Silphidae with 9 species of 6 genera, Cerambycidae (8 species) and Lucanidae – 3 species. Rhysodidae and Cucujidae families were represented only by a single species.

Table 1. Coleopteran fauna from the forest ecosystem of "Codrii" scientific reserve.
Tabel 1. Fauna coleopterelor din ecosistemele forestiere ale rezervației științifice „Codrii".

No.	Species	Oak and hornbeam forest	Oak and beech forest	Oak and lime-ash forest	Trophic spectrum
	Family Carabidae				
1.	*Calosoma inquisitor* (LINNAEUS 1758)	+	+	+	Zoophagous
2.	*Nebria transsylvanica* (GERMAR 1824)	+	+	+	Zoophagous
3.	*Notiophilus laticollis* CHAUDOIR 1850	-	+	-	Zoophagous
4.	*N. biguttatus* (FABRICIUS 1779)	+	+	+	Zoophagous
5.	*Carabus convexus* FABRICIUS 1775	+	+	+	Zoophagous
6.	*C. excellens* KRAATZ 1887	+	+	+	Zoophagous
7.	*C. arvensis* HERBST 1784	+	+	+	Zoophagous
8.	*C. ullrichi* GERMAR 1824	+	+	+	Zoophagous
9.	*C. cancellatus* ILIGER 1798	+	+	+	Zoophagous
10.	*C. intricatus* LINNAEUS 1761	+	-	-	Zoophagous
11.	*C. coriaceus* KRAATZ 1877	+	+	+	Zoophagous
12.	*Cychrus caraboides* (LINNAEUS 1758)	-	-	+	Zoophagous
13.	*C. semigranosus* PALLIARDI 1825	+	-	-	Zoophagous
14.	*Clivina fossor* (LINNAEUS 1758)	+	-	-	Mixophagous
15.	*Pterostichus niger* (SHALLER 1783)	+	+	+	Mixophagous
16.	*Pt. chamaeleon* MOTSHULSKY 1865	+	-	-	Zoophagous
17.	*Pt. oblogopunctatus* (FABRICIUS 1787)	+	+	+	Zoophagous
18.	*Pt. melanarius* (ILLIGER 1798)	+	+	+	Zoophagous
19.	*Pt. melas* (CREUTZER 1799)	+	+	+	Mixophagous
20.	*Pt. hungaricus* DEJEAN 1828	-	+	+	Zoophagous
21.	*Pt. anthracinus* (ILLIGER 1798)	+	-	-	Zoophagous
22.	*Pt. strenuus* (PANZER 1797)	+	-	-	Zoophagous
23.	*Pt. ovoideus* (STURM 1824)	+	+	+	Zoophagous
24.	*Abax parallelopipedus* (PILLER 1783)	+	+	+	Zoophagous
25.	*A. carinatus* (DUFTSCHMID 1812)	+	+	+	Zoophagous
26.	*A. parallelus* (DUFTSCHMID 1812)	+	+	+	Zoophagous
27.	*Molops piceus* (PANZER 1793)	+	+	+	Zoophagous
28.	*Calathus distinguendus* CHAUDOIR 1846	+	+	+	Mixophagous
29.	*C. fuscipes* (GOEZE 1777)	-	-	+	Mixophagous
30.	*C. ambiguus* (PAYKULL 1790)	+	-	-	Mixophagous
31.	*Agonum duftschmidti* SCHMIDT 1994	+	-	-	Zoophagous
32.	*A. viduum* (PANZER 1797)	+	+	-	Zoophagous
33.	*Platynus assimile* (PAYKULL 1790)	+	+	+	Zoophagous
34.	*Pl. krynickii* (SPERK 1835)	+	+	+	Zoophagous
35.	*Anchomenus dorsale* (PONTOPPIDAN 1763)	+	-	+	Zoophagous
36.	*Amara eurynota* (PANZER 1797)	+	-	-	Phytophagous
37.	*A. familiaris* (DUFTSCHMID 1812)	+	-	+	Phytophagous

1	2	3	4	5	6
38.	*A. ovata* (FABRICIUS 1792)	+	+	+	Phytophagous
39.	*Stenolophus discophorus* FISCHER, WALDHEIM 1823	-	-	+	Zoophagous
40.	*Harpalus rufipes* (DE GEER 1774)	+	+	+	Phytophagous
41.	*H. tenebrosus* DEJEAN 1829	+	+	+	Phytophagous
42.	*H. atratus* LATREILLE 1804	+	+	+	Phytophagous
43.	*H. flavicornis* DEJEAN 1829	+	+	-	Phytophagous
44.	*H. calathoides* MOTSKULSKZ 1844	+	+	-	Phytophagous
45.	*H. tardus* (PANZER 1797)	+	+	-	Phytophagous
46.	*H. latus* (LINNAEUS 1758)	+	-	+	Phytophagous
47.	*H. quadripunctatus* DEJEAN 1829	-	-	+	Phytophagous
48.	*Ophonus gammeli* (SHAUBERGER 1933)	-	+	+	Phytophagous
49.	*O. puncticollis* (PAYKULL 1798)	-	-	+	Phytophagous
50.	*O. rufibarbis* (FABRICIUS 1792)	+	+	+	Phytophagous
51.	*O. diffinis* (DEJEAN 1829)	+	-	-	Phytophagous
52.	*O. nitidulus* STEPHENS 1828	+	-	-	Phytophagous
53.	*Panagaeus cruxmajor* LINNAEUS 1758	+	-	-	Zoophagous
54.	*Licinus cassideus* (FABRICIUS 1792)	-	+	-	Zoophagous
55.	*L. depresus* (PAYKULL 1790)	+	-	-	Zoophagous
56.	*Cymindis humeralis* (FOURCROY 1785)	-	+	-	Zoophagous
57.	*C. macularis* FISCHER & WALDHEIM 1824	-	-	+	Zoophagous
58.	*Drypta dentata* (ROSSI 1790)	+	+	-	Zoophagous
59.	*Aptinus bombarda* (ILLIGER 1800)	-	-	+	Zoophagous
60.	*Brachinus crepitans* (LINNAEUS 1758)	+	+	+	Mixophagous
	Family Rhysodidae				
61.	*Rhysodes sulcatus* (FABRICIUS 1787)	+	-	-	Xylophagous
	Family Silphidae				
62.	*Nicrophorus vespilloides* HERBST 1784	+	+	+	Necrophagous
63.	*N. fossor* ERICHSON 1837	+	-	-	Necrophagous
64.	*N. investigator* (ZETT. 1824)	+	-	+	Necrophagous
65.	*Necrodes littoralis* LINNAEUS 1758	+	-	-	Necrophagous
66.	*Tanatophilus rugosus* (LINNAEUS 1758)	+	-	-	Necrophagous
67.	*Oiceoptoma thoracicum* (LINNAEUS 1758)	+	-	-	Necrophagous
68.	*Phosphuga atrata* (LINNAEUS 1758)	+	-	-	Necrophagous
69.	*Silpha carinata* HERBST 1783	+	-	+	Necrophagous
70.	*S. tristis* ILLIGER 1798	+	-	-	Necrophagous
	Family Scarabaeidae				
71.	*Geotrupes stercorarius* (LINNAEUS 1758)	+	-	+	Coprophagous
72.	*G. stercorosus* SCRIBA 1791	+	+	+	Coprophagous
73.	*Aphodius fimetarius* (LINNAEUS 1758)	+	-	-	Coprophagous
74.	*A. luridus* FABRICIUS 1775	+	-	-	Coprophagous
75.	*A. rufipes* LINNAEUS 1758	+	-	-	Coprophagous
76.	*Caccobius schreberi* (LINNAEUS 1761)	+	-	-	Coprophagous
77.	*Onthophagus coenobita* (HERBST 1783)	+	-	-	Coprophagous
78.	*O. fracticornis* PREYSSLER 1790	+	-	-	Coprophagous
79.	*O. illyricus* SCOPOLI 1763	+	-	-	Coprophagous
80.	*O. ovatus* (LINNAEUS 1758)	+	-	-	Coprophagous
81.	*O. ruficapillus* BRULLE 1832	+	-	-	Coprophagous
82.	*O. taurus* SCHREBER 1759	+	-	-	Coprophagous
83.	*O. vacca* (LINNAEUS 1767)	+	-	-	Coprophagous
84.	*O. verticicornis* LEICHARTING 1781	+	-	-	Coprophagous
85.	*Melolontha melolontha* LINNAEUS 1758	-	+	+	Phytophagous
86.	*Gnorimus nobilis* LINNAEUS 1758	-	+	+	Phytophagous
87.	*Epicometis hirta* (PODA 1761)	-	-	+	Phytophagous
88.	*Oxythyrea funesta* (PODA 1761)	-	-	+	Phytophagous
89.	*Cetonia aurata* (LINNAEUS 1758)	+	+	+	Phytophagous
90.	*Liocola lugubris* HERBST 1786	-	-	+	Phytophagous
91.	*Cetonischema aeruginosa* DRURY 1770	+	-	+	Xylophagous

Family Lucanidae					
92.	*Lucanus cervus* LINNAEUS 1758	+	+	+	Xylophagous
93.	*Dorcus paralellopipedus* (LINNAEUS 1758)	+	+	+	Xylophagous
94.	*Platycerus caraboides* (LINNAEUS 1758)	+	-	-	Xylophagous
Family Cucujidae					
95.	*Cucujus cinnaberinus* SCOPOLI 1763	+	-	+	Xylophagous
Family Cerambycidae					
96.	*Rhagium mordax* (DE GEER 1775)	-	-	+	Xylophagous
97.	*Rh. sycophanta* (SCHRANK 1781)	-	-	+	Xylophagous
98.	*Cerambyx scopoli* FUSSLINS 1775	-	-	+	Xylophagous
99.	*Monochamus sutor* (FABRICIUS 1787)	+	-	-	Xylophagous
100.	*Morimus funereus* MULSANT 1863	+	+	-	Xylophagous
101.	*Dorcadion pedestre* PODA 1761	-	-	+	Phytophagous
102.	*D. equestre* (LAXMANN 1770)	-	-	+	Phytophagous
103.	*Agapanthia maculicornis* (GYLLENHAL 1817)	+	-	-	Phytophagous

In terms of quality, the highest number of species was recorded in mixed oak and hornbeam forest (86 species, 57 genera and 7 families), followed by oak forest with lime-ash (59 species) and mixed oak and beech forest (45 species).

After examining the coleopterans composition in the investigated forest types, we found that after the food spectrum, coleopteran fauna in forest ecosystems of the reserve "Codrii" are grouped into six trophic groups: zoophagous, mixophagous, phytophagous, xylophagous, necrophagous and coprophagous species. The majority of species belong to the zoophagous group - 36%, followed by phytophagous 24%. In decreasing order, there are the coprophagous (14%), xylophagous (10%), necrophagous (9%) and mixophagous (7%) (Fig. 1).

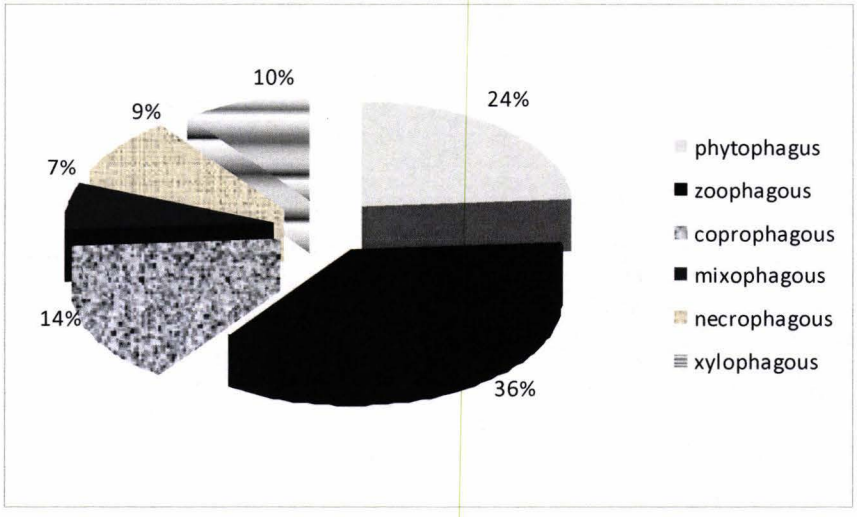

Figure 1. Trophic spectrum of coleopterans from the forest ecosystems.
Figura 1. Spectrul trofic al coleopterelor din ecosistemele forestiere.

At the same time, as a result of the analysis of calculated diversity indices in relation to the investigated forest types it results: the highest value of Shannon diversity index (Ish) was registered in mixed forest of oak and lime-ash (1.09) and in oak and beech mixed forest (1.06), while the diversity with the lowest value was recorded in mixed forest of oak and hornbeam (0.98).

Table 2. Values of diversity indexes of indicator coleopteran group (Carabidae) in studied stations.
Tabel 2. Valorile indicilor de diversitate a grupei de coleoptere indicatoare (Carabidae) în staţiunile investigate.

Ecological index	Oak and hornbeam forest	Oak and beech forest	Oak and lime-ash forest
If ε	0.14	0.24	0.34
%	15	24	34
Simpson index	0.20	0.13	0.11
%	-20	-13	-11
Shannon diversity index	0.98	1.06	1.09
%	65	16	73
Σ %	60	27	96
Species number.	**77**	**49**	**61**

Legend: ε – equity.

Another very important aspect of diversity is the equity index (ε), which characterizes the uniformity of distribution of individual by species. If ε = 1, then equity would be ideal and all species of studied biocoenosis would have the same number of individuals.

From the analysis of the degree of balancing of coleopteran groups, it results that the greatest similarity is observed between oak with lime-ash forest and oak with beech forest, while oak mixed with hornbeam forest is characterized by a greater inequality in the distribution of individual by species, with the equity index value of 0.15.

As a result of summing these three indices, full data can be obtained regarding the stability of biocoenoses in the ecosystem and also its deterioration. Thus, as a result of summing up, it was emphasized that the oak with lime-ash forest has a high diversity, which demonstrates that it is more stable compared to other investigated ecosystems.

Given that the question of secular forest stands at European level, it is necessary that the Republic of Moldova intensify the work on conservation of these forests and urgent action are necessary to stop deforestation in places where they are still preserved. We believe that this problem can be solved only through close cooperation between policy makers, scientists and society.

CONCLUSIONS

1. The coleopteran fauna of "Codrii" Scientific Reserve is represented by 103 species belonging to 52 genera and 7 families, of which the species *Carabus intricatus* L., *Aptinus bombarda* ILL., *Cetonischema aeruginosa* DR., *Lucanus cervus* L., *Cucujus cinnaberinus* SCOP., *Morimus funereus* MULS. are rare and endangered.

2. In terms of quality, the highest number of species was registered in the mixed oak and hornbeam forest (86 species, 37 genera and 4 families), followed by the oak forest mixed with lime-ash (59 species) and oak and beech mixed forest (45 species).

3. Most coleopteran collected species are zoophagous, constituting 36%, followed by phytophagous 24%. In accordance with the food spectrum, in decreasing order are the coprophagous species (14%), xylophagous (10%),.necrophagous (9%) and mixophagous (7%).

4. In "Codrii" Scientific Reserve, the Shannon diversity index Ish showed high values in the mixed forest of oak and lime-ash (1.088) and in the mixed oak and beech forest (1.059), while the diversity value was the lowest in the mixed forest of oak and hornbeam (0.975).

REFERENCES

ADASHKEVICI A. 1970. *Novie vidy zhuzhelitz dlea fauni Moldavii.* Fauna Moldavii i ee ohrana. Edit. Ştiinţa, Chişinău: 85-87.

ANDREEV A. 2001. *Otsenca bioraznoobrazya, monitoring i ecoseti.* Edit. Biotica, Chişinău. 2002. 168 pp.

ARION A. & PANIN S. 1928. *Prodromul faunei entomologice din România. Coleoptera (Cicindelidae, Carabidae).* Supliment la Buletinul Agriculturii. Bucureşti. **6**: 1-66.

BABAN ELENA. 2005. *Diversitatea coleopterelor (Coleoptera: Carabidae, Rhysodidae, Silphidae, Scarabaeidae, Cucujidae, Cerambycidae) din pădurea de gorun cu amestec de carpen.* Analele Ştiinţifice ale Universităţii de Stat a Moldovei. Chişinău: 184-188.

BABAN ELENA. 2006. *Diversitatea coleopterelor din ecosistemele forestiere ale Podişului Moldovei Centrale.* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **22**: 164-169.

BABAN ELENA. 2009. *Diversitatea coleopterelor (Coleoptera: Carabidae, Silphidae, Scarabaeidae, Lucanidae) din pădurea de stejar cu amestec de carpen.* In: Diversitatea, valorificarea raţională şi protecţia lumii animale. Simpozion internaţional. Chişinău: 137-140.

BABAN ELENA & CALESTRU LIVIA. 2011. *Coleopterele rare şi ameninţate cu dispariţia din ecosistemele forestiere ale Podişului Moldovei Centrale.* In: Materialele Simpozionului ştiinţific internaţional Rezervaţia „Codrii" - 40 de ani. Lozova: 30-31.

FREUDE H., HARDE K., LOHSE G. 1976. *Die Käfer Mitteleuropas. Band 2, Adephaga 1.* Krefeld. 300 pp.

IENIŞTEA M. 1938. *Die Cicindeliden und Carabidenfauna Bessarabiens auf Grund ihrer Erforschung bis.* Bulletin du musee regional de Bessarabie. Chişinău. 8: 95-151.

KNEKHTEL A. & PANIN S. 1944. *Oekologisch-Zoogeographisches studium an Coleopteren des Rumanischen Faunengebietes.* Academie Roumain Etudes et Recherches. Bucharest. **15**: 23-26.

KRYŽANOVSKIJ O. 1965. *Semya Carabidae – zhuzhelitzy.* V cn: Opredeliteli nasecomyh evropeiscoi cheasti SSSR. **2**: 29-77. [In Russian]

MEDVEDEV & SHAPIRO. 1957. *K poznaniu fauny zhucov (Coleoptera) Ucrainy.* Trudy Instituta Biologhii i biologhicescogo faculteta Harikovscogo Universiteta. Harikov. **30**: 173-206. [In Russian]

MILLER ED. & ZUBOVSKI N. 1917. *Materalien zur entomologischen Fauna Bessarabiens in Travaux Soc.* In: Trudy Bessarabscogo obshcestva estestvoispitatelei i liubitelei estestvoznania. Kishinef: 119-150.

NECULISEANU Z. 1991. *Obzor fauny zhuzhelitz Moldovy.* Izvestia ANM SSR, serya Biologhiceskih i himiceskih nauk. **2**: 37-42.

NECULISEANU Z. 2004. *Carabidele (Coleoptera, Carabidae) din Republica Moldova.* Buletin Informativ Societatea Lepidopterologica Română. Cluj-Napoca. **14**(1-4): 27-35.

NECULISEANU Z. 2004. *Specii rare de coleoptere (Insecta: Coleoptera) în fauna Republicii Moldova.* Buletin Informativ. Societatea Lepidopterologică Română. Cluj-Napoca. **14**(1-4): 23-26.

NECULISEANU Z., STRATAN V., VEREŞCIAGHIN B., OSTAFICIUC V. 1992a. *Insectele rare şi pe cale de dispariţie din Moldova.* Edit. "Ştiinţa" Chişinău. 115 pp.

NECULISEANU Z., STRATAN V., VEREŞCIAGHIN B. 1992b. *Insectele incluse în "Cartea Roşie" a Moldovei.* In: Ecologia şi protecţia mediului înconjurător în Moldova: Edit. Ştiinţa, Chişinău: 74.

NECULISEANU Z. & MATALIN A. 1995. *Specii noi de carabide (Coleoptera, Carabidae) pentru fauna Moldovei.* Buletinul A.Ş.M. Seria biologie şi chimie. Chişinău. **4**: 66-67.

NECULISEANU Z. & MATALIN A. 2000. *A catalogue of the ground-beetles of the Republic of Moldova (Insecta, Coleoptera, Carabidae).* Edit. Pensoft, Sophia: 164 pp.

PANIN S. 1955. *Familia Carabidae.* In: Fauna Republicii Populare Române. Insecta. Edit. Academiei Republicii Populare Române, Bucureşti. **10**(2): 5-140.

STAN G. 1994. *Metode statistice cu aplicaţii în cercetări entomologice.* Buletin de informare. Societatea Lepidopterologica Română. Cluj-Napoca. **5**(2): 113-126.

SIMIONESCU VIORICA. 1983. *Lucrări practice de ecologie.* Universitatea „Al. I. Cuza", Iaşi: 174-190.

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CHANGES IN CARABID COMMUNITIES (INSECTA: COLEOPTERA) ALONG AN URBANIZATION GRADIENT IN MADRID (SPAIN)

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Abstract. The Carabids were pitfall-trapped in Madrid in 43 sites in the city interior and in its surroundings from late June to early August 1986. Altogether 78 species were recorded. They represented 6.7% of the Carabid fauna of the Iberian Peninsula. The communities consisted exclusively of small or medium sized species. There was not recorded any species of the genus *Carabus* in the city interior in spite of the fact that there exist very extensive areas of seminatural vegetation like the Casa de Campo park. However, their absence in the material from such places could result just from the fact that the sampling took place in the warmest and driest part of the year. Unlike cities in other areas, the Carabid communities of Madrid consisted of a considerable portion of West Mediterranean species or even of the Iberian endemics like *Calathus granatensis*. In contrast, in the city interior, especially in watered grassy plots, an obvious convergence to the fauna of Central European cities and, at a more general level, even to the East Asian cities was observed. The species of larger distributional areas prevailed there. The communities in the seminatural habitats showed very low diversity indices, similarly as in the analogous habitats in Central Europe. In seminatural habitats a considerable portion of highly specialized granivorous species of the genera *Ditomus*, *Carterus* and *Acinopus* was recorded.

Keywords: Coleoptera, Carabidae, urban fauna, Madrid, ecology, zoogeography.

Rezumat. Cenozele carabidelor (Insecta: Coleoptera) oraşului Madrid. Carabidele au fost colectate cu capcane de sol în 43 localităţi în centrul oraşului şi în zonele periurbane începând cu ultima decadă a lunii iunie până la începutul lunii august 1986. În total au fost găsite 78 de specii care reprezintă 6.7% din fauna carabidelor peninsulei Iberice. Cenozele constau exclusiv din specii de talie mică sau medie. În centrul oraşului nu au fost găsite specii ale genului *Carabus* chiar dacă acolo există mari suprafeţe de vegetaţie seminaturală precum parcul Casa de Campo. Absenţa acestor specii în materialul din acest tip de ecosisteme poate rezulta din faptul că toate colectările au avut loc în perioadă cea mai caldă şi uscată a anului. Spre deosebire de oraşele din celelalte regiuni biogeografice, fauna Madridului constă în mare parte din specii vest mediteranee şi chiar de specii iberice endemice precum *Calathus granatensis*. Spre deosebire de aceasta, în centrul oraşului, în mod special în pajiştile irigate, fauna carabidelor manifestă o convergenţă la fauna oraşelor din Europa centrală şi, la un nivel mai general, chiar la fauna oraşelor din Asia răsăriteană. În aceste localităţi au dominat speciile cu mari areale de distribuţie geografică. Cenozele din locurile seminaturale aveau valorile indicilor de diversitate scăzute, asemănător cenozelor din localităţile analoage din oraşele central europene. În localităţile seminaturale o mare parte a cenozelor a constat din specii puternic specializate granivore din genurile *Ditomus*, *Carterus* şi *Acinopus*.

Cuvinte cheie: coleoptere, Carabidae, faună urbană, Madrid, ecologie, zoogeografie.

INTRODUCTION

Large cities represent a highly variable mosaic of habitats ranging sometimes even from almost natural habitats to the s.c. asphalt desert, without any vegetation. In some abandoned sites, some habitats may reach a considerably advanced succession stage toward the climax state, whereas other habitats in their close vicinity are exposed to frequent destructive anthropogenic interventions. At the same time, the ecosystems in cities are continuously subjected to a climatic regime which considerably differs by higher temperatures when comparing with the surroundings (QUITT, 1983). The species composition in concrete sites depends on immigration possibilities from the city surrounding, historical development of each site, existence of biocorridors, size of the site, state of the biota in the immediate surroundings of the city. In general, the concepts of island biogeography can be applied on the rules determining the state and forming of the biocoenoses. In the recent three decades the ecology of large cities becomes an intensively studied topic with a great practical significance (NIEMELÄ *et al.*, 2011).

Although the first observations on the influence of anthropogenic factors (electric illumination), on occurrence of Carabids in human settlements were published by DELAHON (1931), the animal and, in particular, the Carabid communities in urban ecosystems were systematically investigated since 1970-s, especially in West and Central Europe. There exist studies from London (DAVIS, 1978), Birmingham (SMALL *et al.*, 2003, 2006), Kiel (TOPP, 1972), West Berlin (GOSPODAR, 1981, GOSPODAR & SCHLÜTTER, 1982), Leipzig (KLAUSNITZER & RICHTER, 1980. KLAUSNITZER *et al.*, 1980), Warsaw (CZECHOWSKI, 1980a, 1980b, 1981a, 1981b, 1982), Brno (ŠUSTEK, 1979, 1980, 1984, ŠUSTEK & VAŠÁTKO, 1983a, 1983b), Bratislava (ŠUSTEK, 1984, 1987, 1999a, 2002), Moscow (DUSHENKOV, 1983) and in Scandinavia (ALARUIKKA *et al.*, 2002, VENN *et al.*, 2003). In other parts of the world such studies are scarce and have only an orientation character (ŠUSTEK 2011).

Probably the first paper on insect fauna of Madrid, written however from purely practical viewpoint of plant protection, was published already in 1834 (SANGÜESA, 1834). But the systematic interest in the study of its fauna began as late as by the turn of the 20th and the 21th centuries, when the first ecological papers were published on the avian fauna in the parks of Madrid (FERNANDEZ-JURICIC, 2000, 2001, 2004, FERNANDEZ-JURICIC *et al.*, 2001), on Hymenoptera (MARTÍNEZ *et al.*, 1997, NIEVES & LOBO 2006) and Diptera (SORIANO O. & COBO 2006). Recently, a general characteristic of arthropod and beetle fauna of Madrid and its surroundings (Comunidad de Madrid) was published (GONZÁLEZ-GRANADOS *et al.*, 2012a, 2012b), which lists five endangered species occurring there. However,

a special study on Carabid fauna of Madrid does not exist, only some data were published in a more general context by ŠUSTEK (1989). The papers on Carabid communities in different ecosystems in free landscape in Spain are also scarce and were published only recently (BAEHR, 1986, MONZÓ *et al.*, 2005, TABOADA *et al.*, 2004) or deal with more general problems (JIMÉNEZ-VALVERDE & ORTUÑO, 2007).

The aim of this paper is to analyse the structure of Carabid communities in different habitats in Madrid and in its surroundings and to compare it with the analogic communities in other big cities.

MATERIAL AND METHODS

The material was collected during a two-month stage to Spain undertaken on the invitation of the Institute of Edaphology and Vegetal Biology of CISC (Instituto de Edafología y Biología Vegetal). The beetles were pitfall-trapped (plastic jars of 300 ml with 75 mm opening, filled with formalin). The number of traps in each site varied from one to six, depending on the site size (Tables 3, 4) and they were exposed 16-43 days. The exposition depended on time limits to install them after finding of suitable sites and to visit the sites for the last time before the stage end. The traps were emptied at least in three-day intervals, because of the strong evaporation of the fixing solution and to minimize damaging of traps by the public.

The sites were selected so that they represent the urbanization gradient from the surroundings to the very city centre and different modes of their use and management. Their selection was strongly limited by possibilities to control them frequently by walking.

The beetles were identified using mainly the keys by DE LA FUENTE Y MORALES (1927) and JEANNEL (1941-1942). The zoogeographical typification of species was made according to BURMEISTER (1939), HŮRKA (1996), JEANNEL (1941-1942), SERRANO *et al.* (2003). The characteristic of trophic relations was made according to SHAROVA (1981). The statistical evaluation of the material was made by means of the program PAST version 2,16 (HAMMER, 2012).

Study site specification

All sites studied were situated in the Meseta Central plain, in a moderately undulated terrain at altitudes of 550 – 650 m, the highest points reaching about 1,000 – 1,100 m. The climate (Table 1) is arid with maximum precipitation in November and December and minimum precipitation from June to August. The winters are cool, but the average temperatures do not fall below 0°C, while summers are very hot and dry, the temperature reaching 40-42°C by day. The potential natural vegetation consists of the evergreen holm oak (*Quercus ilex*) forests – "encinars", but the actual vegetation is strongly changed. The encinars are mostly very sparse or turned into low shrub stands (matorral), replaced with small artificially planted pine forests or arable land. The smaller water streams are mostly dried in summer. The herbage and grass vegetation becomes yellow by turn of June and July.

In the selection of reference sites, the material collected in the close Sierra de Guadarrama was intentionally omitted, because the forests studied consisted of the deciduous oaks and were note comparable with the vegetation in immediate surroundings of Madrid, although some species like *Carabus quadarramus* LA FERTÉ–SÉNECTÈRE, 1847 or *Carabus lusitanicus* FABRICIUS, 1801 dominant in these forests could be also expected in Madrid and in the encinar-like vegetation.

Table 1. Climatic characteristic of Madrid.
Tabel 1. Caracteristica climatică a oraşului Madrid.

1971 – 2000	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average / sum
Maximum temperature (°C)	9.7	12	15.7	17.5	21.4	26.9	31	30.7	26	19	13.4	10.1	19.4
Minimum temperature (°C)	2.6	3.7	5.6	7.2	10.7	15.1	18	18.2	15	10.2	6	3.8	9.7
Precipitation (mm)	37	35	26	47	52	25	15	10	28	49	56	56	436

The reference localities in free landscape

All sites were situated within distance of about 80 km from Madrid. In parentheses there are given abbreviations of their names used in the tables and diagrams.

- Manzanares el Real – a large water reservoir north of Madrid, altitude about 1,000 m:
  1. a flat shore of the water reservoir overgrown with a high stand of *Juncus* sp. (MMR),
  2. a pasture margin on a low terrace at the water reservoir shore (MRC),
  3. a small ash forest on the shores of the water reservoir (MRF),
- Monte de Campo – a locality about 80 km east of Madrid
  1. a sparse seminatural encinar (MCE),
  2. riverbed of a dry creek (MCA),
- Casa de Monte – farm a locality in the surroundings of Talavera de la Reína, about 80 km west-of Madrid
  1. a sparse seminatural encinar (CMF),
- Fuente la Higuera – a locality in the surroundings of Talavera de la Reína, about 80 km west of Madrid

1. a mattoral – a low dense stand of evergreen shrubs (FHM)
2. a wheat field (FHS)

- Aranjuez – town about 60 km south of Madrid (ACM)

1 – a maize field on a canal of the Tejo river arm terrace close to the city

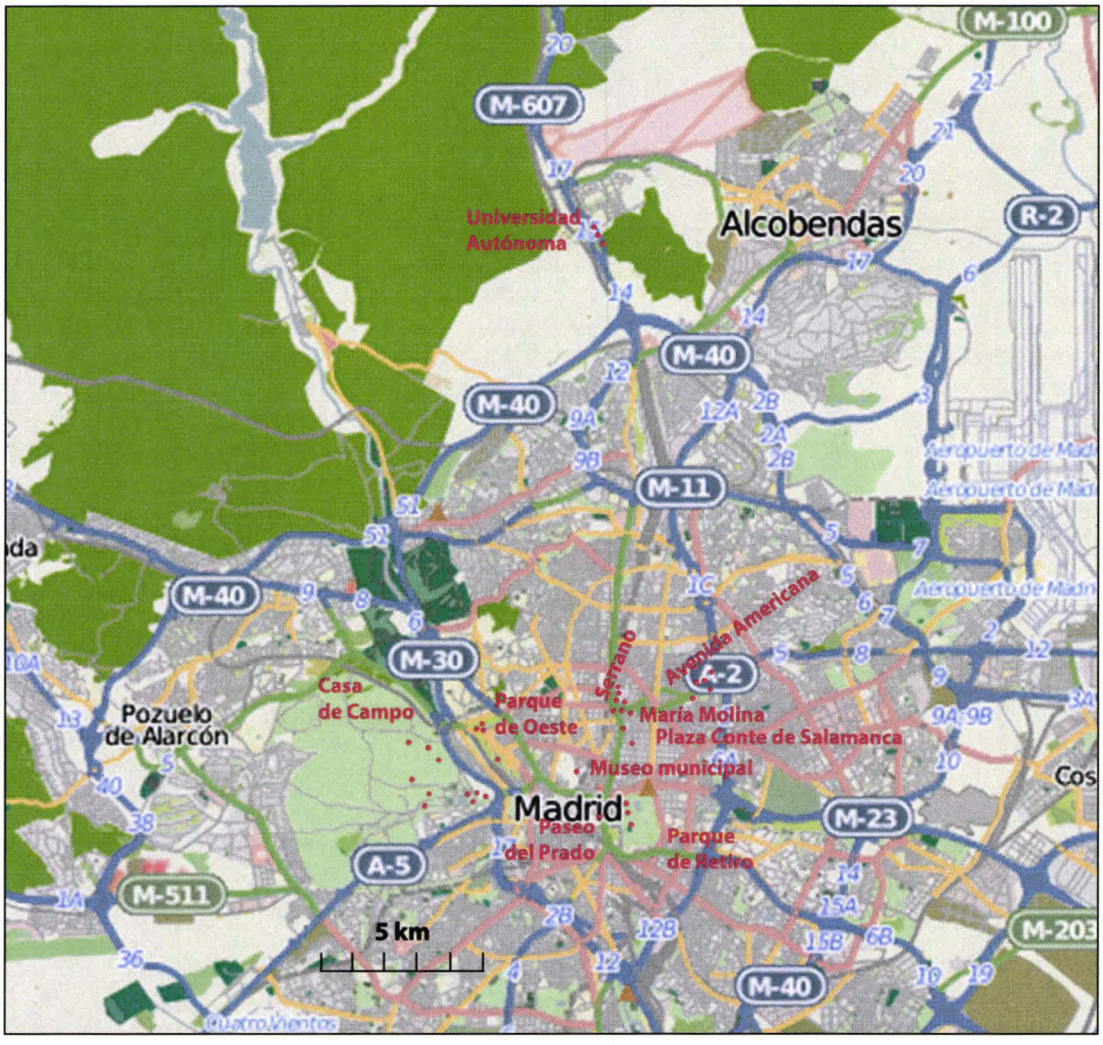

Figure 1. Position of localities study sites in centre of Madrid and at its margins. / Figura 1. Poziţia localităţilor şi a staţionarelor în centrul Madridului şi pe marginea oraşului.

Localities in suburban zone and in city interior (Figs. 1, 2)

Universidad Autónoma – a locality on the margin of Madrid preserving remnants of vegetation typical for the surrounding of Madrid:

1. a sparse ecinar (UAE)
2. bottom of a deep riverbed of dried creek with dense and high shrub vegetation (UAA)
3. a small pine stand (UAP)

Casa de Campo – originally a hunting area of the Spanish kings, transformed into an enormously large seminatural park (1,722 ha) on a moderately undulated terrain, situated in the western part of the city, close to the historical centre. On its major part, it preserves sparse tree vegetation consisting predominantly of sparse encinars and pine stands, locally with undergrowth of shrubs and matorral-like vegetation. Most of the area is covered by grassy or herbage vegetation. The park is intensively used for the short-time recreation, for which various facilities are build up in its southeastern corner, including an artificial lake and creek:

1. pine stand 1 (CCP1),
2. pine stand 2 (CCP2),
3. a matorral-like stand with grass (CCPN),
4. an encinar below the funicular (CCTE),
5. an encinar in the eastern part of the park (CCE1),
6. a stand of planes bellow the lake (CCPT)
7. ash stand under the artificial lake (CCA)
8. bank of a creek running from the lake (CCL),
9. bank of a dried creek (CCD),
10. a stand of planes bellow the lake (CCPT)
11. ash stand under the artificial lake (CCA)
12. bank of a creek running from the lake (CCL),
13. bank of a dried creek (CCD).

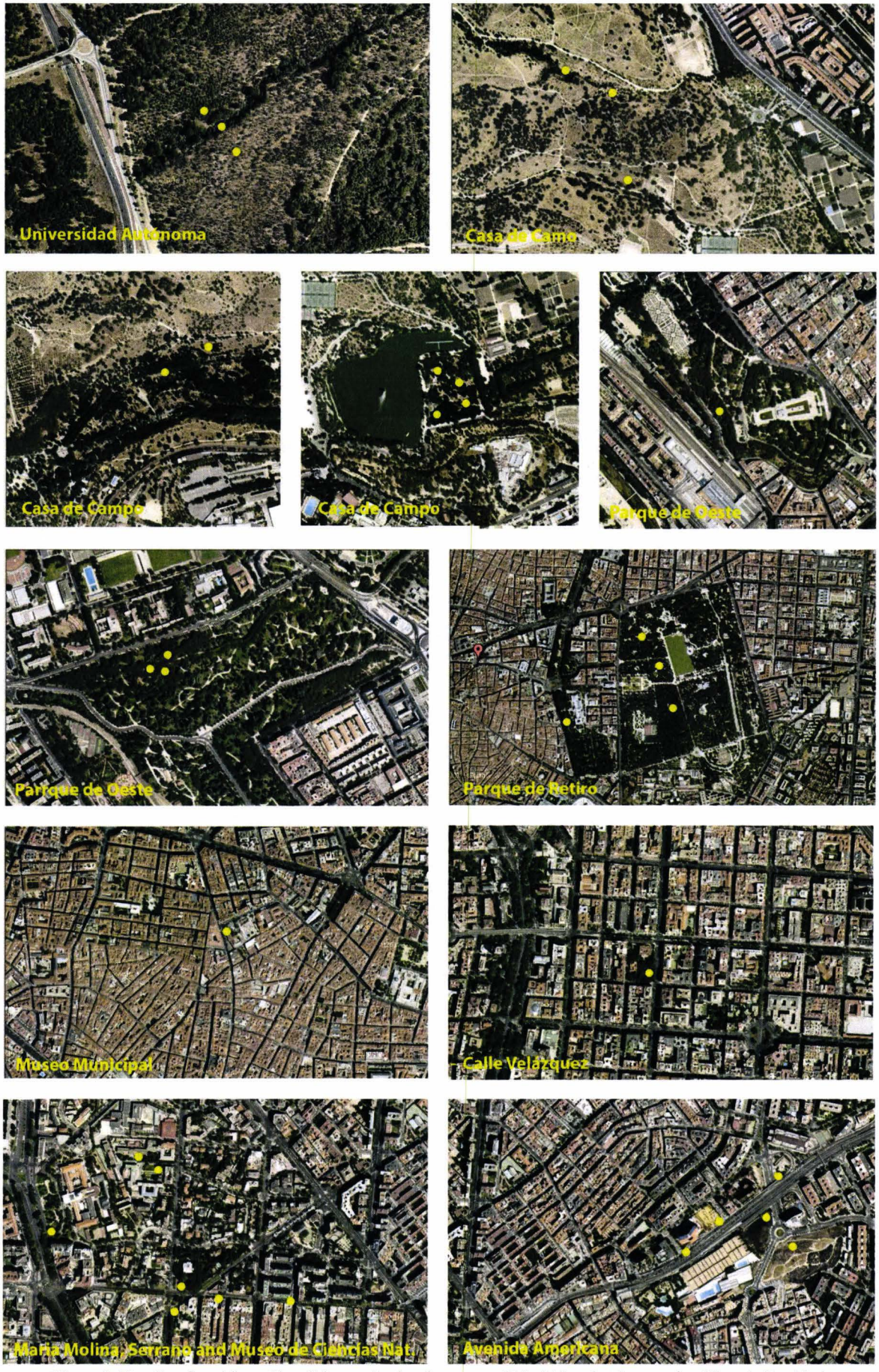

Figure 2. Details of position of localities study sites in centre of Madrid and at its margins (Google Earth). /
Figura 2. Poziţia detaliată a localităţilor şi a staţionarelor din centrul Madridului şi din marginea oraşului.(Google Earth).

Parque de Oeste – an about 30 ha large, intensively cultivated French park of a western slope at margin of the historical centre:

1. bank of an artificial creek, shadowed by trees (POC),
2. a watered grass plot with shrubs close to the creek (POC1),
3. a watered grass plot with shrubs (POW1),
4. a watered grass plot with shrubs (POW2).

Paseo del Prado – a watered grass plot in a little part at the Museo de Prado (PPR).

Parque de Retiro – a 77 ha large park in densely built-up part of the city, the surrounding building originate mostly from the turn of the 19th – 20th century, partly has character of a French and English park:

1. a grass plot (REG),
2. a shadowed grassless plot under trees (REN),
3. an abandoned, partly shadowed plot densely overgrown by umbellate plants (REU).

Serrano, Area of Centro de Investigaciónes Científicos, a park-like area of sparsely situated building of institutes in the modern part of the city with a high portion of the greenery:

1. a dry grass plot (SEG),
2. a watered grass plot (SEW2).

Maria de Mollina – a wide street in the modern part of the city, with narrow grassy strips dividing the traffic ways:

1. a watered grass plot (MOW),
2. a grassy strip at the road margin (MOR),
3. an old abandoned garden, probably after a demolished house (MOG),
4. a watered grass plot at the intersection of the Serrano and Maria Molina streets.

Avenida Americana – a wide four-way street in the modern part of the city, with mostly small strips of dry grassy vegetation at pavement margins or watered plots at residential buildings, in centre a large free area transformed into public park:

1. a ruderal plot at pavement margin (AAR1),
2. a ruderal plot at pavement margin (AAR2),
3. a dry grass margin (AAR),
4. a watered grassy plot (AAW1),
5. a watered grassy plot (AAW2).

Calle Velázquez – a small park at the crossing of this street with Calle de Padilla street, in the densely built-up Salamanca quarter with closed house blocks, mostly built up in the early 20th century:

1. a watered grassy plot under high trees (PSA).

Museo Municipal – a small square in front of the building of the museum in the densely built up historical centre of the city on the Fuencaral street, with narrow streets and almost absolute absence of greenery:

1. a small grassy plot in front of the museum (MUM).

RESULTS

The whole material consists of 7,460 individuals belonging to78 species (Tables 2-4) representing 6.7% of 1,158 species known from the Iberian Peninsula (SERRANO, 2003). Only few of them were really abundant or found simultaneously in more sites and, in addition, the more abundant species were very unequally distributed, being concentrated in one or two sites. Almost 70% of individuals belonged to the endemic *Calathus granatensis* present in 44% of sites. The second most abundant species was the expansive and tolerant open landscape species *Pseudoophonus rufipes* (11.3% of individuals, occurrence in 11.6% of sites). Most of its individuals were found in the maize field at Aranjuez taken as one of the reference localities (Table 3), while a small number of individuals was found also in Madrid centre. The third species was *Calathus fuscipes* (4.73% of individuals) present on 32.6% of sites, exclusively in Madrid. The fourth species was *Poecilus cupreus* (3.4% of individuals) occurring in 2 (4.6%) sites out of the city, particularly in the maize field at Aranjuez (Table 3). The fifth species was *Nebria brevicolis*, a characteristic species of moderately humid floodplain forests or urban parks in Central Europe (2.4% individuals) found in 13.9% of sites, in the humid, directly or indirectly or irrigated localities in Madrid. The sixth species was *Calathus mollis* (2.1% individuals) co-occurring mostly with *Calathus granatensis* in 11.6% of sites, mostly in the reference localities out of the city. These six species represented 93.8% of the material.

They were followed by 12 species, whose share in the entire material was low (0.13-0.55%, cumulative share 3.4%), but they occurred in a relatively large number of sites. In decreasing order of presence (Table 2) they were represented by *Trechus quadristriatus* (30.2%), *Acinopus picipes* (20.9%), *Amara aenea* (16.3%), *Ditomus capito, Ophonus puncticollis, Harpalus wagneri* (each 11.6%), *Ditomus sphaerocephalus, Harpalus distinguendus, Stenolophus teutonus, Microlestes abeilli, Microlestes seladon* and *Microlestes corticinus* (3% each). These species formed two groups. The first consisting of *Trechus quadristriatus, Amara aenea, Ophonus puncticollis* and *Harpalus distinguendus* was represented by widely distributed open landscape species. The second group consisting of *Ditomus capito, Ditomus sphaerocephalus, Microlestes abeilli* and *Microlestes seladon, Microlestes corticinus* included thermoxerophilous Mediterranean species. *Stenolophus teutonus* is a hydrophilous species of water table shores overgrown by reed, cattail of sedge.

Table 2. Survey of species found in Madrid and in reference localities in its surrounding, abbreviation of their names (A), characteristics of their geographical distribution (Z) and trophic relationships (T), number of individuals (N), dominance (D) and presence (P). / Tabel 2. Lista speciilor găsite în Madrid şi în localităţile de referinţă din împrejurimile oraşului: abrevierile numelor speciilor (A), caracteristica răspândirii geografice (Z) şi a relaţiilor trofice (T), numărul indivizilor (N), dominanţa (D) şi prezenţa (P).

Species	A	Z	T	N	D [%]	P [%]
Acinopus picipes (OLIVIER, 1795)	Apic	ME	P	23	0.31	20.93
Acinopus sabulosus (FABRICIUS, 1792)	Asab	WME	P	1	0.01	2.33
Acupalpus brunipes (STURM, 1825)	Abru	WP	P	2	0.03	2.33
Acupalpus exiguus DEJEAN, 1829	Aexi	WP	P	6	0.08	4.65
Agonum marginatum (LINAEUS, 1758)	Amar	WP	C	4	0.05	2.33
Agonum muelleri (HERBST, 1784)	Amue	ES	C	1	0.01	2.33
Agonum nigrum (DEJEAN, 1828)	Anig	WME	C	5	0.07	4.65
Agonum viridicupreum (GOEZE, 1777)	Avir	WP	C	1	0.01	2.33
Amara aenea (DE GEER, 1774)	Aean	PP	P	40	0.54	16.28
Amara apricaria (PAYKUL, 1790)	Aapr	H	P	1	0.01	2.33
Amara communis (PANZER, 1797)	Acom	TP	P	2	0.03	2.33
Amara familiaris (DUFTSCHMIDT, 1812)	Afam	TP	P	6	0.08	4.65
Amara rufipes DEJEAN, 1828	Arif	WE	P	4	0.05	4.65
Anchomenus dorsalis (PONTOPPIDAN, 1763)	Ador	ES	C	11	0.15	6.98
Anisodactylus hispanus PUEL, 1931	Ahis	IB	P	8	0.11	4.65
Anisodactylus nemorivagus (DUFTSCHMIDT, 1812)	Anem	WP	P	2	0.03	2.33
Badister bulatus (SCHRANK, 1798)	Bbul	H	C	3	0.04	2.33
Bembidion aeneum GERMAR, 1824)	Baen	WME	C	1	0.01	2.33
Bembidion biguttatum (FABRICIUS, 1779)	Bbig	ES	C	1	0.01	2.33
Bembidion guttula (FABRICIUS, 1792)	Bgut	WP	C	1	0.01	2.33
Bembidion lampros (HERBST, 1784)	Blam	H	C	1	0.01	2.33
Bembidion quadrimaculatum (LINAEUS, 1761)	Bqua	H	C	1	0.01	2.33
Bembidion tetracolum SAY, 1823	Btet	H	C	3	0.04	2.33
Calathus ambiguus (PAYKULL, 1790)	Camb	WP	C	7	0.09	4.65
Calathus circumscriptus GERMAR, 1824	Ccir	ME	C	1	0.01	2.33
Calathus fuscipes (GOEZE, 1777)	Cfus	WP	C	353	4.73	32.56
Calathus granatensis VUILLEFROY, 1866	Cgra	IB	C	5186	69.52	44.19
Calathus mollis (MARSHAM, 1802)	Cmol	ME	C	158	2.12	11.63
Calathus piceus (MARSHAM, 1802)	Cpic	WE	C	1	0.01	2.33
Carabus melancholicus FABRICIUS, 1798	Cmel	WME	C	5	0.07	4.65
Carterus cephalotes (DEJEAN, 1826)	Ccep	WME	G	1	0.01	2.33
Carterus cordatus (DEJEAN, 1825)	Ccor	WME	G	3	0.04	2.33
Carterus interceptus DEJEAN et BOISDUVAL, 1829	Cint	WME	G	1	0.01	2.33
Carterus microcephalus RAMBUR, 1837	Cmic	WME	G	14	0.19	6.98
Clivina fossor (LINNAEUS, 1758)	Cfos	E	C	4	0.05	2.33
Cymindis variolosa (FABRICIUS, 1794)	Cvar	ES	C	2	0.03	4.65
Diachromus germanus (LINNAEUS, 1758)	Dger	WP	P	9	0.12	6.98
Ditomus capito SERVILLE, 1821	Dcap	ME	G	22	0.29	11.63
Ditomus clypeatus (ROSSI, 1790)	Dcly	ME	G	1	0.01	2.33
Ditomus sphaerocephalus (OLIVIER, 1795)	Dsph	WME	G	23	0.31	9.3
Dromius bifasciatus (DEJEAN, 1825)	Dbif	ME	C	3	0.04	4.65
Drypta dentata (ROSSI, 1790)	Dden	SWP	C	1	0.01	2.33
Harpalus distinguendus (DUFTSCHMIDT, 1812)	Hdist	TP	P	26	0.35	9.3
Harpalus longicollis (RAMBUR, 1838)	Hlon	WE	P	1	0.01	2.33
Harpalus rotundatus (DEJEAN, 1826)	Hrot	WE	P	5	0.07	6.98
Harpalus rubripes (DUFTSCHMIDT, 1812)	Hrub	TP	P	1	0.01	2.33
Harpalus scaritides (STUMR, 1818)	Hsca	ME	P	2	0.03	2.33

Harpalus wagneri SCHAUMERBER, 1936	Hwag	IB	P	27	0.36	11.63
Chlaenius festivus (PANZER, 1796)	Cfes	SWP	C	2	0.03	2.33
Chlaenius variegatus (FOURCROY, 1785)	Cvar	WME	C	2	0.03	2.33
Masoreus wetterhali (GYLLENHAL, 1813)	Mwet	ME	C	1	0.01	2.33
Metophonus bonvouloiri VUILLEFROY, 1866	Mbon	WE	P	6	0.08	6.98
Microlestes abeilli BRISOUT, 1885	Mabe	WME	C	10	0.13	9.3
Microlestes corticalis (DUFOUR, 1820)	Mcor	WP	C	6	0.08	9.3
Microlestes negrita WOLASTON, 1854	Mneg	SWP	C	1	0.01	2.33
Microlestes seladon HOLDHAUS, 1812	Msel	WME	C	17	0.23	9.3
Nebria brevicollis (FABRICIUS, 1792)	Nbre	E	C	180	2.41	13.95
Nebria salina FAIRMAIRE et LABOULBENE, 1854)	Nsal	WE	C	1	0.01	2.33
Ophonus puncticollis (PAYKULL, 1798)	Opun	ES	P	12	0.16	11.63
Ophonus rufibarbis (FABRICIUS, 1792)	Oruf	WP	P	2	0.03	4.65
Paranchus albipes (FABRICIUS, 1796)	Palb	WP	C	7	0.09	6.98
Parophnus hispanus (RAMBUR, 1838)	Phis	WE	P	1	0.01	2.33
Parophnus mendax (ROSSI, 1790)	Pmen	ME	P	1	0.01	2.33
Poecilus distinctus(LUCAS, 1846)	Pdis	E	C	2	0.03	2.33
Poecilus cupreus (LINAEUS, 1758)	Pcup	TP	C	256	3.43	4.65
Poecilus kugelani (PANZER, 1797)	Pkug	WE	C	4	0.05	6.98
Pseudoophonus griseus (PANZER, 1797)	Pgri	TP	P	6	0.08	2.33
Pseudoophonus rufipes (DE GEER, 1774)	Pruf	ES	P	839	11.25	11.63
Pterostichus diligens (STURM, 1824)	Pdil	ES	C	1	0.01	2.33
Pterostichus globosus (FABRICIUS, 1792)	Pglo	WME	C	10	0.13	4.65
Pterostichus nigrita (PAYKULL, 1790)	Pnig	TP	C	13	0.17	4.65
Pterostichus vernalis (PANZER, 1796)	Pver	H	C	8	0.11	4.65
Siagona europea DEJEAN, 1826	Seur	WE	C	2	0.03	2.33
Stenolophus mixtus (HERBST, 1784)	Smix	WP	P	1	0.01	2.33
Stenolophus teutonus (SCHRANK, 1781)	Steu	WP	P	41	0.55	9.3
Syntomus foveolatus (DEJEAN, 1831)	Sfov	ES	C	4	0.05	6.98
Tachys bistriatus (DUFTSCHMIDT, 1812)	Tbis	WP	C	1	0.01	2.33
Trechus quadristriatus (SCHRANK, 1781)	Tqua	WP	C	38	0.51	30.23

Legend:
Geographic distribution: H – holarctic, TP – transpalaearctic, ES – Eurosiberian, WP – west palaearctic, SWP – south-west palaearctic, E – European, ME – Mediterranean, WME – west Mediterranean, IB – Iberian.
Trophic relations: C – carnivor, O – omnivor, G – granivor.
Legendă:
Răspândirea geografică: H – holarctică, TP – transpalearctică, ES – eurosiberiană, WP – vest palearctică, SWP – sud-vest palearctică, E – europeană, ME – mediteraneană, WME – vest mediteraneană, IB – iberică.
Relaţii trofice: C – carnivor, P – omnivor, G – granivor.

Table 3. Survey of species found in reference localities in surroundings of Madrid (arranged alphabetically). / Tabel 3. Lista speciilor găsite în localităţile de referinţa din împrejurimile Madridului (aranjate în ordinea alfabetică).

Species	Locality, habitat and their abbreviation											
	Manzanares Reales			Monte de Casa			Fuente de la Higuera		Aran-juez	Unidersidad Autónoma		
	shore (*Juncus*	pasture	ahs forest	encinar	encinar	low matirral	matorral	cereal field	maize field	encinar	dry riverbed	pine forests
	MRR	MRC	MRF	MCE	MCA	CMF	FHM	FHS	ACM	UAE	UAA	UAP
Acinopus picipes							1	7				
Acinopus sabulosus								1				
Acupalpus exiguus	5		1									

Agonum marginatum	4											
Agonum muelleri	1											
Agonum nigrum	3		2									
Agonum viridicupreum	1											
Amara communis									2			
Amara rufipes	3											
Anchomenus dorsalis			1						7			
Anisodactylus hispanus	7											
Bembidion aeneum			1									
Bembidion biguttatum			1									
Bembidion guttula			1									
Bembidion lampros	1											
Bembidion quadrimaculatum			1									
Bembidion tetracolum			3									
Calathus granatensis	1	1		232	1	7	495	1		7	1	22
Calathus mollis				73	4	3	77					
Calathus piceus	1											
Carabus melancholicus	3	2										
Carterus cephalotes						1						
Carterus cordatus						3						
Carterus interceptus						1						
Carterus microcephalus								1				
Clivina fossor			4									
Diachromus germanus	1		2									
Ditomus capito				7	1							
Dromius bifasciatus					1							2
Drypta dentata	1											
Harpalus distunguendus								22	1			
Harpalus longicollis								1				
Harpalus scaritides								2				
Harpalus wagneri					2		2					1
Chlaenius festivus	2											
Chlaenius variegatus	2											
Masoreus wetterhali				1								
Microlestes abeilli								2				
Microlestes seladon	1											
Nebria salina			1									
Ophonus puncticollis	2		7									
Paranchus albipes	2		4									
Parophnus mendax								1				
Poecilus distinctus								2				
Poecilus cupreus	1								255			
Poecilus kugelani	2	1										
Pseudoophonus griseus									6			
Pseudoophonus rufipes			1						819			
Pterostichus diligens			1									
Pterostichus globosus							5	5				
Pterostichus nigrita	7											
Pterostichus vernalis	6		2									
Stenolophus mixtus		1										
Stenolophus teutonus	13		1									
Syntomus foveolatus	2	1										
Tachys bistriatus	1											
Trechus quadristriatus			1	2	1					1	8	
Number of individuals	**73**	**6**	**35**	**315**	**10**	**15**	**580**	**45**	**1090**	**8**	**9**	**25**
Number of species	**25**	**5**	**18**	**5**	**6**	**5**	**5**	**11**	**6**	**2**	**2**	**3**
Number of traps	**4**	**2**	**3**	**4**	**3**	**3**	**3**	**3**	**10**	**6**	**4**	**10**
Days of exposition	**35**	**35**	**21**	**33**	**33**	**33**	**33**	**33**	**16**	**35**	**35**	**35**

Table 4. Survey of species found localities in center of Madrid (arranged alphabetically). / Tabel 4. Lista speciilor găsite în localităţile din centrul Madridului (aranjat în ordine alfabetică).

Species	Locality, habitat and their abbreviation																																
	Casa de Campoâ										Parque de Oeste				Parque de Retiro			Serrano		Maria Molina			Avenida Americana					Isolated sites			
	pine stans	pine stand	grass + shrubs	encinar	encinar	grass + planes	ash stand	creek bank	dry creek bank	creek banks	creek bank	watered grass	waterde grass	watered grass	grassles plot	grassles plot	Umbelliferes	dry grass	watered grass	watered grass	old garden	grassy margin	ruderal plot	ruderal plot	grassy margin	grassy plot	watered grass	watered grass	PPR watered grass	MUM watered grass	SEW2 watered grass
	CCP1	CCP2	CCPN	CCTE	CCE1	CCPT	CCA	CCL	CCC	CCCD	POC	POC1	POW1	POW2	REG	REN	REU	SEG	SEW1	MOW	MOG	MOR	AAR1	AAR2	AAW1	AAR	AAW2	PSA			
Acinopus picipes	5	1	2		4	1	1	1																							
Acupalpus brunipes									2																						
Amara aenea	12				4	1												15	6			1					1				
Amara apricaria																							1								
Amara familiaris																		5	1												
Amara rufipes									1																						
Anchomenus dorsalis									3																						
Anisodactylus hispanus									1																						
Anisodactylus nemorivagus									2																						
Badister bulatus																	3														
Calathus ambiguus																							5	2							
Calathus circumscriptus																													1		
Calathus fuscipes	1				70	162	29	21	1				7	2	1		1	28	23				2	5							
Calathus granatensis	39	7	3	4	1550	2792	5			17							1														
Calathus mollis						1																									
Carterus microcephalus																							2	11							
Cymindis variolosa				1									1																		
Diachromus germanus									6																						
Ditomus capito			1												1		12														
Ditomus clypeatus																		1													
Ditomus sphaerocephalus	17	2	3			1																									
Harpalus distunguendus							1																	2							
Harpalus rotundatus	1		1	3																											
Harpalus rubripes													1																		
Harpalus wagneri	21				1																										
Metophonus bonvouloiri					1	4	1																								
Microlestes abeilli					1														1					6							
Microlestes corticalis						2	1											2	1												
Microlestes negrita																									1						
Microlestes seladon																							1	14	1						
Nebria brevicollis								22	2	3	122	30					1														

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Ophonus puncticollis						1							1					1													
Ophonus rufibarbis					1														1												
Paranchus albipes									1																						
Parophnus hispanus					1																										
Poecilus kugelani																	1														
Pseudopophonus rufipes											2		5				12														
Pterostichus nigrita									6																						
Siagona europea				2																											
Stenolophus teutonus									26		1																				
Syntomus foveolatus							1																								
Trechus quadristriatus								12	2		1	1	1		2	1	5														
Number of individuals	**96**	**10**	**10**	**10**	**1633**	**2965**	**39**	**56**	**53**	**20**	**126**	**31**	**16**	**2**	**4**	**1**	**36**	**52**	**33**			**1**	**11**	**40**	**2**		**1**		**1**		
Number of species	**7**	**3**	**5**	**4**	**9**	**9**	**7**	**4**	**12**	**2**	**4**	**2**	**6**	**1**	**3**	**1**	**8**	**6**	**6**			**1**	**5**	**6**	**2**		**1**		**1**		
Days of trap exposition	**42**	**33**	**42**	**36**	**36**	**36**	**36**	**36**	**36**	**36**	**40**	**40**	**33**	**40**	**35**	**35**	**35**	**38**	**38**	**32**	**43**	**43**	**43**	**43**	**43**	**43**	**43**	**32**	**30**	**32**	**43**
Number of traps	**4**	**4**	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**2**	**3**	**3**	**3**	**2**	**3**	**3**	**4**	**8**	**1**	**1**	**3**	**2**	**3**	**1**	**2**

The representation of these 19 species in individual sites predominantly decided about the differentiation of the Carabid communities studied. These species are also responsible for the trends in structural changes along the urbanization gradient studied. Almost one half (34) of the species was represented by only 1-2 individuals (Table 2). As such they contributed to a high heterogeneity of the material, but owing to their ecologic and zoogeographic properties they enhanced the specific character of the communities that was indicated by more abundant species in individual parts of the idealized urbanization gradient. In spite of the fact that the studied communities included many strongly xerophilous species, the Carabids did not penetrate to all sites in the very city centre. With the increasing degree of urbanization and decreasing size of the sites studied, they were gradually replaced by more mobile Staphylinids or by non-flying, but more thermoxerophilous and detritophagous Tenebrionids and/or Anthicids (Figs. 3, 4). It is illustrated by a free, moderately positive to slightly negative correlation of the qualitative representation of the Carabids with these three families (Staphylinids 0.29, Tenebrionids –0.06, Anthicids 0.53), and by a moderately negative correlation of their quantitative representation with these families (Staphylinids –0.11, Tenebrionids –0.21, Anthicids –0.15).

The number of species in individual reference sites ranged from 2 to 25, while the number of individuals from 6 to 1,090 (Table 3), with an obvious dependence on only increasing humidity (discontinuous *Juncetum* on lake shores in Manzanares el Real) or density of vegetation cover and humidity (maize field at a branch of the Tajo river at Aranjuez). There was a very low positive correlation between the number of individuals and the number of traps exposed (0.05) and between the number of traps and number of species (0.12). In the city interior, (except of three sites, where Carabids were absent) the number of species ranged from 1 to 12, again with dependence on increasing humidity (sites in vicinity of the lake in Casa de Campo), while the number of individuals from 1 to even 2,965 individuals (Table 4). This extreme fluctuation was caused by the extreme variability in activity abundance of the endemic *Calathus granatensis*, especially in several similar sites in Casa de Campo (3 –2,792 individuals). The number of species in individual sites would be doubtless much larger, when the sampling could be undertaken longer. Many species found only in one or few sites would be also recorded on other sites. The relatively low number of species recorded within the investigation is documented by a considerable speedy right side part of the areal curve (Fig. 5).

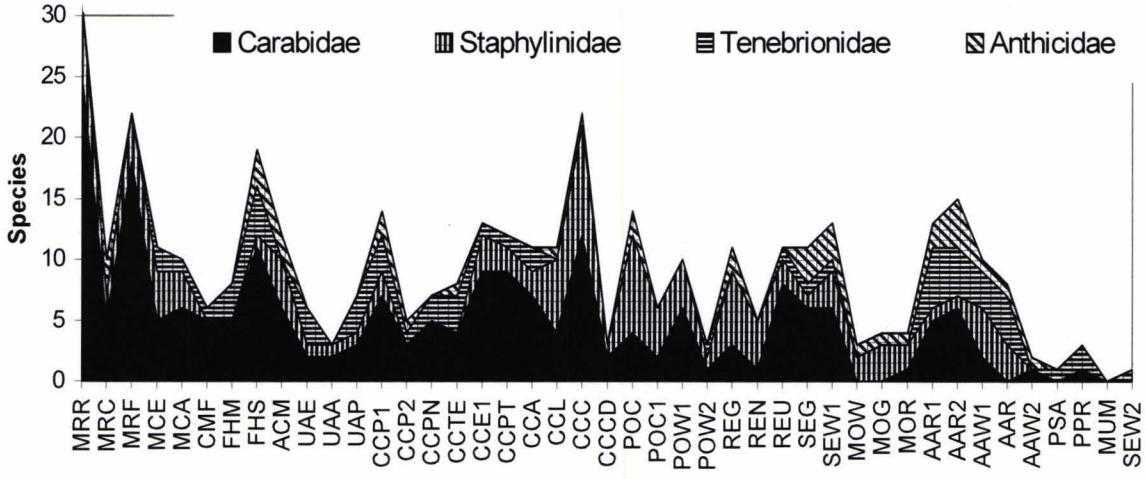

Figure 3. Relationship of number of species of Carabids, Staphylinids, Tenebrionids and Anthicids in Madrid and in references localities. / Figura 3. Relaţia numărului speciilor de Carabidae, Staphylinidae, Tenebrionidae şi Anthicidae din Madrid şi din localităţile de referinţă.

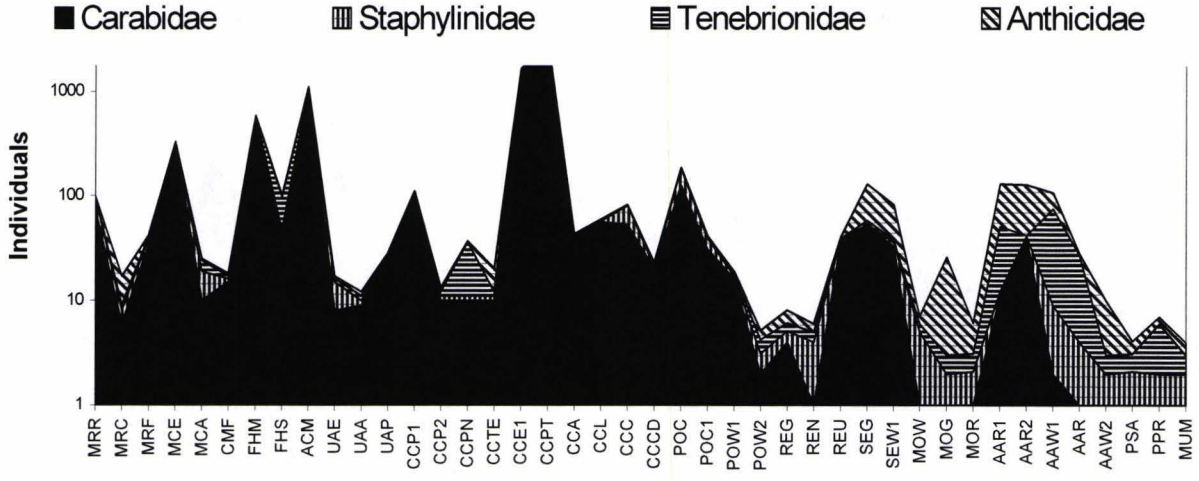

Figure 4. Relationship of number of individuals of Carabids, Staphylinids, Tenebrionids and Anthicids in Madrid and in references localities. / Figura 4. Relaţia numărului indivizilor de Carabidae, Staphylinidae, Tenebrionidae şi Anthicidae din Madrid şi din localităţile de referinţă.

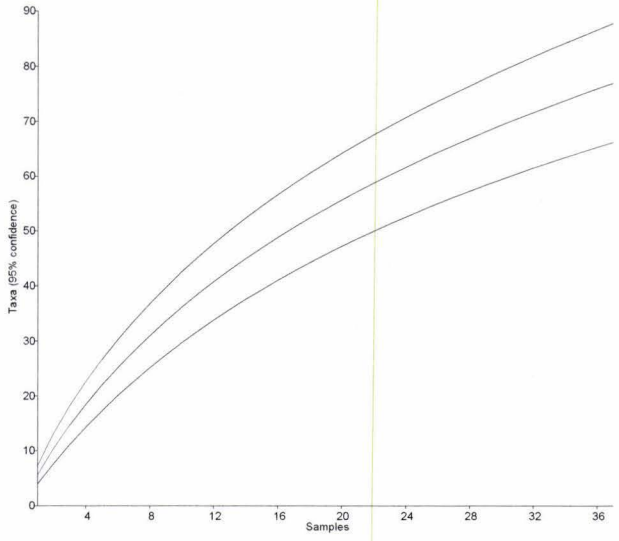

Figure 5. Areal curve of Carabids in 43 sites in Madrid and surroundings (only positive samples considered). / Figura 5. Curba de areal a carabidelor din 43 de locaţii din Madrid şi împrejurimi (luate în considerare numai probele pozitive).

The Shannon-Weawer diversity index ranged from 0.14 to 2.88 bits and equitability from 0.13 to 0.90 (Fig. 6). The highest values of the diversity index were recorded in the rich community from the *Juncetum* in Manzanares el Real. The lowest values of both parameters were observed in the sites with a strong predominance of one or two species. In the reference localities it was the maize field at Aranjuez (*Pseudoophonus rufipes* and *Poecilus cupreus*), in the centre of Madrid, the encinars and pine forests Universidad Autónoma and in Casa de Campo with predominance of *Calathus granatensis* and in Parque de Oeste with predominance of *Nebria brevicollis*. The low values of diversity index, but high values of equitability were recorded in the sites in city centre, where two species occurred in a very limited number of individuals. The high values of equitability coincided with the high values of diversity in the communities from Manzanares el Real.

The communities in the city consisted only of small or medium sized species in the length range of 2 – 18 mm. The only large species found in the reference localities was *Carabus melancholicus* in the shores of the lake in Manzanares el Real.

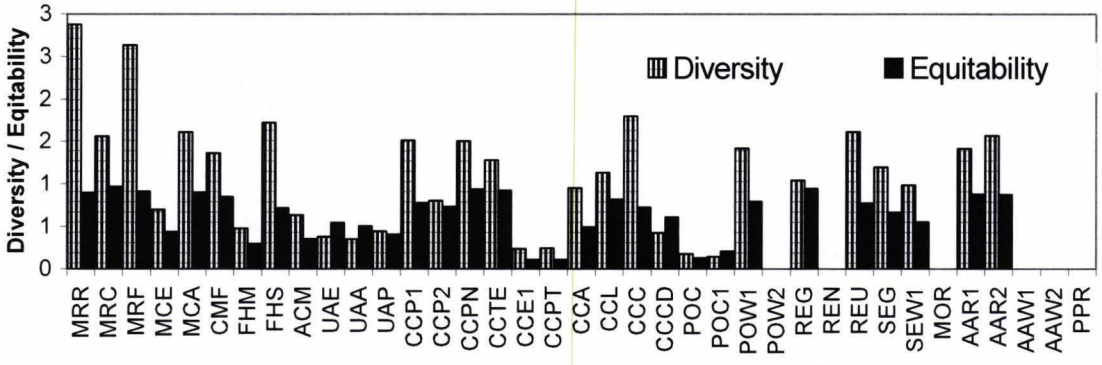

Figure 6. Diversity and equitability of 43 Carabid communities in Madrid and its surroundings (abbreviations of sites as in Tables 3 and 4). / Figura 6. Diversitatea şi echiitabilitatea celor 43 de cenoze de carabide din Madrid şi din împrejurimi (abrevierile locaţiilor ca în tabelele 3 şi 4).

Classification and ordination of communities

The hierarchical classification of the communities was made only on the base of Horn´s similarity index (Fig. 7) that reflects the proportional similarity of the communities and compensates the large difference in the catches size. In this way, it also compensated the great heterogeneity of the material. According to this index, the studied communities form five major clusters. One is characterized by co-dominance of two hydrophilous species, *Stenolophus teutonus* and *Diachromus germanus*, accompanied in individual sites by further hydrophilous species (*Agonum nigrum, Paranchus albipes).* This cluster includes communities from the reference locality Manzanares el Real and from the creek in Casa de Campo. The next four clusters arise owing to the predominance of one of the four species *Trechus quadristriatus, Calathus granatensis, Calathus fuscipes* or *Amara aenea.* With one exception (pasture margin in Manzanares el Real), they include communities from the city. In addition, there exist two outliers – the reference community from maize field with enormous predominance of *Pseudoophonus rufipes* and *Poecilus cupreus* and the community from Paseo del Prado consisting of a single individual of *Calathus fuscipes*.

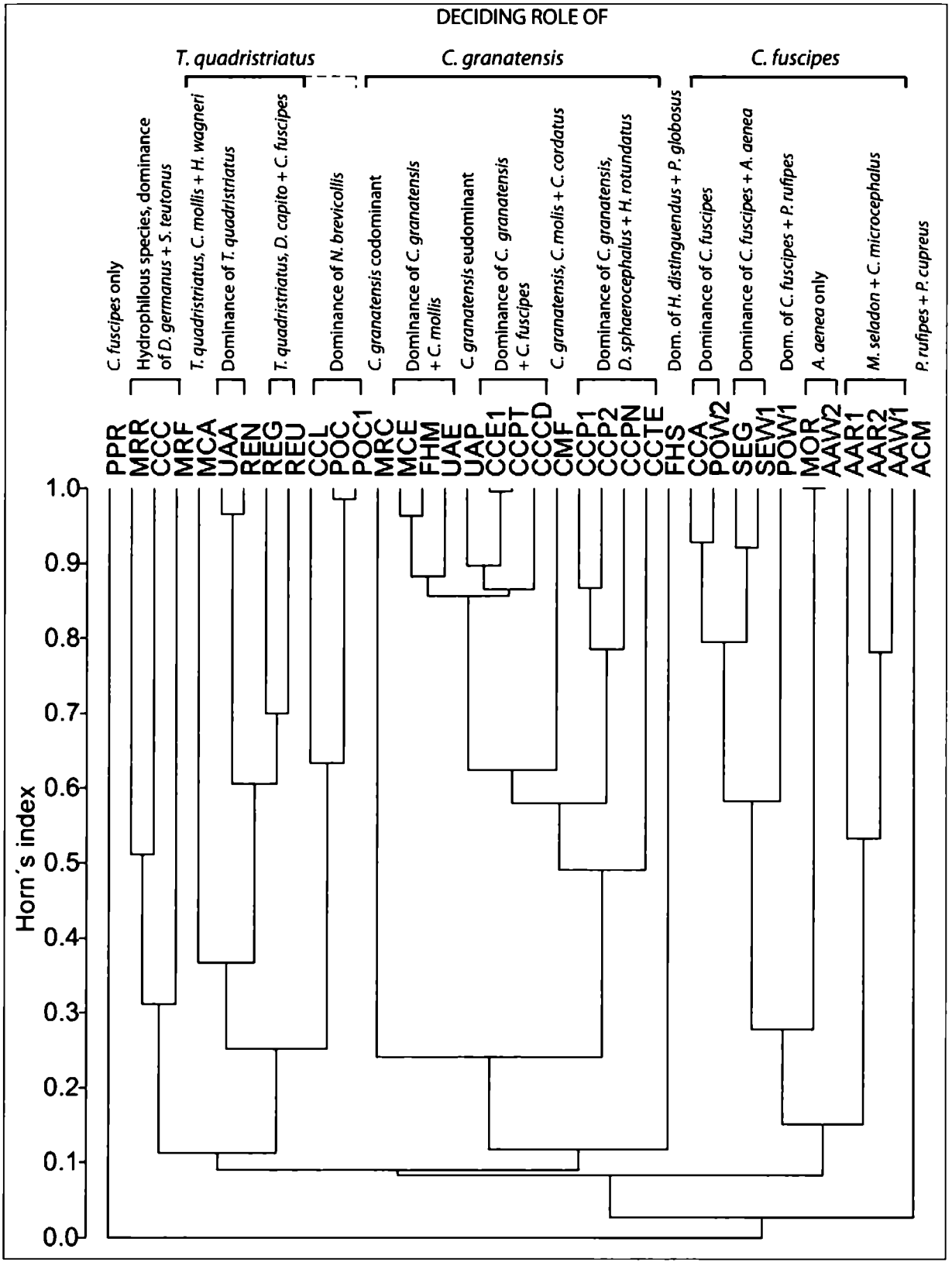

Figure 7. Hierarchical classification of Carabid communities using Horn's similarity index from Madrid and its surroundings (abbreviations of sites as in Table 3 and 4). / Figura 7. Clasificarea ierarhică a cenozelor de carabide din Madrid şi din împrejurimi după indicele lui Horn (abrevierile localităţilor ca în tabelele 3 şi 4).

The cluster with the predominance of *Trechus quadristriatus* consists of three subclusters arising due to dominance of *Trechus quadristriatus* itself or due to its co-dominance with other species *Calathus mollis* + *Harpalus wagneri* or *Ditomus capito* + *Calathus fuscipes*. More freely these subclusters join a subcluster characterized by the predominance of the hygrophilous *Nebria brevicollis*, which also occurs as a subdominant or recedent species in other communities included in the major cluster characterized by the predominance of *Trechus quadristriatus*.

The cluster characterized by the predominance of *Calathus granatensis* consist of six subclusters of communities, in which this species is a single dominant species, or co-dominates with *Calathus mollis* or *Calathus fuscipes* or *Calathus molis* + *Carterus cordatus* or with several further species. Excepting the community from the pasture margin in Manzanares el Real, these communities are the seminatural communities from the city margin (Universidad Autónoma) or from Casa de Campo. At a very low similarity level of 0.12 this cluster joins with the community from wheat field in Fuente de Higuera with a dominance of the transpaleactical typical field species *Harpalus distinguendus* and the west Mediterranean *Pterostichus globosus* and the presence of *Calathus granatensis.*

The subcluster characterized by the predominance of *Calathus fuscipes* also consists of the communities dominated by this species itself or characterized by its co-dominance with *Pseudoophonus rufipes* or *Amara aenea* or the thermoxerophilous species *Carterus microcephalus* + *Microlestes seladon.* An isolated position is taken by a subcluster of the communities consisting of a single individual of *Amara aenea.* This subcluster joins to this cluster just due to the co-occurrence of *Amara aenea* with *Calathus fuscipes* in other communities. This cluster includes the communities from the very city centre and reflects the degree of watering of the grassy plots (co-occurrence of *Calathus fuscipes* with *Pseudophonus rufipes* or *Amara aenea*) or absence of watering (co-occurrence with *Carterus microcephalus* and *Microlestes seladon.*

It is obvious that if a longer lasting sampling can be carried out, many species would be found in more sites and the material would be more homogeneous. But the most abundant species deciding about the classification results would be probably the same and the results of classification would be similar in spite of a greater homogeneity.

The principle coordinate coordination ordination using Horn´s index (Fig. 8) shows clearly the arrangement of the communities according to the quantitative representation of the four deciding species, *Carabus granatensis, Calathus fuscipe, Trechus quadristriatus* and to certain degree also *Nebria brevicollis,* which are placed within the area of the communities dominated by *Trechus quadristriatus.* These groups correspond to the major clusters in the hierarchical classification. Between them, in the ordination space centre, the communities from the reference localities are placed. To certain degree, they take a position according to the representation of the abovementioned four species. The first axis (ordinate is interpretable as a humidity gradient increasing from left to right. The second axis has not a clear ecological interpretation.

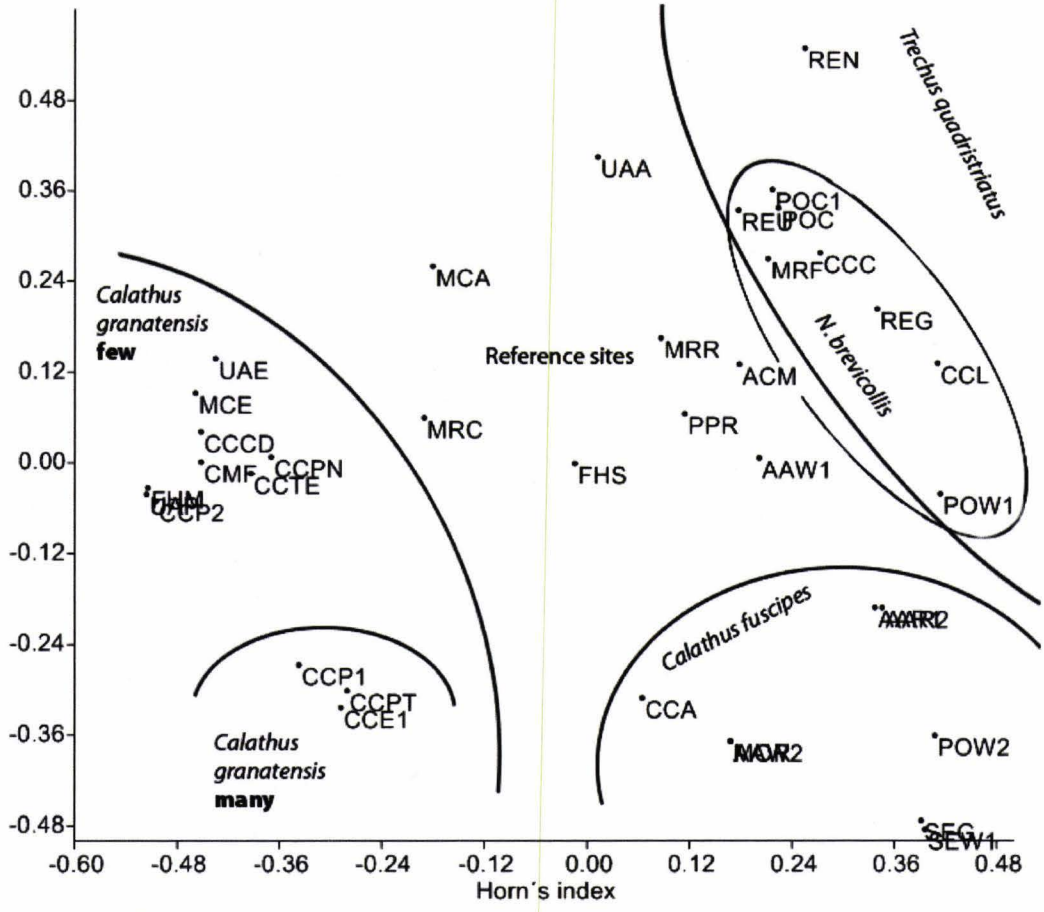

Figure 8. Principal coordinate ordination of Carabid communities from Madrid and its surroundings (abbreviations of sites as in Table 3 and 4). / Figura 8. Ordonarea după coordonata principală a cenozelor de carabide din Madrid şi din imprejurimi (abrevierile locaţiilor ca în tabelele 3 şi 4).

Basing on the above analyses, the sequence of communities along the urbanization gradient can be characterized as it follows. In the dry habitats of matorrals and encinars, the communities are characterized by the combination of predominant *Calathus granatensis* and less dominant *Calathus mollis*. The seminatural dry communities in city are characterized by the predominance of *Calathus granatensis* accompanied with gradually increasing proportion of *Calathus fuscipes*. The next stage of succession is characterized by continuing occurrence of *Calathus fuscipes* accompanied by *Trechus quadristriatus*, *Pseudoophonus rufipes*, *Amara aenea* or *Amara familiaris* and decline or absence of *Calathus granatensis*. Their absolute quantitative representation is low, but proportionally balanced. The final stages represent the sporadic occurrence of *Amara* spp. and of the xerophilous species of the genus *Microlestes* or even the absence of the Carabids. The second, but incompletely reconstructed succession series consists of the reference sites on the shores of stagnant or flowing waters with a rich species spectrum followed by the more or less naturally humid or artificially irrigated habitats with predominating *Nebria brevicollis*, accompanied by some hydrophilous, individually occurring species and *Calathus fuscipes*. These communities do not have a final stage in the most urbanized sites in the very city centre.

Trophic relations

As to the trophic relations, a tendency to decrease of the number of carnivorous species is obvious from the reference localities toward the city centre (Fig. 9). This tendency is more visible in the percentage of carnivorous, omnivorous and purely granivorous species (Fig. 10). A similar, bur not so expressive situation is the percentage of individuals belonging to one of these three trophic groups (Fig. 11). This general tendency is however not so expressive in the localities with increased humidity in the vicinity of the artificial lake in Casa de Campo and at the artificial water streams in Casa de Campo or Parque de Oeste, where *Nebria brevicollis* accompanied by some other hygrophilous species occurred (Figs. 9-11, Tables 3 -4). In the reference localities, as well as in some more xerophilous localities in the city interior (ruderal sites in Avenida Americana) an increased absolute or relative share of purely phytophagous or, more precisely said, specialized granivorous species of the genera *Ditomus, Carterus* or *Acinopus* increased. These species, however, were not found in the irrigated sites, where the species of the genus *Amara* tended to predominate or were the only Carabids found in these places (Fig. 11).

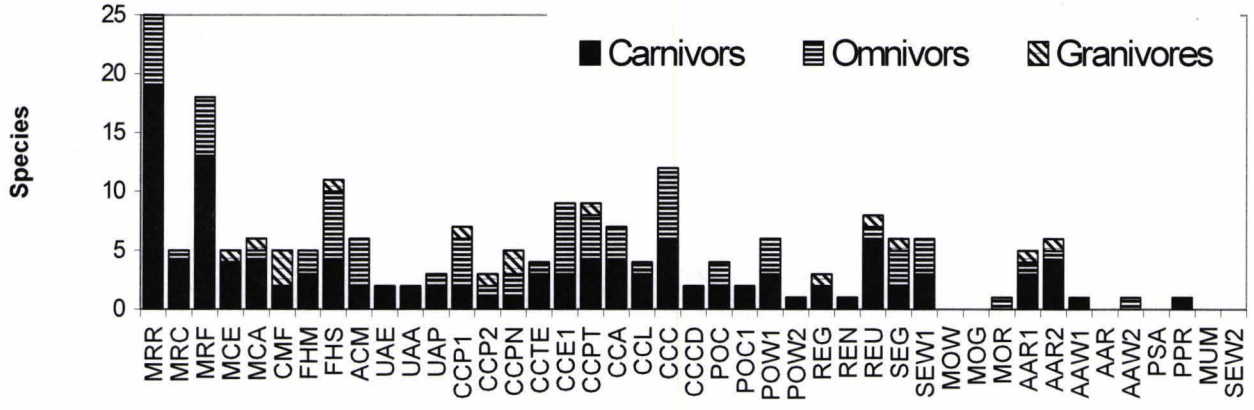

Figure 9. Number of species of three trophic groups of Carabids in Madrid and its surroundings (abbreviations of localities as in tables 3 and 4). / Figura 9. Numărul speciilor a trei grupe trofice de carabide din Madrid şi din împrejurimile lui (abrevierile localităţilor ca în tabelele 3 şi 4).

Figure 10. Relative representation (in %) of species of three trophic groups of Carabids in Madrid and its surroundings (abbreviations of localities as in tables 3 and 4). / Figura 10. Reprezentarea relativă (în%) a speciilor din trei grupe trofice de carabide din Madrid şi din împrejurimile lui (abrevierile localităţilor ca în tabelele 3 şi 4).

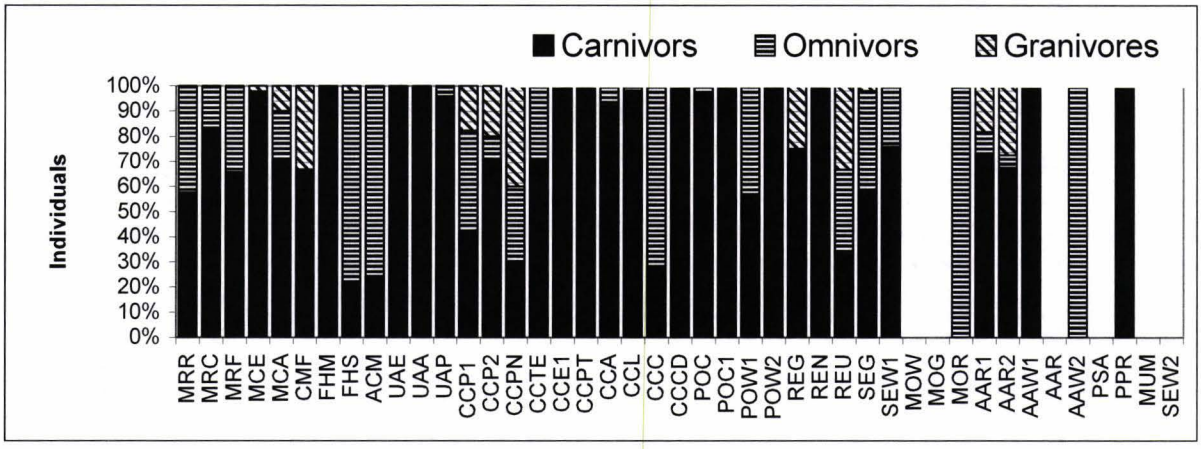

Figure 11. Relative representation (in %) of individuals of three trophic groups of Carabids in Madrid and its surroundings (abbreviations of localities as in tables 3 and 4). / Figura 11. Reprezentarea relativă (în%) a indivizilor din trei grupe trofice de carabide din Madrid şi din împrejurimile lui (abrevierile localităţilor ca în tabelele 3 şi 4).

Zoogeographical structure

In the areographic structure, a trend of decrease of the number of species with small areas of distribution (west Mediterranean, Iberian, and increase or portion of species with large area (transpalaeartic, westpalaearctic, Eurosiberian, European) is visible in the direction toward the city centre (Fig. 12). This trend is still more evident in the percentage of individuals of species belonging to these two groups of areas of geographical distribution (Fig. 13). It is particularly evident in two groups of communities. The first group includes the sites under the artificial lake in Casa de Campo and along the artificial creek in Parque de Oeste, where the succession tends to the azonal communities characteristic of water stream shores in floodplain ecosystems. Unlike the true floodplain Carabid communities there were found no holarctic or transpalaearctic species, but the European or westpalaearctic species dominate there (Table 2). A remarkable feature of these communities is a relatively high share of species with rather small areas, like the west Mediterranean *Carabus melancholicus, Agonum nigrum* and *Bembidion aeneum*.

The second group consists of the communities in city centre, which are shadowed by trees (Parque de Retiro) or in sites where the grass is watered in summer in order to maintain it green from aesthetic reasons. Also in these sites the transpalearctic (*Pseudoophonus rufipes*) or westpalaeartcic species (*Trechus quadristriatus, Calathus fuscipes*) predominate. On the other hand, the non-irrigated more or less abandoned grassy or ruderal plots in city centre are colonized by the thermoxerophilous species having differently extensive, but in general relatively small distribution areas at or around the Mediterranean Sea (genera *Ditomus, Carterus* and *Acinopus, Microlestes corticallis, Microlestes seladon*). Their survival is characteristic for the more modern residential quarters of the city. The endemic *Calathus granatensis* seems to be the most tolerant and adaptive species in the seminatural encinar- or matorral-like habitats, but does not penetrate to the city centre itself.

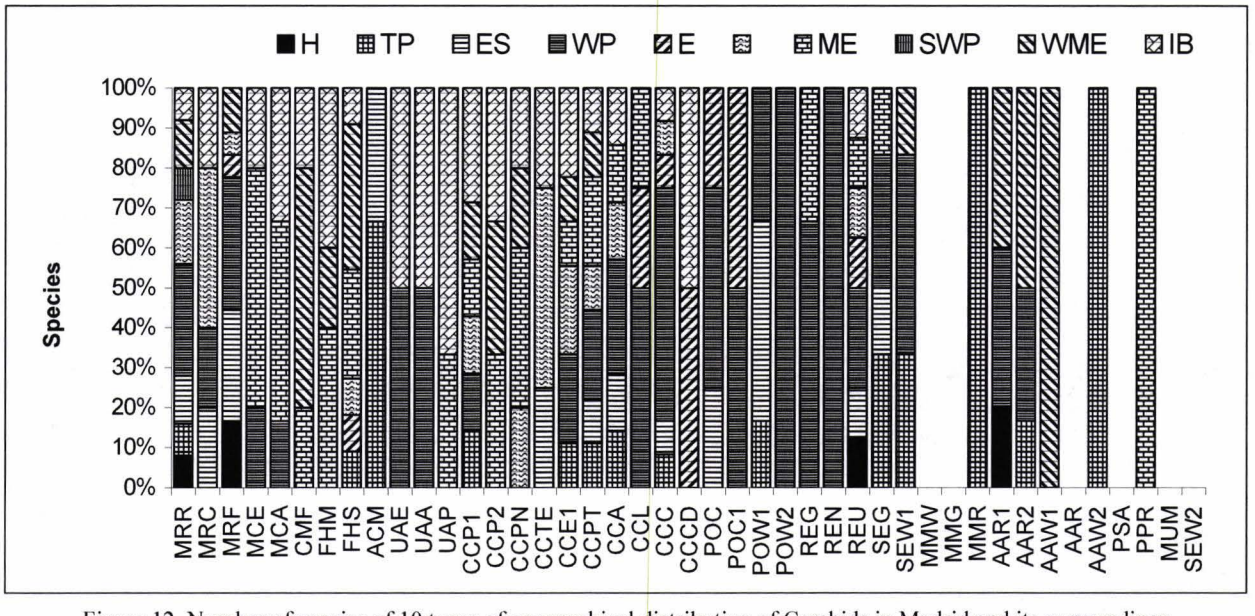

Figure 12. Number of species of 10 types of geographical distribution of Carabids in Madrid and its surroundings (abbreviations of localities as in tables 3 and 4). / Figura 12. Numărul speciilor a 10 tipuri ale răspândirii geografice ale carabidelor din Madrid şi din împrejurimile lui (abrevierile localităţilor ca în tabelele 3 şi 4).

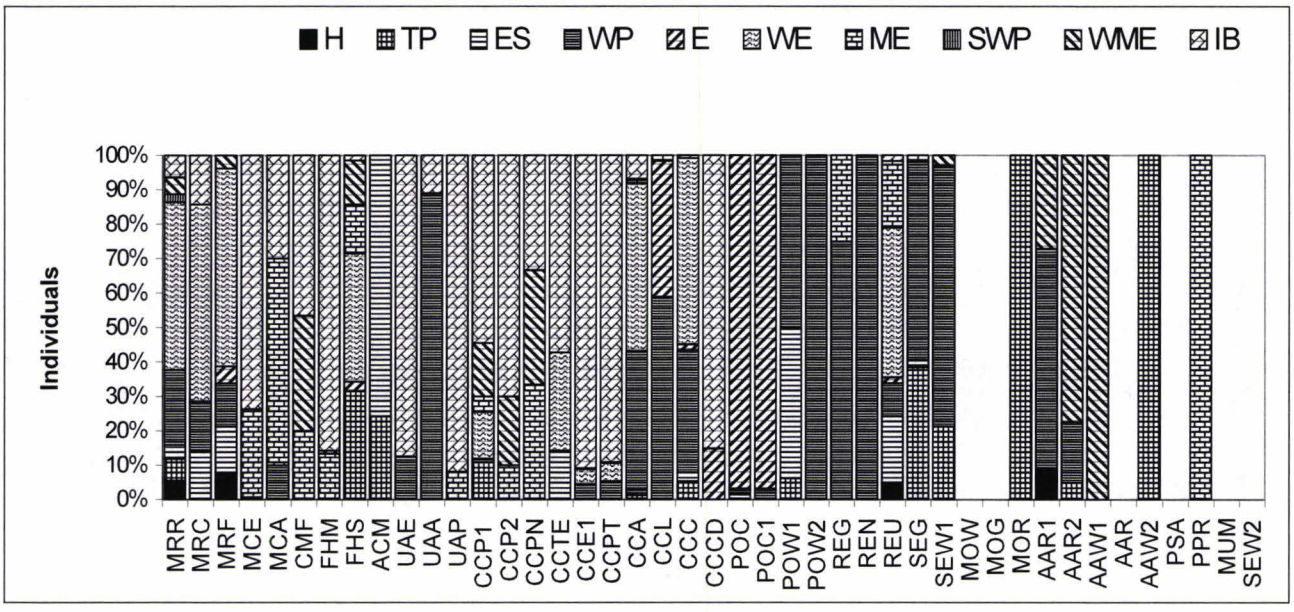

Figure 13. Relative representation of individuals of species of 10 types of geographical distribution of Carabids in Madrid and its surroundings (abbreviations of localities as in tables 3 and 4). / Figura 13. Reprezentarea relativă a indivizilor speciilor celor 10 tipuri de răspândire geografică a carabidelor din Madrid şi din împrejurimile lui (abrevierile localităţilor ca în tabelele 3 şi 4).

DISCUSSION

The constant occurrence of *Calathus granatensis* in sparse stands in reference localities and in urban parks in Madrid is in certain contradiction with the results of TABOADA *et al.* (2004). In their material it preferred the interior of the oak forests studied, while at the edges of the oak and beech stands it was replaced by *Calathus fuscipes*, which is really an open landscape species. The results from Madrid indicate that this species is more tolerant to opening of the tree canopy in the forest (forests-like) habitats than indicated by these authors.

The trends in structural changes along the urbanization gradient in Madrid and in other cities can be generally characterized by the disappearance of typical forests species and their replacement by the open landscapes species and a strong decline of diversity indices in the seminatural habitats. The enormous dominance of *Calathus granatensis* in Casa de Campo or a high dominance of hygrophilous *Nebria brevicollis* in Parque de Oeste has an analogy in the dominance of the couple of the species *Patrobus atrorufus* (STROEM, 1768) + *Platynus assimilis* (PAYKUL, 1790) and *Nebria brevicollis* + *Platynus assimilis* in the Central European cities (ŠUSTEK 1979, 1984) or of *Nebria coreica* SOLSKY, 1875 in the suburban zones of Pyongyang or *Platynus magnus* (BATES, 1873) in the alluvial park Potogang in Pyongyang (ŠUSTEK, 2011). A high dominance of *Nebria brevicollis* was also observed by TOPP (1972) in Kiel.

In spite of the limited time to collect the material in Madrid, the pattern of values of diversity index was very similar with more representative results from Brno and Bratislava (ŠUSTEK 1984), where a strong decline of diversity and equitability was observed in the medium influenced communities, whereas a low diversity but a high equitability was characteristic for the sites in the very city centre. A similar trend, in spite of the extremely limited material, was also observed in Pyongyang.

Unlike the central European cities (CZECHOWSKI, 1982, ŠUSTEK 1984), the strongly expansive species *Pseudoophonus rufipes* played only a secondary role in the Carabid communities in Madrid and did not occur in all studied sites. The less abundant congener *Pseudoophonus griseus* was found in small number of individuals only in the reference locality in maize field at Aranjuez. In Central Europe and East Asia it is one of the most characteristic species of the urban Carabid communities.

Similarly as in most places in centres of the Central European cities and in Pyongyang, no large species (*Carabus* spp.) were found in the city interior, in spite of the fact that at least *Carabus melancholicus* is probable to occur at least in some suburban parts of Madrid, especially at the river banks due to its preference of the riverine and field habitats (BURMEISTER, 1939). Thus this species could be an analogue to *Carabus intricatus* LINNAEUS, 1761, which shows a remarkable ability to penetrate in small number of individuals in urbanized habitats due to its ability to climb on vertical surfaces (BURMEISTER, 1939, ŠUSTEK 1999b). However, the absence or low representation of the large and non-flying species of the genus *Carabus* in Central European cities, in Madrid and Pyongyang is just a property of the more southern cities. In contrast, in the northeastern European cities (Moscow, Yaroslavl, Minsk, Grodno) the lower climatic gradient between the forest surrounding and city allows *Carabus nemoralis* O. F. MÜLLER, 1764 to successfully penetrate in considerable numbers in localities in the city centre, like the Leninskij prospect street in Moscow, and even mate on the street pavements in Yaroslavl (personal observations and personal communication by A. Derunkov).

Unlike other cities, two contradicting trends in the representation of species with differently large areas of the geographic distribution can be observed in Madrid. On the one hand, there is a similar trend to favouring the species with larger areas in the city centre as in East Asia and Central Europe. On the other hand, the species with small areas (west Mediterranean) or even the endemic species are remarkably successful in survival in the seminatural or strongly urbanized habitats. There is however an analogy between Madrid and Pyongyang, where the endemic species – *Calathus granatensis* in Madrid and *Nebria coreica* strongly predominated in the seminatural habitats.

Similarly as in the Central European cities (CZECHOWSKI 1980a, 1980b, 1981a, 1981b, 1982, ŠUSTEK 1979, 1984, ŠUSTEK & VAŠÁTKO 1983a, 1983b), there was a trend to decline of the carnivorous species in favour of the omnivorous ones. In both areas it is a consequence of the absence or very low representation of the omnivorous species in the fauna of forest ecosystems representing the potential natural vegetation and of a considerable share of the omnivorous species among the open landscape species, which are favoured in urban ecosystems. A specific feature of the fauna of Madrid, as a Mediterranean city, is the occurrence of the purely granivorous species typical of this biogeographical area.

The obtained results are, however, influenced by the fact that they were obtained during a relatively short time and at the beginning of the dry and hot period, which could inhibit the activity of many species whose occurrence can be limited to spring. Theoretically, there also arises the question of the winter activity of Carabids, which is know from the subtropical areas or which was observed even in Central Europe in warm winter periods (ŠUSTEK, 1979).

CONCLUSIONS

In spite of a considerable heterogeneity of the material, the character of the communities in individuals sites was predominantly determined by the occurrence and mutual relation of six species, viz. *Calathus granatensis, Calathus mollis, Calathus fuscipes, Trechus quadristriatus, Nebria brevicollis* and *Amara aenea,* accompanied in individual communities by some less abundant species. *Pseudoophonus rufipes* playing a significant role in forming of the urban communities in Central Europe plays only a secondary role in Madrid as a Mediterranean city.

According to the mutual proportion of these species, two parallel successional series can be distinguished:

A) Dry or mesohygrophilous habitats derived from holm oak forests (encinars):

1. More or less natural - combinations of predominant *Calathus granatensis* and less dominant *Calathus mollis.*

2. The seminatural communities in city predominance of *Calathus granatensis* accompanied with gradually increasing proportion of *Calathus fuscipes.*

3. Medium influenced communities – continuing occurrence of *Calathus fuscipes* accompanied by *Trechus quadristriatus, Pseudoophonus rufipes, Amara aenea* or *Amara familiaris* and decline or absence of *Calathus granatensis.* All of them were quantitatively little represented, but with a proportionally balanced share.

4. Strongly influenced sites – sporadic occurrence of *Amara* spp. and of the xerophilous species of the genus *Microlestes* or even absence of the Carabids.

B) Humid habitats on shores or banks of water bodies

1. Natural – communities rich in characteristic hydrophilous species.

2. Seminatural - more or less naturally humid or artificially irrigated habitats with predominating *Nebria brevicollis,* accompanied by some hydrophilous, individually occurring species and *Calathus fuscipes* as an open landscape species.

3. Strongly influenced – not found, probably convergent to the communities of the strongly influenced dry or mesohygrophilous habitats.

The communities show a higher portion of endemic Iberian or Mediterranean species penetrating into the very centre of the city. In spite of it, a general trend to increase of representation of species with large areas of geographical distribution, known from other cities, was confirmed.

Similarly as in other cities, the seminatural communities in the city are characterized by decline of diversity indices and by a low equitability, while the communities in the most exposed sites are characterized by low values of diversity index and by a high equitability.

In contrary to the arid and dry climate, the species composition of the communities in centre of Madrid converges to the communities known from Central Europe. This convergence is however only anthropogenic and results from the intensive care of the urban greenery.

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REFERENCES

ALARUIKKA D., KOTZE D. J., MATVEINEN K., NIEMELÄ J. 2002. *Carabid beetle and spider assemblages along a forested urban-rural gradient in southern Finland.* Journal of Insect Conservation. 6: 195-206.

BAEHR M. 1986. *On the Carabid fauna of the Province of Girona, Northeastern Spain Insecta, Coleoptera).* Miscelanea Zoologica. **10**: 161-171.

BURMEISTER F. 1939. *Biologie, Ökologie und Verbreitung der europäischen Käfer auf systematischer Grundlage. I. Band; Adephaga, I. Familiengruppe: Caraboidea.* Edit. Hans Goecke Verlag. Krefeld. 307 pp.

CZECHOWSKI W. 1980a. *Influence of the manner of managing park areas and their situation on the formation of the communities of carabid beetles (Coleoptera, Carabidae).* Fragmenta faunistica. **25**: 199-219.

CZECHOWSKI W. 1980b. *Carabids (Coleoptera, Carabidae) of the Wistula ecarpments in Warszaw.* Fragmenta faunistica. **25**: 293-316.

CZECHOWSKI W. 1981a. *Carabids (Carabidae, Coleoptera) of Warszaw and Mazowia.* Memorabilia zoologica. **34**: 119-144.

CZECHOWSKI W. 1981b. *Wpływ urbanizcji środowiska na dynamikę sezonową biegaczowatych (Coleoptera, Carabidae).* Przegląd zoologiczny. **26**: 68-74.

CZECHOWSKI W. 1982. Occurrence of carabids (*Coleoptera, Carabidae) in the urban greenery of Warsaw according to the land utilization and cultivation.* Memorabilia zoological. **39**: 1-108

DAVIS B. N. K. 1978. *Urbanisation and diversity of insects.* In: Mound L. A., Waloff N. (Eds.): Diversity of Insect faunas. Symposium of the Royal entomological society of London. **9**: 126-139.

DE LA FUENTE Y MORALES J. M. 1927. *Tablas analítica para la clasificación de los Coleopteros de la Peninsula Ibérica. I. Cicindelidae, II. Carabidae.* Imprenta Altés, Barcellona. 416 pp.

DELAHON I. 1931. *Kleine coleopterologische Mitteilungen 630 – Agonum gracilipes Duft.* Entomologische Blätter. **27.** 142 pp.

DUSHENKOV V. M. 1983. *O faune zhuzhelits g. Moskvy.* Fauna I ekologija pochvennkych bespozvonochnykh. Moskva: 111-112.

FERNANDEZ-JURICIC E. 2000. *Bird community composition patterns in urban park of Madrid. The role of age, size and isolation.* Ecological research. **15**: 373-383.

FERNANDEZ-JURICIC E. 2001. *Avian spatial segregation at edges and interiors of urban parks in Madrid,* Spain. Biodiversity and Conservation. **10**: 1303-1316.

FERNANDEZ-JURICIC E. 2004. *Spatial and temporal analysis of the distribution of forest specialists in an urban-fragmented landscape (Madrid, Spain): implications for local and regional bird conservation.* Landscape and Urban Planning. **69**: 17-32.

FERNANDEZ-JURICIC E., JIMENEZ M. D., LUCAS E. 2001. *Bird tolerance to human disturmance in urban parks of Madrid (Spain): Management impications.* 259-272. In: Marzluff J. M., Bowman R. & Donelly R. (Eds.). Kluwer Academic Publisher, Norwell, Massachustts. 578 pp.

GONZÁLEZ-GRANADOS J. & VIEJO-MONTESINOS J. L. 2012a. *Los artrópodos de la Comunidad de Madrid.* Foresta. **52**: 76-85.

GONZÁLEZ GRANADOS J., BAHILLO DE LA PUEBLA P., LÓPEZ COLÓN J. I. 2012b. *Coleópteros de la Comunidad de Madrid.* Foresta. **52**: 68-75.

GOSPODAR U. 1981. *Statik und Dynamik der Carabidenfauna einer Trümmerschutt-Deponie in LSG Grünewald in Berlin (West).* Dissertation, Freie Universität Berlin. 225 pp.

GOSPODAR U.& SCHÜTTER T. 1982. *Zur Carabiden-Sekundärfauna einiger ehemaligen Personen-Bahnhofanlage in Berlin-West.* Sammelberichte der Gesellschaft der Naturwissenschaft-Freunde Berlin, Neue Folge. **22**: 152-172.

HAMMER Ø. 2012. *PAST: Paleontological Statistics. Version 2,16 Reference manual.* Natural history museum, University of Olso. 227 pp.

HŮRKA K. 1996. *Carabidae of the Czech and Slovak Republics.* Edit. Kabourek. Zlín. 565 pp.

JEANELL R. 1941-1942. *Coleoptéres Carabiques. Faune de France.* Le Chevalier, Paris. 39-40. 1173 pp.

JIMÉNEZ-VALVERDE A. & ORTUÑO V. M. 2007. *The history of endemic Iberian ground beetle description (Insecta, Coleoptera, Carabidae): which species were described first?* Acta Oecologica. **31**: 13-31.

KLAUSNITZER B. & RICHTER K. 1980. *Quantitative und quantitative Aspekte der Carabidenfauna der Stadt Leipzig.* Wissenschaftliche Zeitschrift der Universität Leipzig, Mathematisch-naturwissenschaftliche Reihe. **29**: 567-573.

KLAUSNITZER B., RICHTER K., KÖBERLEIN C., KÖBERLEIN F. 1980. *Faunistische Untersuchungen der Bodenarthropodes zweier Leipziger Stadparks unter besonderer Berücksichtigung der Carabiden und Staphyliniden.* Wissenschaftliche Zeitschrift der Universität Leipzig, Mathematisch-naturwissenschaftliche Reihe. **29**: 583-597.

MARTÍNEZ D., ORNOSA C., GAMARRA P. 1997. *Urban fauna. Hymenoptera in Madrid households, with special reference to ants.* Entomofauna, Zeitschrift für Entomologie. **18**: 417-428.

MONZÓ C., VANACLOCHA P., OUTERELO R., RUIZ-TAPIADOR I., TORTOSA D., PINA T., CASTAÑERA P., URBANEJA A. *2005. Catalogación de especies de las familias Carabidae, Cicindelidae y Staphylinidae en el suelo de los cítricos de la provincia de Valencia, España.* Bolletino San. Veg. Plagas. **31**: 483-492.

NIEMELÄ J., BREUSTE J. H., GUNTENSPERGEN G., NANCY E. MCINTYRE N. E., ELMQVIST T, JAMES P. 2011. *Urban Ecology Patterns.* Processes and Applications. Oxford University Press, Oxford. 388 pp.

NIEVES H. & LOBO J. M. 2006. *Los Cynipidae (Hymenoptera) de la Comunidad de Madrid: Lista anotada, mapas de distribución, riqueza y estatus de conservación.* Graellsia, 62 (número extraordinario): 371-402.

QUITT E. 1983. *Antropogenní vlivy na podnebí Brna* In: Bína J., Folk Č. (Eds.): Geoekologie brněnské aglomerace. Studia Geographica. **83**: 56-61.

SANGÜESA F. 1834. *Insectos que destruyen los arbolyados de Madrid, medios de disminuirlos, é importancia de los arboles en general.* D. L. Amarita, Madrid. 42 pp.

SERRANO J. 2003. *Catálogo de los Carabidae (Coleoptera) de la Península Ibérica.* Monografías S.E.A., 9. Sociedad Entomológica Aragonesa, Zaragoza. 147 pp.

SERRANO J., LENCINA, J. L., ANDÚJAR A. 2003. *Distribution patterns of iberian Carabidae (Insecta, Coleoptera).* Graellsia. 59: 129-153.

SANGÜESA F. 1834. *Insectos que destruyen los arbolyados de Madrid, medios de disminuirlos, é importancia de los arboles en general.* D. L. Amarita, Madrid. 42 pp.

SHAROVA I. KH. 1981. *Zhiznennye formy zhuzhelits (Coleoptera, Carabidae).* Nauka, Moskva. 360 pp.

SMALL E., SADLER J. P., TELFER M. 2003. *Carabid beetle assemblages on urban derelict sites in Birmingham, UK.* Journal of Insect Conservation. 6: 233-246.

SMALL E., SADLER J. P., TELFER M. 2006. *Do landscape factors affect brownfield carabid assemblages?* Science of The Total Environment. 360: 205-222.

SORIANO O. & COBO F. 2006. *Lista faunística de los quironómidos (Diptera, Chironomidae) de Madrid (España).* Graellsia. 62 (número extraordinario): 7-20.

ŠUSTEK Z. 1979. *Výzkum geoekologie brněnských parku na příkladě střevlíkovitých a drabčíkovitých v parku Lužánky.* Zprávy Geografick0ho ústavu ČSAV Brno. **16**: 156-174.

ŠUSTEK Z. 1980. *Některé souvislosti geografického rozšíření střevlíkovitých (Col. Carabidae) a jejich schopnosti pronikat do ekosystémů urbanizované krajiny.* Zprávy Geografického ústavu ČSAV Brno. **18**: 30-40.

ŠUSTEK, Z. 1984. *Bioindikačné vlastnosti bystruškovitých a drobčíkovitých (Coleoptera, Carabidae et Staphylinidae' stredoeurópskeho veľkomesta.* CSc. Thesis, Institute of Exoerimental biology and Ekology of the center of Biological and Ecological Science of the Slovak Academy of Sciencesd Bratislava. 366 pp.

ŠUSTEK Z. 1987. *Changes in body size structure of Carabid communities (Coleoptera, Carabidae) along an urbanisation gradient.* Biológia (Bratislava). **42**: 145-156.

ŠUSTEK Z. 1989. *Properties of Carabid and Staphylinid communities in Central European and Mediterranean cities.* p. 113-122. In: Klausnitzer B. & Dunger W (Eds.): Verhandlungen der SIEEC 1986. Gotha. 398 pp.

ŠUSTEK Z. 1999a. *Light attraction of carabid beetles and their survival in the city centre.* Biologia, Bratislava. **54**: 539-551.

ŠUSTEK, Z. 1999b. *A curious case of wall climbing in Carabus intricatus: do the carabids orient by odour trails?* Entomofauna carpathica. **11**: 58-62.

ŠUSTEK Z. 2002. *Flight of Dytiscidae, Hydrophilidae and Staphylinidae (Coleoptera) on light in centre of a great city.* Entomofauna carpathica. **14**: 59-63.

ŠUSTEK Z. 2011. *Changes in carabid communities along the urbanization gradient in Pyongyang (North Korea).* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **27**(1): 87-96.

ŠUSTEK Z. & VAŠÁTKO J. 1983a. *Modelové skupiny bezstavovcov vo veľkomeste.* Živa. **31**: 142-145.

ŠUSTEK Z. & VAŠÁTKO J. 1983b. *Coleoptera a Mollusca (Gastropoda) brněnské aglomerace.* In Bína J., Folk Č. (Eds.): Geoekologie brněnské aglomerace. Studia Geographica. **83**: 116-123.

TABOADA A., KOTZE D. J., SALGADO J. M. 2004. *Carabid beetle occurrence at the edges of oak and beech forests in NW Spain.* European Journal of Entomolgy. **101**: 555-563.

TOPP W. 1972. *Die Besiedlung eines Stadtparks durch Käfer.* Pedobiologia. **12**: 336-346.

VENN S. J., KOTZE D. J., NIEMELÄ, J. 2003. *Urbanization effects on carabid diversity in boreal forests.* European Journal of Entomology. **100**: 73-80.

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SOME BIOLOGICAL, ECOLOGICAL AND MICROBIOLOGICAL CONTROL DATA REGARDING THE ATTACK OF THE FALL WEBWORM MOTH (*Hyphantria cunea* DRURY), A DANGEROUS PEST IN THE AGRICULTURAL, ORNAMENTAL AND FOREST PLANTATIONS IN THE REPUBLIC OF MOLDOVA

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Abstract. The aim of the present paper is to discuss the results of two years attempt of biological control of *H. cunea* populations with a baculoviral product (HcVPN, VG) previously obtained at The Institute for Plant Protection and Ecological Agriculture, Academy of Sciences of Moldova. In the paper there are presented the results of the researches of the species *H. cunea* DRURY, an important pest for the plantations in Republic of Moldova. Under the conditions of the Republic of Moldova fall webworm has two generation, and in exclusive mode a partial third generation. The investigations were carried out during the period of 2004-2011 years in different agricultural, ornamental and forest ecosystems. The development of *H. cunea* was found to depends not only on temperature but also largely on the food-plant. The larval and pupal stages of both generations in Moldova were shorter on the preferred plants mulberry (*Morus*, L.), apple-tree (*Malus domestica* L.), cherry-tree (*Cerasus avium*) and plum-tree (*Prunus domestica* L.) than on grapevine (*Vitis vinifera* L.), strawberry (*Fragaria moschata* DUCH.), rose (*Rosa damascena* MILL.) or lime (*Tilia cordata* MILL.), walnut-tree (*Juglans regia* L.) and apricot (*Armeniaca vulgaris* L.) occupied an intermediate position. Baculoviral improved product Virin ABB-3 was tested in laboratory against *H. cunea* larvae. In the report there are also submitted the results of the joint application of the biological preparation Virin ABB-3. As to the mortality of the caterpillars on the VG 2011, it has – 78-82%, while VPN has 74-80%. But in the options there were used both viruses VG and VPN (1:1), the mortality increased from 88% to 92%. Being analysed the biological effectiveness of the baculoviruses was 75-90%. The material was used to prepare the biological preparation Virin-ABB-3. Renovated sources of VPN and VG of year 2011 have been used for obtaining viral and experimental material with change of technologies of obtaining the viral preparations on the basis of these sources at the 2nd generation of *H. cunea* in year 2012. The researches point out *H. cunea* the critical stage and will be very useful for the baculovirus treatments management.

Keywords: *Hyphantria cunea* DRURY, Biology, Ecology and control with Virin ABB-3, baculovirus, VG, VPN.

Rezumat. Unele aspecte privind biologia, ecologia şi combaterea microbiologică a omizii păroase a dudului (*Hyphantria cunea* DRURY), dăunător periculos al plantaţiilor agricole, ornamentale şi forestiere din Republica Moldova. Scopul lucrării de faţă este de a discuta rezultatele de control biologic al populaţiilor de *H. cunea* cu un produs baculoviral (HcVPN, VG) care a fost obţinut anterior la Institutul de Protecţia Plantelor şi Agriculturii Ecologice din Republica Moldova. În lucrare se prezintă rezultatele cercetărilor asupra speciei *H. cunea* (omida păroasă a dudului), dăunător important pentru plantaţiile din Republica Moldova. *H. cunea* are două generaţii şi numai în mod excepţional a treia generaţie parţială. Observaţiile au fost făcute în perioada 2004-2011. Dezvoltarea dăunătorului depinde nu numai de temperatură dar şi în mare măsură de regimul trofic. Stadiile larvare şi pupale din ambele generaţii au fost mai scurte pe plantele preferate: dud (*Morus* sp.), măr (*Malus domestica* L.), cireş (*Cerasus avium*) şi prun (*Prunus domestica* L.), decât pe viţa de vie (*Vitis vinifera* L.), căpşun (*Fragaria moschata* DUCH.), trandafir (*Rosa damascena* MILL.) sau tei (*Tilia cordata* MILL.); cele crescute pe nuc (*Juglans regia* L.) şi cais (*Armeniaca vulgaris* L.), ocupă o poziţie intermediară. Produsul baculoviral Virin ABB-3 perfecţionat a fost testat în condiţii de laborator împotriva larvelor de *H. cunea*. Nivelul mortalităţii înregistrate la VG la a 15-a zi a fost de 78-82%, iar la VPN 74-80%, când s-a efectuat infectarea cu monovirusuri. În variante când s-au folosit ambele virusuri VG şi VPN (1:1), mortalitatea a crescut de la 88 până la 92%. Eficacitatea biologică a baculovirusilor era la nivel 75-90%. Materialul a fost utilizat pentru pregătirea preparatului Virin-ABB-3. Suşele reînoite de VPN şi VG din anul 2011 au fost folosite pentru obţinerea materialului viral şi experimente cu schimbarea tehnologiilor de obţinere a preparatelor virale pe baza acestor suşe la generaţia a II-a de *H. cunea* în anul 2012. Cercetările subliniază faza critică a *H. cunea* şi va fi foarte util pentru gestionarea tratamentelor cu baculovirusuri.

Cuvinte cheie: *Hyphantria cunea* DRURY, biologie, ecologie şi combaterea cu Virin ABB-3, baculovirus, VG, VPN.

INTRODUCTION

Fall Webworm *Hyphantria cunea* DRURY, of the Arctiidae family is a polyphagous lepidopteran pest insect, the origin of which is North America (Canada, USA), where it is spread everywhere between the Atlantic Ocean and the Pacific. *H. cunea* spread to the EPPO region after the Second World War (HRUBIK, 2007). *H. cunea* is presently distributed in many areas in the northern hemisphere (WARREN & TADIC, 1970) and New Zealand (KEAN & KUMARASINGHE, 2007). The pest has been introduced in various parts of Europe and Asia (LI *et al.*, 2001). The food spectrum of this pest includes more than 626 plant species (WITTENBERG, 2005). At least 20 countries across Europe have reported *H. cunea*, including Hungary (GYOREY, 1954), Romania (MANOLACHE & BOGULEANU, 1957; BOGULEANU, 1968), Ukraine (SICURA, 1972), Greece (MOULOUDIS *et al.*, 1980), Italy (MAZZON & MARTINI, 2000) and other countries (SICURA, 2005); 2 in Eurasia, Turkey (DEMIR, 2006) and Russia (SHAROV & IZHEVSKIY, 2002), and 10 in Asia, Japan (LI & GOTO, 2001), South Korea (KEAN, 2003), China (YANG & ZHANG, 2011), Azerbaijan (NURIEVA, 2002), Iran (REZAEI *et al.*, 2003), Mongolia and Uzbekistan (GRICHANOV & OVSYANNIKOVA, 2003), Georgia (JAPOSHVILI *et al.*, 2006) and Kazakhstan and Kyrgyzstan (ANONIMOUS, 2007).

A series of problems in the field of plants protection and the growing of ecological products can be solved using three important biological agents: insects, microorganisms (viruses) and bacteria (*B. thuringiensis*, etc.) bioactive substances (CROSS & DICKLER, 1994; VOLOSHCHYUK, 2007, 2008).

The recognition of the necessity for the application of the entomopathogenic viruses and baculoviral preparations elaborated on their basis is determined by the qualitative originality of the pathogenic agents, among which their specificity and epizootic character constitute the main advantages compared with the chemical insecticides. There are necessary certain actions meant to underline the importance of the rational utilization of these otherwise efficient means of pest control according to nature laws, which regulate the pest populations under the action of baculoviruses (CHUKHRII, 1988; CIUHRII & ARMENESCU-CIUHRII, 2008; TANADA & KAYA, 1993; VOLOSHCHYUK, 2010).

MATERIAL AND METHODS

The researches have been realised on the caterpillars of 2-3 ages of the *H. cunea.* In the study, we used the Nuclear Polyhedrosis Virus, selected and identified in the laboratory of the insect viruses.

For the contamination of the laboratory insects, we used the dosed feeding, which contains 10 polyhedrons for each caterpillar. The monitoring of the insects lot and the estimation of the dead caterpillars has been carried out daily, beginning with the 3rd day of the contamination.

The effectiveness of the virus action was established according to the Abbot formula, which provides the insects' natural death rate:

$$E\,ab = \frac{Mo - M_c}{100 - Mc} * 100$$

Where Eab-is the death rate, %; Mo – the number of dead specimens in the experiment; Mc - the number of dead specimens in the control.

The caterpillars *H. cunea* were kept under laboratory conditions at 27°C.

The mathematical treatment was registered on the 15th day after contamination; the statistical treatment was made according to DOSPEKHOV (1985), GAR (1963), SĂVESCU *et al.* (1978), CIUHRII *et al.* (1990).

In order to establish the density or frequency of the attacks and to render certain aspects regarding their biology, there were carried out observations according to the adequate methodology between 2004 and 2008. The experiments were made in several orchards of the Republic of Moldova. The observations were held both on the pest adults and on development of other phases of the ontogenesis: eggs, larvae, pupas. There were taken into account 100 rosettes with leaves. There were marked 5 control trees disposed on the diagonal of the plots.

To determine the beginning of pest activity, there were carried out registrations using trap-belts, which had been attached around the lower part of the trunk of 10 trees during the previous season.

Laboratory investigation of the sampled material attacked by this species of insects were carried out, in correspondence with the present norms, in order to establish their frequency, intensity, and attack degree. To establish the influence of the trophic factor on the insect development, there were grown larvae (from the same lots) on 12 species of host-plants (ornamental, forest and fruit trees): mulberry (*Morus* L.), maple (*Acer negundo* L.), willow (*Salix* L.), poplar (*Populus alba.* L), lime (*Tilia cordata* MILL.), apple-tree (*Malus domestica* L.), walnut (*Iuglans regia* L.), pear-tree (*Pirus sativa* LAM. et DC.), apricot tree (*Armeniaca vulgaris* L.), plum tree (*Prunus domestica* L.), cherry-tree (*Cerasus avium*). Under natural conditions, there were made observations on the appearance of adults, duration of the flight and, copulation. All data were interpreted in relation with the main climatic factors. Control experiments with the viruses preparations were conducted under natural conditions (2-3 trees in each variant), and under laboratory conditions as well, using special rearing boxes, crystallizers (for larvae of different age of development) of both generations. Observations on larvae mortality were accomplished after 12, 14, 48, and 72 hours.

RESULTS AND DISCUSSIONS

Monitoring the appearance of butterflies from the hibernated pupae of the I generation during a period of five years (2004 – 2008) in different places we have stated that the first butterflies appeared between April 30 (2008) and May 22 (2007). As it is remarked, the first butterflies appeared when the average daytime temperature was higher than 10°C (the lower threshold of the pupa) during 25-32 days. The sum of efficient temperature, at the biological threshold of 10°C varied between 106°C (2008) and 145°C (2006), but at the biologic threshold of 8.5°C, it was between 142°C (2004) and 184°C (2007).

The appearance of the butterflies according to the number of days with 10°C ranged between 25 (2004) and 32 butterflies (2006); at 8.5°C, it varied between 36 (2006) and 47 butterflies (2004); at 14°C, it was between 8 (2006) and 13 butterflies (2008); but at 12°C it was between 15 (2006) and 20 butterflies (2008). The maximum flying was on May 4 (2007) at t°C>10°C=170 butterflies and at t°C>8.5°C= 190 butterflies; on May 19 (2008) at t°C>10°C=204 butterflies and at t°C>8.5°C=223 ones (Table 1). The data rendered in table 1 showed that the sum of the effective temperatures presents rather large variations from one year to another and, thus, it cannot be used as the single criterion for the prognosis of the appearance of the first butterflies in spring. They can be taken into consideration informatively and in correlation with other environmental factors as it follows: humidity, sudden changes of temperature, frost, isolation, etc.

Analysing the sex index of the fall webworm in relation with the environment factors it was noticed that it is influenced, to at large extend, by the trophic factor. On host ornamental and forest trees (mulberry (*Morus* L.), maple

(*Acer negundo* L.), willow (*Salix* L.), poplar (*Populus alba* L.), and lime (*Tilia cordata* MILL.), the sex index of pupa varied between 0.33 on poplar (*Populus alba* L.) and 0.57 on maple; in case of butterflies, it oscillated between 0.26 on lime and 0.62 on maple (*Acer negundo* L.). In case of host fruit – trees, the sex index of pupa varied between 0.35 on apricot-tree (*Prunus domestica* L.) and 0.49 on plum-tree; as for butterflies – between 0.33 on cherry-tree (*Prunus avium* L.) and 0.48 on walnut (*Juglans regia* L.) (Table 2).

Table 1. The appearance of the butterflies of *H. cunea* from hibernated pupae in 2004-2008.
Tabel 1. Apariţia fluturilor de *H. cunea* din pupele hibernante în anii 2004-2008.

Year	Date	Appearance of butterflies						Flying maximum		
		Sum of efficient temperatures		By day number				Appearance	10°C	8.5 C
		10° C	8,5° C	8,5° C	10° C	12° C	14° C			
2004	May 7	115	142	47	25	16	9	May 18	157	168
2005	May 5	114	177	40	30	19	12	May 15	155	170
2006	May 22	145	156	36	32	15	8	May 29	225	237
2007	April 30	114	184	40	26	18	12	April 4	170	190
2008	March 8	106	165	43	24	20	13	May 19	204	223

Table 2. Sex index of pupae and butterflies *H. cunea* of fall webworm according to the trophic factor.
Tabel 2. Indexul sexual la pupe şi fluturi de *H. cunea* în funcţie de factorul trofic.

No.	Host plant	Pupa			Butterflies		
		total number	female number	sex index	total number	female number	sex index
1	Mulberry (*Morus*)	681	381	0.55	603	307	0.5
2	Maple (*Acer negundo*)	703	407	0.57	651	409	0.62
3	Willow (*Salix*)	591	302	0.51	511	301	0.58
4	Poplar (*Populus alba*)	377	127	0.33	293	108	0.36
5	Lime (*Tilia cordata*)	345	120	0.34	270	72	0.26
6	Apple tree (*Malus domestica*)	524	219	0.41	480	172	0.35
7	Pear tree (*Pirus sativa*)	453	176	0.38	328	123	0.37
8	Wallnut -tree (*Juglans regia*)	505	231	0.45	435	210	0.48
9	Apricot-tree (*Armeniaca vulgaris*)	317	111	0.35	207	72	0.34
10	Cherry- trees (*Cerasus avium*)	461	204	0.44	383	183	0.47
11	Plum - tree (*Prunus domestica* L.)	585	292	0.49	493	261	0.52
12	Sour cherry tree (*Cerasus vulgaris*)	472	183	0.38	405	137	0.33

As it regards the female fertility it varied according to the host plant. The highest prolificacy was of 570 – 408 eggs on mulberry (*Morus* L.), maple (*Acer negundo* L.), plum (*Prunus domestica* L.), and the lowest of 205 – 286 eggs on cherry tree (*Prunus avium* L.) and willow (*Salix* L.). On some species, especially on fruit trees and fructiferous shrubs, the butterflies the larvae of which fed on the leave of these trees, the fertility was between 301 and 370 eggs – walnut (*Juglans regia* L.) and apple-tree (*Malus domestica* L.) (Table 3).

Table 3. Fertility of butterflies of fall webworm *H. cunea* resulted from larvae which were fed with the leaves of different host plants.
Tabel 3. Prolificitatea la fluturii de *H. cunea* proveniţi din larve care s-au hrănit cu frunzele diferitor plante-gazde.

No.	Host plant	Number of eggs		
		minimum	maximum	average
1.	Mulberry (*Morus*)	370	912	570
2.	Maple (*Acer negundo*)	254	802	510
3.	Willow (*Salix*)	130	438	286
4.	Poplar (*Populus alba*)	122	354	253
5.	Lime (*Tilia cordata*)	112	344	243
6.	Apple – tree (*Malus domestica*)	94	601	370
7.	Pear – tree (*Pirus sativa*)	158	310	304
8.	Walnut – tree (*Juglans regia*)	108	423	301
9.	Apricot – tree *Prunus armeniaca*)	85	524	365
10.	Cherry – tree (*Cerasus avium*)	157	630	408
11.	Plum – tree (*Prunus domestica*)	32	580	370
12.	Sour cherry tree (*Cerasus vulgaris*)	83	360	205

The experiments for the preparation of Virin-ABB-3 with contaminated caterpillars (larvae) of *H. cunea* on different plants became an acute necessity for the determination of the percentage of the mortality of specimens with the same concentration and the same number as well as the determination of biological effectiveness. The results of the experiments are presented in Table 4. The highest mortality rate of the caterpillars was registered in case of the mulberry – 97.3% and the lowest mortality rate in case of acacia – 75.0 %. The biological effectiveness according to Abbott formula on the 15th day represented 73.8%. The mortality rate in the control on the 10th – 15th day was 5%.

Table 4. The degree of infection of *H. cunea* with biopreparation Virin-ABB-3 on different plants.
Tabel 4. Gradul de infectare a *H. cunea* cu biopreparatul Virin-ABB-3 pe diferite specii de plante.

Plants	No. of caterpillars	Solution Conc Poliedre/ cmc	No. of the dead caterpillars / days					Mortality percentage			Biologic Efficacy to the Abbot, on the 15 days %
			3	5	7	10	15	on the 5th day	on the 10th day	on the 15th day	
Mulberry (*Morus*)	40	10^6	0	12	19	34	39	30.0	85.0	97.5	97.3
Maple (*Acer negundo*)	40	10^6	0	8	16	29	38	20.0	72.0	95.5	95.2
Walnut-tree (*Juglans regia*)	40	10^6	0	6	9	28	38	15.0	70.0	85.0	84.2
Cherry tree (*Cerasus avium*)	40	10^6	0	5	10	27	32	12.0	65.0	80.0	78.9
Acacia (*Robinia pseudacacia*)	40	10^6	0	2	5	16	30	5.0	40.0	75.0	73.8
Control	40	10^6	0	0	2	4	4	0	5.0	5.0	-
										$DEM_{0.05}$	3.6

As it regards the mortality of the caterpillars on the VG 2011 it reached 78-82%, while VPN reached 74-80%. In options, there were used both viruses VG and VPN (1:1), and mortality increased from 88 % to 92%. Analysing the biological effectiveness of the baculoviruses we noticed a value of 75-90%. Baculoviruses were used to prepare Virin ABB-3. The material was used to prepare the biological preparation Virin-ABB-3. Being analysed the biological effectiveness of the baculoviruses was 75-90%. The material was used to prepare the biological preparation Virin-ABB-3. Renovated sources of VPN and VG of year 2011 have been used for obtaining viral and experimental material with change of technologies of obtaining the viral preparations on the basis of these sources at the 2nd generation of *H.cunea* in year 2012. The researches point out *H. cunea* the critical stage and will be very useful for the baculovirus treatments management. The results of the experiments are presented in the table 5.

Table 5. The degree of infection of *H. cunea* with new baculovirus in 2011 (I-generation). Natural food - leaves of mulberry.
Tabel 5. Gradul de infectare de *H. cunea* cu baculovirus nou. Hrană naturală frunze de dud.

The options	Repetition	No. of larvae	Larvae age	Solution no. polyhedrons/ml	The mortality of day			
					7		15	
					No. of larvae	%	No. of larvae	%
VG 2011	I	50	II-III	10^5	24	48.0	39	78.0
VG 2011	II	50	II-III	10^5	25	50.0	41	82.0
VPN 2011	I	50	II-III	10^5	26	52.0	37	74.0
VPN2011	II	50	II-III	10^5	27	54.0	40	80.0
VPN±VG (1:1)	I	50	II-III	10^5	28	56.0	46	92.0
VPN±VG (1:1	II	50	II-III	10^5	28	56.0	44	88.0
Control	I	50	II-III	10^5	0	-	1	4.0
Control	II	50	II-III	10^5	0	-	2	6.6

However for early detection of the fall webworm and moth liquidation, and its further settling prevention it is necessary to know the development terms of the pest. For this aim the phenological calendars for the fall webworm moth allows solving other ecological problems, such as prognoses of pairing predictions for pests and entomophagous, precise determination of treatment terms, and number of generation in the given region. If the dynamics of the number of species according to the living conditions is a multifactorial process, then the number of environmental factors, which significantly influences the number of the populations of a species, is always much smaller. This situation can be explained by the fact that non-possessing the ability to adapt simultaneously to a large number of factors, the population is forced to organize its vital activity in order to avoid contact with the majority of limiting factors and to depend on a minimum number of factors. Thus, as the main factor influencing the development of the fall webworm moth is temperature, in connection with the fact that the most efficient treatments were carried out against younger larvae ages of the fall webworm moth we made the phenological calendar for the territory of the Republic of Moldova (Table 6). In order to achieve the calendar, the method of SERGEEV & LEVINA (1973) was used.

The calendar is used in this. Let's suppose that the beginning of egg deposition by fall webworm moth in Moldova occurs on the 15th of May, and the average air temperature in May of the current year is 1°C higher than the multiannual norm. Then at crossing of the first column of the 15th of May and of the column + 1°C we find the date of the appearance of the first larvae generation, namely the 26th of May. Protecţia plantelor impotriva Omizii paroase a dudului este mai eficientă atunci cand larvele sunt de varste mici. At an average deviation of the air temperature for the same period of time by 1 degree, the beginning of the emergence of fall webworm moth larvae will take place on the 30th of May. Normally the larvae do not emerge simultaneously from all laid eggs. The emergence process lasts for another 1-1.5 weeks. Plant protection against *H. cunea* larvae is the most efficient when the larvae are of younger ages. That is why the treatments should be carried out when the larvae emergence from all deposition is finished.

During this period a small part of larvae are at the third, the largest part at the second, and a part at the first stage. Using the presented calendar, it is possible to predict beforehand the terms for beginning protection treatments, that allows not only to prepare the necessary facilities and stock in due time but also to prepare the local human population. By the same

terms it is possible to begin cutting out the caterpillars found within the web feeding in the tree crown. Carrying out this work earlier than this term can lead to the case when a part of the nests will be not observed and destroyed. In consequence, the phenological calendar offers the possibility to precisely and the most advantageously use the protection means against the fall webworm moth, and to carry out the mechanical control by nest cutting out before the elder age larvae are settled.

Table 6. Phenological calendar rendering the beginning of *H.cunea* larvae hatching and the date recommended for the start of protective treatments with Virin ABB-3 depending on the actual dates of oviposition and temperature conditions.
Tabel 6. Calendar fenologic al începutului incubaţiei larvelor de *H. cunea* şi data de protecţie cu Virin-ABB-3 în funcţie de datele reale ale ovipoziţiei şi de condiţiile climaterice.

Date of the laying beginning	The actual deviation of the average air temperature for a part of the prognosticated period from the începerii tratamentelor multiannual mean, °C													
	0	The terms for carrying treatments	+1	The terms for carrying treatments	+2	The terms for carrying treatments	+3	The terms for carrying treatments	-1	The terms for carrying treatments	-2	The terms for carrying treatments	-3	The terms for carrying treatments
May 1	19	29	16	26	14	24	12	22	21	1.06	25	5.06	30	10.06
May 3	20	30	17	27	16	26	14	24	23	3.06	26	6.06	30	10.06
May 5	21	1.06	18	30	17	31	16	26	24	4.06	27	7.06	31	11.06
May 8	23	3.06	21	1.06	19	1.06	18	30	25	5.06	29	9.06	1.06	12.06
May 10	24	4.06	22	2.06	21	1.06	20	31	26	6.06	30	10.06	2.06	13.06
May 13	26	6.06	24	4.06	23	3.06	23	3.06	28	8.06	31	11.06	4.06	15.06
May 15	27	7.06	26	6.06	25	5.06	25	5.06	30	10.06	1.06	12.06	5.06	16.06
July 10	20	27	19	26	19	26	18	25	20	27	20	27	21	28
July 13	22	29	22	29	22	29	21	28	23	30	23	30	24	31
July 15	24	31	24	31	24	31	23	30	25	20	25	20	26	2.08
July 18	27	3.08	27	3.08	27	3.08	26	2.08	28	4.08	28	4.08	29	5.08
July 20	29	5.08	29	5.08	29	5.08	28	4.08	30	5.08	30	5.08	31	6.08
July 23	1.08	7.08	1.08	7.08	1.08	7.08	31	6.08	208	9.08	2.08	9.08	3.08	10.08
July 25	3.08	10.08	3.08	10.08	3.08	10.08	2.08	9.08	4.08	10.08	4.08	10.08	5.08	11.08
July 28	6.08	12.08	6.08	12.08	6.08	12.08	5.08	11.08	7.08	13.08	7.08	13.08	8.08	14.08
July 30	8.08	14.08	8.08	14.08	8.08	14.08	7.08	13.08	9.08	15.08	9.08	15.08	10.08	16.08

CONCLUSIONS

To effectively manage new invasive pest insects and prevent their further expansion, it is necessary to study in detail the biological and ecological aspects of the local insect populations. In addition, specific studies on the efficacy of the indigenous natural enemies and their ability to control or reduce possible outbreaks of the alien species have to be done. In the recent infestations of *H. cunea* in the forests of the Republic of Moldova, it will be important to perform complementary investigation of biological and ecological aspects before implementing microbiological control strategies. Further studies should be carried out on the distribution pattern and preferred host plants in the Republic of Moldova, on different sub-species and forms of the fall webworm are present in other countries. During the years 2004-2011 the fall webworm moth (*H. cunea*) is on average level of population development. Analysing the pest in relation with the environment factors it is established that it is greatly influence by the trophic factor (except for temperature). Analysing the sex index of fall webworm in in relation with the environment factors it is stated that it is influenced, to a large extend, by the trophic factor. On host ornamental and forest trees (mulberry (*Morus* L.), maple (*Acer negundo* L.), willow (*Salix* L.), poplar (*Populus alba*.L), and lime (*Tilia cordata* MILL.), the sex index of pupa varied between 0.33 in case of poplar (*Populus alba* L.) and 0.57 on maple (*Acer negundo* L.); as for butterflies, it ranged between 0.26 on lime and 0.62 on maple (*Acer negundo* L.). In case of host fruit – trees, the sex index of pupa varied between 0.35 on apricot-tree (*Prunus domestica* L.) and 0.49 on plum and in case of butterflies – between 0.33 on cherry-tree (*Prunus avium* L) and 0.48 on walnut (*Juglans regia* L.). Baculoviral improved product Virin ABB-3 was tested in laboratory against *H.cunea* larvae. In the report there are submitted the results of joint application of biological preparation Virin ABB-3. As to the mortality of the caterpillars on the VG 2011 reached 78-82%, VPN reached 74-80%. In the options there were used both viruses VG and VPN (1:1) and mortality increased from 88 % to 92%. Analysing the biological effectiveness of the baculoviruses we obtained a value of 75-90%. The material was used to prepare of biological preparation Virin-ABB-3. Renovated sources of VPN and VG of year 2011 have been used for obtaining viral and experimental material with change of technologies of obtaining the viral preparations on the basis of these sources at the 2nd generation of *H. cunea* in year 2012.The researches point out *H. cunea* critical stage and will be very useful for the baculovirus treatments management.

REFERENCES

ANONYMOUS. 2007. *Global invasive species database.* Available online at: http://www.issg.org/database/welcome/. (accessed: November 12, 2011).

BOGULEANU GH. 1968. *Cercetări asupra biologiei, ecologiei şi combaterii fluturelui alb american (Hyphantria cunea).* Institutul Agronomic „N. Balcescu", Bucureşti. Rezumatul tezei de Doctorat în Agronomie. 46 pp.

CIUHRII M. & ARMENESCU-CIUHRII E. 2008. *Virusul spaimă şi speranţa omenirii.* Edit. Mirabilis. Bucureşti. 248 pp.

CIUHRII M. & VOLOŞCIUC L. T. 1988. *Razrabotca metoda opredelenia infectionogo potentiala u virusov iadernogo poliedroza.* Pervii bolgaro- sovitschii simpozium po microbnim pestitidom. Plovdiv. 123 pp. [In Russian].

CIUHRII M., VOLOŞCIUC L. T, CATANA V. D, MENCER E. M. 1990. *Sistema metodov identificatii virusov iadernogo poliedroza.* Edit. Ştiinţa. Chisinev. 44 pp. [In Russian].

DEMIR I. & LIHNI D. 2006. *A productive Replication of Hyphantria cunea Nucleopolyhedrovirus in Lymantria dispar Cell Line.* Edit. Journal of Microbiology& Biotechnology Departament of Biology, Faculty of Arts and Sciences, Karadeniz Tehnical University, Trobzon, Turkey. **16**(10): 1485-1490.

DOSPEHOV B. A .1979. *Metodica polevogo opita.* Edit. Colos. Moscow. 338 pp. [In Russian].

GYOREY J. 1954. *Hyphantria cunea (Drury).* Edit. Erdeszeti Tudomanyos Intezet Evkonyve, Budapest. **2**: 183-198.

GAR C. A. 1963. *Metodi ispitania tochsicnosty i efectivnosty insectititov (pod red prof. Savzdara E.).* Edit. Seliscohoziastvenaia literatuea, Jurnalov i placatov. Moscow. 288 pp. [In Russian].

GOMI T. M., MURAJ I., TAKEDA M. 2004. *Mitochondrial DNA analysis of the introduced fall webworm, showing its shift in life cycle in Japan.* Edit. Takao Itioka and Kaoru Maeto. Entomology. Scince. **7:** 183-1.

GRICHANOV I. Y. & OVSYANNIKOVA E. I. *Interactive.* 2003. Agricultural Ecological Atlas of Russia and neighbouringcountries. Available online at: http://www.agroatlas.ru/en/content/pests/*Hyphantria cunea/*. (accessed: March 24, 2011).

HRUBIK P. 2007. *Alien insect pests on introduced woody plants in Slovakia.* Edit. Bulletin of the Entomological Society of the Kingdom of Serbs, Croats and Slovenes Acta entomologica Serbica. **12**(1): 81-85.

JAPOSHVILI G., NIKOLAISHVILI A., DZNELADZE N., GOGUADZE L. 2006. *The fall webworm (Hyphantria cunea) in western Georgia.* Proceedings of the Georgian Academy of Science. Biological Series, B. **4**(4): 122-126.

IZHEVSKIY S. & MASLIACOV V. 2002. *Prognozirovanie invazii cujerodnih rastitelinoiadnih nasicomih.* V cn. Sinantropizaţia rastenii i jivotnih. Ircutsk: SIFIBR RAN: 28-31.

KEAN J. M. & KUMARASINGHE L. B. 2007. *Predicting the seasonal physiology of fall webworm (Hyphantria cunea) in New Zealand.* Edit. New Zealand Plant Protection Society New Zealand Plant Protec. **60**: 279-285.

LI Y., GOTO M., ITO S., SATO Y., SASAKI K., GOTO N. 2001. *Physiology of diapause and cold hardiness in the overwintering pupae of the fall webworm Hyphantria cunea (Lepidoptera: Arctiidae) in Japan.* Edit. National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan. J. Insect Physiol. **47**: 1181-1187.

MANOLACHE C., BOGULEANU G., BRATU N. 1957. *Contribuţii la studiul biologiei şi combaterii omizii păroase a dudului (Hyphantria cunea Drury).* Edit. Didactică şi Pedagogică Bucureşti. In: Analele Institutului de Cercetări. Agronomice. **6**(25): 623-658.

MAZZON L. & MARTINI S. 2000. *Fall weborm Hyphantria cunea (DRURY).* Edit. Compagnia delle Foreste. Sherwood Foreste ed Alberi Oggi. **6**(11): 27-28.

NURIEVA I. 2002. *Bioecological abilities of parasitoids parasitising Hyphantria cunea (DRURY) (Lepidoptera, Arctiidae) in Azerbaijan.* Proceedings of the Fifth Turkish National Congress of Biological Control. 4-7 September 2002, Erzurum, Turkye: 161-166.

SĂVESCU A. & RĂFĂILĂ C. 1978. *Prognoza în protecţia plantelor.* Edit. Ceres. Bucureşti: 112-268.

SICURA A. I & CRASNITCAIA R. C. 1972. *Reproductia virusa granuleza americanscoi beloi babocchi.* Voprosi biologicescoi zacsiti rastenii. Edit. Colos. Moscow: 123-127. [In Russian].

STARET V. & IOROSENCO V. A. 1969. *Rastenia povrejdaemie americanscoi beloi babocchi.* Edit. CK CPM. Chisinev: 94-98.

VASILIEV C. V. & DOLGOPOLISCAIA N. L. 1973. *Cvantilinie diagram I ih ispolizovanie dlea haracteristichi osobenostei dinamichi jivotnih.* Edit. Tr.VIZR. Leningrad. **39**: 107-119. [In Russian].

VOLOŞCIUC L. T. 2007. *Soluţionarea Problemelor Fitosanitare în promovarea Agriculturii Ecologice.* Materiale simpozionului ştiinţific International "Realizări şi perspective în orticultură, viticultură, vinificaţie şi silvicultură". Chişinău: 226-230.

VOLOŞCIUC L. T. 2009. *Biotehnologia producerii şi aplicării preparatelor baculovirale în protecţia plantelor.* Edit Î.E.P. Ştiinţa. Chişinău. Mediul ambiant: 262.

VOLOSCIUC L. T. 2010. *Problemele identificării şi ameliorării baculovirusurilor.* Buletinul AŞM, Ştiinţele vieţii.**1**: 96.

WARREN L. O. & TADIC M. 1970. *The Fall Webworm, Hyphantria cunea (DRURY).* Edit. University of Arkansas System's Division of Agriculture.Agricultural Experiments – Station Bulletin. **759**: 1-106.

WITTENBERG R. 2005. *An inventory of alien species and their threat to biodiversity and economy in Switzerland.* Edit. Forests and Landscape SAEFL. Switzerland. CABI Bioscience Switzerland Centre report to the Swiss Agency for Environment, Forests and Landscape. 416 pp.

YANG Z. Q. & ZHANG Y. A. 2011. *Researches on techniques for biocontrol of the fall webworm, Hyphantria cunea, a severe invasive insect pest to China.* Editorial Board of Chinese Bulletin of Entomology. Beijing. China. **44**: 465-471.

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THE PARASITOID COMPLEX OF *Eupoecilia ambiguella* (LEPIDOPTERA: TORTRICIDAE) IN A VINEYARD OF SOUTHERN ROMANIA

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Abstract. Investigating the rearing of the grape moth *Eupoecilia ambiguella* from the larvae and pupae collected in a vineyard of southern Romania. 6 hymenopterans species have been obtained as primary parasitoids. The role played by these parasitoids in the limitation of the host populations is 11.39%. The small number of species identified and the reduced efficiency of the parasite complex of the species *E. ambiguella* in that vineyard can be caused by the poor representation of the host population due to the rather unpropitious climatic conditions for the development of the species, as well as by the treatments conducted over the years, which prevented the gradual strengthening of a set of specific host-parasitoid relationships. *Dibrachys boarmiae* - *E. ambiguella* relationship is new to science. To conclude, the parasitoid complex of the species *Eupoecilia ambiguella* is still insufficiently known in Romania.

Keywords: grape moth, parasitoids, percentage of parasitizing, relationship.

Rezumat. Complexul parazitoid al speciei *Eupoecilia ambiguella* (Lepidoptera: Tortricidae) într-o vie din sudul României. 6 specii de himenoptere parazitoide au fost obţinute ca parazitoizi primari în urma creşterii de larve şi pupe ale moliei strugurilor *E. ambiguella* colectate dintr-o podgorie din sudul României. Rolul jucat de aceşti parazitoizi în reducerea populaţiilor gazdei este de 11.39%. Numărul mic de specii identificate şi eficienţa redusă a complexului parazitar al speciei *E. ambiguella* în această podgorie pot fi cauzate de slaba reprezentare a populaţiei gazdă, datorită condiţiilor climatice mai puţin favorabile, precum şi a tratamentelor efectuate de-a lungul anilor, fapt ce nu a permis întărirea în timp a unor relaţii specifice gazdă – parazitoid. Relaţia *Dibrachys boarmiae* - *E. ambiguella* este nouă pentru ştiinţă. În concluzie, complexul de parazitoizi al speciei *Eupoecilia ambiguella* rămâne puţin cunoscut în România.

Cuvinte cheie: molia strugurilor, parazitoizi, procentaj de parazitare, relaţie.

INTRODUCTION

Polyphagous microlepidoptera *Eupoecilia ambiguella* (HÜBNER 1796) or *Cochylis* have caused significant damage to European vineyards over the centuries. For effective control of their population, research on the pest has also targeted the natural enemy complex. Laborde, in 1900 (VOUKASSOVITCH, 1924), was the first to signal the role of the Ichneumonidae in destroying hibernating chrysalides, with 31-35%. Catoni in the early 20th century (GALET, 1982) studied in Italy the *Cochylis* complex of parasitoids and identified 26 species. Subsequently, in France, VOUKASSOVITCH (1924) found that, largely, parasitoids are similar to those of the *Lobesia botrana* (DENIS & SCHIFFERMÜLLER, 1776) species.

THOMSON (1957) synthesized the parasitoid species signalled so far in the world and submitted a list of 58 species of Hymenoptera and Diptera-Tachinidae.

Geoffrion (in GALET, 1982) noted in 1951 that chrysalis parasitism of *E. ambiguella* in the Loire Valley reached 85%, situation suspected by Gallet as exaggerated. Coscolla & Dalla Monta submitted a list of the grape moth parasitoids, the most abundant species being *Dibrachys affinis* MASI, 1907, which can parasitize up to 8a5% of the hibernating chrysalides of *E. ambiguella* and *L. botrana* (ROEHRICH & SCHMID, 1979). In Germany, SENGONCA & LEISSE (1988) obtained four species of parasitoids from pupae of *Cochylis*.

SCHIRRA & LOUIS (1995), on the occasion of the study on parasitoids of the *Sparganothis pilleriana* (DENIS & SCHIFFERMÜLLER, 1776) species, found that in the German vineyards over 43% of the hibernating *Cochylis* pupae had been parasitized, the Ichneumonidae having the largest weight. COLOMBERA *et al.* (2001) studied the parasitoids of *E. ambiguella* and *L. botrana* in northwestern Piedmont (Italy) and obtained 16 species from larvae and pupae of both hosts.

In Romania, data on *Cochylis* parasitoids come from Moldavia, as a result of significant populations registered in those vineyards. Thus, LEON (1912) obtained from the host larvae and pupae, the *Itoplectis alternans* (GRAVENHORST, 1829), *Pimpla instigator* (FABRICIUS, 1793), *Aritranis confector* (GRAVENHORST, 1829), *Campoplex difformis* (GMELIN, 1790) species. PETCU (1978) obtained the *Diadegma tenuipes* (THOMSON, 1887) species from the host larvae.

LUCA (1981) and ALI (1982), following the research carried out in the vineyards of Bucium, obtained 4 species of ichneumonidae: *Itoplectis alternans* GRAV., *I. maculator* (FABRICIUS, 1775), *Diadegma armillata* (GRAVENHORST, 1829) and *D. varians* (BRISCHKE, 1880). The percentage of parasitizing ranged between 8 and 34%.

Such studies allow highlighting the species of parasitoids with an important role in reducing the host populations. Their subsequent use in biological pest fight programs contributes to the reduction of pesticide used. Consequently, the environmental damage is greatly diminished and thus the quality of food and life increases.

MATERIAL AND METHODS

The observations were carried out in the Ştefăneşti vineyard, Argeş County, situated in South-Central part under the Southern Carpathian Mountains and characterized by a temperate climate; the grape moth has two generations and a small population (BĂRBUCEANU & ANDRIESCU, 2005). The samples have been taken from three (3) vineyards with different neighbourhoods. Thus, Ştefăneşti-Valea Mare vineyard is located next to the forest, while Ştefăneşti-Viişoara and Ştefăneşti-Fitotron are located on a plateau surrounded by other vineyards. The vineyard was treated intensively with pesticides in that period (Table 1). The collection was done during the whole period of activity, in winter including, when the host lives as chrysalis. Only 79 larvae and pupae were growing under laboratory conditions, after isolated and observed until the apparition of adult parasitoids. Subsequently, microlepidoptera populations have decreased substantially, so that in 2009-2010, from those vineyards there were collected only two (2) larvae; none was parasitized.

Table 1. Insecticide treatments regime in the vineyard of Ştefăneşti.
Tabel 1. Regimul tratamentelor cu insecticide în podgoria din Ştefăneşti.

Year	Date of treatment	Generation*	Insecticide
1997	May 26-31	G_1	Neoron 0.600 l/ha
	June 23-26	G_2	Danirun 0.600 l/ha
1998	June 1-7	G_1	Kelthane 1.2 l/ha
1999	May 24-29	G_1	Mitigan 0.2%/ha
2000	May 25-31	G_1	Neoron 0.250 ml/ha
	June 19-26	G_2	Mitigan 0.2%/ha
2001	May 26-31	G_1	Neoron 0.600 l/ha
	June 23-26	G_2	Danirun 0.600 l/ha

Legend: G_1 and G_2 are the generations of grape moth *Eupoecilia ambiguella* and *Lobesia botrana*.

RESULTS AND DISCUSSIONS

From the collected larvae and pupae of *Eupoecilia ambiguella,* we obtained 6 species of primary parasitoids belonging to the Hymenoptera. Among them, 5 species belongs to the Ichneumonidae and one species to the Pteromalidae. A single species was obtained as larval parasitoids - *Endromopoda detrita* (HOLMGREN, 1860). For the first time, for 5 of them there are presented quantitative aspects of the parasitic performance in a vineyard from Romania.

During the period of investigation, these species were found parasitizing 11.39% from the larvae and pupae of grape moth (Table 2). The family Ichneumonidae has the largest contribution to reducing the *Eupoecilia ambiguella* population in Ştefăneşti-Arges vineyards, with a percentage of parasitizing of 10.13%. *Scambus vesicarius* (RATZEBURG, 1844) and *Pimpla spuria* GRAVENHORST, 1829 were the most important parasitoids.

The data about the recorded parasitoids have been arranged in the following order: locality/stage of host/collecting date/date of emergence/individuals (♀ and ♂) obtained.

ICHNEUMONIDAE family

Endromopoda detrita (HOLMGREN, 1860) was reared as a larval, solitary, primary ectoparasitoid in Ştefăneşti-Valea Mare/larva/June 27, 1998/July 11, 1998/1♂.

It is known from this host by CATONI in 1910 (GALET, 1982). This polyphagous species is known as primary parasitoid from many species of Curculionidae, Aegeriidae, Tortricidae, Pyralidae (Lepidoptera), Chloropidae (Dip.), and Cynipidae (Hymenoptera).

In Romania it was obtained from *Lixus elegantulus* BOHEMAN, 1842 (Curculionidae) (PISICĂ, 2001) and *E. ambiguella* (PISICĂ & PĂIŞESCU-BĂRBUCEANU, 2002).

Upon collection, the larva of *E. ambiguella* was almost sucked and presented an ectoparasite larva of about 6 mm, white–pink. In laboratory condit.,edţâî ions, the ectoparasite larva kept on feeding, and on July 1, 1998, it began to make up its cocoon for nymphosis. After one day, it was ready and the nymphosis lasted nine (9) days, until July 11, when the adult hatched.

The role of this parasitoid in limiting of the host populations was 1.27% (Fig. 1).

Scambus vesicarius (RATZEBURG, 1844) was reared as a pupal, solitary, primary endoparasitoid in: Ştefăneşti-Valea Mare/pupa/June 27, 1998/July 8, 1998/1♀; Ştefăneşti-Valea Mare/pupa/June 27, 1998/July 9, 1998/1♀.

It is a polyphagous species known from species of Tischeriidae, Tortricidae, (Lepidoptera), Tenthredinidae and Cynipidae (Hymenoptera). HOFFMANN & MICHL (2002) had mentioned it as parasitoid of *L. botrana* and *E. ambiguella.*

In Romania, it was obtained from *Malacosoma neustria* (LINNAEUS, 1758) (PISICĂ, 2001) and *E. ambiguella* (PISICĂ & PĂIŞESCU-BĂRBUCEANU, 2002).

In the summer of 1998, in the vineyard Ştefăneşti-Valea Mare, it reduces the host population by 12.5%.

Itoplectis alternans (GRAVENHORST, 1829) was reared as a pupal, solitary, primary endoparasitoid in: Ştefăneşti-Viişoara/pupa/February 11, 1997/February 24, 1997/1♂.

It is known from this host as primary parasitoid in Italy (CATONI, 1910 in GALET, 1982; MARCHESINI & MONTA, 1994). In Germany, according to SENGONCA & LEISSE (1988) it was the most important parasite making up to 75 per cent of all parasites.

This polyphagous species is known in Romania as primary parasitoid from many Lepidoptera (PISICĂ, 2001) and as secondary parasitoid from Ichneumonidae, Braconidae and Tachinidae cocoons (DIACONU, 1999; PISICĂ, 2001).

It was obtained in Moldova by LEON (1912), LUCA (1981) and ALI (1982) from *E. ambiguella* pupae.

The parasitizing ratio was only 1.27%.

Pimpla contemplator (MÜLLER, 1776) was reared as a pupal, solitary, primary endoparasitoid in: Ştefăneşti-Valea Mare/pupa/June 27, 1998/July 9, 1998/1♀.

It is a polyphagous species, obtained in Romania as primary parasitoid from many Lepidoptera (PISICĂ, 2001) and as secondary parasitoid from a cocoon of *Macrocentrus pallipes* NEES, 1811 (Braconidae) (DIACONU, 1999).

THOMSON (1957) did not mention it among the parasitoids of this host.

According to PISICĂ & PĂIŞESCU-BĂRBUCEANU (2002), the host-parasitoid relationship is new to science.

The role of this parasitoid in limiting of the host populations was reduced: 1.27%.

Pimpla spuria GRAVENHORST, 1829 was reared as a pupal, solitary, primary endoparasitoid in: Ştefăneşti-Viişoara/pupa/February 11, 1997/March 21, 1997/1♂; Ştefăneşti-Viişoara/pupa/ February 11, 1997/March 21, 1997/1♂.

It is a polyphagous species reared from this host in Europe (CATONI, 1910) (in GALET, 1982). HOFFMANN & MICHL (2002) had mentioned it as parasitoid of *L. botrana* and *E. ambiguella.*

In Romania it is known from several Lepidoptera (PISICĂ, 2001). According to PISICĂ & PĂIŞESCU-BĂRBUCEANU (2002), the host-parasitoid relationship is new for Romania.

These pupae were parasitized during fall, when parasitoids seek hosts for winter, which explains the extensivity of infestation: 18.18%. Thereby, VOUKASSOVITCH (1924) states that the most of the parasitoid species are reared from *E. ambiguella* and *L. botrana* hibernating pupae.

The parasitizing ratio of *E. ambiguella* populations was 2.53%.

PTEROMALIDAE family

Dibrachys boarmiae (WALKER, 1863) was reared as a pupal, gregarious, primary endoparasitoid in: Ştefăneşti-Viişoara/pupa/February 11, 1997/February 26, 1997/5 ♀♀; 3♂♂.

It is a polyphagous species, known as primary parasitoid from species of Pyralidae, Oecophoridae (Lepidoptera), Anobiidae, Ptinidae, Bruchidae (Coleoptera), and as secondary parasitoid from cocoons of Braconidae (TRJAPITZYN, 1978).

Eight larvae, of about 1 mm and white-coloured, were found in a pupa of *E. ambiguella* collected on February 11, 1997 in the locality of Ştefăneşti, its content being entirely consumed. In laboratory conditions, after about seven (7) days the larvae turned into nymphs and after another week, turned into adults. *D. boarmiae* hibernates as mature larva in the hibernating stages of the hosts.

The parasitizing ratio was 1.27% (Fig. 1).

In Romania, this species was obtained for the first time by rearing.

The host-parasitoid relationship is new to science.

The effect of chemical treatments on *Eupoecilia ambiguella* parasitoids

In the Ştefăneşti locality, chemical treatments and unfavourable climate contributed to the reduction of the population of these microlepidoptera.

In terms of the year 1998, favourable to the development of the *E. ambiguella* species (BĂRBUCEANU & ANDRIESCU, 2005) there were identified two sites of collection: the vineyard of the Ştefăneşti-Viişoara, where a parasitizing percentage of only 3.85% was achieved and the vineyard of the Ştefăneşti-Valea Mare village with a parasitizing percentage of 25% (Table 1). Although both sites belonged to the Ştefăneşti vineyard research station and were subjected to the same regime of chemical treatments, the parasitizing difference was due to different ecological neighbourhoods. In this case, the forest, which is located near the vineyard of the Valea Mare, could be, on the one hand, a refuge for parasitoid species of that vineyard, and on the other hand, a source of repopulating the vineyard with the parasitoids living there.

Thus, the forest edge or protection curtains may constitute temporary feeding and sheltering sites for entomofauna and, at the same time, effective sources of repopulating the cultures depleted by treatments.

However, as GALET (1982) noted due to the monocultural character of most vineyards where *E. ambiguella* is found, parasitism that can affect the eggs, larvae and chrysalides remains insignificant and insufficient to play a considerable limiting role.

Table 2. Primary parasitoids obtained from the larvae and pupae of *Eupoecilia ambiguella* and their role in the limitation of host populations in Ştefăneşti (Argeş) vineyard.
Tabel 2. Parazitoizii primari obţinuţi din larve şi pupe de *E. ambiguella* şi rolul lor în reducerea populaţiilor gazdei în podgoria Ştefăneşti (Argeş).

Place	Date of collection	No. of ind.	Primary parasitoids																	
					ICHNEUMONIDAE														PTEROMALIDAE	
			No.	%	No.	%	*Endromopoda detrita*		*Scambus vesicarius*		*Itoplectis alternans*		*Pimpla spuria*		*P. contemplator*		Ihn. non-emerging		*Dibrachys boarmiae*	
							No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ştefăneşti-Viişoara	11.02.1997	11	4	36.36	3	27.27	-	-	-	-	1	9.09	2	18.18	-	-	-	-	1	9.09
	19.06.1997	2	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL 1997		13	4	30.76	3	23.07	-	-	-	-	1	7.69	2	15.38	-	-	-	-	1	7.69
Ştefăneşti-Viişoara	8.06.1998	2	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11.06.1998	8	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	15.06.1998	10	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	22.06.1998	1	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30.06.1998	5	1	20.00	1	20.00	-	-	-	-	-	-	-	-	-	-	1	20.0	-	-
SUBTOTAL 1998		26	1	3.85	1	3.85	-	-	-	-	-	-	-	-	-	-	1	3.85	-	-
Ştefăneşti-Valea Mare	27.06.1998	16	4	25.00	4	25	1	6.25	2	12.5	-	-	-	-	1	6.25	-	-	-	-
TOTAL 1998		42	5	11.90	5	11.90	1	2.38	2	4.76	-	-	-	-	1	2.38	1	2.38	-	-
Ştefăneşti-Viişoara	2.06.2000	5	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	9.06.2000	4	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL 2000		9	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ştefăneşti-Fitotron	25.07.2001	3	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11.09.2001	6	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ştefăneşti-Viişoara	31.07.2001	1	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.08.2001	2	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	21.08.2001	2	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13.12.2001	1	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL 2001		15	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL		**79**	**9**	**11.39**	**8**	**10.13**	**1**	**1.27**	**2**	**2.53**	**1**	**1.27**	**2**	**2.53**	**1**	**1.27**	**1**	**1.27**	**1**	**1.27**

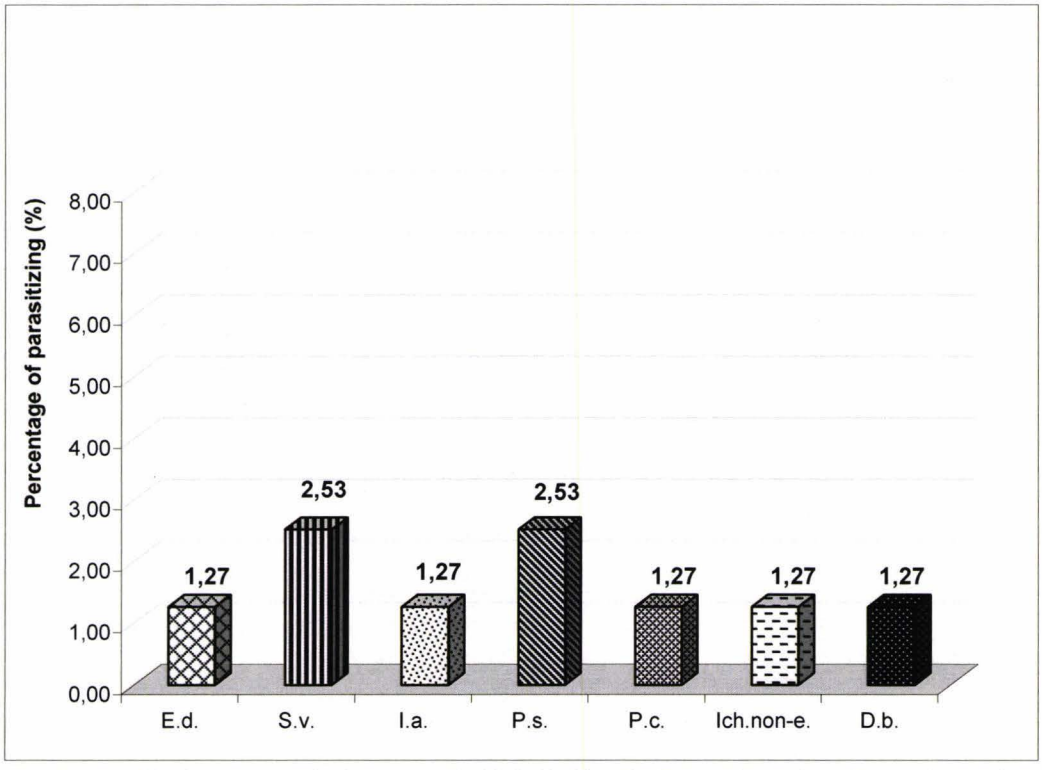

Figure 1. The importance of primary parasitoids in limiting the *Eupoecilia ambiguella* populations.
Figura 1. Importanţa parazitoizilor primari în reducerea populaţiilor de *E. ambiguella*.

Legend: E.d. – *Endromopoda detrita*; S.v. – *Scambus vesicarius*; I.a. – *Itoplectis alternans*; P.s. – *Pimpla spuria*; P.c. – *Pimpla contemplator*; Ich. non-e. – non-emerging Icheumonidae; D.b. – *Dibrachys boarmiae*

CONCLUSIONS

Since in this region, the pest populations remains low, it will be controlled by a small number of parasitoids, generally by polyphagous species that also find other alternative hosts in that area.

Of the six (6) species of parasitoids obtained, only *Itoplectis alternans* GRAV. has already been mentioned in Romania.

The small number of species identified and the reduced efficiency of the parasite complex of the species *Eupoecilia ambiguella* in that vineyard can be caused by the poor representation of the host population due to the rather unpropitious climatic conditions for the development of the species, as well as by the treatments conducted over the years, which prevented the gradual strengthening of a set of specific host-parasitoid relationships.

On the other hand, despite the chemical treatment, parasitoids still remain in the vineyards, but with small parasitizing percentages, to them also contributing the location of the vineyards where observations were made, near the forest.

To conclude, the parasitoid complex of the species *Eupoecilia ambiguella* is still insufficiently known in Romania.

REFERENCES

ALI M. A. 1982. *Tortricide şi Cochilide dăunătoare viţei de vie în Moldova-România (studiul sistematic, biologic, ecologic, economic şi combatere.* Teză de doctorat - rezumat. Facultatea de Agronomie. Iaşi. 28 pp.

BĂRBUCEANU DANIELA & ANDRIESCU I. 2005. *Contribuţii la studiul biologiei şi ecologiei moliei strugurilor Eupoecilia ambiguella Hb. (Lepidoptera: Tortricidae) în condiţiile podgoriei Ştefăneşti-Argeş.* Lucrări ştiinţifice, seria Horticultură USAMV Iaşi. Anul XLVII. **48**(1): 1175-1180.

COLOMBERA S. ALMA A. & ARZONE A. 2001. *Comparison between the parasitoids of Lobesia botrana and Eupoecilia ambiguella in conventional and integrated vineyards.* Integrated Control in Viticul<ture IOBC wprs Bulletin. **24**(7): 91 - 96. Available online at: http://www.iobc-wprs.org/pub/bulletins/iobc-wprs_bulletin_2001_24_07.pdf (accessed: February 02, 2011).

DIACONU A. 1999. *Contribuţii la studiul complexelor parazitare (Insecta) ca factori de reglare ai populaţiilor de tortricide foliofage (Insecta: Lepidoptera, Tortricidae) dăunătoare pomilor fructiferi.* Teză de doctorat. Facultatea de Biologie, Universitatea "Al. I. Cuza", Iaşi. 372 pp.

GALET P. 1982. *Les maladies et les parasites de la vigne.* Tome II, Montpellier: 1473-1607.

LEON N. 1912. *Contribuţiuni la studiul insectei Cochylis ambiguella Hb. în România.* Analele Academiei Române, Bucureşti. **35**(6): 53-82.

LUCA N. 1981. *Contribuţii la studiul sistematic: biologie, ecologie şi combaterea lepidopterelor dăunătoare la cultura viţei de vie în podgoria Bucium-Iaşi.* Teză de doctorat – rezumat. Facultatea de Agronomie, Iaşi. 26 pp.

HOFFMANN C. & MICHL G. 2002. *Etablierung eines Anbausystems pilztoleranter Rebsorten fur den okologischen Weinbau.* 112 pp. Available online at: http://www.landwirt_schaft-mlr.baden-wuerttemberg.de, PDF (accessed: February 02, 2011).

MARCHESINI E. & MONTA L. D. 1994. *Observations on natural enemies of Lobesia botrana (Den. et Schiff (Lepidoptera, Tortricidae) in Venetian vineyards.* Bolletino di Zoologia Agraria e di Bachicoltura. Milano. **26**(2): 201-230

PETCU I. 1978. *Specii de Ichneumonidae (Hym.) obţinute prin culturi din diferite insecte dăunătoare II,* Analele Ştiinţifice ale Universităţii "Al. I. Cuza". Biologie. Iaşi. **24**: 79-80

PISICĂ C. 2001. *Ichneumonidele (Hymenoptera, Insecta) din România şi gazdele lor. Catalog.* Edit. Universităţii "Al. I. Cuza". Iaşi. 406 pp.

PISICĂ C. & PĂIŞESCU-BĂRBUCEANU DANIELA. 2002. *Himenoptere parazitoide (Fam. Ichneumonidae) la moliile strugurilor.* Argessis. Studii şi comunicări, seria Ştiinţele Naturii. Muzeul Judeţean Argeş. Piteşti **9-11**: 207-211.

ROEHRICH R. & SCHMID A. 1979. *Lutte integree en viticulture. Tordeuses de la grappe: evaluation du risque, determination des periodes d' intervention et recherche de methodes de lutte biologique.* Proceedings, International symposium organized by IOBC/WPRS on Integrated Plant Protection in Agriculture and Forestry, Vienna: 245-254.

SENGONCA C. & LEISSE N. 1988. *Occurrence and importance of pupae parasites of the grape berry moth Eupoecilia ambiguella Hb. in the Ahr-valley.* Journal of Applied Entomology. Germany. **106**(2): 173-176. Available online at: http://agris.fao.org/agris-search/search/display.do?f=1989/DE/DE89099.xml;DE88U0651 (accessed: January 05, 2012).

SCHIRRA K.J. & LOUIS F. 1995. *Auftreten von naturlichen Antagonisten des Springwurmwicklers Sparganothis pilleriana in der Pfalz.* Deutsches Weinbau-Jahrbuch. **46**: 129-140.

THOMPSON W. R. 1957. *A catalogue of the Parasites and Predators of Insects pests, Section 2, Part 4. Host of the Hymenoptera (Ichneumonidae).* Commonwealth Institute of Biological Control. Ottawa, Canada. 561 pp.

TRJAPITZYN V. A. 1978. *Oprediteli Nasekomikh Evreopeyskoy Chasti SSR.* In: Medvedev G. S. (Ed.): Hymenoptera. Tom III. The Science. Leningrad. 759 pp.

VOUKASSOVITCH P. 1924. *Contribution a l'etude de l'Eudemis (Polycrosis botrana Schiff), de la Pyrale de la Vigne (Œnophthira pilleriana Schiff.) et de leurs parasites.* These. Librairie Marqueste, Toulouse. 248 pp.

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RESEARCH ON THE CHANGES OF SOME PHYSIOLOGICAL PARAMETERS IN PRUSSIAN CARP (*Carassius auratus gibelio* BLOCH 1782) UNDER THE ACTION OF PHENOL

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Abstract. Phenol and its compounds are ubiquitous water pollutants, which come to the natural water resources from the effluents of a variety of chemical industries and industries of resin, paint, textile, leather, petrochemical, causing ecological unbalance. In this paper we study the action of phenol, under different concentrations 1.2 mg phenol / l water, 2.4 mg phenol / l water on some physiological parameters on Prussian carp (*Carassius auratus gibelio* BLOCH 1782). Phenol had an increasing effect on oxygen consumption for the Prussian carp. In all concentrations, phenol modified the values of breathing frequency (the phenol effect is stimulating at first and then inhibits breathing frequency).

Keywords: phenol, Prussian carp, oxygen consumption, breathing frequency, number of erythrocytes.

Rezumat. Cercetări privind modificările unor parametri fiziologici la caras (*Carassius auratus gibelio* BLOCH 1782) sub acţiunea fenolului. Fenolul şi compuşii fenolici sunt poluanţi omniprezenţi în apă, care ajung în resursele naturale de apă din efluenţii evacuaţi din industriile chimice şi industriile de răşină, vopsea, textile, piele, petrochimie, cauzând un dezechilibru ecologic. În această lucrare am studiat acţiunea fenolului în diferite concentraţii (1.2 mg fenol / l apă, 2.4 mg fenol / l apă) asupra unor parametri fiziologici la caras (*Carassius auratus gibelio* BLOCH 1782). Fenolul a avut un efect inhibitiv asupra consumului de oxigen al carasului. În toate concentraţiile studiate fenolul a modificat valorile ritmului respirator (efectul fenolului este stimulator la început, după care frecvenţa mişcărilor respiratorii scade).

Cuvinte cheie: fenol, caras, consum de oxigen, frecvenţa mişcărilor respiratorii, număr eritrocite.

INTRODUCTION

Phenols and phenolic substances are aromatic hydroxyl compounds classified as monohydric or polyhydric, depending on the number of hydroxyl groups attached to the aromatic benzene ring (MCNEELY *et al.*, 1979). The chemical formula for phenol is C_6H_5OH. Phenols are a major by-product of the pulp and paper, mineral, chemical, steel and metal, and petroleum industries. Phenols are used as disinfectants, biocides, dyes, pesticides, medical and industrial organic chemicals. Phenols may occur naturally in aquatic environments from the decomposition of aquatic vegetation (DOBBINS *et al.*, 1987). The major anthropogenic sources are industrial effluents and domestic sewage. Phenolic wastes may contain cyanide, aldehydes, ketones, alcohols, organic acids, and gases (ALABASTER & LLOYD, 1982).

Fish toxicity studies comparing the various phenols report differential toxicity (DEVI & SASTRY, 1987). Acute toxicities for *Daphnia magna* (MÜLLER 1785) include a 96-h LC50 of 2.12 mg*L-1 2.4-dimethylphenol and a 96-h LC50 of 4 mg*L-1 phenol (EWELL *et al.*, 1986). Other 48-h values for phenol include a LOEL of 0.19 mg*L-1 for the rotifer *Brachinous calyciflorus* (PALLAS 1766) (SNELL & MOFFAT, 1992) and an LC50 of 3.1 mg*L-1 for *Ceriodaphnia dubia* (RICHARD 1894) (ORIS *et al.*, 1991). BRADBURY (1989) reported the occurrence of severe seizures, mediated by the central nervous system, in *Salmo gairdneri* (WALBAUM 1792) after exposure to sublethal phenol concentrations.

Phenols are pollutants in aquatic environments. KOBAYASHI & AKITAKE (1975) reported that fish are able to excrete phenol rapidly. Kinetic studies are of interest because there are two different phases of elimination of phenols from goldfish. According to FORSTER & GOLDSTEIN (1969), gills of fishes ostensibly do not provide an efficient way of elimination even for readily diffusible foreign substances. Dogfish excrete foreign compounds to a limited degree through gills (ADAMSON & SIEBER, 1974).

Phenols penetrate into surface waters with industrial effluents, especially the waste waters from the thermal processing of coal, from petroleum refineries, from the production of synthetic fabrics and other industrial segments.

This study was carried out to analyze the effects of sublethal and lethal concentrations of phenol on some physiological parameters of the Prussian carp (*Carassius auratus gibelio*).

MATERIAL AND METHODS

In all the variants, Prussian carp (*Carassius auratus gibelio*) was captured from the surrounding lakes of Piteşti. After 10 days of adaptation in the lab, where they were fed ad libitum once a day, the fish were separated in lots. The phenol concentrations that were used had been established by preliminary survival tests. The fish were immersed in these solutions, which had been well stirred and aired for five minutes. The water temperature was between 18°C and 20°C, the immersion solution was changed every 24 hours and the water was continuously aired. The energetic metabolism, expressed by the oxygen consumption, was determined by using the closed respiratory chamber method (the oxygen dose in the water was established by using the Winkler chemical method) (PICOŞ & NĂSTĂSESCU, 1988). These determinations were made at intervals of 24, 48, 72, 96, 168 and respectively 336 hours. In some cases the determinations were made at intervals shorter

than 24 hours from immersion. The breathing frequency was determined at the same intervals as in the case of the energetic metabolism. The number of erythrocytes was microscopically determined with a Thoma cells numbering chamber, by using a small amount of blood collected from the caudal artery (PICOŞ & NĂSTĂSESCU, 1988). The measurements were carried out only for the 14 day treatments with Prussian carp individuals subjected to concentrations of 1.2 mg phenol / l water and 2.4 mg phenol / l water.

RESULTS

For a better comparison between the toxic effects of phenol in the concentrations investigated, the average frequency of respiratory movements and oxygen consumption were represented graphically in figure 1 and figure 2.

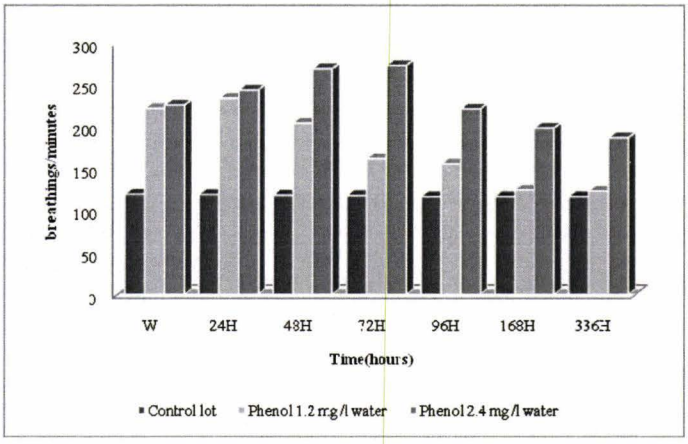

Figure 1. The influence of phenol upon breathing frequency on Prussian carp (*Carassius auratus gibelio*).
Figura 1. Influenţa fenolului asupra frecvenţei respiratorii la caras (*C. auratus gibelio*).

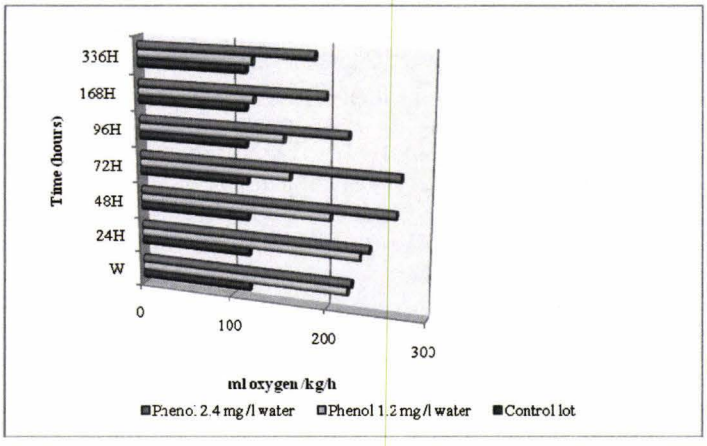

Figure 2. The influence of phenol upon oxygen consumption on Prussian carp (*Carassius auratus gibelio*).
Figura 2. Influenţa fenolului asupra consumului de oxigen la caras (*C. auratus gibelio*).

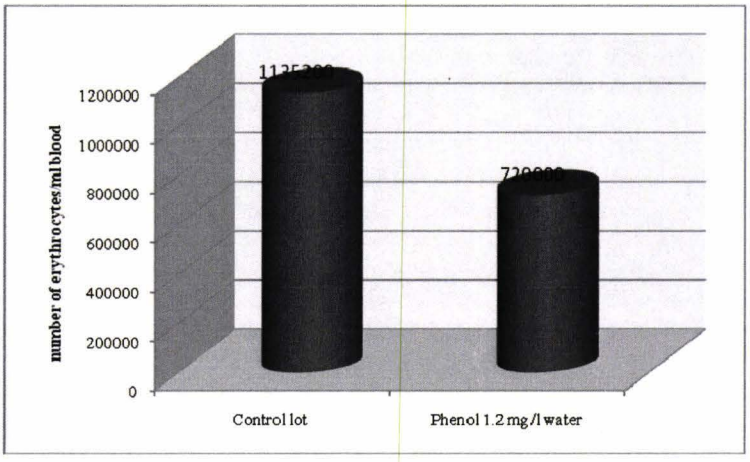

Figure 3. Number of erythrocytes of Prussian carp (*Carassius auratus gibelio*) after 14 days of exposure to phenol.
Figura 3. Numărul eritrocitelor la caras (*C. auratus gibelio* B) după 14 zile de expunere.

DISCUSSIONS

The most important sublethal acute effects observed in freshwater species after phenol exposure were a reduced heart rate and damage to the epithelium of gills, liver, kidneys, intestines and blood vessels. Direct contact between the aquatic environment and the gill epithelium may cause these surfaces to become sensitive to environmental alteration in the presence of toxic materials or other irritants.

Phenol changed the respiratory rhythm of Prussian carp in all investigated concentrations. For all concentrations tested, the effect of phenol was initially stimulating and then inhibitory as regards the frequency of respiratory movements.

The stimulating effect of respiration was maintained for 24 hours after exposure to two concentrations, the strongest stimulation being recorded after 48 hours of exposure to the concentration of 2.4 mg/l water.

Figure 2 shows the average oxygen consumption at Prussian carps (*Carassius auratus gibelio*) exposed to phenol in different concentration for 14 days. At the concentration of 2.4 mg/l water, stimulatory effect was found in the first 72 hours, at first concentration, with 17.44% as compared to the control lot, after which oxygen consumption decreased steadily to a value of 20.98% as compared to the control lot.

Haematological studies in fishes have assumed greater significance because these were to be used as an effective and sensitive index to monitor physiological and pathological changes induced by natural or anthropometric factors. Haematological analysis can provide important information about the internal environment of the organism (MASOPUST, 2000).

After two weeks of exposure to the phenol concentrations of 1.2 mg/l water, the number of erythrocytes in Prussian carp decreased to 63.43% as compared to the control groups (Fig. 3). It can say that these concentrations produce haemolysis, is impaired erythropoiesis.

CONCLUSIONS

Phenol in concentrations of 1.2 mg/l water and 2.4 mg/l water had an overall stimulating effect on oxygen consumption of Prussian carps (*Carassius auratus gibelio*) in the first phase followed by restoration of energy metabolism after 14 days of exposure to toxic.

In all concentrations studied, phenol significantly changed the values of the respiratory rhythm at Prussian carp (*Carassius auratus gibelio*) during the acute test (96 hours), the toxic effects being initially stimulating, followed by reducing the physiological parameter values after 14 days of exposure to phenol were in most cases very close to control.

The phenol, in a concentration of 1.2 mg/l water, has produced a significant decrease in the number of erythrocytes.

ACKNOWLEDGMENT

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REFERENCES

ADAMSON R. H. & SIEBER S. M. 1974. In: KHAN M. A. Q. & BEDERKA J. P. (Eds.) *Survival in Toxic Environments*. Edit. Academic Press. New York and London. 203 pp.

ALABASTER J. S. & LLOYD R. 1982. *Water quality criteria for freshwater fish*. 2nd Edition. Food and Agriculture Organization of the United Nations. Edit. Butterworths Scientific. London. 361 pp.

BRADBURY S. P., HENRY T. R., NIEMI G. J., CARLSON R. W., SNARSKI V. M. 1989. *Use of respiratory-cardiovascular responses of rainbow trout (Salmo gairdneri) in identifying acute toxicity syndromes in fish: Part 3. Polar narcotics*. Environmental Toxicology and Chemistry. Wiley-Blackwell. **9**(3): 247-262.

DEVI C. R. & SASTRY C. A. 1987. *Toxicity of phenols to fish*. Indian Journal of Environmental Protection. Don Mackay Environmental Research. **7**(4): 271-283.

DOBBINS D. C., THORNTON-MANNING J., JONES D. D., FEDERLE T. W. 1987. *Mineralization potential for phenol in subsurface soils*. Journal of Environmental Quality. Science Direct. **16**(1): 54-58.

EWELL W. S., GORUSCH J. W., KRINGLE R. O, ROBILLARD K. A., SPEIGEL R. C. 1986. *Simultaneous evaluation of the acute effects of chemicals on seven aquatic species*. Environmental Toxicology Chemistry. Wiley-Blackwell. **5**(9): 831-840.

FORESTER R. P. & GOLDSTEIN L. 1969. In HOAR W. S. & RANDALL D. J. (Eds.). *Fish Physiology*. Edit. Academic Press. New York and London. 48 pp.

KOBAYASHI K. & AKITAKE H. 1975. *Metabolism of chlorophenols in fish. IV. Absorption and excretion of phenol by goldfish*. Nippon Suisan Gakkaishi. Bulletin of the Japanese Society for the Science of Fish. **41**: 1271-87.

MASOPUST JIŘÍ. 2000. *Clinical biochemistry*. Edit. Karolinum. Prague. 832 pp.

McNEELY R. N., NEIMANIS V. P., DWYER L. 1979. *Water quality sourcebook: A guide to water quality parameters.* Environment Canada. Inland Waters Directorate. Water Quality Branch. Ottawa. Canada. 89 pp.

ORIS J. T., WINNER R. W., MOORE M. V. 1991. *A four-day survival and reproduction toxicity test for Ceriodaphnia dubia.* Environmental Toxicology and Chemistry. Wiley-Blackwell. **10**: 217-224.

PICOŞ C. A. & NĂSTĂSESCU GHE. 1988. *Lucrări practice de fiziologie animal.* Edit. Universităţii din Bucureşti. 232 pp.

SNELL T. W. & MOFFAT B. D. 1992. *A 2-d life cycle test with the rotife Branchionus clyciflorus.* Environmental Toxicology and Chemistry. Springer Link. **11**: 1249-1257.

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INFESTATION OF GIBEL CARP *Carassius auratus gibelio* (CYPRINIDAE) WITH *Piscicola geometra* (HIRUDINEA, RHYNCHOBDELLIDA)

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Abstract. *Piscicola geometra* (LINNAEUS 1761) is the most common species of fish leech, which affects a wide variety of host - fish belonging to natural or aquaculture populations, inducing haemorrhages and ulcerations. The paper focuses on different ecological aspects regarding quantitative indexes (frequency and abundance) in case of captured species, the relation between the parasitized fish and this leech, the parasitic spots, as well as on the visible effects it generates. The studied material was collected from the Preajba Valley hydrographical basin.

Keywords: The Preajba Valley, infestation, *Carassius auratus gibelio, Piscicola geometra.*

Rezumat. Infestarea carasului *Carassius auratus gibelio* (Cyprinidae) cu *Piscicola geometra* (Hirudinea, Rhynchobdellida). *Piscicola geometra* (LINNAEUS 1761), cea mai comună lipitoare a peştilor, parazitează un spectru larg de peşti din populaţiile naturale, ca şi pe cele din culturi, provocând gazdelor hemoragii şi ulceraţii. Lucrarea tratează aspecte ecologice privind indicii biocenotici cantitativi (frecvenţa şi abundenţa) în cazul speciilor capturate, relaţia dintre peştele parazitat şi această lipitoare, situsurile de parazitare precum şi efectele vizibile ale acţiunii acestui ectoparazit. Materialul studiat a fost colectat din bazinul hidrografic Valea Preajba.

Cuvinte cheie: Valea Preajba, infestare, *Carassius auratus gibelio, Piscicola geometra.*

INTRODUCTION

The study was achieved in the first trimester of 2012. The study site was represented by the small reservoirs built along the Preajba River, a small tributary of the Jiu. There were taken samples in order to gather the ichthyologic material necessary for further parasitological studies (GOGA, 2009a, b; 2010; GOGA & TÎMBURESCU, 2011; GOGA & CODREANU BĂLCESCU, 2011), as well as for the calculation of the biocoenotic quantitative indexes (frequency and abundance) of the captured species, the purpose of which was the achievement of a correlation between parasite and parasitized fish.

Piscicola geometra (LINNAEUS 1761) is a non-specific ectoparasite that provokes the disease called "piscicolosis" to fish (Fig. 1). This leech is part of the 60 species of freshwater and marine Hirudinees mentioned in the specialized literature as fish parasites (GHITTINO, 1985); it is brown or green. The leech is up to 35 mm long and 3 mm wide and presents two suckers (MUNTEANU & BOGATU, 2008); it was identified on the gibel carp *C. auratus gibelio*. The anterior extremity of the parasite presents a distinct sucker with some black ocular spots (two pairs of eyes), the first two being larger (Figs. 2; 2a); the posterior extremity presents a much larger and stronger sucker with pigmentation fields radially disposed (Fig. 3) (VULPE, 2007). In the superficial layer of the body wall, there can be noticed small, star-shaped, light-brown pigment cells (Figs. 4; 4a), while in deeper layers, there appear larger, dark-brown pigment cells (Fig. 5). Generally, the colour of these fish leeches varies according to the colour of the host fish. They parasite the fish without any intermediate host (VULPE, 2007).

MATERIAL AND METHODS

In the first months of 2012, there were made some field trips in the area of the small reservoirs located along the Preajba river and taken sporadic samples by means of monofilament net (a net of 100 m length and 2 cm wide meshes). Taking samples was a quite difficult process as the lakes were invaded by macrophytic submerged vegetation. During this sampling period, there were captured 47 samples containing the following fish species: *Scardinius erythrophthalmus, Lepomis gibbosus, Abramis brama, Carassius auratus gibelio, Perca fluviatilis.* The ectoparasite fish leeches belonging to *Piscicola geometra* were identified only on the gibel carp; there were also established the parasitic spots and the incidence of the parasitosis. The collected material was ichthyo-pathologically examined, namely clinical and parasitological, in the Parasitology laboratory of Sanitary Veterinary Direction Dolj. The fish were examined macroscopically in order to study the areas affected by leeches.

The parasites were then placed on a Petri dish, in distilled water, its visualisation being achieved through transparency at the stereomicroscope Olympus SZX7 with objectives 2x, 3,2x; ocular WHSZ 10x/22, as well as at the optic microscope Olympus BX 43, as fresh preparation slide-slide, with the objectives 2x, 10x; ocular WHN 10x/22. After examination, the parasites were fixed in plastic bottles in 4% formaldehyde (Fig. 6).

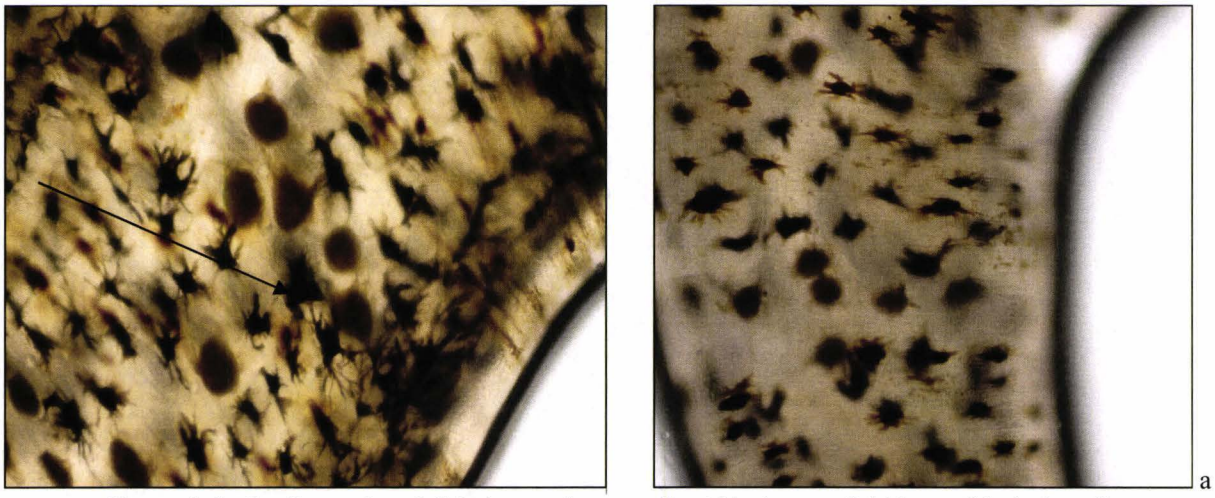
Figure 1. *Piscicola geometra* (LINNAEUS 1761) (original).

Figure 2. Anterior sucker with the four black ocular spots (fresh preparation; optical microscope, objective 2x; ocular WHN 10x/ 22) (original). / Figura 2. Ventuza anterioară prevăzută cu patru pete oculare negre (preparat nativ între lamă şi lamelă; microscop optic, obiectiv 2x; ocular WHN 10x/22) (original).

a

Figure 2a. Anterior sucker with four black ocular spots (stereomicroscope visualisation, objective 2x; ocular WHSZ 10x/22) (original). / Figura 2a. Ventuza anterioară prevăzută cu patru pete oculare negre (vizualizare stereomicroscop, obiectiv 2x; ocular WHSZ 10x/22) (original).

Figure 3. Posterior sucker with pigmentation fields radially disposed (stereomicroscope visualisation, objective 3,2x; ocular WHSZ 10x/22) (original). / Figura 3. Ventuza posterioară prevăzută cu câmpuri pigmentare dispuse radial (vizualizare stereomicroscop, obiectiv 3,2x; ocular WHSZ 10x/22) (original).



Figures 4, 4a. Small, star-shaped, light-brown pigment cells within the superficial layer of the body wall (fresh preparation; optical microscope, objective 10x; ocular WHN 10x/ 22) (original). / Figurile 4, 4a. Celule pigmentare mărunte în formă de stea de culoare brun – deschis, prezente în stratul superficial al peretelui corpului (preparat nativ între lamă şi lamelă; microscop optic, obiectiv 10x; ocular WHN 10x/ 22) (original).

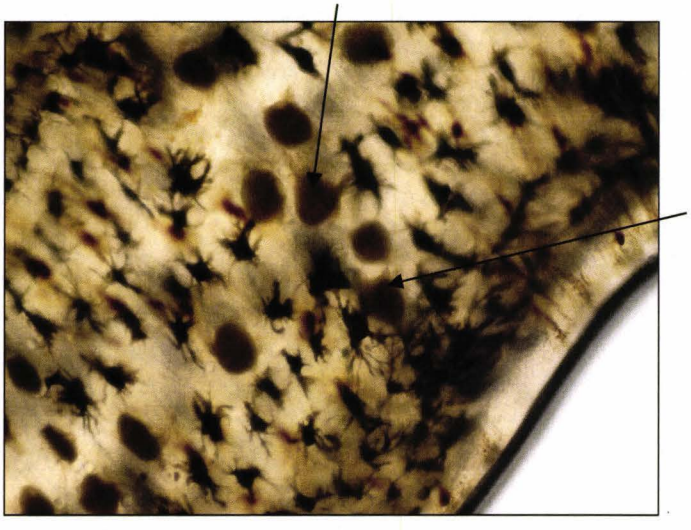


Figure 5. Large, dark-brown pigment cells in the deeper layers of the body wall (fresh preparation; optical microscope, objective 10x; ocular WHN 10x/ 22) (original). / Figura 5. Celule pigmentare mari brun – deschis, prezente în straturile profunde al peretelui corpului (preparat nativ între lamă şi lamelă; microscop optic, obiectiv 10x; ocular WHN 10x/ 22) (original).

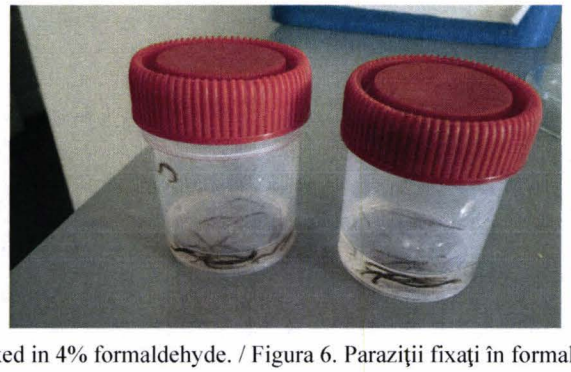


Figure 6. Parasites fixed in 4% formaldehyde. / Figura 6. Paraziţii fixaţi în formaldehidă 4% (original).

RESULTS AND DISCUSSIONS

The 47 samples taken were also analysed from the ecological point of view rendering the quantitative biocoenotic indexes: Frequency (F%) and Abundance (A%) (STĂNICĂ - EZEANU & NEACŞU, 1998).

F % = p / P x 100 where: p – number of samples where a certain species appears;

P – total number of examined samples.*F% (0 – 25%) accidental species ; *F% (25 –50%) accessory species; *F% (50 – 75%) constant species; *F% (75 – 100%) euconstant species.

A% = n / N x 100 where: n – number of individuals per species;
N – number of individuals belonging to all the species of samples.

Table 1. Frequency – qualitative biocoenotic index of captured species.
Tabel 1. Frecvenţa – indice biocenotic cantitativ al speciilor capturate.

No.	Species	F% (0 - 25%) accidental	A/%)	F% (25 - 50%) accessory	F% (50 - 75%) constant	F% (75 - 100%) euconstant
1.	*Carassius auratus*	-	72.3		-	100
2.	*Scardinius erythrophthalmus*	-	12.7	33.3	-	-
3.	*Lepomis gibbosus*	-	4.25	33.3	-	-
4.	*Abramis brama*	-	4.25	-	66.6	-
5.	*Perca fluviatilis*	-	2.12	33.3	-	-

The values of the indexes emphasize that the species *C. auratus gibelio* registers a high density compared with the other species and an increased frequency in captures, thus, possibly illustrating a preference of this fish leech for the species belonging to the family Cyprinidae, as literature in the field mentioned (ROMAN, 1955).

Piscicola geometra is a leech displaying a long, flexible body made up of a definite number of segments. It affects fish populations from the lakes invaded by vegetation. All species of fish may be affected by piscicolosis, but a higher incidence is registered at Cyprinidae. *Piscicola geometra* is the most common freshwater leech species scarce in lakes. It is distributed in Europe, Central Asia, North America, parasitizing freshwater fish, especially Cyprinidae, and was previously reported from 8 host species (*Rutilus rutilus*, *Scardinius erytrophthalmus*, *Blicca bjoerkna*, *Tinca tinca*, *Esox lucius*, *Barbus rajanorum mystaceus*, *Abramis brama*, *Cyprinus carpio*) from different lakes in Turkey (Sapanca Lake, Terkos Lake, Keban Dam Lake, Cavuscu Lake, Uluabat Lake) CEYLAN *et al.*, 2011; ARSLAN & EMIROĞLU, 2011 identified the parasitic leech *Piscicola geometra*, for the first time, at exotic fish species *Carassius gibelio* (on operculum) in Lake Uluabat (Turkey). In the work entitled Research regarding the parasite fauna of the Danube fish (ROMAN, 1955) in case of the Danube Delta, this leech was mentioned on the gills of freshwater bream and on the skin of rudd and perch. Within the Danube basin, it was also identified in case of pike, nase, chub, and perch. In our country, *P. geometra* was mentioned by ANTIPA (1909) at carp, DUMITRU (1937) at pike, barbel, and bream, ZEMIANKOVSKI (1946) at carp.

With regard to the pathogeny of the disease, the parasites sources are represented by old fish, water, macrophytic vegetation and the substratum the leeches lay their cocoons (in summer). An important factor triggering the appearance of the parasitosis is water temperature; the invasion decrease in intensity when water gets warmer. There were collected 75 samples fixed on different parts of the body (oral mucosa, pectoral fins, caudal fin, and the skin covering the ventral part of the body); their length varied between 15 mm and 35 mm.

The fish affected by piscicolosis had bleeding wounds at the body surface provoked by the suckers of the leeches. Some individuals of gibel carp still displayed portions of destroyed tegument at the level of the scales from the dorsal part of the body due to the disappearance of the mucus layer, which enabled the penetration of other pathogen agents, in this case of the fungus *Saprolegnia* sp. The diagnosis of the parasitosis was relatively simply achieved, through macroscopic examination of the body of all collected fish and emphasis of leeches (Figs. 6; 6a).

The parasitosis evolved sub clinically due to the small number of parasitized fish and to the fact it was no longer identified in the next captures.

Specialized literature (MUNTEANU & BOGATU, 2008) mentions as prophylactic measures meant to prevent piscicolosis: destruction of macrophytic vegetation and avoidance of the penetration of other fish species from one basin to another, taking into account the reservoirs have direct communication and the water surplus is discharged through bottom dischargers. Among treatment measures, it is used Trichlorfon 1g/6 m^3 water.

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Figures 6, 6a. Presence of leeches – macroscopic examination (original).
Figurile 6, 6a. Evidenţierea lipitorilor, prin examen macroscopic (original).

CONCLUSIONS

The study was performed during the first trimester of 2012; the studied site was represented by the small reservoirs located along the Preajba river, a small tributary of the Jiu river.

The parasitosis evolved sub-clinically taking into account the reduced number of parasitized fish, as well as the disappearance of leeches in the next captures.

The sampled fish material was examined from the ichthyo-pathological viewpoint, namely clinical and parasitological examinations, in the laboratory of parasitology of the Sanitary Veterinary Direction Dolj. The fish were examined macroscopically and the diagnosis of the parasitosis was relatively simple to achieve, based on the visual observation of the spots affected by leeches, as well as on the observations made with the optic microscope Olympus BX 43 and stereomicroscope Olympus SZX7.

The fish affected by piscicolosis had bleeding wounds at the skin surface provoked by the suckers of the leeches; the disappearance of the layer of mucus enabled the penetration of other pathogen agents, in this case the fungus *Saprolegnia* sp.

An important factor that triggers the development of the parasitosis is water temperature and abundant submerge macrophytic vegetation.

The destruction of macrophytic vegetation, the prevention of fish migration from one reservoir to another and the treatment with Trichlorfon 1g / 6 m^3 water are just some of the measures able to stop this parasitosis.

REFERENCES

ARSLAN N. & EMIROĞLU Ö. 2011. *First Record of Parasitic Annelida – Hirudinea (Piscicola geometra Linnaeus, 1761) on Carassius gibelio (Bloch, 1782) in Lake Uluabat (Turkey).* Faculty of Veterinary Medicine. Kafkas University. Turkey. **17**(1): 131-133.

ANTIPA G. 1909. *Fauna ihtiologică a României.* Edit. Academiei Republicii Populare Române. Bucureşti. 264 pp.

DUMITRU M. 1937. *Cercetări de paraziţi la peştii din apele româneşti.* Revista zootehnică. Facultatea de Agronomie a Universităţii Bucureşti. Bucureşti. **6-7**: 10-11.

CEYLAN M., BAYACI Y. Ö., MEKE T., INCEOĞLU H., KARA A. 2011. *A report of ectoparasite Piscicola geometra on roach Rutilus rutilus (Linnaeus, 1758) from Uluabat Lake.* Parasitolgy. Turkiye. Journal Publications. Izmir. **35**(4): 207-209.

GHITTINO P. 1985. *Tecnologia e patologia in acquacoltura. Patologia Emilio Bono.* Edit. WILEY Publishers Since 1807. Torino. **2**: 1-399.

GOGA IONELIA CLAUDIA. 2009a. *Boli parazitare semnalate la peştii dulcicoli din bazinul hidrografic Valea Preajba.* Diversitatea, valorificarea raţională şi protecţia lumii animale. Edit. Ştiinţa Moldova. Chişinău: 256-260.

GOGA IONELIA CLAUDIA. 2009b. *Basic data on the piscicultural communities from the hydrographic basin Preajba Valley Conferinţa Internaţională.* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **25**: 165-169.

GOGA IONELIA CLAUDIA. 2010. *The mycosis generated by Saprolegnia parasitica in the fresh – water fish of the cyprinidae family.* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **26**(2): 161-164.

GOGA IONELIA CLAUDIA & TÎMBURESCU CONSTANŢA. 2011. *Ichthyophthirius multifiliis* infection at *Carassius gibelio from the small reservoirs within the Preajba Valley*. Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **27**(2): 129-132.

GOGA IONELIA CLAUDIA & CODREANU BĂLCESCU DOINA. 2011. *The trematode Clinostomum complanatum (Platyhelminthes: Digenea) identified at the perch from the small reservoirs along the Preajba river.* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **27**(1): 115-118.

MUNTEANU GABRIELA & BOGATU D. 2008. *Tratat de ihtiopatologie.* Edit. Excelsior Art. Timişoara: 541-552.

ROMAN ELENA. 1955. *Cercetări asupra parazitofaunei peştilor din Dunăre.* Edit. Academiei Republicii Populare Române. Bucureşti: 68.

STĂNICĂ - EZEANU D. & NEACŞU P. 1998. *Sisteme ecologice.* Edit. Universal Cartfil. Ploieşti: 41-47.

VULPE V. 2007. *Paraziţi şi parazitoze ale peştilor dulcicoli.* Edit. Stef. Iaşi: 169-171.

ZEMIANKOVSKI V. 1947. *Fauna peştilor din România.* Analele Institutului de Cercetare Piscicolă. România. Iaşi. **3**: 115-220.

***. http: // fish parasite. *Piscicola geometra* (accessed March, 2012).

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HISTOPATHOLOGICAL CHANGES IN MARSH FROG (*Pelophylax ridibundus*) LUNG TISSUE INDUCED BY THE ACTION OF ROUNDUP® HERBICIDE

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Abstract. The histopathology of Roundup® on the lung tissues in marsh frog (*Pelophylax ridibundus*) was investigated. The animals were exposed to sub-lethal concentrations ($0.138x10^{-3}$/g of body weight) of Roundup® administrated by intraperitoneal shots (one shot every two days in a scheme of 3 weeks) at two thermic levels (4-6°C and 22-24°C). Light microscopy of lung revealed hyperplasia of the respiratory epithelium, an increase in the number of goblet cells, increasing the nucleus diameter of pneumocytes, interstitial edema, presence of melanin deposit. Highly degenerative changes in lung tissue such as interstitial edema, presence of melanin deposit, an increase in the number of hyperplasiated and active goblet cells, were evident in animals that was treated with toxic and kept at 22-24°C.

Keywords: frog, hyperplasia, respiratory epithelium, interstitial edema, pneumocytes, Roundup®.

Rezumat. Modificări histopatologice în ţesutul pulmonar la broasca-de-lac (*Pelophylax ridibundus*) induse de acţiunea erbicidului Roundup®. În prezentul studiu au fost investigate efectele histopatologice induse de acţiunea erbicidului Roundup® asupra ţesutului pulmonar la broasca *Pelophylax ridibundus*. Animalele au fost expuse acţiunii unor concentraţii subletale de Roundup® ($0.138x10^{-3}$/g greutate corporală) administrate prin injecţii intraperitoneale (o injecţie la 2 zile timp de 3 săptămâni) la 2 nivele termice (4-6°C respectiv 22-24°C). Microscopia optică a indicat prezenţa hiperplaziei epiteliului respirator, creşterea numărului de celule mucoase, creşterea diametrului nucleului pneumocitelor, edeme interstiţiale, prezenţa depozitelor de melanină. Cele mai severe modificări (edeme interstiaţiale, prezenţa depozitelor de melanină, creşterea numărului de celule hiperplaziate) au fost înregistrate în cazul animalelor tratate şi ţinute la o temperatură de 22-24°C.

Cuvinte cheie: broască, hiperplazie, epiteliu respirator, edeme interstiţiale, pneumocite, Roundup®.

INTRODUCTION

The application of environmental toxicology studies on non-mammalian vertebrates is rapidly expanding (RELYEA & JONES, 2009).

Aquatic ecosystems can be contaminated with agrochemical products by leaching, run-off or direct or indirect spraying, this latter by action of the wind (WHO, 1994). In this regard, considerable research efforts have focused on the global decline of amphibian populations across the globe.

One of the widely used agrochemical products is glyphosate the herbicide (GP) - N (phosphonomethyl) glycine - known commercially as Roundup® (RAMÍREZ-DUARTE *et al.*, 2008). The Roundup® contains, in addition to GP, a cationic surfactant denominated polyoxyethylamine (POEA) that confers toxicological properties different from those of GP (FOLMAR *et al.*, 1979).

Previous studies demonstrated that the toxicity of Roundup® in fish and mammalian is moderate. In the case of amphibians, because interest in the group is relatively recent, there are few amphibian data upon which to base these assessments.

In fish exposed to commercial formulations of GP, several authors have reported the development of necrotic and proliferative lesions, aneurysms and leukocyte infiltration in the gills (NEŠKOVIC *et al.*, 1996; JIRAUNGKOORSKUL *et al.*, 2002, 2003), as well as degenerative changes, lipidic vacuolization and hyaline droplets in hepatocytes (SZAREK *et al.*, 2000; JIRAUNGKOORSKUL *et al.*, 2003)

The aim of this study was to evaluate sublethal effects of Roundup® herbicide exposure on marsh frog lung tissues at two thermic levels (4-6°C, respectively 22-24°C).

MATERIAL AND METHODS

The animals used in this study were adult of *Pelophylax ridibundus*, of both sexes, captured in spring (April-May) from the surrounding areas of the city Piteşti (South Romania). The animals were kept in laboratory condition in aquaterrariums filled with tap water for five days to test their health and accommodate them for the experiment. The water was changed daily to avoid the accumulation of toxic substances and the animals were fed "ad libitum".

The study was performed with the approval of the local Committee of Bioethics according to the Romanian law 205/2004 art.7, 18, 22 and regulation number 143/400/2002 for care and use of animals for research purposes.

After adaptation in the lab, the frogs (twenty healthy adult frogs male and female) were separated in lots, which were used separately for the following experiments: two lots of control individuals, containing animals kept in laboratory at 4-6°C, respectively at 22-24°C with no treatment, in running water which was changed every day, (1) one lot containing animals which were subjected to treatment with Roundup® in a dose of $0.138x10^{-3}$/g of body weight and kept at 4-6°C, (2) a second lot containing animals which were subjected to treatment with Roundup® in a dose of

$0.138x10^{-3}$/g of body weight and kept at 22-24ºC in a thermostatic chamber. The toxic was administered by intraperitoneal shots, one shot every two days, in a scheme of 3 weeks. The administered dosage of toxic was not lethal as none of the subjects died through the experiment.

We began sacrificing the animals at the end of 3rd week of treatment; the frogs in each lot were sacrificed after chloroform anaesthesia and lung pieces were taken to assess histological changes via light microscope examination. Tissues samples were fixed in 8% neutral formalin for poikilotherms for 24h. Samples were then processed using a graded ethanol series and embedded in paraffin. Paraffin section were cut 5µm-thick slices using a rotary microtome (Slee Maintz Cut 5062) and stained with: haematoxylin (H) as a general screening method and Sirius red (JUNCUEIRA *et al.*, 1979) for collagen stain (fibrosis). The sections were viewed and photographed using an Olympus microscope with an attached camera.

RESULTS AND DISCUSSIONS

The herbicide Roundup® in the lung works in animals kept at a temperature of 4-6˚C, by thickening the second-order connective septa (Fig. 1a). They are composed of smooth muscle fibers, along with collagen fibers and are covered by a pseudo-layered epithelium with a tendency of hyperplasia (Fig. 1a). In this case, hyperplasia of the epithelium is a defence mechanism of the deep structures under the action of irritating stimuli.

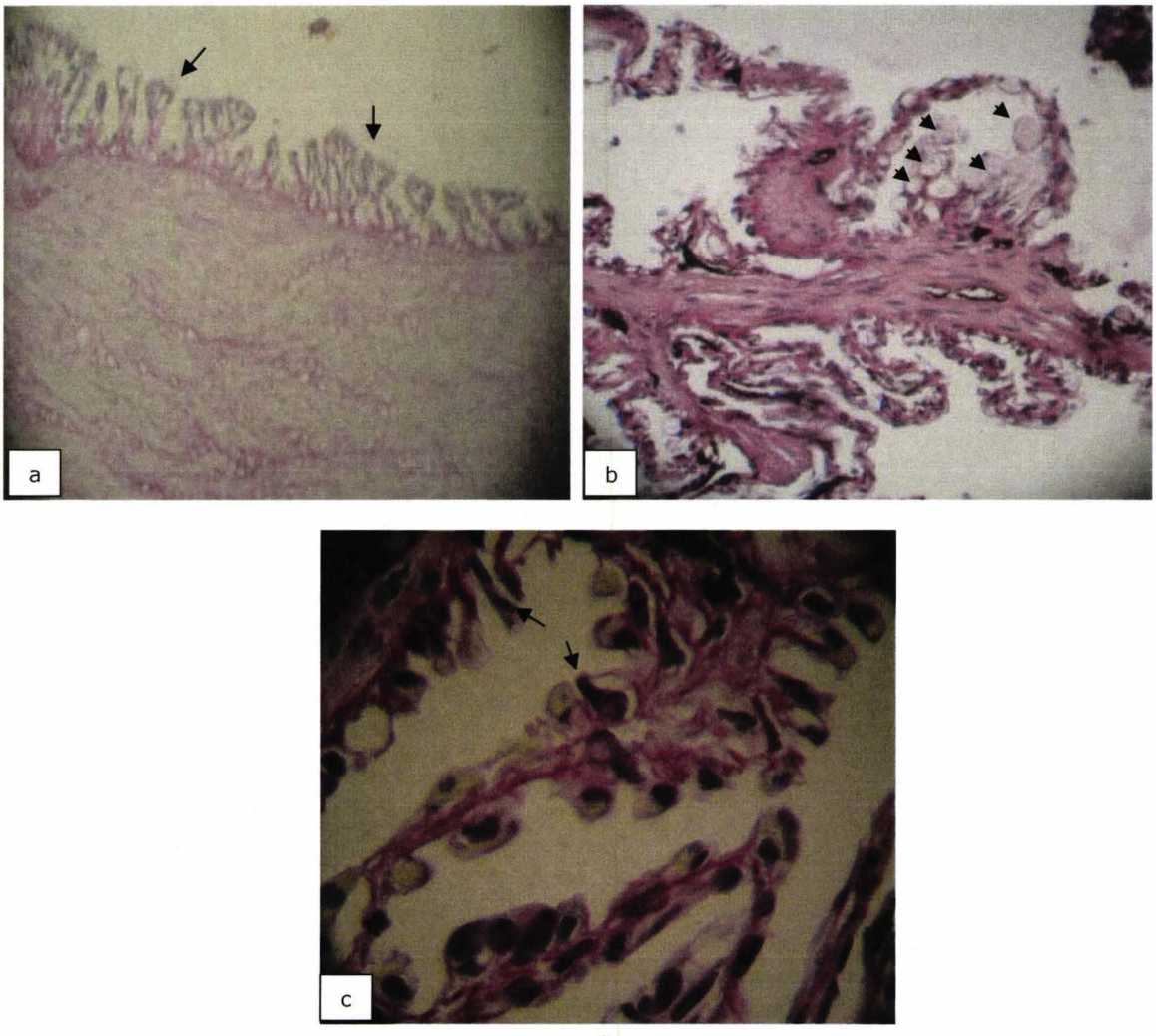

Figure 1. Lung of *Pelophylax ridibundus* species treated with Roundup® herbicide and kept at a temperature of 4-6˚C. a - thickened longitudinal septa composed of smooth muscle fibers and collagen fibers; hyperplasia of the epithelium (arrow). b - hyperplasiated goblet cells (arrow head). 100×. c - pneumocytes with elongated nuclei (arrow). 400×. H-Sirius red staining. / Figura 1. Plămân la exemplarele de *Pelophylax ridibundus* tratate cu erbicidul Roundup® şi ţinute la o temperatură de 4-6˚C. a - septe longitudinale îngroşate formate din fibre musculare netede şi fibre de colagen; hiperplazia epiteliului (săgeata). b - celule caliciforme hiperplaziate (cap de săgeată). 100×. c - pneumocite cu nuclei alungiţi (săgeata). 400×. Coloraţie H-Sirius red (original).

In the epithelium, there is an increase in the number of goblet cells, which are also hyperplasiated (Figs. 1b, c), having a honeycomb appearance. The goblet cells react to the toxic action through the synthesis of large quantities of mucus. This hypersecretion favours diluting or neutralizing of toxic substances reaching this level (FERGUSON *et al.*,

1992), but reduces the respiratory function of the epithelium, by increasing the distance between the air and the respiratory cells (BOLS *et al.*, 2001).

Pneumocytes react by increasing the nucleus diameter in relation to the cell diameter (Fig. 1c). They are enriched with intensely coloured erythrocytes, proved by the presence in their cytoplasm of a large quantity of haemoglobin.

Also, the lung parenchyma shows the presence of interstitial edema, characterized by the presence of dilated blood vessels prone to bleeding, as a result of the irritating action of the glyphosate and surfactant in Roundup® commercial product.

Histopathological effects on lung, following the administration of Roundup® are similar in the animals treated and kept at a temperature of 22-24°C.

Therefore, one can notice a significant thickening of the second-order longitudinal septa and the same hyperplasia of the epithelium covering the septa (Fig. 2a). In the lung parenchyma there appear dilated blood vessels with bleeding areas (Fig. 2b), and deposits of melanin involved in the detoxification processes. The respiratory epithelium responds to the large number of hyperplasiated, active goblet cells, which synthetize a large quantity of mucus (Fig. 2c). Hypersecretion of these cells, which reduces the diffusion of xenobiotic substances, is a response to the electrolyte imbalance caused by the action of glyphosate and / or surfactant in the commercial product, on the permeability of the cell membrane (LIN & RANDALL, 1995).

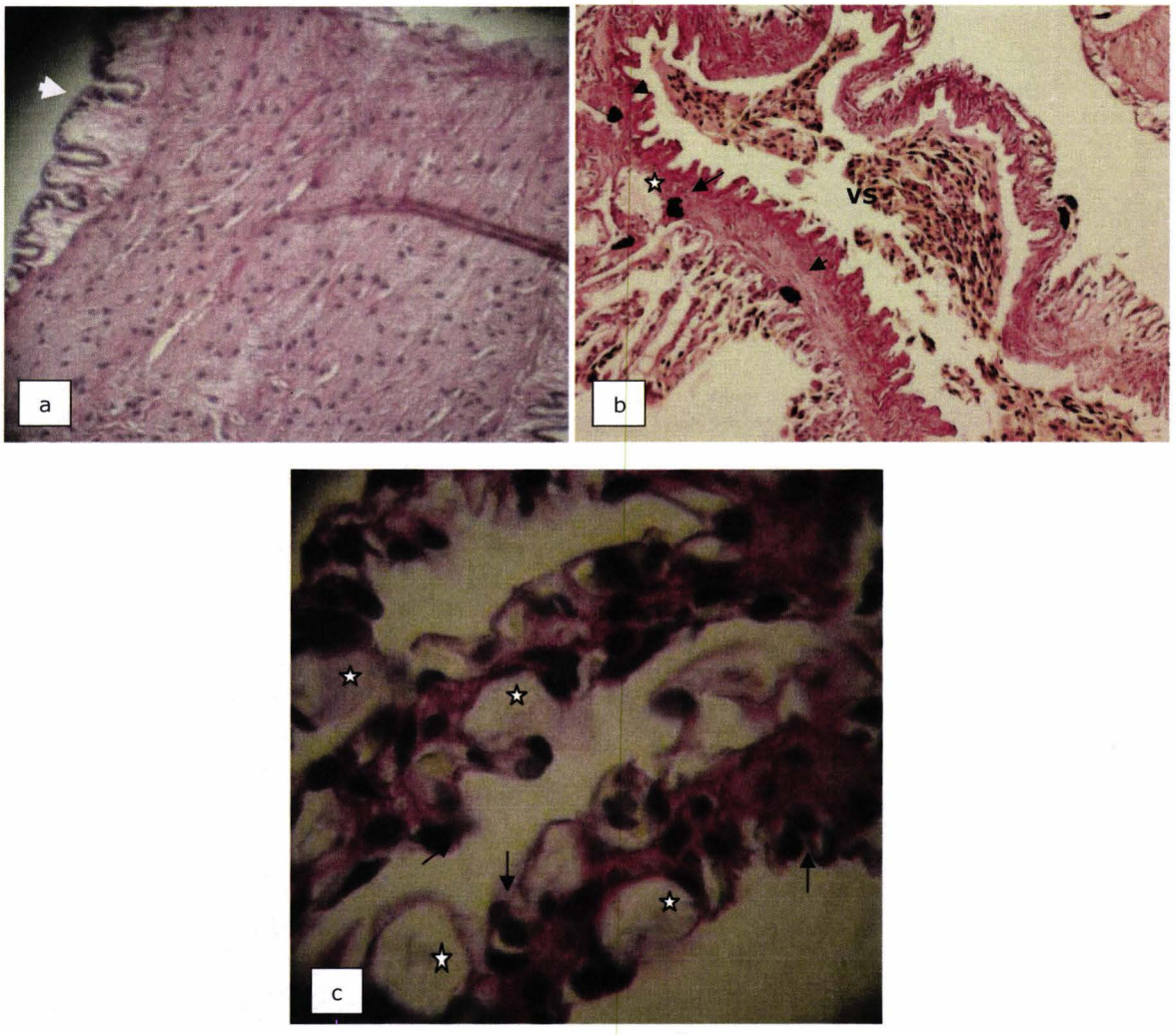

Figure 2. Lung of *Pelophylax ridibundus* species treated with Roundup® herbicide and kept at a temperature of 22-24°C. a - thickened longitudinal septa composed of smooth muscle fibers and collagen fibers; hyperplasia of the epithelium (arrow). b - congested blood vessel (VS); bleeding area (asterisk); deposits of melanin (arrow). 100×. c - hyperplasiated goblet cells (asterisks); pneumocytes with elongated nuclei (arrow). 400×. H-Sirius red staining. / Figura 2. Plămân la exemplarele de *Rana ridibunda* tratate cu erbicidul Roundup® şi ţinute la o temperatură de 22-24°C. a - septe longitudinale îngroşate formate din fibre musculare netede şi fibre de colagen; hiperplazia epiteliului (săgeata). b - vas de sânge congestionat (VS); zona hemoragică (steluţă); depozite de melanină (săgeata). 100×. c - celule caliciforme hiperplaziate (steluţe); pneumocite cu nuclei alungiţi (săgeata). 400×. Coloraţie H-Sirius red (original).

There is an increase of the nucleus surface in the pneumocytes. Around the pneumocytes there are erythrocytes containing more haemoglobin in the cytoplasm.

In order to explain the toxic effect of Roundup® herbicide on the pneumocytes, it was calculated the ratio between the nucleus and the cell diamter, the results being shown in table 1, observing an increase in the value of this ratio in both heat levels studied, due to the increase of the nucleus diameter.

Table 1. The proportions of pneumocytes and their nuclei.
Tabel 1. Raportul dintre diametrul nucleului şi diametrul celulei.

Lots	Number of cells	Arithmetic mean ± Standard deviations
C 4-6°C	200	0.58±0.029
Lot I	200	0.63±0.020
C 22-24°C	200	0.75±0.022
Lot II	200	0.81±0.016

All these changes should reduce the diffusion of toxic substances through the lungs. Similar changes associated with administration of Roundup® herbicide were recorded in the gills of *Clarias gariepinus* species by OLURIN *et al.* (2006), the authors noticing hyperplasia of the epithelium and the goblet cells, fusion of gills lamellae, the presence of bleeding areas in the parenchyma.

In both adults and juveniles of *Oreochromis niloticus* species there were identified histopathological changes in the gills, induced by the action of Roundup® herbicide (JIRAUNGKOORSKULA *et al.*, 2002; AYOOLA, 2008), which causes reduced oxygen consumption and ultimately, death of the bodies by suffocation.

Gills lesions characterized by hyperplasia of the epithelium, interstitial edema, congestion of blood vessels, were identified in *Piaractus branchypomus* species, under the treatment with Roundup® herbicide (WILSON *et al.*, 2008).

CONCLUSIONS

These observations lead us to conclude that Roundup® in a dose of $0.138x10^{-3}$/g of body weight determinates morphologic modifications in the lung tissues of *Pelophylax ridibundus* in both thermic variants (at 4-6° and at 22-24°C). Lung tissue of the frogs showed marked pathological changes such as: hyperplasia of the respiratory epithelium, an increase in the number of goblet cells, which are also hyperplasiated. Also, pneumocytes react by increasing the nucleus diameter in relation to the cell diameter. The lung parenchyma shows the presence of interstitial edema, characterized by the presence of dilated blood vessels and deposits of melanin. Highly degenerative changes in lung tissue were evident in animals that were treated with toxic and kept at 22-24°C.

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REFERENCES

AYOOLA S. O. 2008. *Histopathological Effects of Glyphosate on Juvenile African Catfish (Clarias gariepinus).* American-Eurasian Journal of Agriculture & Environmental Science. IDOSI Publications. **4**(3): 362-367.

BOLS N. C., BRUBACHER J. L., GANASSIN R. C., LEE L. E. 2001. *Ecotoxicology and innate immunity in fish.* Developmental & Comparative Immunology. Elsevier. **25**: 853-873.

FERGUSON H. W., MORRISON D., OSTLAND V. E., LUMSDEN J., BYRNE P. 1992. *Responses of mucus-producing cells in gill disease of rainbow trout (Oncorhynchus mykiss).* Journal of Comparative Pathology. Elsevier. **106**: 255-265.

FOLMAR L. C., SANDERS H. O., JULIN A. M. 1979. *Toxicity of the herbicide glyphosate and several of its formulations to fish and aquatic invertebrates.* Archives of Environmental Contamination and Toxicology. Springer. **8**: 269-278.

JIRAUNGKOORSKULA W., UPATHAMA E. S., KRUATRACHUEA M., SAHAPHONGC S., VICHASRI-GRAMSA S., POKETHITIYOOKA P. 2002. *Histopathological Effects of Roundup, a Glyphosate Herbicide, on Nile tilapia (Oreochromis niloticus).* Science Asia. The Science Society of Thailand. **28**: 121-127.

JIRAUNGKOORSKUL W., UPATHAM E. S., KRUATRACHUE M., SAHAPHONG S., VICHASRI-GRAMS S., POKETHITIYOOK P. 2003. *Biochemical and histopathological effects of glyphosate herbicide on Nile tilapia (Oreochromis niloticus).* Environmental Toxicology. Wiley Online Library. **18**: 260-267.

JUNCUEIRA L. C. U., BIGNOLAS G., BRENTANI R. R. 1979. *Picrosirius staining plus polarization microscopy, a specific method for collagen detection in tissue section.* Histochemical Journal. Kluwer Academic Publishers. **11**: 447-455.

LIN H. & RANDALL D. 1995. *Proton pumps in fish gills*, p.229-255. In: Hoar W. S., Randall D. J. & Farrell A.. P. (Eds.), Fish Physiology: cellular and molecular approaches to fish ionic regulation. Academic Press, New York. 388 pp.

NEŠKOVIC N. K., POLEKSIC V., ELEZOVIC I., KARAN V., BUDIMIR M. 1996. *Biochemical and histopathological effects of glyphosate on carp, Cyprinus carpio* L. Bulletin of Environmental Contamination and Toxicology. Springer-Verlag. **56**: 295-302.

OLURIN K. B., OLOJO E. A. A., MBAKA G. O., AKINDELE A. T. 2006. *Histopathological responses of the gill and liver tissues of Clarias gariepinus fingerlings to the herbicide, glyphosate.* African Journal of Biotechnology. Academic Journals. **5**(24): 2480-2487.

RAMÍREZ-DUARTE W., RONDÓN-BARRAGÁN I., ESLAVA-MOCHA P. 2008. *Acute toxicity and histopathological alterations of Roundup® herbicide on "cachama blanca" (Piaractus brachypomus).* Pesquisa Veterinária Brasileira. Colégio Brasileiro de Patologia Animal. **28**(11): 547-554.

RELYEA R. A. & JONES D. K. 2009. *The toxicity of Roundup original Maxh to 13 species of larval amphibians.* Environmental Toxicology and Chemistry. Wiley Online Library. **28**(9): 2004-2008.

SZAREK J., SIWICKI A., ANDRZEJEWSKA A., TERECH-MAJEWSKA E., BANASZKIEWICZ T. 2000. *Effects of the herbicide RoundupTM on the ultrastructural pattern of hepatocytes in carp (Cyprinus carpio).* Marine Environmental Research. Elsevier. **50**: 263-266.

WILSON F. R. D., IANG S. R. B., PEDRO R. E. M. 2008. *Acute toxicity and histopathological alterations of Roundup® herbicide on "cachama blanca" (Piaractus brachypomus).* Pesquisa Veterinária Brasileira. Colégio Brasileiro de Patologia Animal. **28**(11): 547-554.

***. WHO 1994. *Glyphosate.* Environmental Health Criteria no. 159, World Health Organization, Geneva.

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OBSERVATIONS REGARDING THE STOCKING SOLUTIONS IN TO AQUATIC ENCLOSURES, UNDER CONTROLLED CONDITIONS, WHILE PRESERVING THE BALANCE BETWEEN ICHTHYOLOGICAL LIVESTOCK AND A SMALL POPULATION OF *Pelecanus onocrotalus*

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Abstract. The paper regards an experiment carried in the years 2010-2011on the pond from the Complex Museum of Natural Sciences Constanta. This pond, isolated from a part of the coastal lake Tăbăcărie, was stocked with native and also with allochtone fish species. It was considered, in relation to this stocking but also with the development and reproduction of the introduced species, the maintenance of the ecological balance between these effects and a population of 10 specimens of white pelican (*Pelecanus onocrotalus*) living in the warm season in mentioned aquatorium.

Keywords: *Pelecanus onocrotalus*, stocking, ecological balance.

Rezumat. Observaţii privind soluţiile de populare a unei incinte acvatice în regim dirijat, cu păstrarea echilibrului între efectivele ihtiologice şi o populaţie restrânsă de *Pelecanus onocrotalus*. Lucrarea priveşte un experiment desfăşurat în anii 2009-2011 privind popularea iazului Complexului Muzeal de Ştiinţe ale Naturii Constanţa, iaz izolat dintr-o parte a lacului litoral Tăbăcărie, cu specii de peşti autohtone, dar şi alohtone. S-a avut în vedere, în raport cu această populare dar şi cu dezvoltarea şi reproducerea speciilor introduse, menţinerea unui echilibru ecologic între aceste efective şi o populaţie de 10 exemplare de pelicani comuni (*Pelecanus onocrotalus*) care habitează în sezonul cald în acvatoriul menţionat.

Cuvinte cheie: *Pelecanus onocrotalus*, populare, echilibru ecologic.

INTRODUCTION

The pond from Microrezervaţie, section of the Museum Complex of Natural Sciences, Constanţa, is the result of actions undertaken to isolate some of the coastal water of Lake Tăbăcărie, part of Tăbăcărie – Siutghiol Complex. The whole area is surrounded by a landscaped green area, well fitted, and a coastal belt with plant species characteristic to limnetic ecosystem.

The pond covers a surface of approx. 2.5 ha of the Microrezervaţie section area, which has 4 ha. The shores are relatively high, resulting from damming and dredging processes; generally strong grassy, with common reed (*Phragmites communis*) and common tule (*Scirpus lacustris*). Cores of *Typha* sp. (*Typha angustifolia* and *T. latifolia*) are rare and generally concentrated on the west side of the pond. We mention the presence of three island formations separated by narrow channels and the shores of the pond in the most westerly point of peninsular area.

In the proximity of the peninsular area, in 2009, there were made two drillings, 150 m deep, which supply the geothermal heat pumps from the Dolphinarium system, which in its turn discharges overflow clean water, in the pond. There is also discharged sea water from the two pools of the Dolphinarium (S = 20-24‰). Salt water discharges are occasional (usually once every spring and in autumn) and are quickly annihilated by the circulation of the pond water.

The pond has a sewage overflow, protected with mesh to prevent the escape of juvenile fish.

At the beginning of the study, fish population consisted exclusively in carp (*Carassius auratus gibelio*) and pumpkinseed (*Lepomis gibbosus*).

Ornithological fauna is quite rich, but, we first mentioned the presence on the pond, during summer, of 11 individuals of pelicans, 10 individuals of Great White Pelicans (*Pelecanus onocrotalus*) and 1 individual of Dalmatian Pelican (*Pelecanus crispus*), plus 6 individuals of swans (*Cygnus olor*), 2 of black swan (*C. atratus*), 2 of Black-necked Swan (*C. melacoryphus)* and 4 of stork (*Ciconia ciconia*). To these species, which are part of the heritage CMSN, there can be added some specimens of the species: Mallard (*Anas platyrhynchos*), Great Bittern (*Botaurus stellaris*), Common Moorhen (*Gallinula chloropus*), Eurasian coot (*Fulica atra*), etc., individuals in passage or nesting each year in the vegetation on the banks of Microreserve pond.

MATERIAL AND METHODS

Between June 28, 2010 and July 7, 2010, in collaboration with the Maritime University of Constanţa, there were performed observations on the physicochemical water pond in the four stations established in its area. Sampling was performed at 8:30 a.m. and 2 p.m., measurements being made in the laboratory of the Maritime University during students' practical activities.

The analysed parameters in terms of water quality were: pH, salinity, total dissolved mineral salt content (TDS) and temperature.

Determinations of species for the fish populations were carried out using the source papers: BĂNĂRESCU (1964), CĂRĂUŞU (1952), VASILIU (1959), WILLOCK (1980).

For bird species we used in determining ichthyophagous species the papers of IORDACHE & STĂNESCU (1992), ALDERTON (2009), POLAK (2007) and for plants ANTONESCU (1951).

In order to establish the structure of the ichthyologic population at the beginning of the experiment, we used monofilament gill nets, a tool "năpatca" called and cast nets. For fishing trips we used a inflatable boat equipped with a 15CP two-stroke engine.

After carrying out the stocking actions of the pond with ichthyologic material for about 2-3 months, we were carried out fish surveys (with monofilament gillnet with meshes of 2a = 30 mm, two gill nets with a total length of 60 m, located in various places, but also fished in fixed points with a special tool (năpatcă), once a week, to check the progress made by the biological material.

Measurements were made both to each lot and the specimens obtained in random fishing, taking into consideration the great length (L) and occasionally total weight (W).

We made observations on the degree of maturation of the gonads, the scale I-VI. CĂRĂUŞU (1952).

For transporting the species used in November 2009, were used CMSN cars, two-FIAT Doblo equipped with tanks with a 100-150 l and aeration-oxygenation systems.

RESULTS

In the adjacent tables (Table 1 and Table 2), there are rendered the main characteristics of pond water, based on the observations from 2010.

Table 1. Water parameters values registered at 8:30 a.m.
Tabel 1. Valorile parametrilor apei urmărite la orele 8:30.

Sample	Temperature °C	pH	Salinity g/l (‰)	TDS (ppt)
P1	23.5	7.36	0.943	1.088
P2	22.6	7.38	0.767	1.086
P3	23.1	6.62	0.943	1.086
P4	23.6	7.49	0.928	1.059

Table 2. Water parameters values registered at 2.30 p.m.
Tabel 2. Valorile parametrilor apei urmărite la orele 14:00.

Sample	Temperature °C	pH	Salinity g/l (‰)	TDS (ppt)
P1	26.8	7.62	1	1.158
P2	26.3	7.64	0.946	1.095
P3	26.6	7.55	1.043	1.095
P4	26.4	7.74	0.992	1.155

Ichthyologic population of the pond at the start of the observations, as mentioned above, consisted exclusively of Prussian carp (*Carassius auratus gibelio*) and pumpkinseed (*Lepomis gibbosus*). After establishing ichthyologic composition and making physico-chemical analyses of water, we passed to the second stage that is populating the pond with various species of fish.

Comparing obtained data with those in **Directive EEC 78/659 of July 18, 1978 - quality of freshwaters needing protection or improvement for fish farming practice** we find that the values for pH, suspended solids and temperature are within the limits provided for cyprinid waters and therefore decided that the most adequate species to populate the pond are: mirror carp (*Cyprinus carpio* var.), Chinese cyprinid - grass carp (*Ctenopharyngodon idella*), bighead carp (*Aristichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*).

It was considered possible the introduction of adult specimens of wels catfish (*Silurus glanis*) and its feeding European weatherfish (*Misgurnus fossilis*) and mosquitofish (*Gambusia affinis*), the last one with a role in the eradication of local populations of mosquitoes (*Culex pipiens*). Conditions also allowed populating the pond with a number of sturgeons (*Huso huso, Acipenser ruthenus, A. gueldenstaedti*).

Pond stocking was done in several steps:

2009 - Two actions:

- Prussian carp (*Carassius auratus gibelio*) - from Iormac farm - Băneasa, Constanţa County - there have been brought about 1,000 specimens with different sizes (L = 8-22 cm);
- Catfish (*Silurus glanis*) - 8 specimens (L = 80-110 cm and the W = 8.5 kg), breeders, with gonads in maturation stage IV-V.

2010 - The following actions:

- Mirror carp (*Cyprinus carpio* var.) specimens from Brateş farm / Galati, (L = 12-20 cm and the W = 25-75 g / specimen), (4 transports);
- Chinese cyprinid - grass carp (*Ctenopharyngodon idella*), bighead carp (*Aristichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), of different sizes (L = 10-30 cm) from Brateş farm / Galaţi (four shipments totalling 400 kg);
- Prussian carp (*Carassius auratus gibelio*) - juveniles 1-3 summers, from different backgrounds (Sarinasuf / Iormac / Băneasa, Constanţa Pomacost S. C.) of different sizes (L = 20-25 cm) and the W = 40-250 g (4 transports totalling 350 kg);

- Material from S. C. Pomacost Constanţa consisted entirely of specimens belonging to the red variety of ornament;

➢ European weatherfish (*Misgurnus fossilis*), specimens of varying sizes (L = 18-25 cm and the W = 80-150 g), two transports totalling 200-300 specimens;

➢ Mosquitofish (*Gambusia affinis*), biological material derived from Năvodari farm, Danube-Black Sea Canal, (L = 1.5 to 4 cm), approx. 2,000 specimens in two transports;

➢ Beluga (*Huso huso*) – three specimens from Horia farm, Tulcea County (L = 74-77 cm and the W = 2000 to 2100 g), a single transport;

➢ Sterlet (*Acipenser ruthenus*) and the Danube sturgeon (*Acipenser gueldenstaedti*) - 15 specimens from Horia, Tulcea county, (L = 61-63 cm and the W = 1100-1500 g), a single transport.

After the completion of these populating actions and the random fishing we noticed that initial results are poor, being composed of isolated catches of carp, with gonads in stage II of maturity.

The first fishery survey was conducted in the cold period, when fish winters.

In the cold period of 2009, there were applied aeration holes in the ice covering the pond. Later, in 2010-2011, by bringing water with temperatures between 17-19°C, from the Dolphinarium geothermal station, central and northern areas remained ice-free, frost being limited to the southern area.

In 2011, from May until early October it was made again random fishing, with "năpatca" and cast nets.

There were identified specimens belonging to the following species:

➢ Common carp (*Cyprinus carpio*) - L = 27-30 cm;

➢ Prussian carp (*Carassius auratus gibelio*) - L = 14 to 18.5 cm (W = 5-126 g)

➢ Pumpkinseed (*Lepomis gibbosus*) - L = 5-6 cm;

➢ Leaping mullet l (*Mugil saliens*) - L = 25-30 cm (W = 250 g);

➢ Golden grey mullet (*Mugil auratus*) - L = 28-30 cm (W = 250 g);

➢ Common rudd (*Scardinius erythrophthalmus*) - L = 5 - 6 cm;

➢ Catfish (*Silurus glanis*) - juvenile

- With "năpatcă", there were also fished specimens of beluga (L = 1 m, W = 7 kg) and the Danube sturgeon (L = 0.75 m, W = 3 kg), all in excellent condition.

The presence of those two species of mullet was a surprise; their presence is probably due to the marine waters discharged from the Dolphinarium basins, or the accidental transports of embryonated eggs, brought by the ichthyophagous birds.

CONCLUSIONS

The conducted experiment allowed us to draw the following conclusions:

- At present, the pond water is kept clean by bringing fresh water facilitated by the geothermal pump system.
- During the winter of the years 2010-2011, the pond water did no longer freeze except for small areas.
- In summer, since 2010, it has not been reported any algal blooming
- We mention the presence of two dominant species, namely the native carp and the Prussian carp. Of the two species mentioned, the second one, the Prussian carp, is the most abundant. The caught specimens belong to pre-existing population in the pond, which increased in number naturally or from biological material.
- The random fishing revealed specimens of Asian cyprinids. There were observed either isolated specimens or compact groups jumping out of water in summer. There were not caught-specimens of European weatherfish, catfish and mosquitofish because fishing methods are not appropriate. Regarding the 8 specimens of catfish, even though mature individuals have not been caught, we are sure that they reproduced, as some juveniles were captured in summer 2010. Moreover, it was noted a concentration of juveniles in surface waters.
- The summer 2011 favoured the explosive growth of the population of *Gambusia* (mosquitofish).
- The common Rudd specimen identified during the fishing survey was probably brought with the biological material in the transport from Sarinasuf and Brateş, as well as the Prussian carp. The presence of two species of Mugilidae is probably due to sea water intake in ponds from the Dolphinarium, reaching the pond by circulating water through the basins of this section, as juveniles or hatched eggs. The study of the caught specimens revealed that these species found excellent conditions in this water. This is underlined by the fact that all specimens were in excellent health status, stage III-IV gonads maturation and digestive tract filling grade III-IV.
- Introduced sturgeons have excellently resisted to the water conditions in the winter of 2010-2011: a single-noted sturgeon in the 2012 spring.

From March to October, on the lakes, there appeared 11 individuals of pelicans beside swans and storks.

The losses of populating actions were estimated to about 40%.

Given that daily intake of a pelican is 1-2 kg of fish per day (WERNER, 2004), we can say that they would have consumed about 12-24 kg of fish / day from the brought biological material. Regarding other species of birds present on the pond the quantity consumed by them is very small, e.g. swans consume 3-4 kg-day moist biomass (submerged vegetation and molluscs) (BAILEY *et al.*, 2008), and can eat only accidentally juveniles hiding in submerged vegetation; the Great bittern (*Botaurus stellaris*) consumes about 0.500 kg / day moist biomass (50% benthic invertebrates and 50%

small fish) EPA (2009). From the swallow fish, especially in lakes where aquaculture is practiced, 33.3% of the consumed biomass may consist of carp (Summer I and Summer II), 9.2% Prussian carp (juveniles), 1.6% European weatherfish (*Misgurnus fossilis*) POLAK (2007).

The appetite of the pelicans present on the pond is moderate because they are given a quantity of 15-20 kg Prussian carp, or 6-10 kg capelin (*Mallotus villosus*) (derived from sorting food for marine mammals) daily.

However the presence of fish in the pond, made them act very naturally; every morning the flock fished like in the Danube Delta, grouped in a circle, with wings beating the water. Fishing pelicans were directed at the pelagic and Asian cyprinid shoal of fish and mullet.

Therefore, to maintain balance in aquatorium requires a continuous input of Cyprinid juveniles and Gambusia and European weatherfish occasionally. As the predators, given that catfish is reproduced, and the lake is quite small, a new restocking with this species may achieve only after 6-8 years. However, it is necessary to identify a species of predator the food spectrum of which include pumpkinseed (*Lepomis gibosus*), as this is a fish species detrimental to the introduced livestock, causing big losses as they eat eggs, fertilized eggs and larvae.

The Chinese cyprinid species are compatible with the pond conditions, as food resources are rich. These species may represent an excellent source of food for catfish and pelicans, and occasionally for predators living on the shore, such as Mustelidae (mink).

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REFERENCES

ALDERTON D. 2009. *Enciclopedie completă ilustrată - Păsările lumii.* Edit. AQUILA '93, Oradea. 512 pp.

ANTONESCU C. S. 1951. *Plante de apă şi de mlaştină.* Edit. de Stat pentru Literatura Ştiinţifică şi Didactică, Bucureşti. 228 pp.

BAILEY MEGAN, PETRIE S. A., BADZINSKI S. SHANNON. 2008. *Diet of Mute Swans in Lower Great Lakes Coastal Marshes.* The Journal of Wildlife Management. **72**(3): 726-732.

BĂNĂRESCU M. P. 1964. *Fauna Republicii Populare Române. Pisces - Osteichthyes (peşti ganoizi şi osoşi).* Edit. Academiei Republicii Populare Române, Bucureşti **13**. 962 pp.

CĂRĂUŞU S. 1952 . *Tratat de ihtiologie.* Edit. Academiei Republicii Populare Române, Bucureşti. 500 pp.

EPA 2009. *User's Guide and Technical Documentation KABAM Version 1.0 (K_{ow} (based) Aquatic BioAccumulation Model) Appendix E - Selection of Bird Species of Concern and Corresponding Biological Parameters*, U.S. Environmental Protection Agency, Washington, D.C.

IORDACHE I. & STĂNESCU D. 1992. *Ornitologie practică.* Edit. Universităţii "Alexandru Ioan Cuza", Iaşi. 370 pp.

POLAK M. 2007. *Food of nestling Great Bitterns Botaurus stellaris at fishpond complexes in eastern Polan.* Bird Study. **54**: 280-283.

VASILIU D. G. 1959. *Peştii apelor noastre.* Edit. Ştiinţifică, Bucureşti. 404 pp.

WERNER S. J. 2004. *Diel Foraging Behavior of American White Pelicans (Pelecanus erythrorhynchos) on Experimental Aquaculture Ponds*, United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, USDA National Wildlife Research Center – Staff Publications. 6 pp.

WILLOCK C. 1980. *The ABC of Fishing* Edited Colin Willock -TENNEY. 363 pp.

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PRELIMINARY STUDY ON THE AVIFAUNA IN RADOVAN LOCALITY AREA (DOLJ COUNTY, ROMANIA)

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Abstract. The paper presents the preliminary results regarding the diversity of the avifauna in Radovan area (Dolj county), as well as some estimates of the population of some bird, mainly aquatic. The area under discussion has called our attention by its geomorphological, ecological (ensemble of terrestrial biotopes: forests, bushes, meadows, arable lands, etc., and aquatic biotopes: lake, stream, floodplain forest, etc.) and avifaunistic features, which meet the qualities of a Natura 2000 site. Many of the bird species that we have recorded in the ecosystems of this area are of European conservation interest, which encourages us to support its inclusion on the list of avifaunistic importance areas (AIA), having potential to become avifaunistic special protection area (SPA).

Keywords: Radovan, important bird areas.

Rezumat. Studiu preliminar asupra avifaunei din aria localităţii Radovan (judeţul Dolj, România). În lucrarea de faţă sunt prezentate rezultate preliminare privind diversitatea avifaunei din aria Radovan, precum şi unele estimări de efective ale unor specii de păsări, cu precădere acvatice. Zona la care ne referim ne-a atras atenţia prin particularităţile geomorfologice, ecologice (complex de biotopuri terestre: păduri, tufărişuri, pajişti, terenuri arabile ş.a. şi acvatice: lac, apă curgătoare, pădure de luncă ş.a.) şi avifaunistice, care întrunesc calităţile unui sit Natura 2000. Multe din speciile de păsări consemnate de noi în ecosistemele acestei zone sunt de interes conservativ european, ceea ce ne încurajează să susţinem includerea ei în lista ariilor de importanţă avifaunistică (AIA) cu potenţial de arie de protecţie specială avifaunistică (SPA).

Cuvinte cheie: Radovan, arie de importanţă avifaunistică.

INTRODUCTION

Radovan area is located in the centre of Dolj county, at the intermission of two different geomorphological units, at the southern limit of the Getic Plateau and the northern limit of the Oltenia Plain (coordinates: 44^0 09'– 44^0 09'N, 23^0 38'– 23^0 38'E) respectively. The access to the area is made by the national road DN 56 (Craiova – Calafat), setting out from Radovan locality (Map 1).

The altitude of the land varies between 60 and 250 m. The relief is made up of a plateau/tableland crossed both by the Desnăţui river, which forms a large valley, and by other smaller streams (e.g. Valea Rea and Bănăgui brooks), which are tributary streams of the Desnăţui river. The river has a winding course, with fluctuating flow, strongly influenced by rainfalls and waters collected from the area (CETĂŢEANU *et al.*, 1981). On the course of the Desnăţui river, in the north-western part of Radovan area, there was built a water storage dam, called Fântânele lake, with a total surface of about 300 ha, of which 53.5 ha belong to the public domain of Radovan commune, and the difference administratively belongs to Vârvor commune.

During periods with heavy rainfalls, Târnava pond/lake is formed on the course of Bănăgui brook, having a surface of about 2 ha, but it dries during drought periods.

The climate is temperate continental with long hot summers, long cold winters, and the springs and autumns are short.

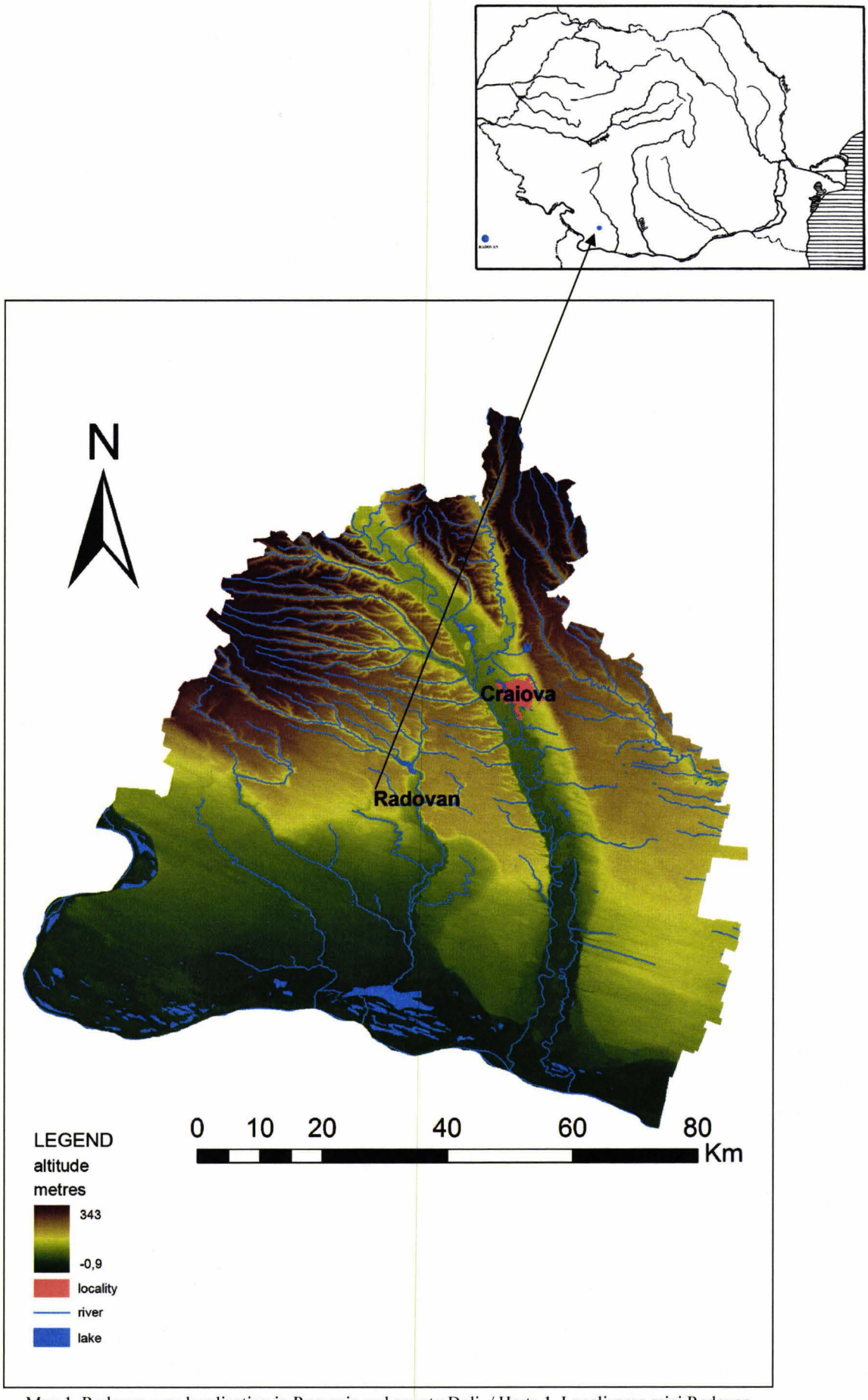
The lithological substratum of the area is made up of loess, and the soils are reddish-brown, typical to the forest steppe area (CERNESCU *et al.*, 1960).

In the perimeter of the area under discussion there exist many types of deciduous forests that are natural (in proportion of 85%), dense and well preserved, which offers them great stability. These forests have a well-developed shrub layer and they shelter many elements of flora and fauna which are very valuable. The surface and the composition of the forests on the territory of Radovan locality, to which we refer in our study, are presented in table 1.

Fântânele lake, as well as the courses of the Desnăţui river and of Valea Rea and Bănăgui brooks create aquatic habitats (water surface area), as well as transition/semiaquatic habitats (floodplain forest, reed beds, hygrophilic meadows), which attract many species of aquatic, resident and migratory birds.

The arable land occupies a total surface of 4,935 ha, and the surfaces covered with pasture comprise about 100 ha. These represent the habitats of some bird species which breed and feed on the ground, some of them being of European interest (e.g. *Anthus campestris, Galerida cristata*).

In the area under discussion, a surface of 20 ha, called Valea Rea-Radovan, was declared protected area of the national concern, 2.385 code (Law 5/2000), due to the presence of some rare botanical elements such as: *Ziziphora capitata* (specific to Radovan and some areas in Dobrogea), *Dianthus leptopetalus, Lathyrus sphaericus, Crucianella angustifolia, Crocus flavus, Platanthera bifolia, Erythronium dens-canis ssp.niveum* (an endemic and threatened taxon), *Hordeum bulbosum,* etc., (POPESCU *et al.*, 2003) and also due to some faunistic elements (LAZĂR *et al.*, 2001). This area is under responsibility of the Local Council of Radovan commune and under the observation of the Environmental Protection Agency (APM – Dolj) and it is intended for the protection and conservation of nature (SÀRBU, 2007).



Map 1. Radovan area localization in Romania and county Dolj. / Harta 1. Localizarea ariei Radovan în România şi judeţul Dolj (original).

Table 1. The composition and the surface of the forests in Radovan locality area (Dolj county). / Tabel 1. Compoziţia şi suprafaţa pădurilor din aria localităţii Radovan (judeţul Dolj).

Forest	Composition	Surface (ha)
Lunca Radovanului	oak tree, ash tree and other broadleaf trees	about 350
Vlădăşel	oak tree, ash tree and other broadleaf trees	300
Fântânele	Turkey oak, Hungarian oak and other broadleaf trees	600
Târnava	Turkey oak, Hungarian oak and other broadleaf trees	1,000
Total		2,250

The variability of the biotopes (terrestrial: deciduous forests, transition areas forests-bushes, pastures, arable lands, human and aquatic settlements: streams, lake, floodplain forest, marshes, reed beds), and the bioecological characteristics make Radovan area and its surroundings an objective of both scientific and economic interest (Figs. 1a, b, c and Figs. 2a, b, c, d, e). Our interest for Radovan area lies in the faunal value of some bird species, mostly of those of European conservation interest which underlie the designation of avifaunal importance areas/AIA (MUNTEANU, 2004).

Although the area has the qualities of a potential Natura 2000 site, there do not exist any elaborated faunistic studies for this area, therefore our study regarding the bird fauna represents a first step for the knowledge of the ecosystems of this territory and it also opens the perspective for the extension of the network of avifaunal importance areas and/or of avifaunal special protection areas (SPA).

Anthropogenic activities (the use of the land for constructions and infrastructure works, grazing, scything, intensive and touristic fishing, mechanized agriculture, agrochemical treatments) are carried on in the area, which may lead in time to the expansion of anthropically modified surfaces and, consequently, to the alteration of biodiversity.

MATERIAL AND METHODS

The study has been made on the basis of our own observations done in Radovan area and its surroundings, on June 7, 2010; June 26, 2010; July 3, 2010, February 28, 2011, March 3, 2010; June 15, 2012; July 20, 2012. The investigations in 2010 were made within the development project of Natura 2000 network, coordinated by the 'Danube Delta' National Institute for Research and Development (I.N.C.D "Delta Dunării") in Tulcea. The data collected so far are preliminary and we will continue researching the biotopes in all ecological aspects of the year.

The observations have been made with binoculars (Zeiss Jena 10x50, Norconia 10x50, and Bushnell 12x40), from fixed points and in motion, on routes settled beforehand. The photographing and the filming of the birds have been made with proper equipment (Sony 15x digital camera, Canon Sx40HS digital camera, Panasonic SDR-H20 camera).

For the correct identification of some species we have used the following guides for determining species: BRUUN *et al.* (1999), PETERSON *et al.* (1989). For the list of the bird species we have also taken into account the data provided by the ornithological collection of the Oltenia Museum of Craiova (RIDICHE, 2011) – (Table 2). The classification of the bird species by systematic criteria has been made according to SZABÓ-SZELEY & BACZÓ (2006). The belonging to biotopes of the bird species has been determined according to CĂTUNEANU *et al.* (1978).

The administrative data regarding the status and the surface of the lands afferent to the area under study have been provided by the Local Council of Radovan commune.

Table 2. Birds captured in Radovan area, present in the patrimony of the Oltenia Museum. / Tabel 2. Păsări capturate în zona Radovan, prezente în patrimoniul Muzeului Olteniei.

No.	Species	Number of specimens	Sex and age	Place of capture	Date of capture
1.	*Tachybaptus ruficollis*	1	♀, ad.	Fântânele	April 17, 1976
2.	*Ixobrychus minutus*	1	♀, ad.	Fântânele	June, 1999
3.	*Branta ruficollis*	1	♂, ad.	Fântânele	January 13, 1997
4.	*Anas platyrhynchos*	1	♀, ad.	Fântânele	February 23, 1976
5.	*A. acuta*	1	♂, ad.	Fântânele	October 15, 2000
6.	*Pernis apivorus*	1	♂, ad.	Fântânele	June 11, 2002
7.	*Accipiter nisus*	1 1	♀, ad. ♀, ad.	Fântânele Radovan	March 14, 1991 January 10, 1996
8.	*Falco tinnunculus*	2	♂, ad.	Fântânele	January 8, 2003
9.	*Phasianus colchicus*	1	♀, ad.	Fântânele	January 30, 1985
10.	*Fulica atra*	1	♂, ad.	Fântânele	March 10, 1997
11.	*Cuculus canorus*	1	♀, ad.	Radovan	July 11, 1988
12.	*Asio otus*	1 1 1	♀, ad. ♀, ad. ♀, ad.	Radovan Fântânele Fântânele	February 6, 1976 January 12, 1978 January 9, 2003
13.	*A. flammeus*	1	♀, ad.	Fântânele	January 28, 1978
14.	*Alcedo athis*	1	♀, ad.	Fântânele	November 15, 1988
15.	*Merops apiaster*	8	♀, ad.	Fântânele	July 15, 1993
16.	*Coracias garrulus*	4 1	♂ ad., ♀, juv. ♂, ad.	Fântânele Fântânele	July 21, 1973 October 31, 1995
17.	*Picus viridis*	1	♂, ad.	Fântânele	July3, 2002

18.	*Galerida cristata*	1	♀, ad.	Fântânele	March 27, 1978
19.	*Oriolus oriolus*	1	♀, ad.	Fântânele	May 5, 1998
		1	♂, ad.	Fântânele	May 7, 2002
20.	*Lanius excubitor*	1	♀, ad.	Radovan	January 5, 1996
21.	*Garrulus glandarius*	1	♂, ad.	Fântânele	January 21, 1978
		1	♀, ad.	Fântânele	March 27, 1978
		1	♀, ad.	Fântânele	January 20, 1980
		1	♀, ad.	Fântânele	January 23, 1980
		1	♀, ad.	Fântânele	February 9, 1980
		1	♀, ad.	Fântânele	February 28, 1991
22.	*Pica pica*	1	♀, ad.	Fântânele	January 21, 1978
		1	♀, ad.	Fântânele	February 2, 1978
		1	♀, ad.	Fântânele	February 1, 1978
		1	♀, ad.	Fântânele	March 28, 1978
23.	*Corvus monedula*	1	♀, ad.	Fântânele	March 5, 1978
		1	♀, ad.	Fântânele	March 31, 1978
24.	*C. frugilegus*	1	♀, ad.	Fântânele	February 10, 1980
25.	*Passer montanus*	1	♀, ad.	Fântânele	1993

Legend: Sex and age: ad. – adult, juv. – juvenile, ♀ – undetermined sex. / **Legendă**: Sexul şi vârsta: ad. – adult, juv. – juvenil, ♀ – sex nedeterminat.

RESULTS AND DISCUSSIONS

Following our research, we have identified a number of 106 species distributed to 15 orders and 38 families (Table 3). In what concerns the belonging of the species to the typical biotope (favourable to feeding and mostly to breeding), in the aquatic biotopes on the studied territory we have recorded a number of 44 of which 32 typical species and 12 accessory species and in the terrestrial biotopes we have recorded 76 species, of which 69 species are typical and 7 species are accessory. The last ones have a temporary (nutrition) relation with the respective biotope. In the area under research, there are also euritope species (*Cuculus canorus, Motacilla alba, Hirundo rustica*), whose presence we have equally observed, both in the aquatic and terrestrial biotopes.

Among the aquatic species present in the analysed area, our attention has been called by the colony of grey herons (*Ardea cinerea*) settled in Lunca Radovanului forest in the vicinity of Fântânele lake. The 20-25 nests were placed in an ash (*Fraxinus angustifolia*) and alder (*Alnus glutinosa*) forest, at heights over 10 m. Some of them had larger dimensions, which proves that they had been used for several successive years.

Table 3. The preliminary systematic list of the avifauna in Radovan locality area (Dolj county). / Tabel 3. Lista sistematică preliminară a avifaunei din aria localităţii Radovan (judeţul Dolj).

No.	Order, Family, Species	Phenological Status (Romania)	Ecological type (Habitat)		SPEC Category	Threat Status		Own observation (Estimated of bird populations)
			Aqu.	Ter.		Romania	Europe	
ORD. PODICIPEDIFORMES								
Fam. Podicipedidae								
1.	*Tachybaptus ruficollis*	SV, WR	t	–	Non-SPEC	-	S	5-8 in.; on passage
2.	*Podiceps cristatus*	SV, WR	t	–	Non-SPEC	-	S	3-7 in.; possible breeding
ORD. PELECANIFORMES								
Fam. Phalacrocoracidae								
3.	*Phalacrocorax carbo*	SV, WR	t	–	Non-SPEC	-	S	7-16 in.
4.	*P. pygmeus*	SV, WR	t	–	2	V	V	+ 4 in.
ORD. CICONIIFORMES								
Fam. Ardeidae								
5.	*Ixobrychus minutus*	SV	t	–	3	-	(V)	+ 4 in.; possible breeding
6.	*Nycticorax nycticorax*	SV	t	–	3	V	D	9-20 in.; possible breeding
7.	*Egretta garzetta*	SV	t	–	Non-SPEC	E	S	5-22 in.; frequent
8.	*Ardea cinerea*	SV, WR	t	+	Non-SPEC	-	S	colony with 20-25 nests
Fam. Ciconiidae								
9.	*Ciconia nigra*	SV, P	+	t	3	V	R	1-2 in.; relatively frequent
10.	*C. ciconia*	SV	t	+	2	V	V	3-5 pairs; nests in localities
Fam. Threskiornitidae								
11.	*Plegadis falcinellus*	SV, P	t	–	3	V	D	12-25 in. in flight to the northern part of the lake
ORD. ANSERIFORMES								
Fam. Anatidae								
12.	*Branta ruficollis*	WV	t	–	1	E	L	+ 1 in.; accidental;
13.	*Anas penelope*	P, WV	t	–	Non-SPEC	-	S	3-20 in.
14.	*A. crecca*	P, WV	t	–	Non-SPEC	-	S	12-50 in.
15.	*A. platyrhynchos*	PM, WV	t	+	Non-SPEC	-	S	120-150 in. on passage; 4-10 pairs possible breeding
16.	*A. querquedula*	SV, P	t	–	3	-	V	3-10 in. on passage

17.	*A. clypeata*	P, SW, WR	t	–	Non-SPEC	-	S	about 14-20 in.; on passage
18.	*Aythya ferina*	PM, WV	t	–	4	-	S	on passage; reduced flocks
ORD. ACCIPITRIFORMES								
Fam. Accipitridae								
19.	*Pernis apivorus*	SV, P	–	t	4	V	S	+ 2 in.; possible breeding
20.	*Haliaeetus albicilla*	PM, WV	t	+	3	CE	R	2 in.;
21.	*Accipiter gentilis*	R	+	t	Non-SPEC	-	S	+ 2 in.; possible breeding
22.	*A. nisus*	R, WV, P	+	t	Non-SPEC	-	S	+ 2 in.; possible breeding
23.	*Buteo buteo*	R, P, WV	+	t	Non-SPEC	-	S	+ 3 in; possible breeding
24.	*Aquila pomarina*	SV, P	+	t	3	V	R	+ 1 in.
ORD. FALCONIFORMES								
Fam. Falconidae								
25.	*Falco tinnunculus*	R	+	t	3	-	D	+ 2 pairs
26.	*F. vespertinus*	SV	+	t	3	V	V	+ 2 in.; possible breeding
27.	*F. subbuteo*	SV	+	t	Non-SPEC	-	S	+ 2 pairs
ORD. GALLIFORMES								
Fam. Phasianidae								
28.	*Perdix perdix*	R	–	t	3	-	V	
29.	*Phasianus colchicus*	R	–	t	Non-SPEC	-	S	present in small groups
ORD. GRUIFORMES								
Fam. Gruidae								
30.	*Fulica atra*	PM, WV	t	–	Non-SPEC	-	S	+ 10 in.
ORD. CHARADRIIFORMES								
Fam. Charadriidae								
31.	*Charadrius dubius*	P, SV	t	–	Non-SPEC		(S)	+ 7 in.; on passage
32.	*Vanellus vanellus*	SV, P	t	+	Non-SPEC	-	(S)	relatively numerous on passage
Fam. Scolopacidae								
33.	*Calidris* sp.	P	t	–	Non-SPEC	-	S	+ 20 in.
34.	*Philomachus pugnax*	P	t	–	4	-	(S)	tens of in. on passage
35.	*Limosa limosa*	P, SV	t	–	2	-	V	+ 150 in.
36.	*Tringa ochropus*	P	t	–	Non-SPEC	-	S	
Fam. Laridae								
37.	*Larus ridibundus*	MP, P, WV	t	–	Non-SPEC		S	14-25 in.
38.	*L.cachinnans*	R	t	–	Non-SPEC	-	S	few in. on feeding trips
39.	*L. michahellis*	R	t	–	Non-SPEC	-	S	6-10 in. ; on feeding trips
Fam. Sternidae								
40.	*Sterna hirundo*	SV, P	t	–	Non-SPEC			3-15 in.
41.	*Chlidonias hybrida*	P, SV	t	–	3	-	D	+ 40 in.; possible breeding
ORD. COLUMBIFORMES								
Fam. Columbidae								
42.	*Columba livia domestica*	R	–	t	Non-SPEC	-	S	in localities; common
43.	*Streptopelia decaocto*	R	–	t	Non-SPEC		(S)	in localities; common
44.	*S. turtur*	SV, P	–	t	3	V	D	+ 8 in.
ORD. CUCULIFORMES								
Fam. Cuculidae								
45.	*Cuculus canorus*	SV	+	+	Non-SPEC	-		frequent; breeding
ORD. STRIGIFORMES								
Fam. Strigidae								
46.	*Otus scops*	SV	–	t	2	-	(D)	sound identification
47.	*Athene noctua*	R	–	t	3	-	D	more frequent in localities
48.	*Strix aluco*	R	–	t	4	-	S	unevaluated flocks
49.	*Asio otus*	R	–	t	Non-SPEC	-	S	
50.	*A. flammeus*	WV, P	–	t	3	V	(V)	+ 2 in.
ORD. CORACIIFORMES								
Fam. Alcedinidae								
51.	*Alcedo atthis*	PM	t	–	3	-	D	2-3 in.
Fam. Meropidae								
52.	*Merops apiaster*	SV	–	t	3	-	D	40-100 in.; colonies in ground quarries
Fam. Coraciidae								
53.	*Coracias garrulus*	SV	–	t	2	-	(D)	+ 10 in.
Fam. Upupidae								
54.	*Upupa epops*	SV	–	t		V	S	well represented
ORD. PICIFORMES								
Fam. Picidae								
55.	*Jynx torquilla*	SV	–	t	3	E	D	
56.	*Picus viridis*	R	–	t	2	-	D	frequent; unevaluated
57.	*Dendrocopos major*	R	–	t	Non-SPEC	-	S	frequent; unevaluated
58.	*D. syriacus*	R	–	t	4	-	(S)	frequent; unevaluated
59.	*D. medius*	R	–	t	4		S	rare; 1-2 in.

ORD. PASSERIFORMES								
Fam. Alaudidae								
60.	*Galerida cristata*	R	–	–	3	-	(D)	
61.	*Alauda arvensis*	PM	–	t	3	-	V	tens/hundreds of in.
Fam. Hirundinidae								
62.	*Hirundo rustica*	SV	+	+	3	-	D	tens of in.; common
63.	*Delichon urbicum*	SV	+	+	Non-SPEC	-	S	tens of s in.; common
Fam. Motacillidae								
64.	*Anthus campestris*	SV	–	t	3		V	frequent
65.	*Motacilla flava*	SV	–	t	Non-SPEC	-	S	frequent
66.	*M. alba*	SV	+	+	Non-SPEC	-	S	common
Fam. Turdidae								
67.	*Luscinia luscinia*	SV	–	t	4		S	little numerous
68.	*L. megarhynchos*	SV	–	t	4	-	(S)	frequent
69.	*Saxicola rubetra*	SV	–	t	4		S	+ 2 in.
70.	*Turdus merula*	PM	–	t	4	-	S	
71.	*T. pilaris*	PM. WV	–	t	4	-	S	tens/hundreds of in.
72.	*T. philomelos*	SV	–	t	4	-	S	
Fam. Sylviidae								
73.	*Acrocephalus arundinaceus*	SV	t	+	Non-SPEC	-	(S)	
74.	*Sylvia curruca*	SV	–	t	Non-SPEC		S	frequent
75.	*S. communis*	SV	–	t	4		S	
76.	*S. atricapilla*	SV	–	t	4		S	relatively numerous
77.	*Phylloscopus collybita*	SV	–	t	Non-SPEC		S	more numerous on passage
Fam. Muscicapidae								
78.	*Muscicapa striata*	SV	–	t	3		D	more numerous on passage
79.	*Ficedula albicollis*	SV	–	t	4	-	S	
Fam. Aegithalidae								
80.	*Aegithalos caudatus*	R	–	t	Non-SPEC	-	S	frequent
Fam. Paridae								
81.	*Parus lugubris*	R	–	t	4	-	(S)	frequent
82.	*P. ater*	R	–	t	Non-SPEC	-	S	
83.	*P. caeruleus*	R	–	t	4	-	S	tens/hundreds of in.
84.	*P. major*	R	–	t	Non-SPEC	-	S	tens/hundreds of in.
Fam. Sittidae								
85.	*Sitta europaea*	R	–	t	Non-SPEC	-	S	frequent
Fam. Oriolidae								
86.	*Oriolus oriolus*	SV	–	t	Non-SPEC	-	S	frequent
Fam. Laniidae								
87.	*Lanius collurio*	SV	–	t	3	-	(D)	+ 25 pairs; common
88.	*L. minor*	SV	–	t	2		(D)	+ 6 - 12 in.
89.	*L. excubitor*	WV. PM	–	t	3	-	D	+ 10 in.; on spring passage
Fam. Corvidae								
90.	*Garrulus glandarius*	R	–	t	Non-SPEC	-	(S)	common in forests; appears in localities
91.	*Pica pica*	R	–	t	Non-SPEC	-	S	common
92.	*Corvus monedulla*	R	–	t	4	-	(S)	common
93.	*C. frugilegus*	R	–	t	Non-SPEC	-	S	common
94.	*C. corone*	R	+	t	Non-SPEC	-	S	common
Fam. Sturnidae								
95.	*Sturnus vulgaris*	PM	–	t	Non-SPEC		S	common; tens and hundreds of sp.; colonies in ground quarries
Fam. Passeridae								
96.	*Passer domesticus*	R	–	t	Non-SPEC		S	common; tens/hundreds of in.
97.	*P. montanus*	R	–	t	Non-SPEC	-	S	common; tens/hundreds of in.
Fam. Fringillidae								
98.	*Fringilla coelebs*	PM	–	t	4	-	S	common
99.	*F. montifringilla*	WV	–	t	Non-SPEC	-	S	frequent
100.	*Carduelis chloris*	R	–	t	4	-	S	frequent
101.	*C. carduelis*	R, WV	–	t	Non-SPEC	-	(S)	common
102.	*Pyrrhula pyrrhula*	R	–	t	Non-SPEC	-	S	relatively frequent
103.	*Coccothraustes coccothraustes*	R	–	t	Non-SPEC	-	S	relatively frequent
Fam. Emberizidae								
104.	*Emberiza citrinella*	R	–	t	4	-	(S)	frequent
105.	*E. hortulana*	SV	–	t	2	-	(V)	rare; little numerous (1-5 in.)
106.	*E. calandra*	PM	–	t	4	-	(S)	common

Legend: Phenological Status (Romania): R – resident; PM – partial migrant, P – passage visitors; SV – summer visitors, WV – winter visitors; WR – winter rare; Ecologic type (Habitat): Aqu. – aquatic, Ter. – terrestrial, t – typical; + accessory; SPEC category: SPEC 1 – species of global conservation concern (in the entire spreading area), implicitly dependent on conservation; SPEC 2 – species concentrated in Europe, with unfavourable conservation status; SPEC 3 – species which are not concentrated in Europe and have unfavourable conservation status; SPEC 4 – species concentrated in Europe, with favourable conservation status; Non-SPEC – species which are not concentrated in Europe and whose European populations are in a favourable conservation state; Threat status: D – Declining, CE – critically endangered, E – Endangered, L – Localized, R – Rare, S – Secure, V – Vulnerable, () – provisional status; Estimated of bird populations: in. – number of individuals.

Legendă: Tipul fenologic: S – sedentară, Mp – migratoare parţial, P – specie de pasaj, Ov – oaspete de vară, Oi – oaspete de iarnă; Tipul ecologic: Acv. – acvatică, Ter. – terestră, t – tipică; + accesorie; Categoria SPEC: SPEC 1 – specii ameninţate pe plan global (în tot arealul de răspândire), implicit dependente de conservare; SPEC 2 – specii concentrate în Europa, cu statut de conservare nefavorabil; SPEC 3 – specii care nu sunt concentrate în Europa şi au statut de conservare nefavorabil; SPEC 4 – specii concentrate în Europa, cu statut de conservare favorabil; Non-SPEC – specii care nu sunt concentrate în Europa şi ale căror populaţii europene se află într-o stare favorabilă de conservare; Statutul de ameninţare: D – în declin, CE – critic periclitată, E – periclitată, L – localizată, R – rară, S – sigură, V – vulnerabilă, () – statut provizoriu; Efective estimate: in. – număr de exemplare.

The observation of the black stork (*Ciconia nigra*) often overflying the forest to the water meadow of the Desnăţui river indicates the possibility of its breeding, especially because the area provides enough trophic resources necessary for the living of this species. This fact will be established in the future studies.

The Anseriformes (*Anas* sp., *Aythya* sp.) and limicolous birds (e.g. *Charadrius dubius, Vanellus vanellus, Philomachus pugnax*) are numerically well represented during the spring passage, in the north-western part of Fântânele lake. In the rest of the year, the number of species and populations is considerably reduced.

Fântânele lake managed for intensive fishing attracts some fish eating birds such as: *Phalacrocorax* sp., *Sterna hirundo, Chlidonia hybrida, Larus* sp., *Haliaeetus albicilla.*

The large surfaces of natural forest, which interfere with the other terrestrial and aquatic biotopes, favour the presence of diurnal and nocturnal birds of prey, as breeding species.

The Passeriformes, best represented by the Turdidae, Sylviidae and Fringillidae, represent the dominant order during the whole year and they are predominant among the breeding species in the studied area.

A continuous and fierce competition for the breeding habitat has been observed between *Merops apiaster* and *Sturnus vulgaris* which claim both the cavities and the galleries dug in the earth quarries near Radovan locality.

According to SPEC categories into which the species in Radovan area fit, we notice that the area includes 54 species of European conservation interest, of which 1 species (*Branta ruficollis*) is of global conservation concern (SPEC 1), 8 species are concentrated in Europe and have unfavourable conservation status (SPEC 2), 24 species are not concentrated in Europe and have unfavourable conservation status (SPEC 3), 22 species are concentrated in Europe and have favourable conservation status (SPEC 4). The rest, namely 51 species are not concentrated in Europe and their European populations are in a favourable conservation state (Non-SPEC).

In accordance with the conservation concern status at European level, the situation in the territory that we have investigated stands as it follows:

- 11 bird species are vulnerable, meaning that they depend on conservation, and their inclusion in the category of endangered species is possible in the near future if the causal factors persist (*Phalacrocorax pygmeus, Ixobrychus minutus, Ciconia ciconia, Anas querquedula, Falco vespertinus, Perdix perdix, Limosa limosa, Asio flammeus, Alauda arvensis, Anthus campestris, Emberiza hortulana*);
- 3 species are rare, meaning that at global level they have rarely distributed populations on large areas (*Ciconia nigra, Haliaeetus albicilla, Aquila pomarina*);
- 1 species has limited spreading area in Europe (*Branta ruficollis*);
- 19 species are in decline, meaning that they have broody stocks in regression at European or global level (*Nycticorax nycticorax, Plegadis falcinellus, Falco tinnunculus, Chlidonias hybrida, Streptopelia turtur, Otus scops, Athene noctua, Alcedo atthis, Merops apiaster, Coracias garrulus, Jynx torquilla, Picus canus, P. viridis, Galerida cristata, Hirundo rustica, Muscicapa striata, Lanius collurio, L. minor, L. excubitor*);
- 50 bird species are safe, meaning that their populations maintain themselves as viable components of the natural habitats, and their areas do not present the risk of reduction.

The species with unfavourable conservation status at national level are registered in the Red Book of Vertebrates (MUNTEANU, 2005), therefore, taking it into account, the situation of the birds in Radovan area stands as it follows: 1 species is critically endangered, 3 species are endangered, and 11 species are vulnerable.

We consider that the inclusion of Radovan area on the AIA list and its designation as SPA in the network of Natura 2000 sites would ensure a better management of the habitats, namely of the bird species with unfavourable conservation status, simultaneously with the sustainable development of the area.

Because of a difficult delimitation and the similarity of the habitats with the ones in the neighbouring areas, we consider the extension of the avifauna research also in the neighbouring territories, so that the potential AIA or the potential Natura 2000 (SPA) site may have correct and scientifically proven limits.

CONCLUSIONS

The present paper represents a preliminary study regarding the characteristics of the avifauna in Radovan locality area and its surroundings. The studied area meets the qualities of a potential Natura 2000 site, by its geomorphological, ecological and faunal features. Following the observations carried on, we have identified a number of 106 bird species, systematically classified into 15 orders and 38 families. Most of them have been recorded in terrestrial biotopes. The aquatic species are more numerous, both qualitatively and quantitatively, during spring passage. The majority of bird species are of European conservation interest and they represent indicators for designating important bird areas (special protected areas).

A number of 25 species from the researched area are found in the patrimony of the Oltenia Museum, representing scientific documents which emphasize once again the faunal value of the analysed area.

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REFERENCES

BRUUN B., DELIN H., SVENSSON L. 1999. *Păsările din România şi Europa. Determinator ilustrat* (versiunea românească: Munteanu D.). Edit. Hamlyn. Londra. 320 pp.

CĂTUNEANU I. I., KORODI G. I., MUNTEANU D., PAŞCOVSCHI S., VESPREMEANU E. 1978. *AVES. Fauna R.S.R.* Edit. Academiei. **15**(1). Bucureşti. 314 pp.

CERNESCU N, DZERDZEEVSKI B. L., FORMOZOV A. N. 1960. *Monografia geografică a R. P. R.* Edit. Academiei R. P. R. Bucureşti. 742 pp.

CETĂŢEANU I, HINOVEANU I, TRĂISTARU ELISABETA (Coordonatori). 1981. *Dolj. Monografie.* Edit. Sport-Turism Bucureşti. 308 pp.

LAZĂR V., NĂSTASE A., NICOLI V. 2001. *Ocrotirea naturii în judeţul Dolj.* Edit. Genessa. Craiova. 121 pp.

MUNTEANU D. 2004. *Arii de importanţă avifaunistică din România.* Edit. Alma Mater. Cluj-Napoca. 307 pp.

MUNTEANU D. 2005. *Păsări (Aves)* In: Cartea Roşie a Vertebratelor din România (Eds.: Botnariuc N. & Tatole Viorica). Edit. Academia Română şi Muzeul Naţional de Istorie Naturală „Grigore Antipa", Tipografia "Curtea Veche", Bucureşti: 85-172.

PETERSON R., MOUNTFORT G., HOLLOM P.A.D. 1989. *Guide des Oiseaux d'Europe.* Edit. Delachaux et Niestlé, Neuchatel – Paris. 460 pp.

POPESCU GH., COSTACHE I., RADUTOIU D., BORUZ VIOLETA. 2003. *Valea Rea-Radovan Dolj district, floristic and vegetation point of great scientific importance.* Acta Horti Botanici Bucurestiensis. Bucureşti. **30**: 83-94.

RIDICHE MIRELA SABINA. 2011. *Catalogul colecţiei de păsări (Aves) a Muzeului Olteniei Craiova / The catalogue of the birds (Aves) collection of the Museum of Oltenia.* Edit. Arves. Craiova.184 pp.

SÂRBU ANCA (coordonator). 2007. *Arii speciale pentru protecţia şi conservarea plantelor în România.* Edit. Victor B. Victor. Bucureşti: 284-285.

SZABÓ-SZELEY L. & BACZÓ Z. 2006. *Nomenclatorul păsărilor din România – Nomenclator Avium Romaniae.* Edit. Aves. Odorheiu Secuiesc. 117 pp.

***. Legea nr. 5 din 6 martie 2000 privind aprobarea Planului de amenajare a teritoriului naţional - Secţiunea a III-a - zone protejate. Publicată în M. Of. nr. 152/12 apr. 2000.

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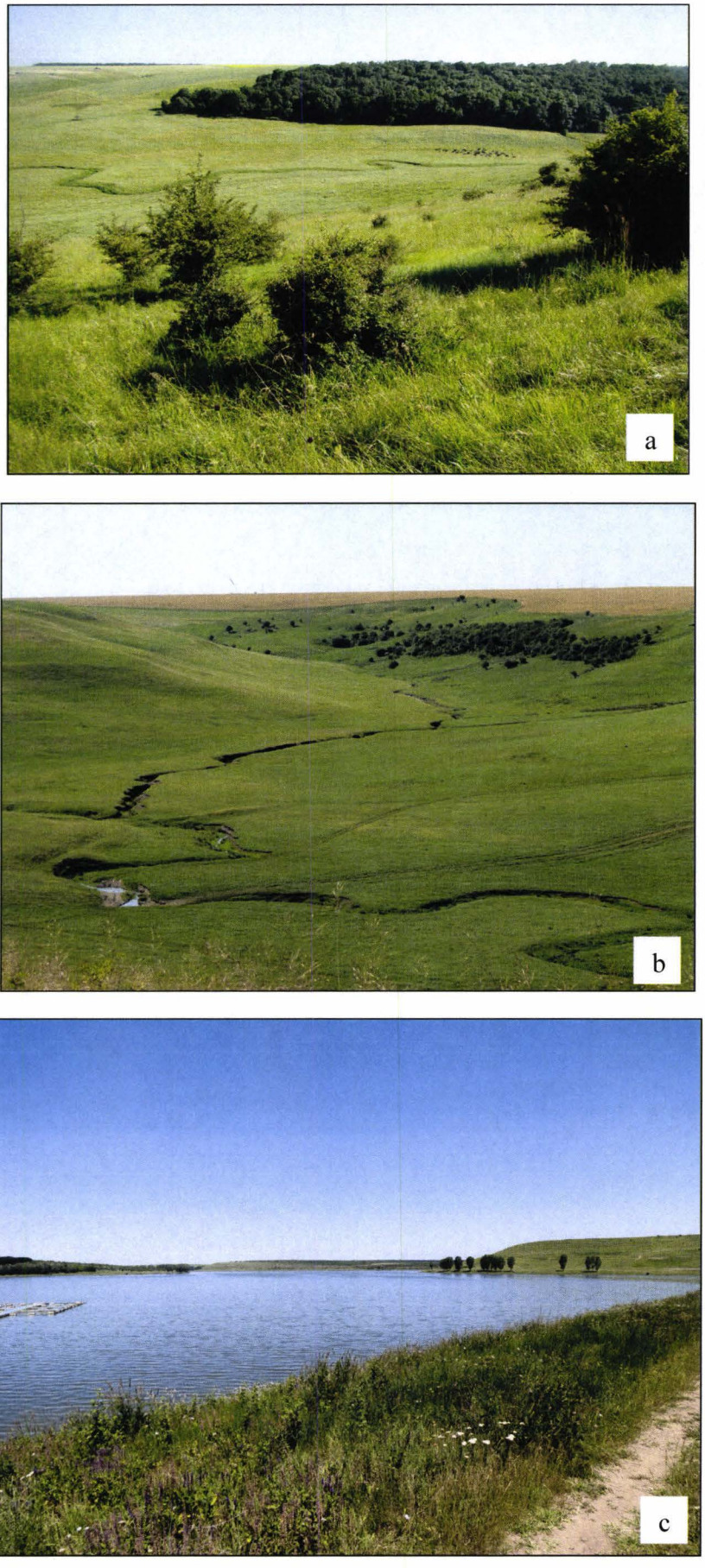

Figure 1. Biotopes from Radovan area: a – Radovan forest, b – brook Valea Rea, c – Fântânele lake.
Figura 1. Biotopuri din aria Radovan: a – pădurea Radovan, b – pârâul Valaea Rea, c – lacul Fântânele (original).

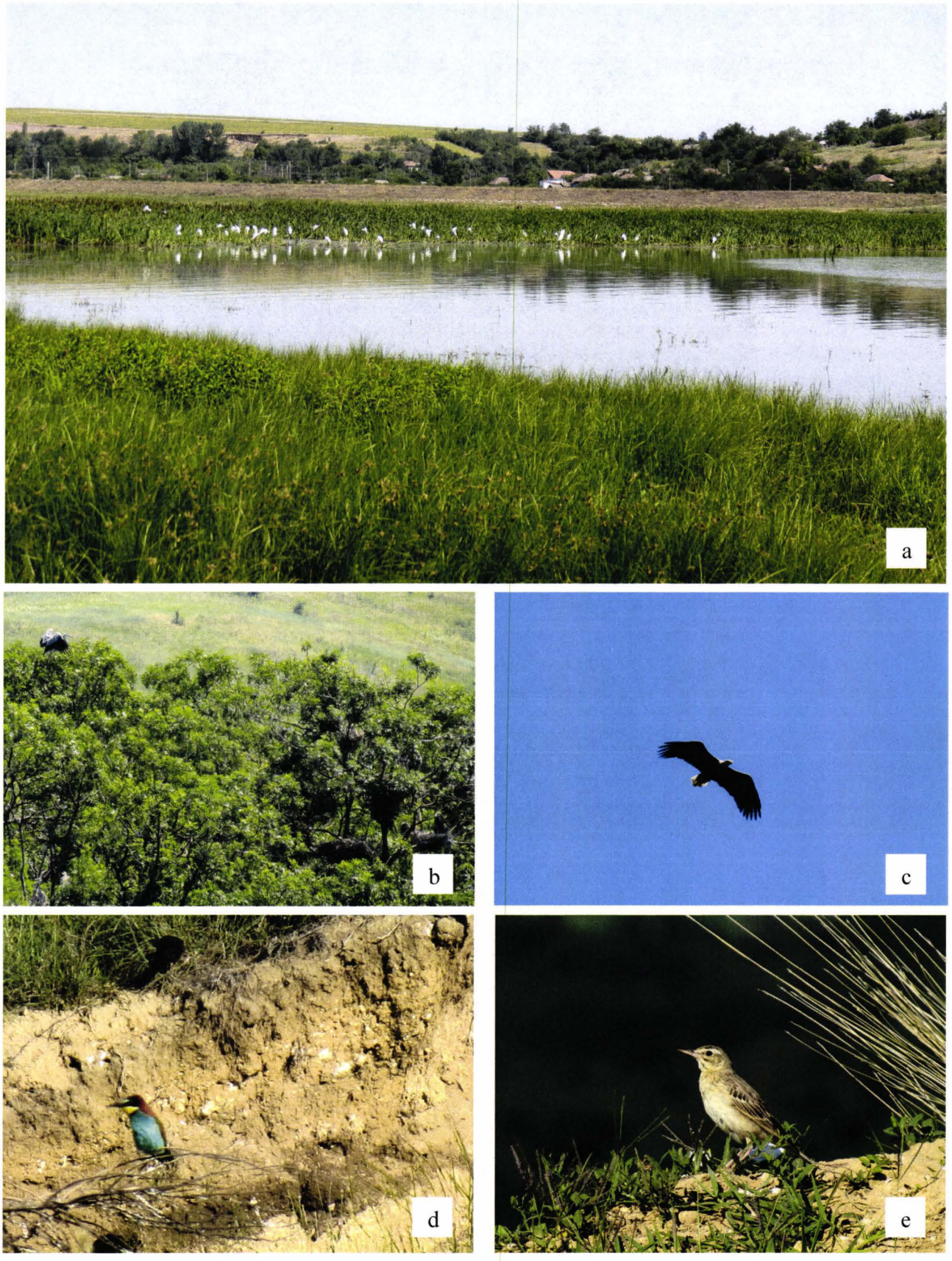

Figure 2. Birds from Radovan area: a – Little Egret (*Egretta garzetta*), b – colony of Grey Heron (*Ardea cinerea*), c – White-tailed Eagle (*Haliaeetus albicilla*), d – Bee-eater (*Merops apiaster*) and Starling (*Sturnus vulgaris*), e – Tawny Pipit (*Anthus campestris*).
Figura 2. Păsări din aria Radovan: : a – egreta mică (*Egretta garzetta*), b – colonie de stârc cenuşiu (*Ardea cinerea*), c – codalb (*Haliaeetus albicilla*), d – prigorie (*Merops apiaster)* şi graur (*Sturnus vulgaris*), e – fâsă de câmp (*Anthus campestris*) (original).

ASPECTS CONCERNING REPRODUCTIVE BEHAVIOUR OF EUROPEAN MOUFLON (*Ovis ammon mussimon*) INTO ENCLOSURES FROM ROMANIA

ANTONE Veronica, URSU Nicoleta

Abstract. This paper presents the results obtained in 3 years of field research on mouflon nucleus* from folds, hunting complexes and zoological gardens across the country. Two conducted studies in controlled conditions - the separation of ewes from rams in mating season and the introduction of two new mouflon specimens from other geographical areas, have confirmed the field results and showed the importance of socio-signals, sexual glands maturity and season climatic conditions. The study shows behavioural differences between the European and Canadian mouflon and underlines changes of the reproductive behaviour and the breeding period for the colonized mouflon in Romania.

Keywords: mouflon, reproductive behaviour, breeding season, mating, Romania.

Rezumat. Aspecte privind comportamentul de reproducere al muflonului european (*Ovis ammon mussimon*) în împrejmuiri din România. Lucrarea de faţă prezintă rezultatele a 3 ani de cercetare pe nuclee de mufloni din ţarcuri, complexuri de vânătoare şi grădini zoologice din ţară. Două studii realizate în condiţii controlate - separarea femelelor de masculi în perioada de rut şi introducerea în ţarc de noi exemplare de mufloni din alte zone geografice, au confirmat datele obţinute din teren şi au evidenţiat importanţa sociosemnalelor, a maturităţii glandelor sexuale şi a condiţiilor sezoniere specifice. Studiul arată diferenţe de comportament între muflonul european şi cel canadian, evidenţiază modificări ale comportamentului şi a perioadei de reproducere la muflonul colonizat în România.

Cuvinte cheie: muflon, comportament de reproducere, sezon de rut, împerechere, România.

INTRODUCTION

In Romania, the mouflon - *Ovis ammon mussimon* (PALLAS 1811) is found only in confined areas such as hunting complexes, folds or zoological gardens, all these areas being located at small altitudes - under 700 m. The locations, with history on trophy quality and/or the size of population, are Negureni, Şarlota, Scroviştea and among the zoological gardens - CMSN Constanţa.

The settled relations between individuals belonging to the same group govern the characteristic behaviours, which favours the development of the population, even if certain individuals are underprivileged or eliminated. Several behaviours could be discerned: social, territorial, feeding, reproductive and defence (MICU, 1999).

The mouflon has a group behaviour, including flocking. Both genders reached sexual maturity in the second year of life. The gestation period is about 22 weeks (MICU, 2004). Field observations point to major variations of mouflon behaviour in the period of reproduction, which is October - December.

MATERIAL AND METHODS

The field research was made in 3 years (2009 - 2011) and covered 80% of mouflon locations across the country, meaning 4 folds out of 5 with permanent population and 10 zoological gardens out of 13 with mouflon populations in patrimony - representing more than 300 specimens. Detailed studies were made on mouflon nucleus from Negureni - where the population have had between 45 and 75 individuals in last three 3 years, and CMSN - where the population was between 25 and 15 individuals in last three 3 years (ANTONE & VICOVAN, 2009; ANTONE & UNICI, 2011).

Field observations were made from fixed points (scouting pickets) and itinerantly.

For remote observations it has been used a Bresser 7x21x40 binocular and a Fuji Finexpix S1000FD digital camera.

The observations have been recorded on typical observations' forms - data concerning number of individuals, gender, location, altitude, age, weather conditions, time-stamp or time interval etc., and on an observations' notebook in which there were recorded the behavioural manifestations or any other relevant data. Most of the enclosures from Romania have mouflon specimens identified by ear tags or by RFID tags, including CMSN. Thus, it was possible to create a database, register cards and individual observations' forms.

According to TIMBERGEN (1951), the breeding implies the synchronization of sexual activities of two partners, and the synchronization is mainly based on three factors: specific season conditions such as length of day and temperature; the maturity and the activity of sexual glands plus the presence of the adult opposite gender; the presence of certain socio-signals in mating behaviour. For underlining the importance of these three factors, two studies in controlled conditions have been conducted:

1. The isolation of the rams, starting in August until December - which represents the ending of mating period. The groups of ewes and rams had no visual contact (Figs. 1A, 1B). In December, a single ram, 2 years old, was put inside the ewes' enclosure.

2. A pair of mouflon was brought from Dobrick (Bulgaria) zoological garden, and the estrous cycle was put under observation in the following year.

RESULTS AND DISCUSSIONS

Although a wild animal, the mouflon has a specific social behaviour determined by the isolation of groups into enclosures/folds and by the human presence.

The majority of mouflon lives in groups with variable sizes depending on the density of population and season. The living area and food availability - both being controlled by people, have no major influence on group.

In the beginning of the mating period (September), the food is abundant and the spring lambs become fully independent. At this time, the behaviours of threat and fight, hierarchical and sexual behaviours emerge. Now it begins the fight between rams for the participation in the reproductive act. The vigorous adult males have precedence, they are the winners. More often, the hierarchy between rams suffers modifications.

Figure. 1. European mouflon in C.M.S.N. - Constanţa: A - Ewes' enclosure; B - Rams' enclosure.
Figura 1. Muflonul european la CMSN – Constanţa: A - incinta femele, B - incinta masculi (original).

The state of sexual motivation is hormonally determined and is under the influence of key stimulus triggers. (ACATINCĂI, 2003).

The ram acquires the relevant information by smelling, meaning the detection of female proestrus. The rams smells the anal zone of the ewes (Fig. 2); they scent by uplifting their neck and by increasing the contact surface area of their upper lip with the air (Fig. 3).

Figure 2. Detection by smelling.
Figura 2. Detecţie prin mirosire (original).

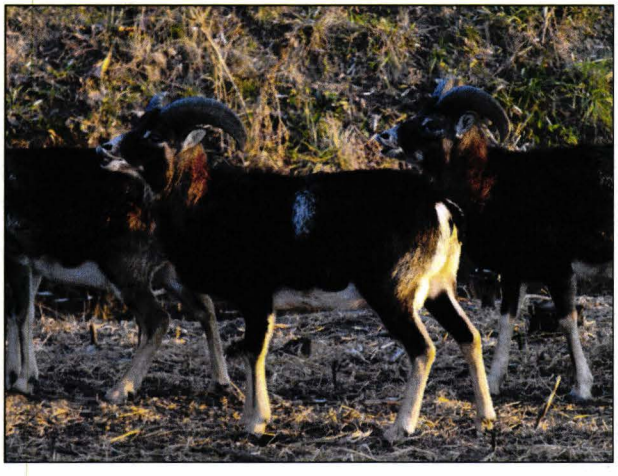

Figure 3. Ram, scenting specific posture.
Figura 3. Berbec, postură specifică de adulmecare (original).

Outside the estrus period the females do not accept mating, they adopt a surviving behaviour - they simply run.

Inside the mouflon groups under study, although the youth rams stay along the ewes, it was not observed a sexual ambivalent behaviour such as that described by the M. Cociu at the Canadian mouflon (*Ovis canadensis*) (see pages 749-750, COCIU, 1999). He points out that the Canadian mouflon behaviour regarding congeners is not dependent on gender, but only on size and rank among the group; females behave such as being underdeveloped rams. Also native from Corsica and Sardinia, the mouflon sheep brought into the west-central Texas, U.S.A., show a more aggressive behaviour (MCCLELLAND, 1991).

However, as in the case of the Canadian mouflon, the strong rams, which participate in the reproductive act, are those with ages between 5 and 7 years old. This fact was underlined by the experiment no.1, because all the isolated females gave birth in May – June of the following year, meaning that their ovules were fecundated after December 1, when a ram ageing 5 or 6 years old was put in their enclosure.

Comparing the sexual behaviour of the European mouflon, described in literature (GAREL *et al.*, 2005; STEKLENEV, 2006) with data collected from the field, it was found that in Romania the mouflon females reach the puberty in the second year of life, and thus at the age of three they are already ewes. That fact could argue that in Romania there are good conditions, which leads to a good development of the females, although slightly accelerated, but in spite all these, the reproductive capacity does not exceed the age of 12.

The first experiment has also put in evidence the Whitten effect: the estrous cycle is adjusted by the presence of the male inside the group; the females living in a group mate quicker when are presented to a male than the solitary ones.

The significance of season changes and the presence of the socio-signals were clearly showed in the second experiment. The ewe brought from Bulgaria gave birth in December, so she was mated in July. In the next year, the first proestrus period was in August, but mating was barely in November – the same period with the other females from group.

If the ram finds an ewe in estrus period, he begins the courting by slow approach and then by touching or stroking her in an affectionate manner (Fig. 4). If the ewe is detected in the same time by two or more rams, it will start the fight between the rams. The ewe will couple with the strongest one, the winner, while the other rams will run.

Figure 4. Courting the female. / Figura 4. Curtarea femelei (original).

The mouflon coupling has the following stages:

- The ram stalks the ewe (Fig. 5);
- Parallel running, the ram guides the ewe (by gentle kicks with his head) to a certain place and to prevent the getting away of the ewe (Fig. 6);
- Lateral gentle (foot) kicks;
- Dorsoventral coupling position, with ram having its neck uplifted and minimal body contact with the female.

Figure 5. Stalking the ewe. / Figura 5. Urmărire femelă (original).

Figure 6. Parallel running. / Figura 6. Fuga în paralel (original).

CONCLUSIONS

The mouflon mating behaviour includes three stages: searching, courting and mating.

The mating behaviour of the European mouflon is different from the behaviour of the Canadian mouflon. In the case of the European mouflon, it was not observed an ambivalent sexual behaviour, or any deviant one.

The mouflon females reach the puberty in the second year of life, and at the age of three, they are already ewes.

The Whitten effect was also highlighted in the case of the European mouflon.

It is necessary that older rams have to be removed from folds or enclosures, because there is a risk to be accidentally killed by the 5 to 7 years old rams (younger and stronger).

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REFERENCES

ACATINCĂI S. 2003. *Etologie-Comportamentul animalelor domestice*. Edit. Eurobit, Timişoara. 196 pp.

ANTONE VERONICA & VICOVAN G. 2009. *Dynamics of the mouflon population (Ovis ammon musimon) from C.M.S.N. Constanţa*. Book of Abstracts, Annual Zoological Congress of "Grigore Antipa" Museum, Bucharest: 130.

ANTONE VERONICA & UNICI R. 2011. *Dinamika populacije muflona iz Dobrudze*. Zbornik radova sa 6. medjunarodnog simpozijuma o lovstvu i odrzivom koriscenju biodiverziteta. Lovacki savez Srbije, Zagubica: 141-148.

COCIU M. 1999. *Etologie - Comportamentul animal*. Edit. All, Bucureşti. 856 pp.

GAREL M., CUGNASSE J.-M., GAILLARD, J.-M., LOISON A., GIBERT P., DOUVRE P., DUBRAY D. 2005. *Reproductive output of female mouflon (Ovis gmelini musimon×Ovis sp.): a comparative analysis*. Journal of Zoology. 266: 65-71. Available online at:http://onlinelibrary.wiley.com/doi/10.1017/S0952836905006667/abstract (accessed: March 16, 2012).

MCCLELLAND BLINDA. 1991. *Courtship and agonistic behavior in mouflon sheep*. Applied Animal Behaviour Science, 29(**1**): 67-85. Available online at: http://www.journals.elsevierhealth.com/periodicals/applan/article/0168-1591(91)90238-S/ (accessed: March 15, 2012).

MICU I. 2004. *Etologia faunei cinegetice*. Edit. Ceres. Bucuresti. 352 pp.

STEKLENEV E. P. 2006. *Characteristic of Reproduction Ability of Mouflon, Ovis musimon (Bovidae), which is acclimatized under the Semi-Free Conditions of the South Ukraine*. Vestnik zoologii. **40**(3): 249-255. [In Ucrainian with English abstract]. Available online at:http://www.nbuv.gov.ua/portal/chembiol/vzl/2006/pdf-/2006/3/05_Steklenev.pdf (accessed: February 27, 2012).

TIMBERGEN N. 1951. *The Study of Instinct*. Oxford University Press. 228 pp.

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BIOTIC AND ABIOTIC FACTORS CONTROLLING ORGANIC MATTER DECOMPOSITION IN AQUATIC ECOSYSTEMS OF SFÂNTU GHEORGHE BRANCH, THE DANUBE DELTA

PĂCEŞILĂ Ioan

Abstract. Decomposition of organic matter by heterotrophic microorganisms is a key process to ecosystems survival. Through this process the mineral elements present in the composition of the organic matter are released and reintroduced in the biogeochemical cycles. Thus, it is prevented an excessive accumulation of organic matter and, also, nutritional sources of primary producers are recycled. In the aquatic ecosystems most part of the organic matter consists of polymeric macromolecules which cannot be decomposed directly by microorganisms. In this case, the first stage of decomposition occurs outside of microbial cells under the action of extracellular enzymes synthesized by heterotrophic microorganisms. These enzymes hydrolyse polymeric macromolecules into monomers, directly usable by microbial cells. For this reason, nowadays, measuring extracellular enzymatic activity represents an important tool in the evaluation process of decomposition of organic matter in the aquatic ecosystems. This paper presents some characteristics of decomposition processes of organic matter in water and sediment samples from the riverine ecosystems of Sf. Gheorghe branch, the Danube Delta, assessed through the hydrolysis rate of extracellular enzymes and, also, evaluates the interaction of these processes with different biotic and abiotic factors. α-amylase, alkaline phosphatase and β-glucosidase extracellular enzymatic activities were determined using specific fluorogenic substrates. The water and sediments samples were collected in spring, summer and autumn between 2008 and 2010. Simple linear regression method was used to estimate the significance degrees between enzymatic activity and the environmental factors.

Keywords: extracellular enzymatic activity, aquatic ecosystems, the Danube Delta.

Rezumat. Factorii biotici şi abiotici care controlează procesele de descompunere a materiei organice în ecosistemele acvatice de pe braţul Sfântu Gheorghe, Delta Dunării. Descompunerea materiei organice de către microorganismele heterotrofe reprezintă un proces cheie care contribuie la supravieţuirea în timp a ecosistemelor. Prin acest proces elementele minerale din compoziţia materiei organice sunt eliberate şi reintroduse în ciclurile biogeochimice. Este astfel evitată acumularea în exces a materiei organice şi de asemenea, este reciclată sursa nutriţională a producătorilor primari. În ecosistemele acvatice, cea mai mare parte a materiei organice este alcătuită din macromolecule de natură polimerică, fapt pentru care nu pot fi preluate direct de către microorganisme. În acest caz, prima etapă a procesului de descompunere are loc extracelular sub acţiunea enzimelor extracelulare sintetizate de celulele microbiene care, prin hidroliză, disociază macromoleculele polimerice în monomeri direct utilizabili. Din această cauză, astăzi, măsurarea activităţii enzimatice extracelulare reprezintă un instrument important în evaluarea proceselor de descompunere a materiei organice în ecosistemele acvatice. Lucrarea de faţă prezintă unele caracteristici ale proceselor de descompunere a materiei organice din apa şi sedimentele ecosistemelor acvatice de pe braţul Sf. Gheorghe, Delta Dunării, estimate prin rata de hidroliză a enzimelor extracelulare, şi, de asemenea, evaluează interacţiunea acestor procese cu factorii biotici şi abiotici determinaţi. Enzimele extracelulare măsurate au fost: α-amilaza, fosfataza alcalină şi β-glucozidaza, utilizând substrate enzimatice specifice. Studiul a avut loc în perioada 2008-2010 în sezoanele de primăvară, vară şi toamnă. Compararea rezultatelor obţinute cu parametrii biotici şi abiotici determinaţi a fost realizată utilizând metoda regresiei liniare simple.

Cuvinte cheie: activitate enzimatică extracelulară, ecosisteme acvatice, Delta Dunării.

INTRODUCTION

Detrital organic matter, resulting from the activity of living organisms (excretion) or after their death, is subject to decomposition and mineralization processes by heterotrophic microorganisms; through these processes, the mineral constituents of the organic matter are released in the aquatic environment and recycled by the living organisms (BOTNARIUC & VĂDINEANU, 1982; SIMON-GRUIŢĂ, 2000; ZARNEA, 1994). Consequently, the decomposition of detrital organic matter is one of the key processes that contribute to ecosystem survival (SULKAVA & HUITA, 1998), avoiding the excessive accumulation of nutrients and organic matter that could lead to oxygen depletion and death of oxyphilic organisms.

The decomposition is a biological process that includes the physical breakdown and biochemical transformation of complex organic molecules of dead material into simpler organic and inorganic molecules (JUMA, 1998). In aquatic environments, most part of the organic matter (>95%) is composed of polymeric, high-molecular-weight compounds (CHROST & OVERBECK, 1990). In this case, the first stage of the decomposition process usually takes place outside the microbial cells, under the action of extracellular enzymes. Extracellular enzymes hydrolyse large organic molecules, such as polymers, leading to the formation of compounds with simpler structure that can be taken further by microbial cells (WETZEL, 1991). Extracellular enzymatic hydrolysis is the first step in mineralization of most of the polymeric constituents included in the composition of the organic matter (polysaccharides, proteins, organo-esters) by heterotrophic microorganisms, playing therefore an important role in the transfer of matter and energy through aquatic ecosystems (HARBOTT *et al.*, 2005).

Between 2008 and 2010, the structural and functional parameters of the aquatic communities were evaluated in Sf. Gheorghe branch, the Danube Delta, the southernmost of the three main branches through which the Danube flows into the Black Sea. This branch was subject of channelization in the 80's, when six meanders were cut to shorten the

navigation route; consequently, different types of sections were formed in the river branch: the free-flowing sector (FS), the meanders section (MS) and the newly built channel (NBC) (GÎŞTESCU & ŞTIUCĂ, 2006).

This paper presents the activity of three extracellular enzymes in water and sediment samples from Sf. Gheorghe branch: α-amylase, alkaline phosphatase and β-glucosidase and, also, evaluates the interaction of these processes with different biotic and abiotic factors. α-amylase and β-glucosidase are specific enzymes that act on polysaccharides starch and cellulose (in the final phase of degradation) (NICOLESCU *et al.*, 2000), while alkaline phosphatase is a nonspecific enzyme that catalyses the hydrolysis of a large variety of phosphate esters (JANSON *et al.*, 1988). The enzymatic activity was assessed together with other ecological characteristics, in order to emphasize the differences between the three sections.

MATERIAL AND METHODS

Samples were taken from the water column and water-sediment interface in April, July and October 2008-2010, from six stations (S2-S7) (Fig. 1) corresponding to the three sectors mentioned above, as it follows:

- the free-flowing sector (FS): stations S4 and S7
- the meanders section (MS): stations S2 and S5
- the newly built channel (NBC): stations S3 and S6.

Water samples were collected on water column using a modified Patalas device and kept in sterile bottles until the analyses. Sediment samples were collected from the top layer (the sediment-water interface) with a Corer device and stored in plastic bags. After sampling, both water and sediment samples were introduced in freezing bags and kept at 4°C for transport to the laboratory, where they were processed in short time to avoid major changes of enzymatic activities.

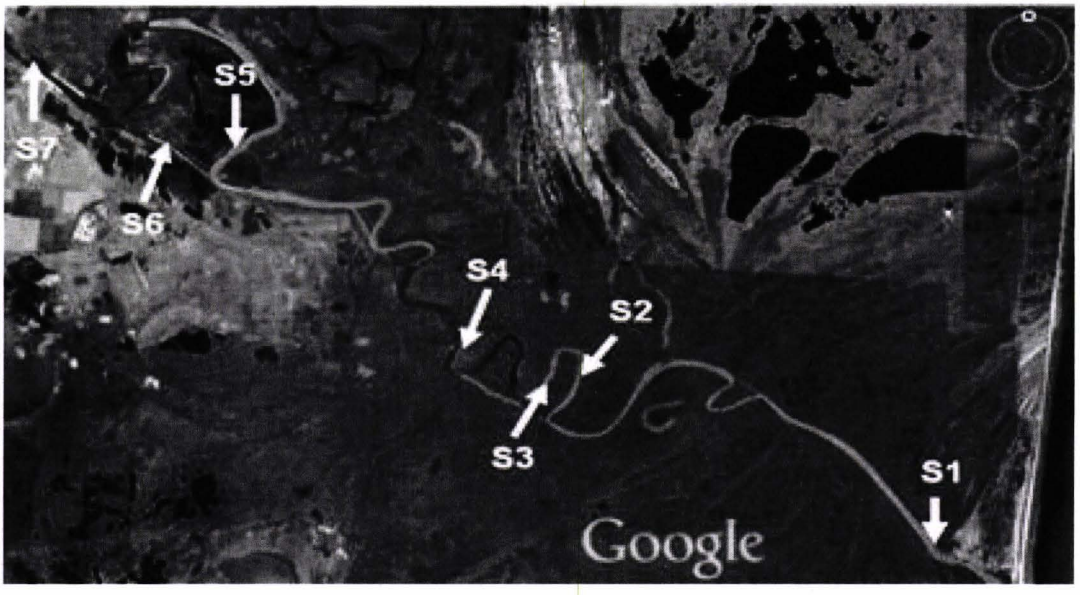


Figure 1. Location of sampling stations along Sf. Gheorghe branch (image from Google Earth).
Figura 1. Locaţia staţiilor de prelevare a probelor de pe braţul Sf. Gheorghe (imagine după Google Earth).

The intensity of the enzymatic activities was evaluated based on the estimation of substrate consumption by the existing enzymes; the absorbance of the reaction product was measured spectrophotometrically and its concentration was estimated by extrapolating the standard curve. The enzyme substrates used in the assessment were: 4-nitrophenyl phosphate for alkaline phosphatase, p-nitrophenyl-α-D-glycopyranozide for β-glucosidase and Amylopectin Azzure B-chloride for α-amylase (OBST, 1985). Water samples were used without processing, while sediment samples were dissolved in sterile tap water, the supernatant beings used for the enzymatic analyses. The incubation time for alkaline phosphatase and β-glucosidase activities was 6 h at 28°C for water samples and 24 h at 28°C for sediment samples, while for α-amylase both the water and sediment samples were incubated for 24 hours at room temperature under continuous shaking. After incubation, the enzymatic reactions were stopped and products determined spectrophotometrically. Alkaline phosphatase and β-glucosidase reaction product (nitrophenol) shows maximum absorbance at 405 nm wavelength, while the α-amylase catalysed reaction product (Azzure-B-Chloride) has maximum absorbance at 595 nm. All samples were analysed in triplicates.

The following physico-chemical and biological parameters were also determined:

- in water column: microbial biomass, pH, temperature, transparency, depth, concentrations of oxygen, total organic carbon, nitrite, nitrate and ammonium, dissolved inorganic nitrogen, organic and total phosphorous;
- in sediment: pH, temperature and organic matter concentration.

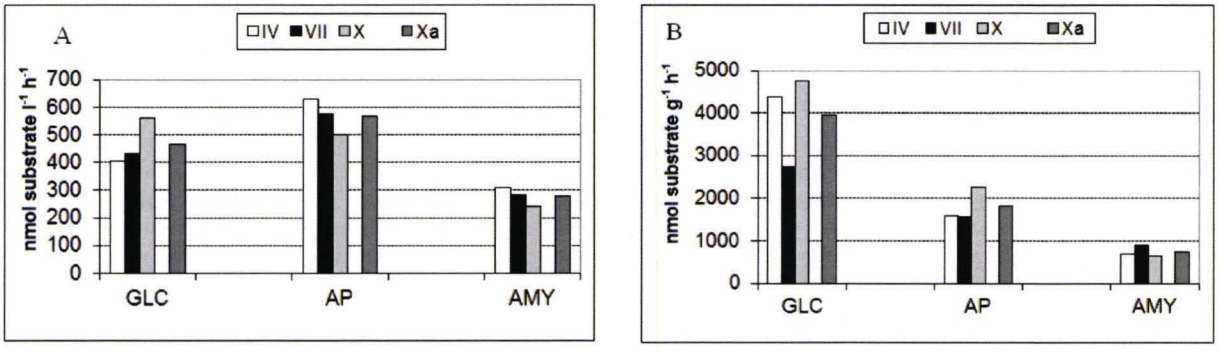
RESULTS AND DISCUSSIONS

The study of extracellular enzymatic activity was performed throughout the entire research program, except for α-amylase activity that was not measured in April 2008 in the water column. Hydrolysis rates of the studied enzymatic activities fluctuate in a wide range, recording different average values between the three sectors and in the same sector in different seasons or in different years.

Recorded enzymatic activity fluctuated within the following limits:

- in water column: - amylase : 137 – 396 nmol Azure-B-chloride/l/h
  - alkaline phosphatase : 190 – 920 nmol p-nitrophenol/l/h
  - glucosidase: 190 – 925 nmol p-nitrophenol/l/h
- in sediment: - amylase: 355 – 1269 nmol Azure-B-chloride/g/h
  - alkaline phosphatase : 908 – 6117 nmol p-nitrophenol/g/h
  - glucosidase: 1731 – 9336 nmol p-nitrophenol/g/h

a)



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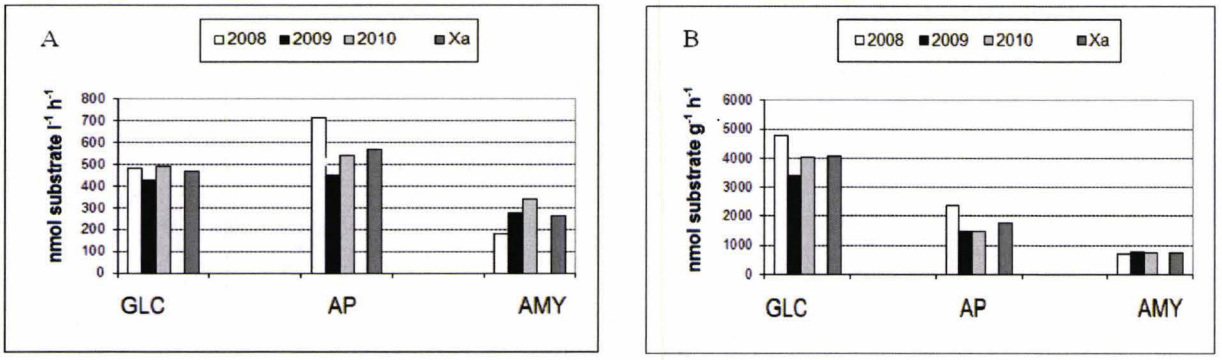

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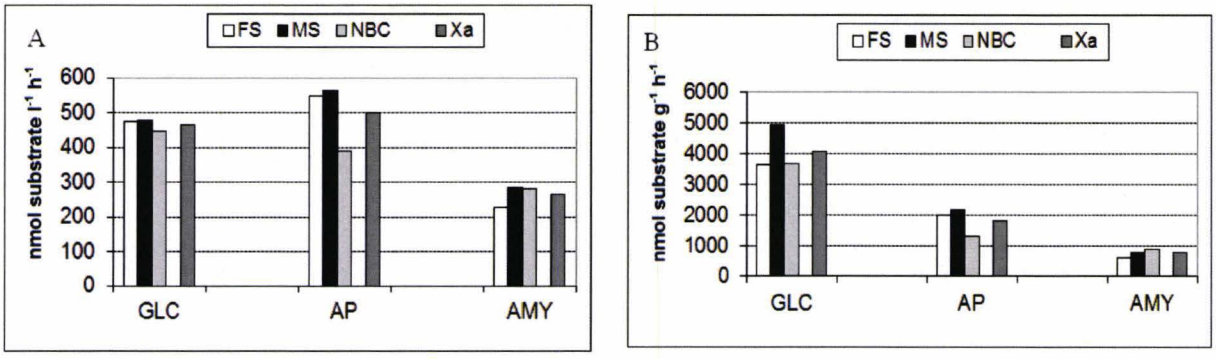

Figure 2. Seasonal (a), annual (b) and spatial (c) dynamics of amylase (AMY), glucosidase (GLC) and alkaline phosphatase (AP) activities in water column (A) and sediments (B). / Figura 2. Dinamica sezonieră (a), anuală (b) şi spaţială (c) a activităţilor amilazică (AMY), glucozidazică (GLC) şi fosfatazică (AP) în coloana de apă (A) şi în sediment (B).

In the water column, the most intense was phosphatase activity, which recorded a multiannual average value of 566 nmol p-nitro-phenol/l/h, while in the sediment was glucosidase activity with a multiannual average value of 4070 nmol p-nitrophenol/g/h.

Seasonal dynamics did not follow a common pattern for the investigated enzymatic activities in the water column or in the sediment. The amylase activity recorded the highest values in summer season, both in the water column and sediment (Fig. 2a), probably due to higher temperatures and substrate abundance, especially of algal origin; amylase is an enzyme that breakdown starch into glucose, a compound easily assimilated by microbial cells (IONICĂ *et al.*, 2006).

Glucosidase activity has shown maximum values during autumn in the water column, except for 2008 in the MS and NBC. Usually, the highest values of β-glucosidase activity were recorded during the decline of phytoplankton due to the release of large amounts of polysaccharide substrate from the dead algae (CHRÓST & OVERBECK, 1990). Similar results were recorded by WILCZECK *et al.* in 2002 in a study on the dynamics of extracellular enzyme activities performed on the Elbe River. (WILCZECK *et al.*, 2005). The highest intensity values in sediment were recorded in the spring season in 2008 and 2010 and in the autumn season in 2009.

The dynamics of phosphatase activity in water and sediment did not show a clear pattern, probably due to the changes occurred in the quantity and quality of the substrate, this enzyme catalysing the hydrolysis of a large variety of phosphate esters (JANSON *et al.*, 1988). In the water column, the highest average seasonal values were recorded in summer for 2008, while in 2009 and 2010 the maximum occurred in the spring season. In the sediment, the maximum seasonal average values were recorded in autumn for 2008, in summer for 2009 and in spring for 2010.

Like seasonal dynamics, the annual dynamics did not show a common trend for the studied enzymatic activities (Fig. 2b). Amylase activity has shown an upward trend in water column in all the three sectors, with minimum values in 2008 and maximum in 2010, while in sediment, the maximum values were recorded in 2009 and minimum in 2008.

For glucosidase activity, the annual average values did not show a clear dynamics in the water column and sediment in the three sectors. Most likely this is due to substrate availability and fluctuation of physico-chemical parameters during the study period. The highest annual average values were recorded in 2010 for the water column and in 2008 for the sediment, while the lowest annual average was recorded in 2009 in both water and sediment.

Generally, the highest intensity was recorded in the MS, except for phosphatase activity in the water column and amylase activity in sediment (Fig. 2c).

Since the dynamics of enzymatic activity is strongly correlated with the dynamics of other environmental parameters (NENIȚESCU, 1974; NELSON & COX, 2004), relationships between enzymatic activities and physico-chemical and biological parameters were investigated using mathematical modeling. Nowadays mathematical modelling is an important tool in studying a wide range of environmental areas (MOLDOVEANU & FLORESCU, 2011). The simple regression equations and the statistical significance between pairs of biotic and abiotic parameters of the obtained correlation matrices were screened in order to identify the parameters with the highest influence on the enzymatic activity.

For α-amylase activity, highly significant linear correlations were obtained with several physico-chemical parameters, emphasizing their role in controlling the enzymatic activity in the investigated ecosystems (Table 1). The intensity of α-amylase activity in the water column was dependent on the variation of pH and oxygen concentration, amylolitic microorganisms - the main group of organisms responsible for the synthesis of α-amylase – acting in the presence of oxygen (IONICĂ, 2006). An increase of pH above 9 caused a significant decrease of the intensity of this enzymatic activity, suggesting that this parameter may become a limiting factor of enzymatic activity under certain conditions such as powerful algal blooms. Highly significant correlations were also obtained with the concentration of dissolved inorganic nitrogen, an important source of nutrients for phytoplankton, as well an important source of polysaccharide compounds in the water column.

Another significant correlation was obtained between α-amylase and the transparency of the water column: in general, the highest values of intensity of amylase activity were recorded in areas with lower transparency, probably due to the presence of high amounts of dissolved and particulate organic matter, derived from the death of aquatic organisms or their excretes, which are the main substrate source for α-amylase (SIVARAMAKRISHNAN *et al.*, 2006). Between α-amylase activity and the microbial biomass in the water column a low significant linear correlation was identified, which may suggest that the biomass of the microorganisms that synthesize extracellular amylase have no significant quantitative contribution to the total microbial biomass.

In the sediment, several correlations were identified between α-amylase activity and temperature, the amount of organic matter and the microbial biomass (Table 2) indicating the dependence of this enzymatic activity of temperature fluctuation, the quantity and quality of the substrate and also a quite high contribution of microorganisms that synthesize extracellular α-amylase to the total microbial biomass.

Table 1. Linear correlations between the intensity of amylase activity and physico-chemical parameters from the water column for which the null hypothesis was rejected ($p < 0.05$). / Tabel 1. Corelațiile liniare obținute între intensitatea activității amilazice și parametrii fizico-chimici din coloana de apă față de care ipoteza nulă nu a fost respinsă ($p < 0.05$).

Physico-chemical parameters	n	r	p	Significance degree
pH	48	0.45	< 0.01	***
Transparency (m)	48	0.44	< 0.01	***
O_2 (mgO/l)	48	0.449	< 0.01	***
NH_4 (mgN/l)	48	0.47	< 0.01	***
NO_3 (mgN/l)	48	0.48	< 0.01	***
DIN (mgN/l)	48	0.32	< 0.05	**

Between phosphatase activity and microbial biomass in the water column there was a highly significant linear correlation, indicating that in general, high phosphatase activity values correspond to high microbial biomass values. This suggests a high abundance of groups of microorganisms involved in the mineralization of phosphorus compounds in Sf. Gheorghe aquatic ecosystems. A very important factor that influenced the overall dynamics of phosphatase

activity was the concentration of hydrogen ions present in the water column (Table 3); increasing the intensity of the enzymatic activity is in general proportional with the increase of pH value. Most intense activity of this enzyme was recorded in the 8-10 pH range.

Table 2. Linear correlations between the intensity of amylase activity and physico-chemical and biological parameters from sediment for which the null hypothesis was rejected ($p < 0.05$). / Tabel 2. Corelaţiile liniare obţinute între intensitatea activităţii amilazice şi parametrii fizico-chimici şi biologici din sediment faţă de care ipoteza nulă a fost respinsă ($p < 0.05$).

Physico-chemical parameters	n	r	p	Significance degree
Microbial biomass (mgC/l)	54	0.331	< 0.05	**
Temperature (m)	54	0.45	< 0.01	***
Organic matter %	54	0.378	< 0.01	**

It was found that high depth did not lower the intensity of enzyme activity by the dilution phenomenon of the substrate (NICOLESCU *et al.*, 2000). Enzyme substrate is present, therefore, throughout the water column.

Nitrate and nitrite concentrations in the water column influenced also the dynamics of phosphatase activity. These compounds are an important nutritional source for phytoplankton (MARTENS, 1989), which together with heterotrophic microorganisms is responsible for the presence in the water column of alkaline phosphatase, this enzyme being involved in the organophosphorus ester metabolism of algal cells (JANSON *et al.*, 1988).

Table 3. Linear correlations between the intensity of phosphatase activity and physico-chemical parameters of the water column for which the null hypothesis was rejected ($p < 0.05$). / Tabel 3. Corelaţiile liniare obţinute între intensitatea activităţii fosfatazice şi parametrii fizico-chimici şi biologici din coloana de apă faţă de care ipoteza nulă a fost respinsă ($p < 0.05$).

Physico-chemical parameters	n	r	p	Significance degree
Microbial biomass (mgC/l)	54	0.431	< 0.01	***
pH	54	0.62	< 0.0001	****
Depth (m)	54	0.35	< 0.01	**
NO_2 (mgN/l)	54	0.435	< 0.01	***
NO_3 (mgN/l)	54	0.28	< 0.05	*
Org P (µg/l)	54	0.46	< 0.001	***
Total P (µg/l)	54	0.434	< 0.01	***

Alkaline phosphatase is an enzyme responsible for the release of phosphorus from organic compounds and the reintroduction of this element in the biogeochemical cycles. The intensity of alkaline phosphatase synthesis is dependent on the amount of phosphorus present in aquatic ecosystems. This was also confirmed in St. Gheorghe ecosystems, where changes in the concentration of organic phosphorus were positively correlated in most cases with changes in the intensity of phosphatase activity. In sediment, a moderate correlation with the amount of organic matter was obtained, indicating the dependence of this enzymatic activity on the quantity and quality of the substrate (Table 4).

Table 4. Linear correlations between the intensity of phosphatase activity and physico-chemical parameters from sediment for which the null hypothesis was rejected ($p < 0.05$). / Tabel 4. Corelaţiile liniare obţinute între intensitatea activităţii fosfatazice şi parametrii fizico-chimici din sediment faţă de care ipoteza nulă a fost respinsă ($p < 0.05$).

Physico-chemical parameter	n	r	p	Significance degree
Organic matter %	54	0.34	< 0.05	**

Between β-glucosidase activity and microbial biomass in the water there was a moderately significant linear correlation (Table 5) during the study period, suggesting that the biomass of microorganisms that synthesize extracellular β-glucosidase had an important quantitative contribution to total microbial biomass, respectively that the polysaccharidic substrate was abundant. This confirms the results from the literature showing that, usually, the intensity of β-glucosidase activity in the water column is associated with the dynamics of microbial biomass (CHRÓST & OVERBECK, 1990).

A highly significant correlation and similar dynamics were obtained with transparency, probably due to increasing phytoplankton photosynthesis and productivity in these areas, respectively the increased number of algal organisms leading to the release of large amounts of phytoplanktonic polysaccharidic exudates – an important substrate source for this enzyme (FAJON *et al.*, 1999). Therefore, increasing the number of algal organisms lead to an increased rate of "sloopy feeding" of phytophagous zooplankton and, therefore, to the release of intracellular polymeric compounds in the environment (including the polysaccharidic compounds) which also contribute to increase the glucosidase activity (BOCHDANSKY *et al.*, 1995). A low significant correlation was recorded between the β-glucosidase activity and total phosphorus concentration, phosphorus being a mineral element essential in the development of phytoplankton (SYLVAN *et al.*, 2006).

Compared with other enzymatic activities, β-glucosidase activity showed the highest significant correlation with the amount of organic matter in the sediment; this may suggest that glucosidase activity represents an important factor contributing to the decomposition of the organic matter from the sediments of the investigated ecosystems. A significant correlation was also obtained with pH and temperature (Table 6).

Table 5. Linear correlations between the intensity of glucosidase activity and physico-chemical and biological parameters from the water column for which the null hypothesis was rejected ($p < 0.05$). / Tabel 5. Corelaţiile liniare obţinute între activitatea glucozidazică şi parametrii fizico-chimici şi biologici din coloana de apă faţă de care ipoteza nulă a fost respinsă ($p < 0.05$).

Physico-chemical parameters	n	r	p	Significance degree
Microbial biomass (mgC/l)	54	0.383	< 0.01	**
Transparency (m)	54	0.493	< 0.001	****

Table 6. Linear correlations between the intensity of glucosidase activity and physico-chemical parameters from sediment for which the null hypothesis was rejected ($p < 0.05$). / Tabel 6. Corelaţiile liniare obţinute între intensitatea activităţii glucozidazice şi parametrii fizico-chimici din sediment faţă de care ipoteza nulă a fost respinsă ($p < 0.05$).

Physico-chemical parameters	n	r	p	Significance degree
pH	54	0.426	< 0.01	***
Temperature °C	54	0.346	< 0.05	**
Organic matter %	54	0.404	< 0.01	***

CONCLUSIONS

The intensity of enzymatic activities evaluated in the water column and sediments of the aquatic ecosystems of Sf. Gheorghe branch, varied significantly in terms of seasonal, annual and spatial dynamics. In the water column, the most intense was phosphatase activity, while in sediment was glucosidase activity. Also, the intensity of the enzymatic activity was higher in sediment compared with the water column. Although a clear pattern of seasonal and annual dynamics for the three enzymatic activities could not be revealed, the spatial dynamics has shown in general the highest values in the meanders section. The calculation of linear regression between the enzymatic activity, the microbial biomass and different physico-chemical parameters revealed the significant role of the environmental factors (pH, temperature, transparency of the water column, microbial biomass, nutrients and oxygen concentration in the water column and temperature and organic matter in sediment) in controlling the enzymatic activity, respectively the organic matter decomposition, in the investigated ecosystems.

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REFERENCES

BOCHDANSKY A. B., PUSKARIC S., HERNDL G. J. 1995. *Influence of zooplankton grazing on free dissolved enzymes in the sea.* Marine Ecology Progress Series. New York. **121**: 53-63.

BOTNARIUC N. & VĂDINEANU A. 1982. *Ecologie*. Edit. Didactică şi Pedagogică. Bucureşti. 396 pp.

CHRÓST R. J. & OVERBECK J. 1990. *Substrate-ectoenzyme interaction: significance of β-glucosidase activity for glucose metabolism by aquatic bacteria.* Archive fur Hydrobiologie. Beih. Erghebn. Limnol. Stuttgart. **34**: 93-98.

FAJON C., CAUWE G., LEBARO P., TERZI S., AHE M., MALE A., MOZETI P., TUR V. 1999. *The accumulation and release of polysaccharides by planktonic cells and the subsequent bacterial response during a controlled experiment.* FEMS Microbiological Ecology. Stuttgart. **29**: 351-363.

GIŞTESCU P. & ŞTIUCĂ R. 2006. *Delta Dunării – Rezervaţie a biosferei*. Edit. Dobrogea Publishing House. Constanţa. 279 pp.

HARBOTT E. L., GRACE M. R., WEBB J. A., HART B. T. 2005. *Small-scale temporal variation and the effect of urbanisation on extracellular enzyme activity in streams*. Journal of Environmental Monitoring. New York. **7**: 861-868.

IONICĂ DOINA. 2006. *Comunităţi microbiene planctonice şi bentonice*. In: ZINEVICI V., IONICĂ D., PARPALĂ L., SANDU C., MUŞA R., DOBRE D. S. *Diversitatea unor comunităţi de microorganisme acvatice în sisteme ecologice din zonele Erenciuc şi Gorgostel (Delta – Dunării)*. Edit. Ars Docendi. Bucureşti. 302 pp.

JANSON M., OLSSON H., PETTERSSON K. 1988. *Phosphatases; origin, characteristics and function in lakes.* Hydrobiologia. Oxford. **170**: 157-175.

JUMA N. G. 1998. *The pedosphere and its dynamics: a systems approach to soil science.* Quality Color Press Inc. Edmonton. Canada. **1**. 315 pp.

MARTENS P. 1989. *Inorganic phytoplankton nutrients in the Wadden Sea areas off Schleswig-Holstein. I. Dissolved inorganic nitrogen.* Helgoland Marine Research. Australia. **43**(1): 77-85.

MOLDOVEANU M. & FLORESCU L. 2011. *Cauze şi efecte ale dinamicii structurale ale comunităţilor fitoplanctonice în sistemele lotice fluviale. Posibilităţi de predicţie.* Rezumat. A 51-a sesiune anuală de comunicări ştiinţifice. Institutul de Biologie. Edit. Ars Docendi. Bucureşti: 100.

NELSON D. L. & COX M. M. 2005. *Lehninger Principles of Biochemistry*, 4th Edition. W. H. Freeman and Company. New York. 1100 pp.

NENIŢESCU C. D. 1974. *Chimie organică*. Edit. Didactică şi Pedagogică. Bucureşti. **2**. 1051 pp.

NICOLESCU D., IONICĂ D., SANDU C., SIMON-GRUIŢĂ ALEXANDRA, GHEORDUNESCU V. 2000. *Microbial degradation of the organic matter from the Danube Delta lakes. 2. Extracellular enzymatic activity*. Proceedings of the Institute of Biology. Annales Scientifique Session. Bucharest. **2**. 396 pp.

OBST U. 1985. *Test instructions for measuring the microbial metabolic activity in water sample*. Annalles Chemistry. Springer Verlag. Stuttgart. **321**: 166-168.

SULKAVA P. & HUHTA V. 1998. *Habitat patchiness affects decomposition and faunal diversity: a microcosmos experiment on forest floor*. Oecologia. Budapest. Hungary. **116**: 390-396.

SIMON-GRUIŢĂ ALEXANDRA. 2000. *Rolul bacterioplanctonului în procesele ecologice în ecosistemele acvatice din Delta Dunării*. Teză de doctorat. Universitatea Bucureşti. 350 pp.

SIVARAMAKRISHNAN S., GANGADHARAN D., NAMPOOTHIRI K. M., SOCCOL. C. R., PANDEY A. 2006. *α-Amylases from microbial sources. An overview on recent developments*. Food Technology Biotechnology. New York. **44**(2): 173-184.

SYLVAN J. B., DORTCH Q., NELSON D. M. 2006. *Phosphorus limits phytoplankton growth on the Louisiana shelf during the period of hypoxia formation*. Environmental Science and Technology. New York. **40**(24): 7548-53.

WETZEL R. G. 1991. *Extracellular enzymatic interactions: storage, redistribution, and interspecific communication*. In: R. CHRÓST. Editors. Microbial Enzymes in Aquatic Environments. Brock/Springer Series in Contemporary Bioscience. Springer. New York. 317 pp.

WILCZECK S., FISCHER H., PUSCH M. T. 2005. *Regulation and seasonal dynamics of extracellular enzyme. Activities in the sediments of a large lowland river*. Microbial Ecology. University of Zurich. **50**: 253-267.

ZARNEA G. 1994. *Tratat de microbiologie generală*. Edit. Academiei Române. Bucureşti. **5**. 1008 pp.

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ASSESSMENT AND CONSERVATION STATUS OF FERNS FROM BUILA-VÂNTURARIŢA NATIONAL PARK

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Abstract. Scarce flora and vegetation studies were developed long time ago in the area occupied today by Buila-Vânturariţa National Park. The paper represent a biginning and a base for the future assessment studies and monitoring for framing the requirement of Habitat Directive for species conservation. The assessment of 25 species of ferns from the Park revealed that still there are sufficiently large habitats and low impact to maintain ferns' populations on a long-term basis if the impact is kept at least at the present intensity (2011). The well represented diversity, frequency, development and distribution of the ferns' species from Buila-Vânturariţa National Park demonstrate the favourable conservation status of ferns and of all integrating habitats.

Keywords: ferns, assessment, conservation, Buila-Vânturariţa, specific diversity.

Rezumat. Evaluarea şi statutul de conservare al ferigilor din Parcul Naţional Buila-Vânturariţa. De-a lungul timpului au fost realizate doar câteva studii privind flora şi vegetaţia din teritoriul ocupat astăzi de Parcul Naţional Buila-Vânturariţa. Lucrarea reprezintă un început şi o bază pentru viitoarele studii de evaluare şi monitoring în vederea aplicării cerinţelor Directivei Habitate pentru conservarea speciilor. Evaluarea a 25 specii de ferigi din parc a evidenţiat că există încă habitate suficient de mari şi impact încă scăzut pentru a menţine populaţiile de ferigi pe termen lung dacă impactul este menţinut cel puţin la intensitatea actuală (2011). Diversitatea bine reprezentată, frecvenţa, dezvoltarea şi distribuţia speciilor de ferigi din Parcul Naţional Buila-Vânturariţa demonstrează statutul de conservare favorabil al ferigilor şi al habitatelor integratoare.

Cuvinte cheie: ferigi, evaluare, conservare, Buila-Vânturariţa, diversitatea specifică.

INTRODUCTION

According to Habitat Directive 92/43/CEE on the conservation of natural habitats and of wild fauna and flora, conservation means a series of measures required to maintain or restore the natural habitats and the populations of species of wild fauna and flora at a favourable status.

There are few studies in Buila-Vânturariţa National Park concerning flora and vegetation (BUIA & PĂUN, 1956; PĂUN & POPESCU, 1971; 1978). Due to its floristic and faunistic owneness the Government Decizion declared Buila-Vânturariţa National Park in 2004 and ROSCI0015 in 2008.

Our study is the base for the future assessment and monitoring for framing the requirement of the Habitat Directive that define the conservation status of a species as the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within the territory.

MATERIAL AND METHODS

Buila is a montanous Massif spread between Olăneşti (East) and Bistriţa (West) rivers going toward South as steep slopes by Oltenian subcarpathian depression. Oriented from North-East to South-West, Buila Massif is dominated by cretaceous limestone (PĂUN & POPESCU, 1978).

Data were collected using GPS, during field trips in the Park. The former distribution sites (mentioned in literature) of the species were confirmed, other new sites were added in the data base. The entire distribution areas of the species were dificult to be established with high accuracy due to the fragmented and irregular habitat. Itinerary research perpendicularly or along contour lines in accordance with accesibility (less difficult climbing) were performed in order to determine the populations limits. The observations included the factor affecting ferns' populations. Biological and ecological traits are presented according to CIOCÂRLAN (2009).

RESULTS AND DISCUSSIONS

We identified 25 fern species on the teritory ROSCI0015 Buila-Vânturariţa. In accordance with their distribution recorded in 2011 in the field on Buila-Vânturariţa National Park territory, are highlighted their frequency and the sinergetic impact of the environmental factors (including the most important- anthropic one) (Table 1).

The distribution and frequency at the country level (CIOCÂRLAN, 2009) of the identified ferns reveal that most of them are frequent and sporadic and none of them are rare or occasional (Table 2).

In Vb Annex of Habitat Directive and 5A Annex of Romanian Government Ordonance 57/2007 all species of *Lycopodium* genus are taken into account as species with European concern/interest. Thus, the key and indicator species were established both according to the conservation importance at the European level (Habitat Directive) and their ecological treats, mainly based on substrate (Table 3).

Table 1. Ferns' frequency on Buila-Vânturariţa National Park territory and the intensity of the environmental factors.
Tabel 1. Frecvenţa ferigilor de pe teritoriul Parcului Naţional Buila-Vânturariţa şi intensitatea factorilor de mediu.

No.	Species	Frequency	Impact intensity
1.	*Asplenium ruta-muraria* L.	Rare	Low
2.	*A. scolopendrium* L.	Frequent	Low
3.	*A. trichomanes* L.	Very frequent	Low
4.	*A. viride* HUDS.	Rare	Low
5.	*Athyrium filix-femina* (L.) ROTH	Frequent	Low
6.	*Blechnum spicant* (L.) ROTH	Rare	Low
7.	*Botrychium lunaria* (L.) SW.	Rare	Low
8.	*Ceterach officinarum* DC.	Rare	Low
9.	*Cystopteris fragilis* (L.) BERNH.	Frequent	Low
10.	*Dryopteris affinis* (LOWE) FRASER-JENK.	Rare	Low
11.	*D. dilatata* (Hoffm.) A. GRAY	Rare	Low
12.	*D. filix-mas* (L.) SCHOTT	Very frequent	Low
13.	*Gymnocarpium dryopteris* (L.) NEWMAN	Rare	Low
14.	*G. robertianum* (HOFFM.) NEWMAN	Rare	Low
15.	*Huperzia selago* (L.) BERNH. ex SCHRANK & MART	Rare	Low
16.	*Lycopodium annotinum* L.	Rare	Low
17.	*L. clavatum* L.	Rare	Low
18.	*Phegopteris connectilis* (MICHX.) WATT	Frequent	Low
19.	*Polypodium vulgare* L.	Frequent	Low
20.	*Polystichum aculeatum* (L.) ROTH	Rare	Low
21.	*P. lonchitis* (L.) ROTH	Rare	Low
22.	*P. setiferum* (FORSSK.) WOYN	Rare	Low
23.	*Pteridium aquilinum* (L.) KUHN	Frequent	Low
24.	*Selaginella helvetica* (L.) SPRING	Rare	Low
25.	*S. selaginoides* (L.) P. BEAUV. ex SCHRANK & MART	Rare	Low

Table 2. Fern species identified on the teritory of Buila-Vânturariţa National Park, their distribution and frequency at national level, biological and ecological traits. / Tabel 2. Specii de ferigi identificate pe teritoriul Parcului Naţional Buila-Vânturariţa, distribuţia şi frecvenţa lor la nivel naţional.

No.	Species	Frequency	Distribution	Biological traits	Ecological traits
Family Aspleniaceae					
1.	*Asplenium ruta-muraria*	f	On cliffs in grasslands	perennial, hemicryptophyte, polyploid (2n=143)	calciphilous, helsciaphilous
2.	*A. scolopendrium*	s	grassland, screes, forest on rocky substrate	perennial, geophyte, polyploid (2n=72)	calciphilous, mezo-hygrophilous, sciaphilous
3.	*A. trichomanes*	f	On cliffs in grassland and forest	perennial, hemicryptophyte	eurifita., helsciaphilous
4.	*A. viride*	f	cliffs	perennial, hemicryptophyte, polyploid (2n=72)	calciphilous, mezophilous, helsciaphilous
5.	*Ceterach officinarum*	s	cliffs	perennial, hemicryptophyte, polyploid (2n=144)	calciphilous, xerophilous – xeromezophilous, heliophilous – helsciaphilous, termophilous
Family Blechnaceae					
6.	*Blechnum spicant*	s	grassland, shrubland	perennial, hemicryptophyte, polyploid (2n=68)	mezo- mezohygrophilous, sciaphilous, helsciaphilous
Family Ophioglossaceae					
7.	*Botrychium lunaria*	f	grassland	perennial, geophyte	xeromezophilous-mezophilous, weak acidotrophic-neutrophilous, oligotrophic
Family Dryopteridaceae					
8.	*Dryopteris affinis*	s	forest, shrubland, weeds	perennial, hemicryptophyte	mezophilous, sciaphilous, mesotrophic
9.	*D. dilatata*	s		perennial, hemicryptophyte, polyploid (2n=164)	
10.	*D. filix-mas*	f			
11.	*Polystichum aculeatum*	f			
12.	*P. lonchitis*	f	Forest clearcut, shrubland, weeds, cliffs	perennial, hemicryptophyte, polyploid (2n=82)	mezophilous, mesotrophic
13.	*P. setiferum*	f	forest, weeds, shrubland	perennial, hemicryptophyte, polyploid (2n=164)	mezo-mezohygrophyte, sciaphilous, mesotrophic
Family Lycopodiaceae					
14.	*Huperzia selago*	s	Grassy places, more or less humid, forest, shrubland, bogs	perennial, chamaephyte, polyploid (2n = 90, 264, 272)	oligotrofa, microtermophilous, calciphilous, mezohygrophilous, sciaphilous–helsciaphilous

15.	*Lycopodium annotinum*	s	forest, shrubland, humid places	perennial, chamaephyte, polyploid (2n=68)	oligotrophic, mezohygrophilous, helsciaphilous-sciaphilous
16.	*L. clavatum*	s	Edge of the forest, shrubland, grassland		oligotrophic, euryphilous, helsciaphilous-sciaphilous
Family Thelypteridaceae					
17.	*Phegopteris connectilis*	f	forest, shrubland	perennial, geophyte, polyploid (2n=90)	mezophilous- mezohygrophilous, sciaphilous
Family Polypodiaceae					
18.	*Polypodium vulgare*	f	forest, shady cliffs	perennial, geophyte, polyploid (2n=148)	saxicolous, euryphilous, helscia-sciaphilous
Family Dennstaedtiaceae					
19.	*Pteridium aquilinum*	f	Edges and clearings of the forest, grassland	perennial, geophyte, polyploid (2n=104)	mezoxer-mezophitous, helophilous-sciaphilous, oligotrophic
Family Selaginellaceae					
20.	*Selaginella helvetica*	f	grassland, on rochy substrate	perennial, chamaephyte, diploid (2n=18)	calciphilous
21.	*S. selaginoides*	f	Grassland, shrubland		
Family Woodsiaceae					
22.	*Athyrium filix-femina*	f	forest, weeds	perennial, hemicryptophyte, polyploid (2n=80)	mezohygrophilous, mezotrophic
23.	*Cystopteris fragilis*	f	cliffs	perennial, hemicryptophyte, polyploid (2n=168)	
24.	*Gymnocarpium dryopteris*	f	weeds, forest	perennial, geophyte, polyploid (2n=160)	sciaphilous, mezotrophic
25.	*G. robertianum*	s	Forest clearings on skeletal or stony soil		mezophilous- mezohygrophilous, helsciaphilous, calciphilous

Legend: f - frequent, s - sporadic.

Table 3. Key and indicator fern species from Buila-Vânturariţa National Park. / Tabel 3. Specii de ferigi cheie şi indicatoare din Parcul Naţional Buila-Vânturariţa.

No.	Species	Key species	Indicator species
1.	*Asplenium ruta-muraria*		Calcareous
2.	*A. scolopendrium*		Calcareous
3.	*A. viride*		Calcareous
4.	*Blechnum spicant*	Tertiary relict	
5.	*Ceterach officinarum*		Calcareous
6.	*Gymnocarpium robertianum*		Calcareous
7.	*Huperzia selago*	Habitat Directive	Calcareous
8.	*Lycopodium annotinum*	Habitat Directive	
9.	*L. clavatum*	Habitat Directive	
10.	*Selaginella helvetica*		Calcareous
11.	*S. selaginoides*		Calcareous

The studied species growing in forests, forests clearings, shrublands and even those growing in grasslands are clonal and clumped distributed in small sites but on large area; therefore we can declare that the populations are formed by small subpopulations (dems) with aboveground shoots sometimes in small number but the underground shoots are largelly and dense distributed in the soil or beneath the bryophytes or the thick litter layer (i.e. *Polypodium vulgare*). Their regeneration potential from the undergound biomass is high in spite of impact of tourists or animal trampling, both impacts not a significant in the Park.

The fact that these species are clonal prevents us to take the number of aerial shoots as unit measures. Even they were counted on square meter unit, the extrapolation were made to the clonal individuals (genets) because we were not able to separate one genet from other. But the high density of the above ground shoots on square meter combined with the large distribution of the species (high number of micro-areals) pointed that the species are well represented in studied area. We can highlight that the total number of aerial shoots on the Park territory is high these species being frequent in the area.

Another clonal species growing on cliffs, screes, in the forest, at the cliffs foot in the litter layer, in semi-shaded grassy places is *Asplenium scolopendrium*, well represented by numerous old individuals. Our observations showed that the old age of the individuals is given by the high number of the leaves in rossets. The more leaves are presented in the rossets the oldest are individuals. The number of genets is high, the population is largely distributed. They are also present individuals with small number of leaves (2-3 young leaves) this demonstrating that the imput of new individuals in the population still occur. The anthropic impact (tourists, grazing) is present in the area but because the area is less accesible favorise the existence, development and distribution of the species.

Polystichum aculeatum and *P. lonchitis* are rare but still well represented at the Park level; as well as *P. setiferum*. In spite of the reduced number of the individuals and small populations, these species are not affected by anthropic impact, being distributed in sites (i.e. high and big cliffs) difficult to be reached by tourists and animals.

The number of *Asplenium trichomanes* individuals is high, the population is largely distributed in cliffs cracks,

alone or together with *Cystopteris fragilis*, *Asplenium ruta-muraria*, etc. On the south-eastern slope the density of *A. trichomanes* individuals is higher than on the north-western slope, they growing not only in cliffs cracks but also at the base of cliffs from grasslands, on pathes, etc. In this area, sheeps pass towards grazing places. It might that the high development of *A. trichomanes* individuals to be due to nutrient input from the decomposition of sheep manure. There are also individuals with big rossets (large number of leaves), showing their old age. The small individuals demonstrate that the population expands. The distance among individuals is not high, thus the gene flow is frequent, the genetic diversity not being threatened.

On both slopes of the Massif grows *Asplenium ruta-muraria*, more frequent than *A. trichomanes* with which might share the same sites. On the south-western slope we noticed dry individuals in cliff's crack but the phenomenon was due to high insolation and dryness. These natural processes ussually affect plant species growing on cliffs (ONETE *et al.*, 2010).

Species density is different according to their ecological requirements and integrator habitat. The anthropic factors that might affect the ferns' populations in Buila-Vânturariţa National Park are tourism and grazing. Up to now, 2012, there has not been identified a significant negative impact on fern populations. The negative impact on grasslands for grazing usage is given by *Pteridium aquilinum* individuals highly developed in some grasslands.

Even if most of the ferns from Buila-Vânturariţa National Park do not have their own conservation status, they are distributed in habitats with high conservation values (DONIŢĂ *et al.*, 2005; GAFTA & MOUNTFORD, 2008):

Romanian habitat: R6108 South-carpathian communities of calcareous screes with reduced mobility and increased humidity with *Rumex scutatus*, *Saxifraga moschata*, *S. aizoides* and *Doronicum columnae*.

Coresponding to:

NATURA 2000: 8120 Calcareous and calchist screes of the montane to alpine levels (*Thlaspietea rotundifolii*)

EMERALD: 61 Screes

CORINE: 61 Screes

PAL. HAB 1999: 61.242 East Carpathian calcareous screes; 61.2424 East Carpathian dock screes

EUNIS: H2.44 Carpathian calcareous screes

Romanian habitat: R6209 South-East Carpathian communities on calcareous cliffs with *Asplenium trichomanes* ssp. *quadrivalens* and *Poa nemoralis*.

Coresponding to:

NATURA 2000:

EMERALD: 6 Inland rocks, screes and sands

CORINE: 62 Inland cliffs and exposed rocks

PAL. HAB 1999: 62 Inland cliffs and exposed rocks

EUNIS: H3 Inland cliffs and exposed rocks habitats

Romanian habitat: R3401 South-East Carpathian Grasslands with *Asperula capitata* and *Sesleria rigida*.

Coresponding with:

NATURA 2000: 6170 Alpine and subalpine calcareous grasslands

EMERALD:

CORINE: 36.4 Alpine and subalpine calciphilous grasslands

PAL. HAB 1999: 36.43921 East Carpathian Sesleria-evergreen sedge grasslands

EUNIS: E4.4392 East Carpathian calciphile stepped grasslands.

CONCLUSIONS

According to Habitat Directive 92/43/CEE the conservation status will be taken as "favourable" when: population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

In this stage do not exist data regarding the dynamic of the fern populations and the status of the populations' range. The present data represent only the population distribution and frequency in 2011, therefore our oppinion stipulates that the present data represent the reference population data for future studies that might establish, on the scientific base, the conservation status of the ferns.

We can argue that there still are sufficiently large habitats to maintain ferns' populations on a long-term basis if the present impact is kept at least at the present intensity. They are needed long term studies for stipulating the conservation status of the ferns from Buila-Vânturariţa National Park.

The diversity, frequency, development and distribution of the ferns' species from Buila-Vânturariţa National Park is well represented, this demonstrating the favourable conservation status of all integrating habitats.

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REFERENCES

BUIA M. & PĂUN M. 1956. *Materiale pentru flora Muntelui Buila.* Studii şi Cercetări. Edit. Cluj Napoca: 85-105.

CIOCÂRLAN V. 2009. *Flora Ilustrată a României. Pteridophyta et Spermatophyta.* Edit. Ceres. Bucureşti. 1141 pp.

DONIŢĂ N., POPESCU A., PAUCĂ-COMĂNESCU MIHAELA, MIHĂILESCU SIMONA, BIRIŞ I. A. 2005. *Habitatele din România.* Edit. Tehnică şi Silvică. Bucureşti. 442 pp.

GAFTA D. & MOUNTFORD J. O. (coord.). 2008. *Manual de interpretare a habitatelor Natura 2000 din România.* Edit. Risoprint. Cluj Napoca. 104 pp.

ONETE MARILENA, ION R., ION M., PAUCĂ-COMĂNESCU M. 2010. *Brebu cliffs - basic research and possibility of practical approaches.* Book of Abstract. The Anniversary Conference of the Institute of Biology. 50 years of Academic Research in Biology. Edit. Ars Docendi. Bucureşti: 95-96.

PĂUN M. & POPESCU G. 1971. *Cercetări asupra vegetaţiei de pădure din munţii Buila.* Analele Universităţii din Craiova. Biologie-Ştiinţe Agricole. Craiova. **13**(3): 21-30.

PĂUN M. & POPESCU G. 1978. *Date despre vegetaţia ierboasă a catenei calcaroase Buila-Vânturariţa din Munţii Căpăţânii jud. Vâlcea.* Analele Universităţii Craiova. Edit. Universitaria. Craiova. **19**(9): 67-73.

***. Habitat Directive 92/43/CEE, in EU Nature Legislation, http://ec.europa.eu/environment/nature/legislation/ (accessed: February 22, 2012).

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THE POSSIBILITY AND EFFICIENCY OF BIOINDICATION METHOD IN FOREST AIR QUALITY MONITORING

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Abstract. The investigation concluded upon the existence of a sufficient number of indicator species of lichens which can be applied in monitoring the environment quality in the Republic of Moldova. The investigation also contributed to the establishment of legitimate facts that under the action of gaseous pollutants (i.e. SO_2 etc.) and depending on the source of pollution, geographic location, species sensitivity, duration of exposure induce the modification or total degradation of lichen thallus. Additionally, the Air Quality Gradation Scale (AQGS) and Lichens Toxitoleration Scale (LTS) towards different concentration of SO_2 in atmosphere air were developed. The efficiency of AQGS with some additional modifications was tested through assessing the quality of air in 62 forest ecosystems. Thus, in order to meet the country obligations under the Geneva Convention (1979), *Parmelia sulcata* species was proposed as a referent species (standard) in performing the monitoring of air quality at national and international level.

Keywords: lichens, indication, pollution, monitoring.

Rezumat. Posibilitatea şi eficacitatea metodei bioindicaţiei în monitoringul calităţii aerului din păduri. Lucrarea include rezultatele studiului premizelor implementării ecobioindicaţiei în evaluarea calităţii mediului ecosistemelor forestiere din Republica Moldova, stabilindu-se existenţa unui număr suficient de specii indicatoare de licheni, care pot sta la baza realizării monitoringului calităţii mediului. Sunt stabilite legităţi privind modificarea sau degradarea totală a talului lichenilor sub acţiunea poluanţilor gazoşi (SO_2 ş. a.), în funcţie de sursa de poluare, condiţiile geografice, sensibilitatea speciei, durata expunerii etc. Sunt elaborate Gradaţii de Evaluare a Calităţii Aerului (GECA) şi Scala Toxitoleranţei Lichenilor (STL) faţă de SO_2. A fost demonstrată eficienţa aplicării GECA, cu unele modificări, în testarea calităţii aerului din 62 ecosisteme forestiere. Astfel, în scopul îndeplinirii obligaţiilor ţărilor impuse de Convenţia de la Geneva (1979), specia *Parmelia sulcata* este propusă ca obiect de referinţă (standard) în realizarea monitoringului calităţii aerului la nivel naţional şi internaţional.

Cuvinte cheie: licheni, indicaţie, poluare, monitoring.

INTRODUCTION

The presence of lichens as such is not necessarily an indication criterion, as previously stated by VICTOROV *et al.* (1962) for higher plants. To have an indicative value the lichens must have a certain abundance. In our view, a coverage of 10% of the substrate surface could be a clear indicator. This threshold is very important, especially for toxitoleration grades I and II since we cannot state that the air is clean upon identifying a few plants of lichens very sensitive to pollution. For certain species which could be used as indicators for the Republic of Moldova there were no information or the available information was controversial. Based on our research, which included results from laboratory and field observation on lichens from natural habitats, transplanted lichens and trials in laboratory, there were established new toxitoleration gradations or their initial toxitoleration was modified.

MATERIAL AND METHODS

Proceeding from the indicators abundance and toxitoleration we elaborated a scale with gradations for the evaluation of the air quality (Table 1). The evaluation of air quality by applying the lichens indication method to 62 forest ecosystems throughout the Republic of Moldova, allowed us to identify 90 lichens species out of which 50 species are bioindicators.

Table 1. Scales in air quality assessment based on abundance of lichens with different toxitoleration (BEGU, 2011).
Tabel 1. Gradaţii de evaluare a calităţii aerului în baza abundenţei lichenilor de diversă toxitoleranţă (BEGU, 2011).

Air quality	SO_2 content in the air, mg/m^3	Abundance of species with different toxitoleration degree, % of substrate surface	Conventional colour
1. Clean	<0,05	I > 10 or I < 10 and II > 75	blue
2. Slightly polluted	0,05-0,1	I – 0 -10 or II – 50-75	light blue
3. Moderately polluted	0,1-0,2	II - 10-50 or III > 50	green
4. Polluted	0,2-0,3	III - 10-50 or IV > 50	yellow
5. Heavily polluted	0,3-0,5	IV - 10-50 or V - 1-100	red
6. Critically polluted	>0,5	Complete absence of lichens	brown

RESULTS AND DISCUSSIONS

Basing on this method, four forest ecosystems were evaluated as clean air (Ocniţa-Hădărăuţi, Bahmut, Seliştе-Leu, and Potoci); the number of ecosystems with slightly polluted air reaches 11, moderately polluted - 31, polluted - 13, heavily polluted - 3 (Criva, Saharna, Copanca), while those with critical pollution level are not present (Fig. 1). The

air quality from the ecosystems which were reported as clean is confirmed by the presence of lichens species very sensitive to pollution, the coverage of which was over 10% of substrate surface (i.e. *Usnea hirta* in Ocniţa-Hădărăuţi, *Peltygera canina* - in Bahmut and *Ramalina fraxinea* - in Selişte-Leu).

The ecosystems with slightly polluted air (SO_2 = 0,05–0,1 mg/m^3 air) are primarily located in the North of the country (Trebisăuţi, Feteşti, La Castel, Zabriceni, Lipnic, Donduşeni) and some of them in the central part (Bujor, Cimişeni, Logăneşti) and in the middle part of the Dniester (Lopatna) and the Prut (Cotul Morii) river basins.

The ecosystems with moderately polluted air (SO_2 = 0,1–0,2 mg/m^3 air) are more numerous (31) and have a wide distribution throughout the country, often being subject to impact from local pollution sources (i.e. - Hâjdieni, Criva, Orhei, Selişte, Durleşti, Budeşti, Văleni, Giurgiuleşti etc.) or from transboundary sources, particularly areas on hillsides with Western exposition (e.g. Bălăneşti, Cobac). The number of ecosystems with polluted air (SO_2 = 0.2–0.3 mg/m^3 air) is 13, prevailing in the vicinity of the cities and industrial pollution sources (e.g. Trinca, Chetroşica Nouă, Mândreştii Noi, Papauţi, Şoldăneşti, Tohatin, Hârbovăţ, Ciobruciu). Heavily polluted air (SO_2 = 0.3–0.5 mg/m^3 air) is set for 3 ecosystems - Criva, Saharna, and Copanca, which have a location in the immediate vicinity of pollution sources and are positioned in the path of the prevailing winds. The ecosystems with critical polluted air (SO_2 > 0.5 mg/m^3 air) were not recorded.

A more pronounced air pollution with SO_2 is specific for the ecosystems located around obvious sources of pollution. Here, the bioindicators with toxitoleration degree II and III do not exceed 5% of the substrate coverage (sometimes over 10% in case of nitrophilous species - Văleni, Giurgiulesti, Criva region), and the persistent species with the toxitoleration III, IV, V are most of the times nitrophilous species. In addition, the ecosystems with polluted air are poor in diversity (often only 4 – 6 species).

Typically, the ecosystems with slightly polluted air are located at altitudes above 200 m and those with polluted air - below 200 m, but there are many exceptions, because the distance from the pollution source and the direction of prevailing winds are also important factors (for example the sites Trinca, Călăraseuca, Chetroşica Nouă, Mândreştii Noi, Saharna – are situated at altitudes above 200 m but are still rather polluted). Compared with Potoci site (mountain type), most forest ecosystems in the Republic of Moldova are hilly type (200-600 m) or flat (0-200m). Rather enhanced can be considered the effects of pollution in ecosystems located on plain areas for instance those around Valea Mare, Nemţeni, Crihana Veche, Vilcovo (Ukraine), and for Criva, Hâjdieni, Orhei, Tohatin, Copanca, Hârbovăţ, Cioburciu; the determining role was played by the distance from the pollution source of and the direction of prevailing winds.

Most of SO_2 emissions from local sources are concentrated in the South East of the country with a mega-source in Tighina - Tiraspol - Cuciurgan area. This led to the pollution of ecosystems located in the SE due to prevailing winds from NW to SE, which were confirmed by us through bioindication. The emissions of SO_2 from Soroca and Bălţi sources led to the Hâjdieni ecosystem degradation. The geological exploration of Criva and Trinca, the later being as well affected by unauthorized burning in the lime production process, have placed these ecosystems in the category with highly polluted air. High emissions of SO_2 are characteristic for the town of Hânceşti that left their prints on the state of bordering ecosystems air - Sărata Galbena and Sărata-Mereşeni. Chişinău emissions have evidently contributed to the pollution of ecosystems Balmaz - Hârbovăţ located in the South East and Tohatin - Budeşti located towards East. The effects of pollution from the Rezina - Rabniţa source were reported only in direct vicinity (Saharna, Cioma, Popăuţi), due to the direction of winds from NW to SE, leaving unaffected the ecosystems Pohribeni and Lopatna. The possible harmful effects, catastrophic for vegetation, from the Cuciurgan source were more pronounced in Copanca and less in Cioburciu - Răscăieţi, again due to the direction of winds from the NW to SE. The South part of the country is affected by transboundary pollution (Galaţi city, Romania), especially Crihana Veche, as well as Giugiuleşti and Văleni. The effects of pollution from the sources located in Iaşi, inseparable from those of Ungheni, strengthen the pollution of ecosystems in the region around - Valea Mare, Nemţeni, less Bălăneşti, Cobac, but fortunately pollution does not reach Bahmut and Corneşti, located NE of the pollution sources; as a result, they are protected by the high relief of Codrii forest reservation.

According to the EMEP Report 1/2003 issued by the Meteorology Institute, Norway, transboundary pollution is manifested in many countries in Europe. Moldova is located in the area of annual SO_2 deposition equal to 700 - 1000 kg/km^2. The comparison between the results of lichen indication applied to 62 ecosystems, to the EMEP results, presented in table 2, shows that the EMEP network (50x50 km grid) hinders the real environmental state, probably because pollution effects are more pronounced within the 25-30 km from the pollution source. For example, in the 86/64 sectors the 11 studied ecosystems showed the air as clean (e.g. Ocniţa), slightly polluted (Feteşti, Trebisăuţi, Zăbriceni ecosystems), moderately polluted (Clocuşna and Cernoleuca) or polluted (Trinca and Chetroşica Nouă). In the same time, the EMEP matrix characterizes the state of the air as polluted.

The 50x50 km grid is likely to be indicative in large forest areas and/or plain landscape (for instance Belarus, the Baltic states, Poland, Russia, etc.) but is less meaningful for the Republic of Moldova, a country with low forest coverage and fragmented landscape, which can re-direct pollution effects. Thus, at the national level it is recommended the application of 25x25 km grid.

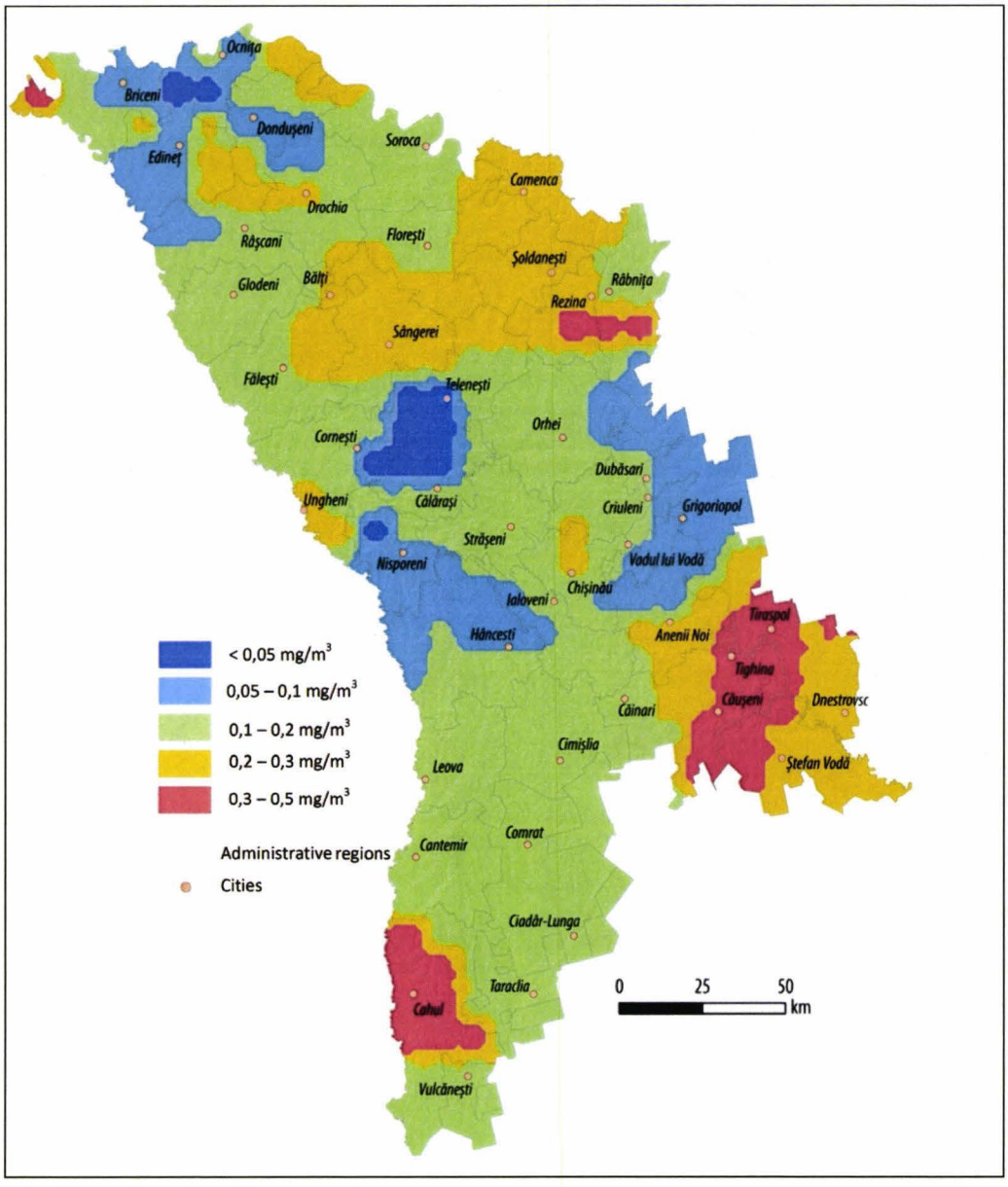

Figure 1. Spatial distribution of air pollution with SO_2, based on lichen indication. / Figura 1. Distribuţia spaţială a poluării aerului cu SO_2, bazată pe lichenoindicaţie.

Table 2. Air quality of researched forest ecosystems, according to EMEP 50x50km (large rectangles) comparing to our evaluations based on AQGS (small squares). / Tabel 2. Calitatea aerului din ecosistemele forestiere studiate, conform EMEP 50x50km (dreptunghirile mari) comparative cu evaluările noastre pe baza GECA (dreptunghiurile mici).

North -South Direction	Ecosystems EMEP networking distribution (32dials 50x50km grid) West – East Direction						
	62	63	64	65	66	Total	Ro, Ua
85	Ro	1	0	Ua	Ua	1	
86	Ro	3	9	2	Ua	14	
87	Ro	3	1	1	-	5	
88	Ro	2	2	1	4	7	1- Ro
89	Ro	3	6	4	1	14	
90	Ro	1	4	3	-	8	
91	2	2	1	3	-	6	
92	3	2	-	-	-	5	
93	-	Ua	Ua	Ua	Ua	-	
94	Ua	Ua	1- Ua	Ua	Ua	-	1- Ua
Total	3	13	25	14	5	60	2

Legend: Ro - Romania; Ua - Ukraine; low polluted air; moderate polluted air; polluted air; highly polluted

CONCLUSIONS

1. The Republic of Moldova Lichens Register was elaborated, based on literature review and own research, which includes about 200 species and varieties (22 set by the author).

2. The premises of lichens eco-bioindication were established basing on the presence of 40 indicator species, sensitive to air pollution with SO_2, NOx, etc.

3. Two criteria for the evaluation of the state of environmental components were proposed: a Lichens Toxitoleration Scale (LTS) with 6 steps, taking into account the degree of air pollution with SO_2, the similarity of geographical conditions, and the results of own testing through gasification, transplantation and studies in the field; and Gradations for Air Quality Assessment (GAQA) in forest based ecosystems, based on indicator abundance/coverage, toxitoleration and correlation between different bioindicator species.

4. The results obtained from the biological monitoring of 62 forest ecosystems allowed us to argue the possibility and efficiency of lichens indication method in air quality monitoring.

REFERENCES

BEGU A. 2011. *Ecobioindicaţia: premise şi aplicare.* Digital Hardware SRL. Buletin Ştiinţa Moldova. Chişinău. 166 pp.

VIKTOROV S. V., VOSTOKOVA E. A., VIŞIVKIN D. D. 1962. *Vvedenie v indikaţionnuiu geobotaniku.* Izdatelistvo Moskovskogo Universiteta. Moskva. 227 pp. [In Russian].

***. *Convenţia asupra Poluării Atmosferice Transfrontaliere pe Distanţe Lungi* (Geneva, 1979). Adoptată de Parlamentul RM prin Hot. nr. 399-XII din 16.03.95. Chişinău. 11 pp.

***. *Rewiew and Revision, Emmission data reported to CLRTAP, MSC-W Status Report, 2003, Vigdis Vestreng, Convention on Long-range Transboundonary Air Pollution.* Co-operativ programe for monitoring and evolution of the long range transmission of Air pollutants in Europe. Tehnical Report. July, 2003. Chişinău.

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ASPECTS CONCERNING GROWING FLORICULTURAL SPECIES *Hydrangea macrophylla* ON THE SUBSTRATE WITH COMPOST AND MICROORGANISMS PRESENT IN THESE SUBSTRATES

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Abstract. Organic fertilization with compost derived from municipal treatment plants represent at least up to now disputed fertilization, its effects in horticulture are contradictory, due to presence of heavy metals and possible pathogens. The main objective of this paper was to exploit and identify microbiological risks associated with the use of compost made from municipal household waste mixed with vegetable waste by applying it as rooting substrate for floricultural species *Hydrangea macrophylla*, assessing the microorganisms present in these substrates. This paper presents the results of the microbial load determination in four variants (V2-V5) in comparison with the control variant (V1).

Keywords: fermented sludge, composting, *Hydrangea macrophylla*, pathogenic microorganisms.

Rezumat. Aspecte privind creşterea speciei floricole *Hydrangea macrophylla* pe substrat cu compost şi microorganismele prezente în aceste substraturi nutritive. Fertilizarea organică cu compost provenit din staţiile de epurare municipale reprezintă cel puţin până în prezent o fertilizare controversată, efectele sale în sectorul horticol fiind contradictorii, datorită prezenţei metalelor grele şi posibilelor microorganisme patogene. Obiectivul principal al lucrării de faţă a fost acela de a valorifica şi de a identifica riscurile microbiologice asociate utilizării compostului obţinut din deşeuri menajere municipale în amestec cu deşeuri vegetale prin aplicarea acestuia ca substrat de înrădăcinare pentru specia floricolă *Hydrangea macrophylla*, evaluând microorganismele prezente în aceste substraturi. Lucrarea prezintă rezultatele determinărilor microbiologice din cele patru variante experimentale (V2-V5) în comparaţie cu proba martor.

Cuvinte cheie: nămol fermentat, compostare, *Hydrangea macrophylla*, microorganisme patogene.

INTRODUCTION

"Sewage sludge" or "biosolids" is the insoluble residue produced during wastewater treatment and subsequent sludge stabilization procedures such as aerobic or anaerobic digestion (ARTHURSON, 2008). Composting is the process by which organic materials such as sewage sludge is decomposed and stabilized under aerobic conditions, which support the development of thermophilic microorganisms (HIGHLAND *et al.*, 2004; HERSELMAN *et al.*, 2008). According to BERNAL *et al.* (1998b), MC CLINKTOCK (2004) compost maturity and stability imply lack of phytotoxic compounds and pathogens. Microbial activity is widely accepted as the most reliable indicator of compost stability and several studies have attempted to correlate the physical and chemical parameters with breathing. Pathogens survive in compost a limited time depending on microbial species and conditions it offers. This leads to the need to establish to what extent and under what conditions the compost can be responsible for transmitting the disease. Studies confirm that it can be contaminated without carrier of pathogens, but their occurrence can ever become possible (JIANLONG & JIAZHUO, 2007). In this case is used the term of indicatory germs which may indicate whether the product studied is contaminated and therefore is able to become a broadcaster of pathogens. Similar experiments were performed by MARK *et al.*, 2004 by investigation plants test *Antirrhinum majus* "Rocket White", *Viola* × *wittrockiana* "Crown Azure", Oriental Hybrid *Lilium* "Siberia", and *Chrysanthemum* × *grandiflorum* "Yellow Kodiak".

PRASAD & FREITAS (2003) mentions that *Hydrangea* is part of plants used for laboratory experiments, the results serve to advance the knowledge of metal bioremediation and environmental monitoring as *Hydrangea* is a strong aluminum hiperacumulator. WU *et al.*, 1995, studied the effects of regenerated wastewater irrigation on growth and ions uptake in many plants, inclusive in *Hydrangea macrophylla*.

MATERIAL AND METHODS

Fermented sludge analyzed in accordance with Government Decision 708/2005 technology in the laboratory of the Institute INCD-ECOIND Bucharest was mixed with biodegradable vegetable wastes, the proportion was 70% sludge from sewage treatment plant Pitesti and 30% of the vegetable residues (leaves, grass, straw), a total of 1 m^3 of mixture, obtaining the final product compost at Albota Experimental Research Station. The research program used fermented sludge collected from Wastewater Treatment Plant Pitesti, compost from Albota Experimental Research Station, as nutrient substrates for floricultural species *Hydrangea macrophylla*. Their vegetation grown process was studied in pots in the greenhouse environmental conditions at Craiova Botanical Garden belonging to the Discipline of Floriculture - Faculty of Agriculture and Horticulture from Craiova.

Has been developed a mono-factorial experience type, following the present microbial community in the substrate for *Hydrangea macrophylla* – 50 seedlings and the cuttings percentage (during the period December-March) on five experimental variants:

V1 - peat: compost: perlite (1: 0: 1)
V2 - peat: compost: perlite (0: 5: 1.5)
V3 - peat: compost: perlite (2.5: 2.5: 1.5)
V4 - peat: compost: perlite (1: 4: 1.5)
V5 - peat: compost: perlite (3: 2: 1.5).

It is known that the waste water, waste sludge and compost have a very rich indigenous bacterial biocoenosis which is developing at relatively low temperatures, so the research studies involves the total mesophilic germs and total number of germs (TNG) (JIANLONG & JIAZHUO, 2007). All known characteristics are taken into consideration for the classification of microorganisms, but certain features are selected and used for identification purposes.

Usually that involves some simple tests to identify primary such as morphology (usually by Gram stain), growth in the presence or absence of O_2, growth on various types of culture media, catalase and oxidase tests. Using these few simple tests is usually possible to place provisional microorganism, in one of the main groups. The compost well homogenized sample was weighed at 100 g sediment and placed in a sterile bottle containing glass beads. Was added 1000 cm^3 sterile distilled water and shaked through magnetic stirrer for 30 minutes to make suspension of germs, then leave to stand for 5 minutes settling coarse particles (dilution 1/10). From the obtained supernatant were prepared decimal dilutions in sterile buffered water. Frequently made to 1/100.000 dilutions to obtain a density suitable microbial identifications. Quantitative determination of total and faecal coliform is required in order to evaluate quality in terms of bacteriological using multiple tube method, which provides assessment data the most likely germ Most Probable Number (MPN) (SIDHU *et al.*, 1999).

Determining Most Probable Number of coliform per gram is done using probability tables McCrady. Various combinations of positive and negative results allow to estimate the probable number of total coliform (TC), faecal coliform (FC), total streptococci (TS) and faecal streptococci (FS).

The following tests were used in the experiment:

- To identify group D streptococci - Strep Pastorex agglutination rapid tests for streptococci of Lancefield classification.

- To identify *Staphylococcus aureus* - latex agglutination rapid tests for simultaneous detection of antigen affinity fibrinogen (clumping factor), protein A and capsular polysaccharides of *Staphylococcus aureus*: (Bio-Rad Pastorex ® Staph Plus kit).

- For yeasts and moulds - Fungitest™ studying test fungi growth in the presence of 6 antifungal, each in two different concentrations. Fungal growth is based on the colour change from blue to pink. When fungal growth is inhibited, the wells are keeping their blue colour.

RESULTS AND DISCUSSIONS

Microbiological test results are presented in table 1 and figure 1.

Table 1. Microbial load of the experimental variants of compost-perlite mix-peat substrate MPN/g. / Tabel 1. Încărcătura microbiană din variantele experimentale ce conţin ca substrat amestecul de compost-perlit-turbă MPN/g.

Experimental variants	Total coliform/ dm^3	Faecal coliform/ dm^3	*Escherichia coli* / dm^3	Total streptococcus/ dm^3	Faecal streptococcus/ dm^3	Total aerobic bacteria (UFC) / cm^3	Observations
V1 control variant	$13 \cdot 10^2$	< 20	< 20	< 20	< 20	$6 \cdot 10^3$	*Salmonella, Shigella, Staphylococcus*, yeasts and molds = absent
V2	$2 \cdot 10^2$	< 20	< 20	< 20	< 20	$7 \cdot 10^3$	*Salmonella, Shigella, Staphylococcus*, yeasts and molds = absent
V3	$5 \cdot 10^1$	< 20	< 20	$2 \cdot 10^1$	$2 \cdot 10^2$	$9 \cdot 10^4$	*Salmonella, Shigella, Staphylococcus*, yeasts and molds = absent
V4	$2 \cdot 10^1$	< 20	< 20	$3 \cdot 10^1$	$3 \cdot 10^2$	$7 \cdot 10^6$	*Salmonella, Shigella, Staphylococcus*, yeasts and molds = absent
V5	$5 \cdot 10^3$	< 20	< 20	$3 \cdot 10^3$	$8 \cdot 10^2$	$11 \cdot 10^4$	*Salmonella, Shigella, Staphylococcus*, yeasts and molds = absent

Concerning the microbial load (TNG) in compost-perlite mix-peat substrate it was observed that samples analyzed microbiologically (MPN/g <2 x 10^6/g colony forming units), quality qualifies for the U.S. Environmental Protection Agency for compost that can be used in agriculture.

The results of the performed microbiological analyzes showed that although compost presented MPN values of germs/g of order 10^2 to 10^4; it could be considered that it has no risk of contamination by its application in agriculture domain. It was also observed the absence of pathogens such as *Shigella, Salmonella, Staphylococcus aureus* species.

Analyzing the microbial load through the types of germs, for the five studied variants was observed the following aspects:

- For total coliform (TC) - MPN/g has the highest value in V3 variant and the lowest in variant V2;
- For faecal coliform (FC) - MPN/g values were identified in <20 in all experimental variants;
- *Escherichia coli* - MPN/g had identified values of <20 in all experimental variants;
- Total streptococci (TS), faecal streptococci (FS) had slightly elevated values MPN/g for variants V3, V4 and V5, but low risk of contamination, while the variants V1 and V2 recorded lowest values.

The highest total aerobic bacteria number was recorded in V4 variant and the lowest one in variant V1. Comparing the total microbial load of the analyzed compost - perlite mix-peat substrate in all five variants it has been observed that microbial load in V4 and V5 have the highest and lowest version in V2 (version V1 as control). V2 could be considered optimal way of nutrient substrate for floriculture area.

- Faecal coliform (FC) MPN/g values were identified in <20 in all experimental variants;
- *Escherichia coli*, MP/g values was identified in <20 in all experimental variants.

La nivel global, rezultatele din tabelul nr.1 au arătat un grad mic de contaminare a compostului cu microorganisme fecale si ca atare valorificarea sa in agricultura va avea efecte benefice.

The analyzed variants were used as substrate for rooting and growing floricultural species *Hydrangea* sp. obtaining the following catch percent of cuttings (Fig. 1).

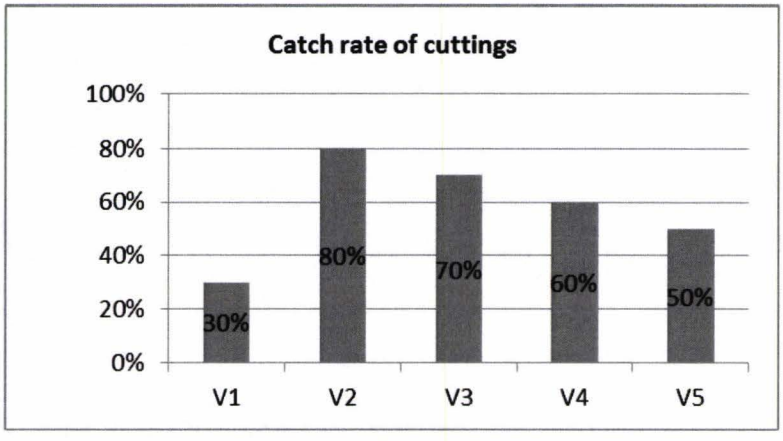

Figure 1. Catch percentage of cuttings. / Figura 1. Procentul de prindere al butaşilor.

It could be appreciated that the low number of pathogens in V2 variant could represent an additional factor of stimulating the caulogenesis process.

CONCLUSIONS

Based on the obtained results it can be concluded that:

- The process of composting, although the fact that its sterilizing effect is not total for all potentially pathogenic bacteria, may still be considered as one of the most effective methods for decontamination of waste products for soil fertilization.
- Our researching results showed a low degree of contamination with faecal microorganisms in compost-perlite mix-peat substrate studied variants and it could be recommended for capitalization in floriculture.
- Applying the compost obtained from fermented sludge mixed with residues plants as rooting substrate for floricultural species *Hydrangea* sp., it was observed that variant V2 presented the highest percentage of attachment cuttings.
- Analysing the microbial load as pathogen incidence demonstrates that compost can be applied without risk of contamination of soil and for manipulating people, with respect to the environment.
- Effects of using compost in the horticultural sector are diverse and not yet fully elucidated, despite the theoretical premises, in practice it fails to reduce the risk due pathogens present. Consequently, at least for now, organic fertilizer and compost derived from municipal sludge treatment plants will not only show in horticulture as a preventive measure and in accordance with the law.

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REFERENCES

ARTHURSON V. 2008. *Proper hygienization of sewage sludge – a critical issue ! for a sustainable society; Microbial quality of sewage sludge.* AEM Accepts, published online ahead of print on 7 July 2008 Applied Environmental Microbiology. American Society for Microbiology. ACS Publications. Washington: 18-25.

BERNAL M. P., PAREDES C., SÁNCHEZ-MONEDERO M. A., CEGARRA J. 1998b. *Maturity and stability parameters of composts with a wide range of organic wastes.* Bioresource Technology. University of Regina. Saskatchewan. **63**: 91-99.

HERSELMAN J. E., BURGER L. W., MOODLEY P. 2008. *Requirements for thermalsludge management practices and for commercial products containing sludge.* Environment and tourism. The Water Environment Commission. South Africa. Cape Town. **5**. 93 pp.

HIGHLAND T. F. M., SCLAR C. D., INGHAM R. ELAINE, GARTLEY E. KAREN, SWASEY E. J. 2004. *Effects of Compost Amended Container Media on Ornamental Plant Growth.* Hort Science July 2004. Kansas State University. **39**(4750): 1616-1621.

JIANLONG W. & JIAZHUO W. 2007. *Application of radiation technology to sewage sludge processing.* A review Journal of Hazardous Materials. China. Beijing. **143**: 2-7.

MC CLINKTOCK NATHAN CRANE. 2004. *Production and use of compost and vermicompost in sustainable farming systems.* A thesis submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the Degree of Master of Science. 118 pp.

PRASAD M. N. V. & FREITAS H. M. O. 2003. *Metal hyperaccumulation in plants. Biodiversity prospecting for phytoremediation technology.* Electronic Journal of Biotechnology. Universidad Católica de Valparaíso. **6**(3): 285-321.

SIDHU J., GIBBS R. A., HO G. E., UNKOVICH I. 1999. *Selection of Salmonella Typhiumurium as an Indicator for Pathogen Regrowth Potential in Composted Biosolids.* Letters in Applied Microbiology. North Carolina. **29**: 303-307.

WU L., CHEN J., LIN H., VAN MANTGEM P., HARIVANDI M. A., HARDING J. A. 1995. *Effects of regenerated wastewater irrigation on growth and ion uptake of landscape plants.* Journal Envionmental Horticulture. University of Florida. **13**(2): 92-96.

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STUDY ON THE BIOMASS AND PRODUCTIVITY OF LUMBRICIDAE POPULATIONS IN THE DECIDUOUS ECOSYSTEM

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Abstract. The present study analyses the earthworms in the deciduous ecosystem (Ruginoasa Station) of Cândeşti Platform, in the south-east of Argeş County, in terms of biomass and monthly productivity during March-October 2007. Besides numerical dominance, the biomass of Lumbricidae species highlights the role of each species in the activity of matter and energy transfer within an ecosystem. The special dynamics of the two parameters showed different values, given the structure of the vegetation, soil and soil layers, and especially the differences between the individual weights of the species. *Octolasion lacteum* species was dominant in terms of biomass density and recorded high values at the soil levels analysed, except in the litter. Of the total calculated biomass (27.598 mg d.s./square meter), this species dominates in a ratio of 74.69%. Biological productivity was increased at 0-10 cm, with the highest value for *Octolasion lacteum* species (4.03 mg d.s./m^2), followed by *Eisenia lucens* species (0.9 mg d.s./m^2) and *Aporrectodea rosea rosea* species (0.641 mg d.s./m^2). Also, the highest values of the biomass were recorded in spring and autumn months. The species with a lower numerical density recorded low values of the biomass, leading to low biological productivity and vice versa.

Keywords: deciduous forest, lumbricidae, biomass, productivity.

Rezumat. Studiu privind biomasa şi productivitatea populaţiilor de Lumbricidae într-un ecosistem de foioase. În acest studiu sunt analizate comunităţile de râme dintr-un ecosistem de pădure de foioase (Staţia Ruginoasa) situat în Platforma Cândeşti în partea sud-estică a Judeţului Argeş, din punct de vedere al biomasei şi productivităţii lunare în perioada martie-octombrie 2007. Alături de dominanţa numerică, biomasa speciilor de lumbricide evidenţiază rolul fiecărei specii în activitatea de transfer de materie şi energie din cadrul unui ecosistem. Dinamica spaţială a celor doi parametri a evidenţiat valori diferite, având în vedere structura covorului vegetal, a solului şi nivelurile de sol şi mai ales a diferenţelor dintre greutăţile individuale ale speciilor. Specia *Octolasion lacteum*, fiind dominantă din punct de vedere a densităţii în biomasă, a înregistrat valori ridicate la nivelurile de sol analizate, mai puţin în litieră. Din totalul biomasei calculate (27.598 mg.s.u./m^2), această specie domină în proporţie de 74.69%. Productivitatea biologică a fost ridicată la nivelul 0–10 cm, cea mai mare valoare deţinând-o specia *Octolasion lacteum* (4.03 mg.s.u./m^2), urmată de specia *Eisenia lucens* (0.9 mg.s.u./m^2) şi *Aporrectodea rosea rosea* (0.641 mg.s.u./m^2). De asemenea, cele mai mari valori ale biomasei s-au observat în lunile de primăvară şi de toamnă. Speciile care au avut o densitate numerică scăzută, au înregistrat şi valori scăzute ale cantităţii de biomasă, ceea ce a condus la o productivitate biologică scăzută şi invers.

Cuvinte cheie: pădure de foioase, lumbricide, biomasă, productivitate.

INTRODUCTION

The term **earthworms** includes a diverse group of Oligochaeta (Annelida), consisting of over 3,500 species (COLEMAN *et al.*, 2004), found in soil, trees, wet areas of tropical forests; others are important benthonic organisms of freshwater and marine water (BRINKHURST & JAMIESON, 1971; JAMIESON, 1988). Most European earthworms belong to the Lumbricidae Family, containing about 600 species. The scientific literature began with the taxonomic description of LINNAEUS (1758) on *Lumbricus terrestris* species. Later, DARWIN (1881), made observations and experiments on Lumbricidae behaviour and made the first assumptions about their role in soil formation.

Darwin also highlighted the beneficial effects of earthworms in his book "Formation of agricultural soil by earthworms action", stating that "it is doubtful whether there are many animals that played such an important role in the history of the world, as did these creatures so little organized". Since then, many studies have investigated the role of earthworms in soil formation, decomposition of organic matter, circulation of nutrients and plant growth (LEE, 1985; LEE & FOSTER, 1991; EDWARD & BOHLEN, 1996; SCHEU, 2003; BROWN *et al.*, 2004; COLEMAN *et al.*, 2004).

Earthworm populations exhibit an irregular and aggregated distribution that may be related to vegetation, soil characteristics and biotic interactions. However, the spatial distribution of earthworms is an important parameter of their populations depending on both internal (community structure, abundance and individual parameters) and external factors (biotic and abiotic). Their contribution to processes such as decomposition, soil aggregation and plant production is presumably limited to patches where earthworms are active. Despite of the vast increase in scientific literature on earthworms in recent years, much remains to be known in their basic biology and ecology (NACHTERGALE *et al.*, 2002; KOOCH & JALILVAND, 2008). Among the latter, single tree influence plays a major role. In some forests, earthworm populations are associated with plant species that provide a favourable microhabitat through their architecture and degree of ground cover, or because of the amount and quality of above - or below - ground litter they produce (ZALLER & ARNONE, 1999; CAMPANA *et al.*, 2002; NACHTERGALE *et al.*, 2002). Earthworm-free forest soils that have not been previously ploughed by humans tend to have very low bulk densities, due to the presence of a thick litter layer and the burrowing action of many species of native invertebrates (MCLEAN & PARKINSON, 1997a; BOHLEN *et al.*, 2004). The quantitative retrieval of earthworms is affected by the size and shape of the collection area, which may also influence the accuracy of earthworm population estimates (DICKEY & KLADIVKO, 1989).

The ecosystem studied is located in the upper third of a slope, at the point called "Ruginoasa". The average slope inclination is 20 degrees, altitude varies between 380 – 400 m, and the exhibition is sunny south-east. Litter is still thin, due to rapid decomposition of the layer of leaves, branches, fruit, etc., in humus. The type of flora is *Asarum stellaria.* The stand is fundamentally natural of average productivity, relatively homogenous in terms of age, with the actual composition 4 Common Oak (*Quercus petraea*), 4 Beech (*Fagus sylvatica)*, 2 Various Hardwood (*Carpinus betulus, Tilia platyphyllos, Ulmus glabra, Prunus avium, Acer pseudoplatanus*), aged 65, being managed in forest regime (natural regeneration from the seed).

The consistency of 0.7- 0.8 stand is the third class of production, age of exploitability 120 years. The forest type is common oak – beech. The station type is hilly common oak. Due to the consistency of 0.7 – 0.8, indicating a reduction in the stand density, there were formed several levels of vegetation. The trees holding and filtering the light, heat and rain, leave less favourable conditions to the grasses and shrubs, thus providing each level with a certain regime, light, heat, moisture, wind, etc.

The purpose of this study was to evaluate the monthly dynamics of biomass and productivity of Lumbricidae communities in a mixed deciduous forest. The basis for this is that the impact of various trees on earthworm abundances is not only through their effects on litter and microclimate (FRAGOSO *et al.*, 1997; NEHER, 1999), but also through altering the chemical and physical properties of the soil (ZOU & GONZALEZ, 2002). Hypothesis was that different seasons may affect biomass of earthworms at various stands and there will be relationships between seasonal variation of earthworm abundance with some of the site and species characteristics (VALCKX *et al.*, 2006; NAGUMANOVA, 2007). Recognition of parameters affecting earthworm population under natural and planted forests would be useful for cultural interventions.

MATERIAL AND METHODS

The Lumbricidae samples were taken randomly, from March to October 2007, by making ten holes in the station, using a metal frame with sides of 25/25 cm. The sample units were built on depth levels, namely: L = litter; S_1 = 10 cm; S_2 = 20 cm; S_3 = 30 cm; S_4 = 40 cm. The earthworms were manually extracted from the samples, immediately after making the holes and put in tightly closed containers of 90° alcohol. The containers had labels containing: sampling place, date (day, month and year), depth of the soil, sample number.

The fauna material was taken to the laboratory in order to test each species, using a determinator (EASTON, 1983; POP, 1949).

The biomass of Lumbricidae species was calculated by the ratio between individual weight and dry weight of each individual (mg.d.s./m^2). Individual live weight and individual weight after drying was determined by weighing on analytical balance. To remove water from the body, the fauna material was dried in a drying cabinet, at a temperature of 105°C. By successive weighings, after 48 hours, the weight of the individuals remained constant and drying was complete. Estimation of gravimetric abundance in the form of dry weight, per square meter, facilitated the calculation of biological productivity of Lumbricidae during one year, expressed as gravimetric increases on a time unit. Data on biological productivity were obtained by adding gravimetric differences between collection time within a month.

RESULTS AND DISCUSSIONS

Lumbricidae specific composition in the ecosystem of mixed deciduous forest presented 17 species: *Allolobophora* sp., *All. dacica, All. calliginosa, All. leoni, Aporrectodea r. rosea, Dendrobaena biblica, D. octaedra, Dendrodrilus r. rubidus, Eisenia lucens, Lumbricus rubellus, L. castaneus, L. terrestris, L. t. linnaeus, Octodrilus complanatus, O. lissaensis, Octolasion lacteu.*

The biomass calculated for Lumbricidae species in the deciduous ecosystem (Ruginoasa Station) in 2007, at the five levels of soil (Fig. 1), based on numerical density, emphasizes *Octolasion lacteum* species as dominant in terms of biomass, accounting for high values at the levels of soil analysed, except in the litter. Of the total biomass (27.598 mg.d.s./m^2) calculated from March to October 2007, this species dominates in a ratio of 74.69%, with a key role in the transfer of matter and energy. *Aporrectodea rosea rosea* species, also dominant in this ecosystem, shares only 4.64% of the total biomass. The biomass stratifies vertically, from level S1 (0 – 10 cm), with a very low biomass in the litter. The largest biomass was observed at the levels S1 (0 – 10 cm), S2 (10 – 20 cm) and S3 (20 – 30 cm). Higher values of the biomass were recorded in spring and autumn. It was also found that the species with a high numerical density in this habitat, recorded a higher biomass and vice versa.

The analysis of monthly dynamics of total biomass of Lumbricidae during March-October 2007 (Fig. 2) revealed a faster increase in spring months, with a maximum value of 11.948 mg.d.s./m^2 recorded in April, followed by a decrease in May. The increase of the biomass in August was not significant, while the curve fell again in September and October. The monthly values of total biomass in 2007 ranged from 1.411 – 11.948 mg.d.s./m^2.

Estimation of the biomass of lumbricidae species, in the form of dry weight per square metre, allowed the calculation of their biological productivity during March - October 2007, expressed as the increase of the biomass per time unit. The data on biological productivity were obtained by summing the biomass differences between the times of collection, within a month. The analysis of biological productivity of Lumbricidae in the soil layers, illustrated in figure 3, revealed an increase of biological productivity in *Octolasion lacteum, Aporrectodea rosea rosea, Eisenia lucens, Dendrobaena* and *Lumbricus* species.

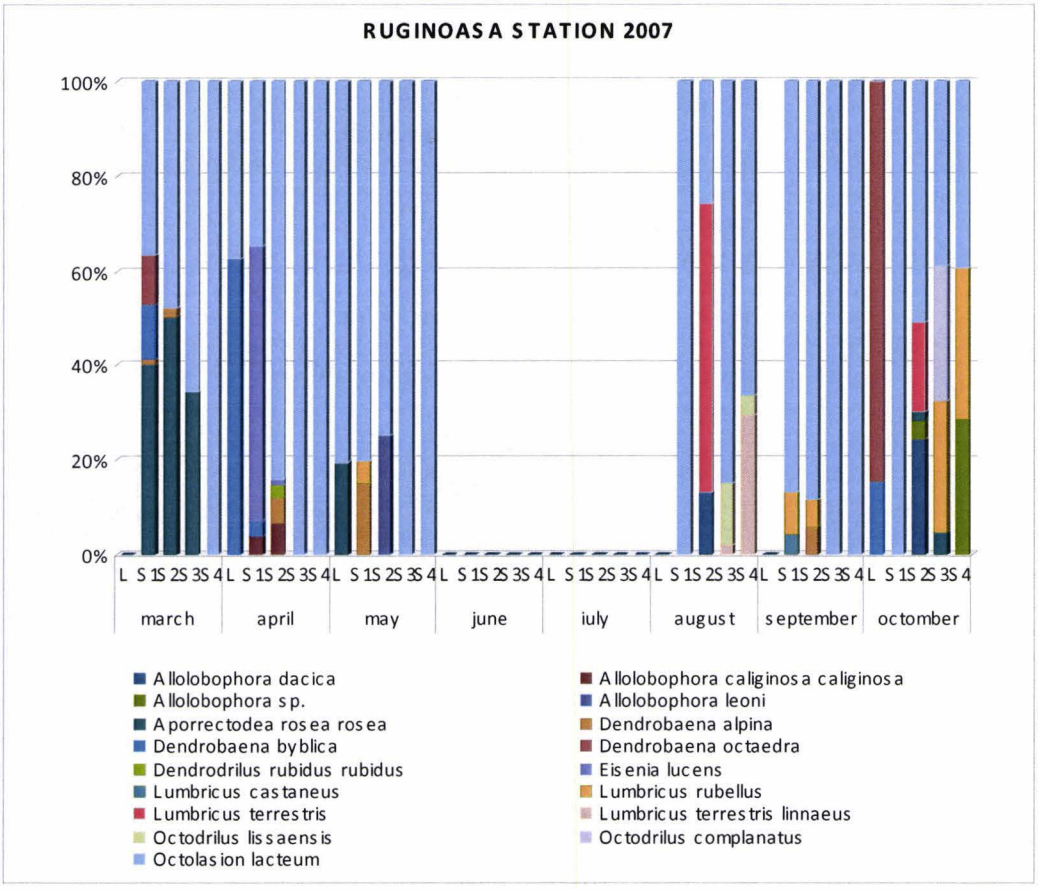

Figure 1. Biomass of Lumbricidae in the soil layers (mg.d.s./mp) in the deciduous forest (Ruginoasa Station) March-October 2007.
Figura 1. Biomasa lumbricidelor în straturile de sol (mg.s.u/mp) din pădurea de foioase (Staţia Ruginoasa) martie-octombrie 2007.

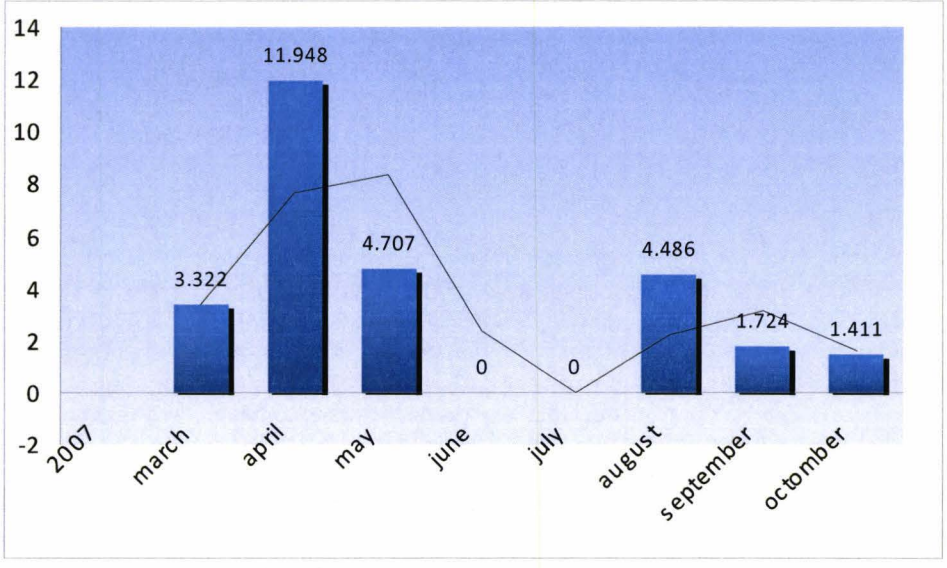

Figure 2. Monthly dynamics of total biomass of Lumbricidae (mg.d. s./mp) during March-October 2007.
Figura 2. Dinamica lunară a biomasei de lumbricide (mg.s.u/mp) în perioada martie-octombrie 2007.

Biological productivity of the soil layers in 2007 was high at the level 0– 10 cm, with a maximum value of (4.03 mg.d.s./m^2) for *Octolasion lacteum* species, followed by *Eisenia lucens* (0.9 mg.d.s./m^2) and *Aporrectodea rosea rosea* (0.641 mg.d.s./m^2). A high biological productivity was recorded at levels 10-20 cm and 30-40 cm in *Octolasion lacteum* species. The lowest biological productivity was recorded in the litter, where the biomass was also low.

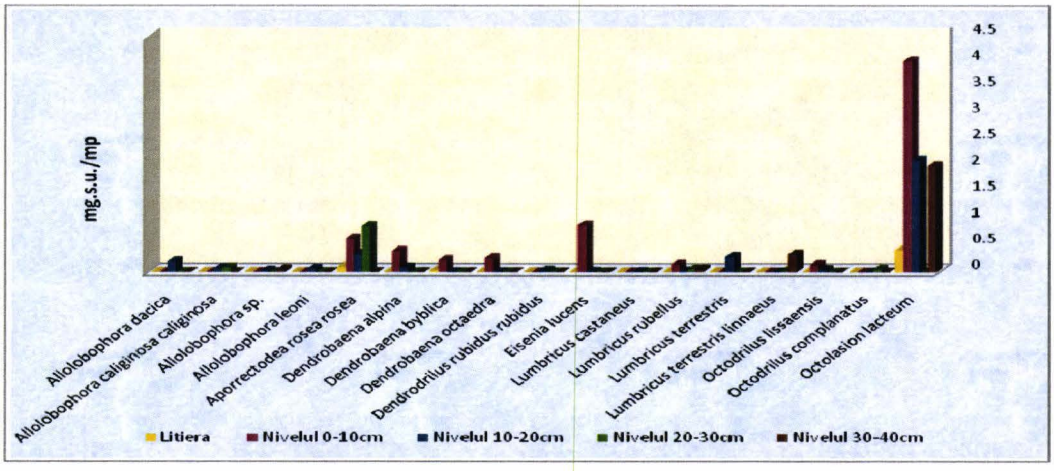

Figure 3. Biological productivity of Lumbricidae in the soil layers during March-October 2007.
Figura 3. Productivitatea biologică a lumbricidelor în stratele de sol în perioada martie-octombrie 2007.

Total productivity of *Lumbricidae* in 2007, illustrated in figure 4, results from the analysis of the lumbricidae biomass and biological productivity at the soil levels and highlights *Octolasion lacteum* species with the highest total productivity, followed by *Aporrectodea rosea rosea* and *Eisenia lucens* species. The remaining species had low productivity.

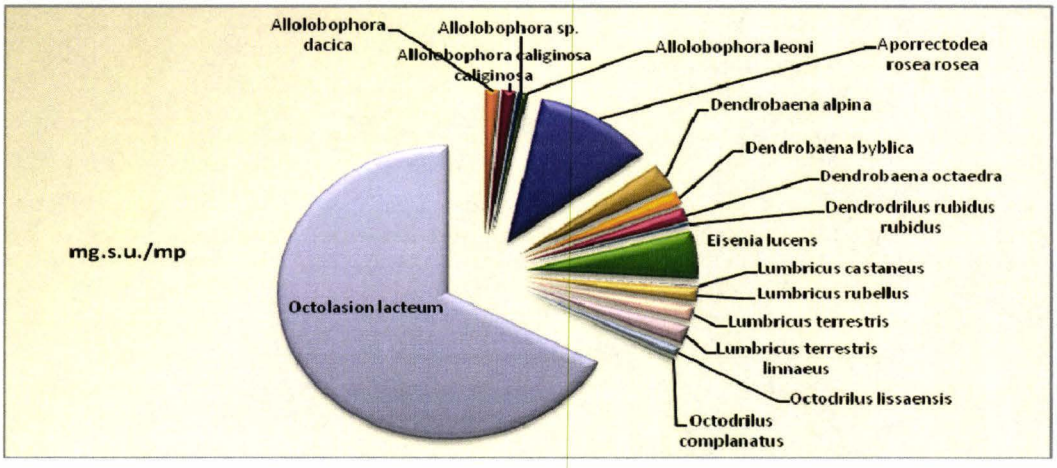

Figure 4. Total productivity of Lumbricidae in the deciduous forest (Ruginoasa Station) 2007.
Figura 4. Productivitatea totală a lumbricidelor în pădurea de foioase (Staţia Ruginoasa) 2007.

The results of this study confirmed the information according to which the biotope, vegetation, seasonal, micro-habitat and individual differences have a significant influence on the dynamics of the analysed parameters.

Direct effect of tree species on soil and litter biota are caused by the plant inputs of organic matter above and below ground, while indirect effect of trees on biota include shading, soil protection and uptake of water and nutrients by roots (NEHER, 1999). Soil properties may constrain earthworm populations only at the extremes of each variable (EDWARDS & BOHLEN, 1996), and the factors that determine earthworm population aggregations may operate at different scales from those that determine soil physical–chemical properties (WHALEN & COSTA, 2003; ROSSI, 2003).

The analysis of the biomass density of Lumbricidae at the soil levels in the ecosystem of deciduous forest (Ruginoasa Station) revealed certain differences, thus highlighting the ecological valences of *Octolasion lacteum*, *Allolobophora caliginosa caliginosa* and *Aporrectodea rosea rosea* species, with important functions in the activity of Lumbricidae populations in this ecosystem. Low, even absent biomass in June and July 2007 was mainly due to prolonged drought at that time of the year and lack of moisture in the soil layers during the sampling period, which caused the animal withdrawal in the deeper layers of the soil or formed aggregations where there was an optimal minimum for survival, moisture accounting for a limiting factor of Lumbricidae.

This might indicate that the aggregation of earthworms is more probable under shady conditions, presumably because of the better microclimate created by the tree shade. Different tree species influence the composition and the abundance of soil fauna differently, particularly the litter fauna (DEHARVENG, 1996). The composition of the over story has an impact on soil structure (READ & WALKER, 1950). Earthworm population density at a specific site is the result of the interaction of a number of factors such as soil texture moisture, pH and organic matter content (BLANCHART & JULKA, 1997; LAVELLE, 1993; SATCHELL, 1983). Other studies have shown the earthworm biomass is significantly

influenced by type of tree species (NEIRYNCK *et al.*, 2000; SARLO, 2006). Also in another research, conversion of pure Scots pine treatments to mixed treatments with broad-leaved species, caused an increase in abundance and biomass of earthworms (AMMER *et al.*, 2006). Earthworm activity and populations are determined essentially by the moisture content of the soil (LAVELLE, 1988).

Species with a lower numerical density recorded low values of the biomass, thus leading to a low biological productivity. There were also situations in which certain species had a low density, but a higher biomass, due to the larger body waist, which led to an increase of the individual weight, especially for *Lumbricus* species.

CONCLUSIONS

The obtained biomass depended to a great extent on the density of each species and equally on the individual biomass of individuals of different species. Also, increasing the number of species caused an increase of total biomass. In the summer months, metabolism and activity of Lumbricidae were lower, causing a decrease in the biomass and productivity. The highest biomass, especially at higher levels of the soil was achieved mainly due to the dominant species *Octolasion lacteum* and *Aporrectodea rosea rosea*. Dynamics in time and space of the biomass of Lumbricidae species was closely related with and directly proportional to the micro-habitat conditions and the depth from which the soil samples were taken. From this viewpoint, spatial and temporal patterns of fauna changes induced by modifications in vegetation, especially at the transition from one successional stage to another, should give us valuable information. Hence, experimental studies should focus on the evolution of the micro-habitat diversity and its relationships with the population dynamics of Lumbricidae.

REFERENCES

AMMER S., WEBER K., ABS C., AMMER C., PRIETZEL J. 2006. *Factors influencing the distribution and abundance of earthworm communities in pure and converted Scote pine treatments.* Applied Soil Ecology. Elsevier. Stuttgart. Germany. **33**: 10-21.

BLANCHART E. & JULKA J. M. 1997. *Influence of forest disturbance on earthworm communities in Western Ghat, South India.* Soil Biology and Biochemistry. Elsevier. Stuttgart. Germany. **29**: 303-306.

BOHLEN P. J., GROFFMAN P. M., FAHEY T. J., FISK M. C., SUAREZ E., PELLETIER D. M., FAHEY R. T. 2004. *Ecosystem consequences of exotic earthworm invasion of north temperate forests.* Scientific Facts on Ecosystem Change. Ecosystems. Oregon. USA. **7**:1-12.

BRINKHURST R. O. & JAMIESON B. G. M. 1971. *Aquatic Oligochaeta of the world.* Oliver and Boyd. Edinburgh: 665-698.

BROWN G. G., EDWARDS C. A., BRUSSAARD L. 2004. *How earthworms affect plant growth: burrowing into the mechanisms.* In: Edwards CA (Ed.) Earthworm Ecology, 2nd ed. CRC Press, Boca Raton: 13-49.

CAMPANA C., GAUVIN S., PONGE J. F. 2002. *Influence of ground cover on earthworm communities in an unmanaged beech forest: linear gradient studies.* European Journal of Soil Biology. University of Amsterdam. **38**: 213-224.

COLEMAN D. C., CROSSLEY JR. D. A., HENDRIX P. F. 2004. *Fundamentals of Soil Ecology.* 2nd Edn., Elsevier Academic Press. San Diego. 384 pp.

DARWIN C. 1881. *The formation of vegetable mould through the action of worms with observations on their habits.* Murray. London: 767-779.

DEHARVENG L. 1996. *Soil Collembola diversity, Endemism, and reforestation: A case study in the Pyrenees (France).* Conservation Biology. Washington. **10**: 74-84.

DICKEY J. B. & KLADIVKO E. J. 1989. *Sample unit sizes and shapes for quantitative sampling of earthworm populations in crop lands.* Soil Biology and Biochemistry. Great Britain. **21**: 105-111.

EASTON E. G. 1983. *A guide to the valid names of Lumbricidae (Oligochaeta).* In: J. E. Satchell (Ed.) Earthworm. Ecology – From Darwin to Vermiculture. Chapman end Hall. London: 475-487.

EDWARDS C. A. & BOHLEN P. J. 1996. *Biology and Ecology of Earthworms.* Third edition. Chapman & Hall. London. 426 pp.

FRAGOSO C., BROWN G., PATRON J. C. 1997. *Agriculture intensification, soil biodiversity and agro ecosystem function in the tropics: the role of earthworms.* Applied Soil Ecology. Elsevier. Stuttgart. Germany. **6**: 17-35.

JAMIESON B. G. M. 1988. *On the phylogeny and higher classification of the Oligochaeta.* Evolutionary Biology. Cladistics. The International Journal of the Willi Hennig Society. London. **4**: 367-410.

KOOCH Y. & JALILVAND H. 2008. *Earthworms as ecosystem engineers and the most important detritivors in forest soils (Review).* Pakistan Journal of Biological Sciences. International College of Surgeons Pakistan Chapter and SAARC Association of Surgeons Pakistan Chapter. **11**: 819-825.

LAVELLE P. 1988. *Earthworm activities and the soil system.* Biology and Fertility of Soils. Universita di Firenze. Italy. **6**(3): 237-251.

LAVELLE P. 1993. *The structure of earthworm communities.* In: Satchell J. E. (Ed.). Earthworm Ecology from Darwin to Vermiculture. Chapman and Hall. London: 449-446.

LEE K. E. 1985. *Earthworms: ecology and relationships with soils and land use.* Academic Press. Sydney. 411 pp.

LEE K. E. & FOSTER R. C. 1991. *Soil fauna and soil structure.* Australian Journal ol Soil Research. Edinburgh. **29**: 745-775.

LINNAEUS C. 1758. *Systema Naturae.* Laurentii Salvii Holmiea. Oklahoma. 824 pp.

MCLEAN M. A. & PARKINSON D. 1997. *Changes in structure, organic matter and microbial activity in pine forest soil following the introduction of Dendrobaena octaedra (Oligochaeta, Lumbricidae).* Soil Biology and Biochemistry. London. Great Britain. **29**: 537-540.

NACHTERGALE L., GHEKIERE K., DE SCHRIJVER A., MUYS B., LUYSSAERT S., LUST N. 2002. *Earthworm biomass and species diversity in windthrow sites of a temperate lowland forest.* Pedobiologia. University of Ankara. Turkey. **46**: 440-451.

NAGUMANOVA N. G. 2007. *Spatial differentiation of invertebrates in soils of the transural steppe region.* Entomological Review. Petersburg. Russia. **87**: 692-700.

NEHER D. A. 1999. *Soil community composition and ecosystem processes: Comparing agricultural ecosystems with natural ecosystems.* Agroforestry Systems. Elsevier Science. Amsterdam. **45**: 159-164.

NEIRYNCK J., MIRTCHEVA S., SIOEN G., LUST N. 2000. *Impact of Tilia platyphyllos Scop., Fraxinus excelsior L., Acer pseudoplatanus L., Fagus sylvatica L. on earthworm biomass and physico-chemical properties of a loamy topsoil.* Forest Ecology and Management. Elsevier Sciense. Stuttgart. Germany. **15**: 275-286.

POP V. 1949. *Lumbricidele din România.* Analele Academiei Republicii Populare Române. Bucureşti. **1**(9): 383-505.

READ R. A. & WALKER L. C. 1950. *Influence of eastern red cedar on soil in Connecticut pine plantations.* Journal of Forestry. Stuttgart. Germany. **23**: 337-339.

ROSSI J. P. 2003. *Clusters in earthworm spatial distribution.* Pedobiologia. University of Ankara. Turkey. **47**: 490-496.

SARLO M. 2006. *Individual tree species effect on earthworm biomass in a tropical plantation panama.* Caribbean Journal of Science. Puerto Rico. **43**: 419-422.

SATCHELL J. E. 1983. *Earthworm ecology in forest soil.* In: Satchell J. E. (Ed.). Earthworm Ecology from Darwin to Vermiculture, Chapman and Hall. London: 161-170.

SCHEU S. 2003. *Effects of earthworms on plant growth: patterns and perspectives.* Pedobiologia. University of Ankara. Turkey. **47**: 1-11.

VALCKX J., HERMY M., MUYS B. 2006. *Indirect gradient analysis at differentspatial scales of prorated and nonprorated earthworm abundance and biomass datain temperate agroecosystems.* European Journal of Soil Biology. University of Amsterdam. **42**: 341-347.

WHALEN J. K. & COSTA C. 2003. *Linking spatio-temporal dynamics of earthworm populations to nutrient cycling in temperate agricultural and forest ecosystems.* Pedobiologia. University of Ankara. Turkey. **47**: 801-806.

ZALLER J. G. & ARNONE J. A. 1999. *Earthworm responses to plant species' loss and elevated CO_2 in calcareous grassland.* Plant Soil and Entomological Sciences. Moscow. Russia. **208**: 1-8.

ZOU X. & GONZALE G. 2002. *Earthworms in tropical tree plantation: effects of management and relations with soil carbon and nutrient use efficiency.* In: Reddy MV (Ed.) Management of Tropical Plantation-Forests and their Soil Litter System. Chapter Science Publishers Inc. Enfield (NH). USA: 289-301.

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THE ACTUAL STATE OF THE BENTHIC FAUNA IN THE INNER DANUBE DELTA, ROMANIA

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Abstract. The benthic invertebrates are one of the most important components of the aquatic ecosystems and are considered in the research and monitoring programs dealing with dynamics of the ecological state of the Lower Danube Wetland System. During 2009-2010 period, field observations were made on the benthic fauna of the shallow lakes and channels in the Inner Danube Delta, located in Romania, between r.km 170 (Brăila) and r.km 365 (Călăraşi) on the Danube River. The sampling program, with seasonal periodicity, included 23 stations along a longitudinal gradient according to the water loading in the complex of ecosystems. The present work discusses the composition and structure of the benthic fauna and compares the results with those obtained in the previous period (1993-2009) in the same area and in the costal Danube Delta (1975-2000) with the aim of identifying the main trends of its dynamics. Aquatic worms and insects, represented by Oligochaeta and Chironomidae respectively, continued to represent the constant and dominant components of the bottom fauna in terms of both number and biomass abundances.

Keywords: Inner Danube Delta, natural aquatic systems, benthic fauna, structure, dynamics.

Rezumat. Starea actuală a faunei bentonice din delta interioară a Dunării, România. Fauna nevertebratelor bentonice este una dintre cele mai importante componente ale ecosistemelor acvatice, fapt pentru care este luată în considerare în programele de cercetare şi de monitorizare privind dinamica ecosistemelor identificabile la scara Sistemul Dunării Inferioare. În perioada 2009-2010, s-au făcut cercetări asupra faunei bentonice din lacurile şi canalele puţin adânci, situate în zonele inundabile (insulare şi riverane) ale deltei interioare a Dunării, distribuită în lungul sectorului fluvial cuprins între kilometrul 170 (Brăila) şi 365 (Călăraşi). Frecvenţa programului de prelevare a probelor bentonice a fost sezonieră şi a inclus 23 de staţii distribuite de-a lungul unui gradient hidrologic longitudinal, în funcţie de încărcarea apei din Dunăre în complexul de ecosisteme. Lucrarea de faţă discută compoziţia şi structura faunei bentonice şi compară rezultatele actuale cu cele obţinute în perioada anterioară din aceeaşi zonă (1993-2009) şi cu seturile de date din Delta Dunării (1975-2000), cu scopul de a identifica principalele tendinţe în dinamica acesteia. Viermii şi insectele acvatice, reprezentate de Oligochaeta şi respectiv Chironomidae, continuă să reprezinte componente constante şi dominante în structura faunei bentonice atât din punct de vedere al abundenţelor numerice cât şi în biomasă.

Cuvinte cheie: delta interioară a Dunării, ecosisteme acvatice naturale, fauna bentonică, structura, dinamica.

INTRODUCTION

The benthic invertebrate fauna of inland waters are one of the most abundant, diverse, and a key component found on/in submerged substrates. Their well-adapted biological and behaviour mechanisms to the contrasting challenges of living, makes them excellent competitors for their integral role in the ecological processes, nutrient cycling and energy flow. The structural and functional peculiarities of the benthic species make them excellent indicators considered in research and monitoring programs dealing with biomonitoring, dynamics of the ecological state, restoration ecology and so on (COVICH *et al.*,1999; CHALONER *et al.*, 2009; STRAYER, 2009).

Knowledge of the benthic fauna inhabiting various aquatic ecosystems of the Lower Danube Wetland System (LDWS) is further compounded by a lack of information. This fact has been proven by different authors that especially studied the aquatic systems of the costal Danube Delta and the river stretch (BOTNARIUC *et al.*, 1985, 1987; POPESCU-MARINESCU, 1992; IGNAT *et al.*, 1997; RÎŞNOVEANU *et al.*, 1997; RÎŞNOVEANU & VĂDINEANU, 2003; RÎŞNOVEANU, 2006; VĂDINEANU *et. al.*, 2000, 2001, 2003).

In comparison with the extensive and intensive research programs performed in the costal Danube Delta, in the eight decade of the former century, as well as with results of the studies implemented in the former floodplain lakes, in the 1960's, the current state of the benthic fauna of the lakes remained under natural flooding regime in the inland delta is relatively less known. In addition, as RUSSEV (1998) and TUDORANCEA (2006) emphasized "except for general faunistic and taxonomic studies, the attention has been focused on three major groups: Gastropoda, Oligochaeta, Chironomidae" the others receiving far less concern.

The benthic fauna of the shallow lakes from the insular and riparian zones of the Inner Danube Delta (IDD - one of the six components of LDWS) (VĂDINEANU, 2009) become of particular interest especially after 1990's, since the Small Island of Brăila (SIB - a remnant wetland in the former inner delta), became a pilot region for sustainable development and an International Long Term Ecological Research (ILTER) site. The respective data has been published in few papers and mainly in the project reports (i.e. "Functional Role of Biodiversity in the Lower Danube System" - RFB, 1999, "Ecological Network of the Lower Danube System" - REDI, 2001).

Taking into consideration the state of knowledge and the role of the benthic fauna for the bioeconomy of the aquatic systems from IDD, the research brings contributions to the knowledge of composition and structure of the benthic communities inhabiting the aquatic ecosystems remained in this area.

MATERIAL AND METHODS

The present study is a subprogram of a complex, multi - and trans - disciplinary research program developed by the Research Center of System Ecology, Eco-Diversity and Sustainability (RCSEES/CCESES) of the University of Bucharest. The subprogram was designed at a temporal and spatial scale of the aquatic complex of ecosystems in the IDD.

Study area. In the LWDS (Fig. 1. A), the IDD (Fig. 1. B) extends over 2,413 (km^2) between Southern Romanian Plain and Dobrogea Plateau along the river Danube stretch of 215 kilometers long, from Brăila (r.km 170) to Călăraşi (r.km 365) (CRISTOFOR *et al.*, 2003; VĂDINEANU *et al.*, 2003). The region constitutes an environmental mosaic that is characterized by a network of heterogeneous and dynamic complexes of aquatic ecosystems, in different stages of succession, according to the degree of connectivity and location (***REDI, 2001). From the entire surface of IDD, only the SIB (Fig. 1. C) remained under natural flooding regime and is now a Long Term Ecological Research platform, a natural reserve and also a Ramsar Site (Figs. 1 A-E).

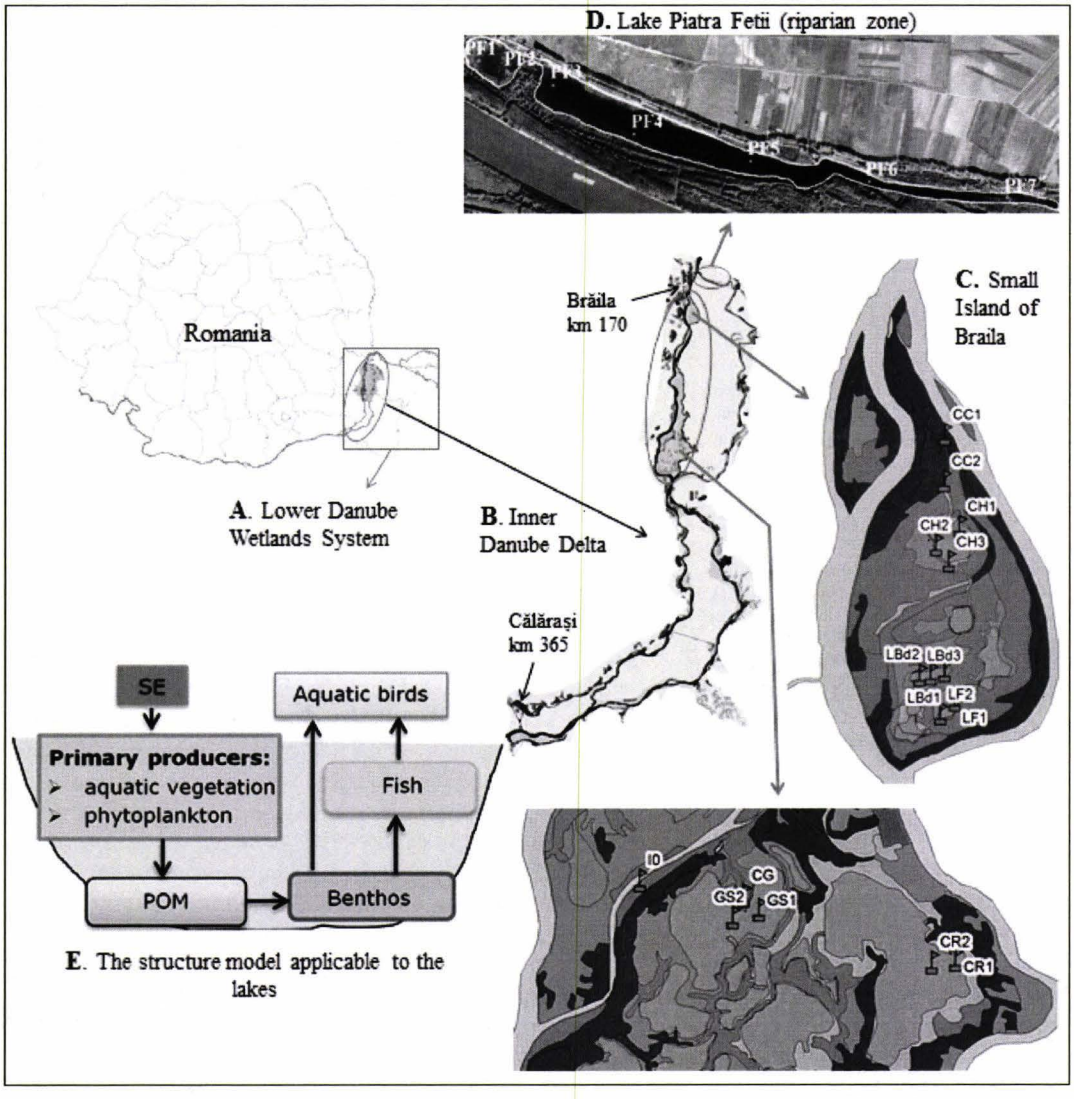

Figure 1. A – E. Location of the sampling sites in the IDD, Romania (I0 – the Danube riverbank; CC1, CC2 – Chiriloaia Channel; CG – Gâsca Channel; CH1, CH2, CH3 – Lake Chiriloaia; LBd1, LBd2, LBd3 – Lake Bordeiele, LF1, LF2 – Lake Fundu Mare; GS1, GS2 – Lake Gâsca; CR1, CR2 – Lake Curcubeu; PF1 – PF7 – Lake Piatra Fetii). E: The structural model showing the pathway crossed by the zoobenthos in the SIB. The arrows show the unidirectional matter and energy flows into the system. SE – solar energy, POM – particulate organic matter (redrawn from ADAMESCU, 2004; VĂDINEANU, 2009). / Figura 1. A – D: Localizarea siturilor de cercetare la nivelul deltei interioare a Dunării, România (I0 – mal Dunăre; CC1, CC2 – canal Chiriloaia; CG – canal Gâsca; CH1, CH2, CH3 – lac Chiriloaia; LBd1, LBd2, LBd3 – lac Bordeiele, LF1, LF2 – lac Fundu Mare; GS1, GS2 – lac Gâsca; CR1, CR2 – lac Curcubeu; PF1 – PF7 – lac Piatra Fetii). E: Model structural care arată locul faunei bentonice la nivelul insulei mici a Brăilei. Săgeţile indică fluxul de masă şi energie în sistem (adaptată după ADAMESCU, 2004; VĂDINEANU, 2009).

Figure (1. E) shows a general pattern of mass and energy flows applicable to the shallow lakes (less than 3 meter deep) characteristic and representative for the SIB. The primary producers are represented mainly by aquatic vegetation. The plants represent an important habitat for epiphytic invertebrates and also a significant source of detritus (POM) for zoobenthos. Nevertheless, heavily vegetated areas, as is the case of the shallow lakes in SIB, can get oxygen

limited and become a stressor for benthic fauna, limiting invertebrate diversity and the provision of ecosystem services they are supporting (***RFB, 1999; ***REDI, 2001; VĂDINEANU *et al.*, 1992, 2000; WHILES & GRUBAUGH, 2009).

Sampling methods. The benthic invertebrate communities were sampled, and the main physical and chemical parameters of the water bodies were measured in six representative shallow lakes, two channels and the Danube riverbank in the IDD (Figs. 1. C, D) Totally, 23 stations were established along a longitudinal gradient according with the water loading into aquatic complex from the river. During 2009-2010, ten samples were sampled from spring to autumn, each of them consisting in 6 to 21 sampling unites per system, in accordance to the expected heterogeneity of the natural capital. Benthic samples have been taken randomly including 3 replicates per sampling point (station), using a core with a surface area of 24.6 cm^2. The bottom samples were washed through a 230 μm mesh sieve and preserved in formalin 4%, in plastic bags. In the laboratory, the taxonomical identification has been performed to the main taxa groups using a stereomicroscope Olympus SZX7 and the appropriate identification guidebooks (PENNAK, 1953; GODEANU, 2002).

In order to analyse and integrate the data of the benthic fauna, a number of structural parameters have been investigated. The invertebrate abundance (ind./m^2 and g. dry mass /m^2), numerical (A1%) and biomass (A2%) relative abundance and the frequencies of occurrence (F%) were calculated. The dominant taxa were established following the usual conventional criteria (A1 ≥ 15% and A2 ≥ 10%), (VĂDINEANU, 1998).

Taxa richness, Shannon-Wiener and equitability were examined for their potential value in describing the state of the benthic communities.

RESULTS AND DISCUSSIONS

During 2009 – 2010, a total of 15 invertebrate taxa were identified in the structure of benthic fauna of the studied systems (Fig. 2). In each aquatic system at each sampling moment, the number of invertebrate groups varied between 2 and 7. The maxim number was recorded in spring (April and May 2010, L. Piatra Fetii located in the riparian zone) and autumn (November 2010, C. Chiriloaia). High taxa richness (5-6 taxa per sample moment and aquatic ecosystem) was recorded in June 2009 (Danube riverbank, channel and lake Chiriloaia and L. Curcubeu), June 2010 (C. Chiriloaia and L. Bordeiele) and November 2010 (lakes Chiriloaia, Fundu Mare and Piatra Fetii). Frequently, the diversity of the benthic communities remained at a low level, only two invertebrate groups being present.

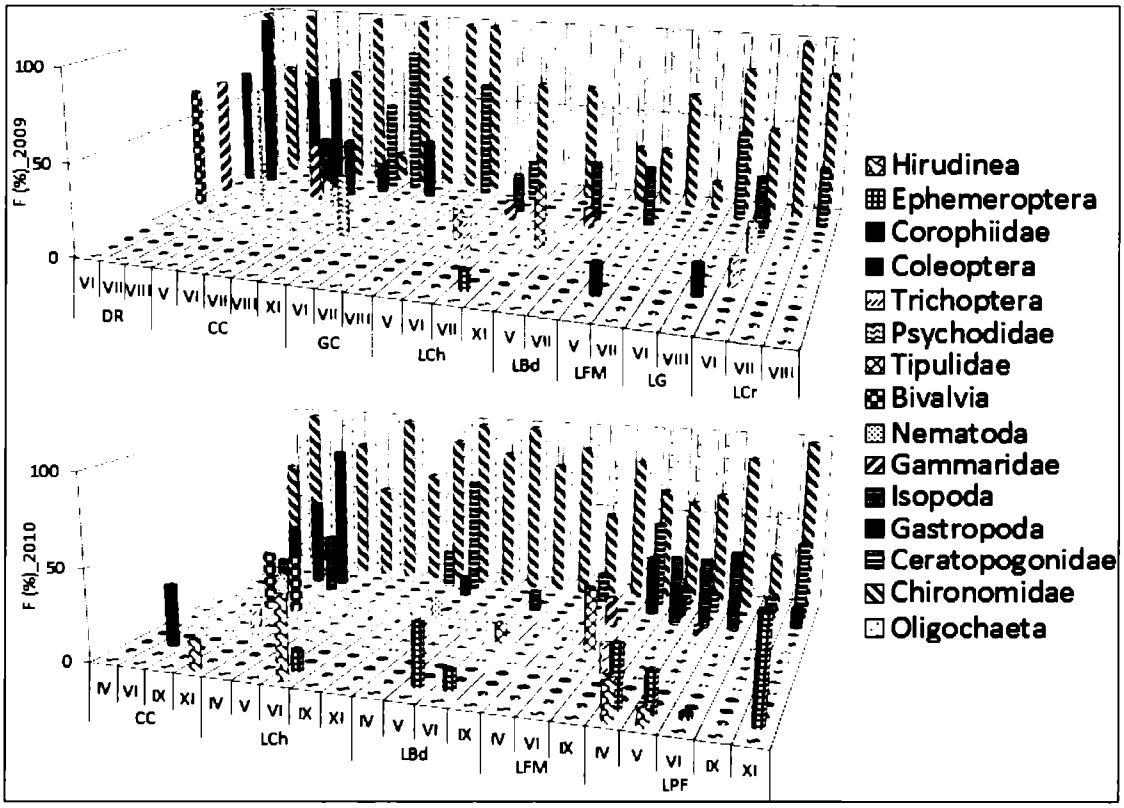

Figure 2. Spatial-temporal distribution and occurrence frequencies of taxa groups identified in the benthic fauna from the IDD during 2009-2010. DR – the Danube riverbank; CC – Chiriloaia Channel; GC – Gâsca Channel; LCh – L. Chiriloaia; LBd – L. Bordeiele; LFM – L. Fundu Mare; LG – L. Gâsca; LCr – L. Curcubeu; LPF – L. Piatra Fetii. / Figura 2. Distribuţia spaţio-temporală şi frecvenţele de apariţie în probe ale grupelor de organisme identificate în cadrul comunităţilor bentonice din delta interioară a Dunării în perioada 2009-2010. DR – mal Dunăre; CC – canal Chiriloaia; GC – canal Gâsca; LCh – lac Chiriloaia; LBd – lac Bordeiele;LFM – lac Fundu Mare; LG – lac Gâsca; LCr – lac Curcubeu; LPF – lac Piatra Fetii.

Particularly this was the case in five out of seven systems sampled in July 2009 (Gâsca channel and lakes Chiriloaia, Bordeiele, Fundul Mare and Curcubeu). Dynamics of the taxa richness at the level of benthic communities may be related with the hydrological regime and the morphology of the aquatic systems that favour development of aquatic weeds and high level of hypoxia or anoxia at the sediment water interface during the summer time. Similar results were reported also by BOTNARIUC *et al.* (1987) and RÎŞNOVEANU *et al.* (1997) in aquatic systems of the Danube Delta.

The spatiotemporal distribution of the identified taxa revealed that 8 benthic groups had occurrence frequencies of over 50% being constant components of benthic communities. They are represented by Nematoda, Oligochaeta, Gastropoda, Bivalvia, Gammaridae, Ephemeroptera, Chironomidae and Ceratopogonidae. Among that, Oligochaeta and Chironomidae were the most frequent components of the bottom fauna across the entire study area. Oligochaeta recorded values between 56 and 100%, except in June and July 2009 in the Gâsca Channel (F - 33%). Chironomidae recorded occurrence frequencies over 50%. Nevertheless, in some samples they were absent or did not fulfil the constancy criteria (F≥ 50%): April and July 2009 in channel and lake Chiriloaia, L. Bordeiele and L. Gâsca and September 2010 in Chiriloaia Channel and L. Piatra Fetii. This could be related to their life cycles.

Gastropoda and Bivalvia were the groups that meet the constancy criteria in the Danube riverbank and C. Chiriloaia. Nematoda and Gammaridae, were generally absent in lakes and accessory or even accidental in lotic ecosystems (channels Chiriloaia and Gâsca, and the Danube riverbank). Ceratopogonidae met the constancy criteria in C. Gâsca, August 2009, C. Chiriloaia, November 2009 and L. Chiriloaia, November 2010. In the same time, they were accessory or even accidentally present in both lakes and channels. Ephemeroptera reaches occurrence frequency of 56% in L. Piatra Fetii in November 2010. All other taxonomic groups were sporadic (Fig. 2).

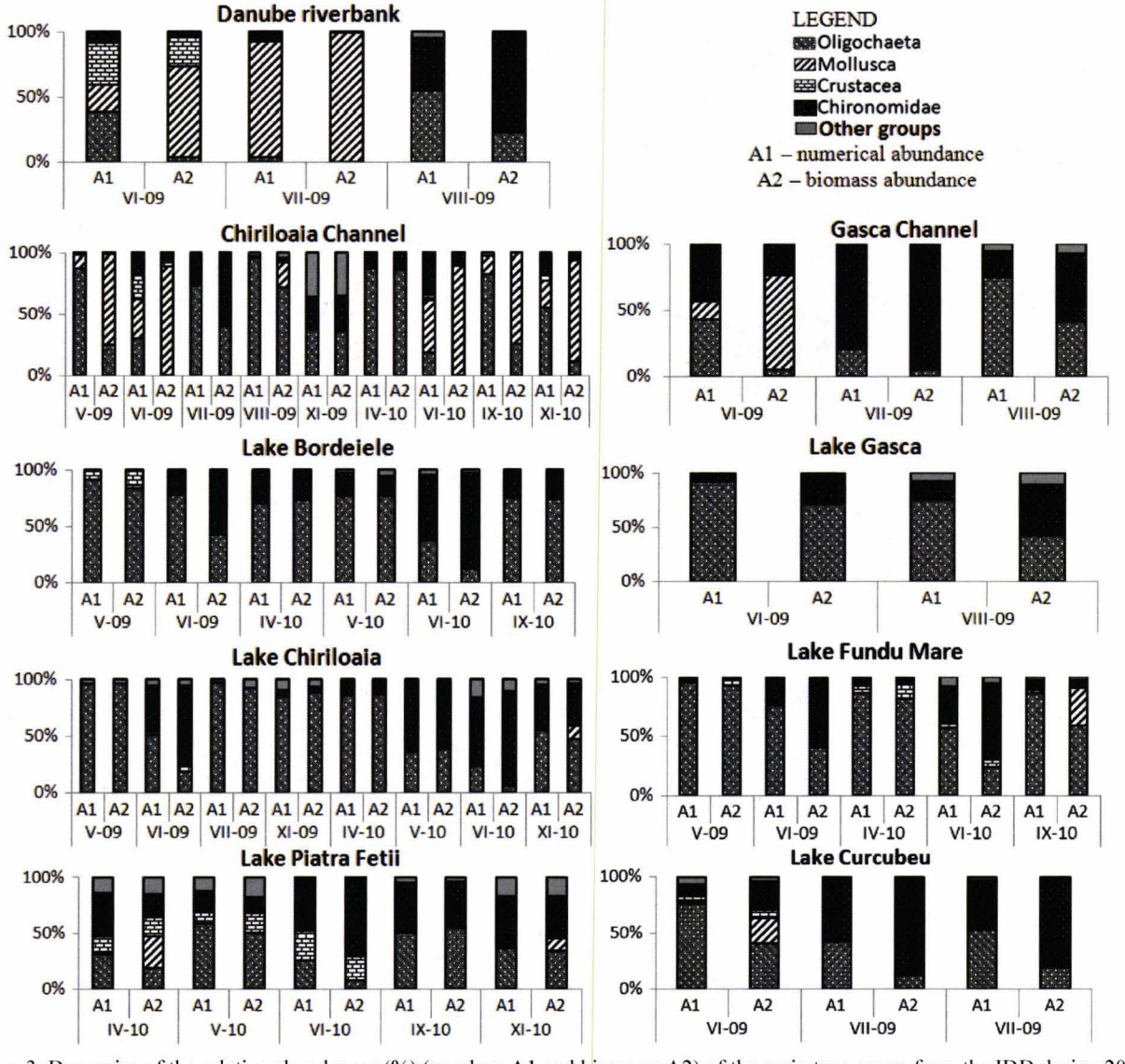

Figure 3. Dynamics of the relative abundances (%) (number: A1 and biomass: A2) of the main taxa group from the IDD during 2009-2010. / Figura 3. Abundenţa relativă (%) (numerică: A1 şi în biomasă: A2) înregistrată de principalele grupe bentonice la nivelul deltei interioare a Dunării, pe parcursul anilor 2009-2010.

The relative abundances (%) of the different zoobenthic groups recorded fluctuations across space and time. Two to four different invertebrates groups (Oligochaeta, Mollusca, Crustacea and Chironomidae) fulfill the dominance criteria in every freshwater system (Fig. 3). Oligochaeta met the criteria of dominance in all aquatic ecosystems with a few exceptions as biomass in summer (June and July 2009 in the Danube riverbank and C. Gâsca, June 2009 and 2010 in C. Chiriloaia and June 2010 in lakes Chiriloaia and Piatra Fetii). Also, Oligochaeta recorded an exception in the numerical abundances in the Danube riverbank (July 2009). Chironomidae reached their highest values of the relative abundances in the channel Gâsca and lakes Curcubeu and Piatra Fetii. As well, Chironomidae fulfill the dominance criteria with some exception in the Danube riverbank, channel and lake Chiriloaia and lakes Bordeiele, Fundu Mare and Curcubeu.

When were presented in the structure of communities, with a good frequency of occurrence, Mollusca – represented by Gastropoda and Bivalvia – fulfill the dominance criteria just in biomass. Nevertheless, few exceptions were noticed in lotic systems (June and July 2009 in the Danube riverbank and June 2009 and 2010 in Channel Chiriloaia) where they recorded numerical relative abundances of over 21%. With a sporadic frequency of occurrence (less than 38%), Crustacea (represented by Isopoda, Gammaridae and Corophiidae) met the criteria of dominance in the Danube riverbank and channel Chiriloaia (June 2009), lakes Fundu Mare (April 2010) and Piatra Fetii (April, May and July 2010).

In lakes (e.g. Gâsca, Chiriloaia, Bordeiele), Oligochaeta and Chironomidae recorded the highest relative abundances. Together they represent over 83% of the total main taxa groups as both number and biomass. Generally, the lotic ecosystems are characterized by a higher diversity of the benthic fauna (higher number of taxonomic groups that fulfill the criteria of dominance, better equitability) as compared to lakes. Lake Piatra Fetii, located in the riparian zone, has a higher benthic diversity as compared to the lentic systems from inland of SIB (Fig. 4). During 2009-2010, Shannon diversity index varies between 0.5185 in L. Gâsca and 1.1759 in L. Piatra Fetii and the values of equitability are between 0.4718 in L. Gâsca and 0.7593 in C. Gâsca (Fig. 4) indicating a low diversity of the studied communities.

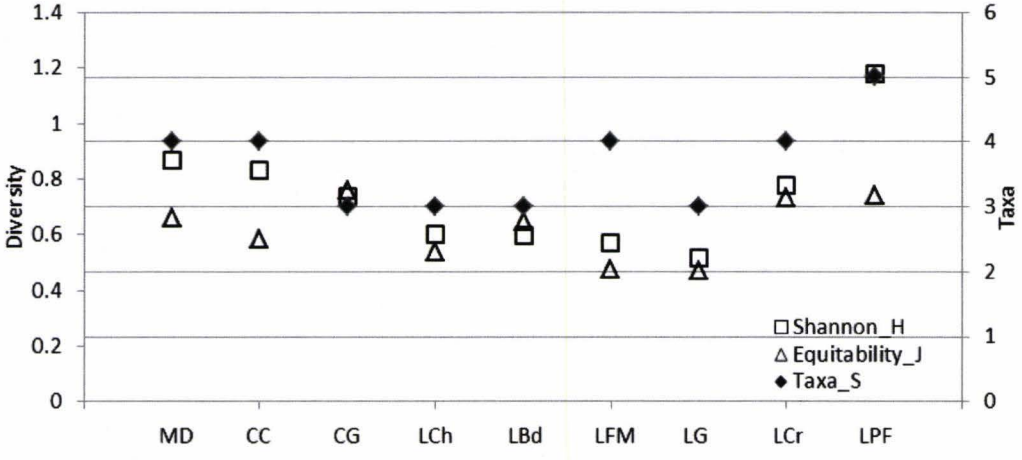

Figure 4. Taxa richness, Shannon diversity and equitability of the benthic taxonomic groups in the IDD during 2009-2010. / Figura 4. Bogăţia taxonilor, diversitatea şi echitabilitatea grupelor bentonice la nivelul deltei interioare a Dunării, în perioada 2009-2010.

The main changes in the composition of benthic invertebrates and fluctuations in the density of the dominant taxonomic groups are represented in figures 3 and 5. The highest numerical density values were recorded for Oligochaeta, and they represent the predominant taxa from the numerical point of view. A similar situation was noticed in the structure of benthic fauna of the shallow lakes in the Danube Delta between 1984 and 1986, when the maximum abundance of Oligochaeta was about six times higher than the abundance of Chironomidae (BOTNARIUC *et al.*, 1987; VĂDINEANU *et al.*, 2000). In SIB, the numerical densities of Oligochaeta ranged between 407 and 20.461 ind./m^{-2} and the biomass densities between 0.05 and 2.7 g. dry mass/m^{-2} in the Danube riverbank (July 2009) and channel Chiriloaia (August 2009), respectively (Fig. 5). In August 2009 in the lotic ecosystems, the numerical densities of Oligochaeta were over 5000 ind./m^2 whereas the biomass values remained at low values. Considering these data and the peculiarities of the life cycle of oligochaetes reported in the area (RÎŞNOVEANU & VĂDINEANU, 2002) this fact could be explained by hatches of new individuals in those communities.

The numerical densities of Chironomidae were between 68 ind./m^{-2} (L. Gâsca, June 2009) and 14.634 ind./m^{-2} (the Danube riverbank, August 2009) and the biomass densities was within 0.02 – 9.06 g. dry mass/m^{-2}. Mollusca and Crustacea reached the lowest numerical densities values with an exception in the Danube riverbank (June and July 2009). The molluscs biomass densities were between 0.3 g. dry mass/m^{-2} (L. Piatra Fetii, November 2010) and 50.7 g. dry mass/m^{-2} (the Danube riverbank, July 2009) and those of crustaceans between 0.02 g. dry mass/m^{-2} (L. Chiriloaia, June 2009) and 8.5 g. dry mass/m^{-2} (the Danube riverbank, June 2009) (Fig. 5).

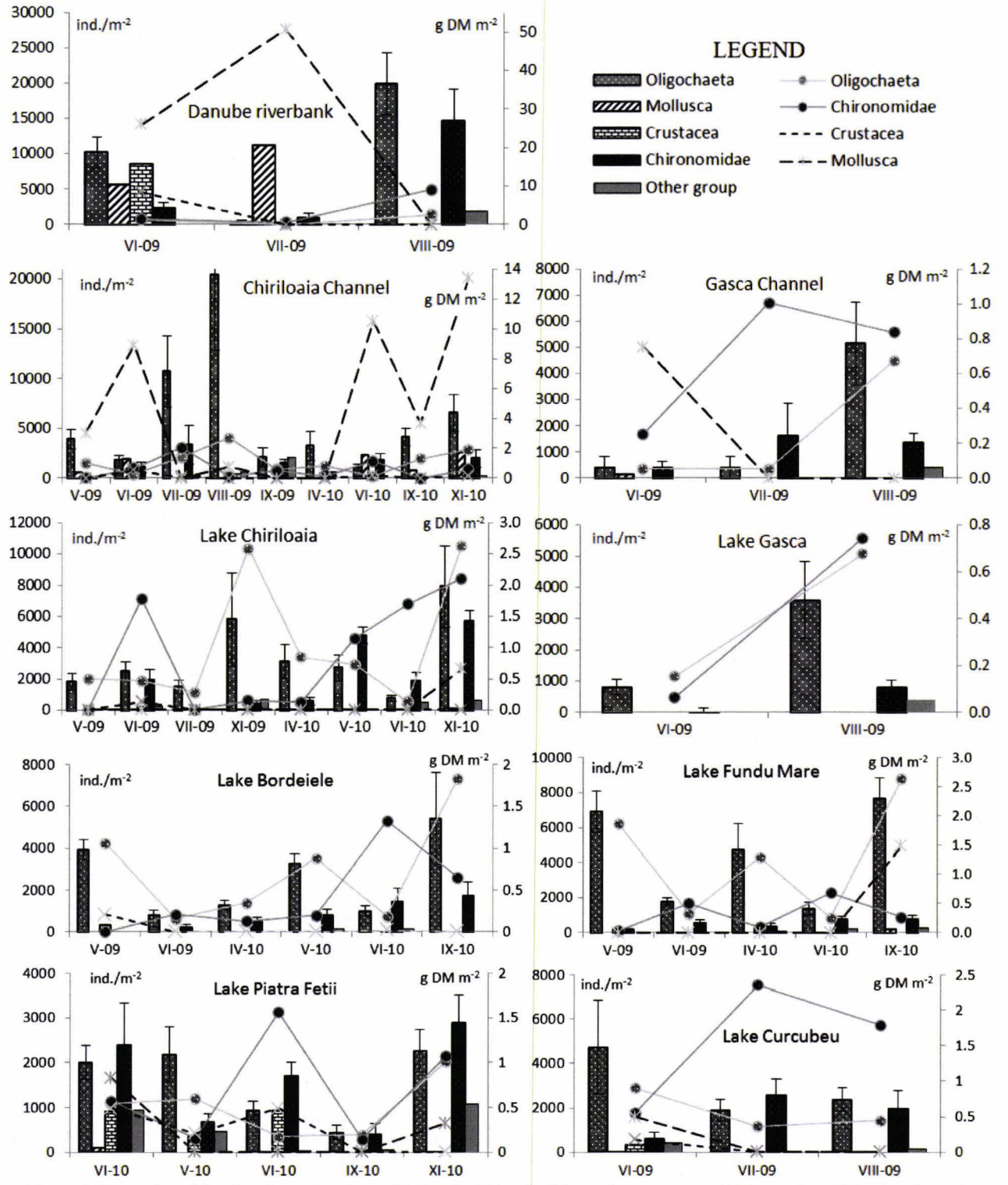

Figure 5. Dynamics of the abundance (number with Standard Error) of the main taxa groups (histogram) and biomass dynamics (lines) of Oligochaeta, Chironomidae Mollusca and Crustacea in the IDD, during 2009-2010. / Figura 5. Densitatea numerică (cu eroare standard) la grupe bentonice (histograme) şi densitatea în biomasă (linii) a grupelor de Oligochaeta, Chironomidae, Mollusca şi Crustacea din delta interioară a Dunării, în perioada 2009-2010.

A similar structure of benthic fauna, dominated by Oligochaeta and Chironomidae was also registered in the same area (***RFB, 1998; ***REDI, 2001) and the costal Danube Delta (RÎŞNOVEANU *et al.*, 1997). The authors relieve that the simplification of the benthic fauna structure is a consequence of eutrophication.

CONCLUSIONS

During 2009-2010, Oligochaeta and Chironomidae were both constant and dominant groups in the bottom fauna of all studied systems and Mollusca fulfilled the criteria of dominance just as biomass and only in the lotic systems.

The abundances of Oligochaeta and Chironomidae were significantly higher than those of other taxa groups. These groups reached up to 63% in L. Piatra Fetii and up to 95% in L. Bordeiele from the overall biomass of the community.

The maximum biomass abundance of Mollusca, about 19 times higher than the Oligochaeta and seven times higher than the Chironomidae, was recorded in the Danube riverbank (July, 2009). The lotic ecosystems (Danube riverbank and channel Chiriloaia) showed the largest range of benthic invertebrates densities (407 – 19919 ind./m^{-2}, 0.1 – 50.7 g. dry mass/m^{-2} and 68 – 20461 ind./m^{-2}, 0.1 – 13.4 g. dry mass/m^{-2} respectively).

In these conditions, the Oligochaeta and Chironomidae, with their well-adapted biological and behaviour mechanisms, and the Mollusca in some ecosystems remained the key components of the benthic fauna, representative for achieving its role within the integrating ecosystems.

The results sustain the conclusion that the composition and structure of the benthic fauna in the network of aquatic systems in the IDD is in an advanced degree of simplification.

More researches are required in order to identify the main driving forces structuring the benthic communities and to estimate their value in the resources and services flows through the studied aquatic ecosystems.

ACKNOWLEDGEMENTS

The research was carried out in the frame of the POSDRU /88/1.5/S/ 61150 project, financed by European Social Fund for Human Resources Development, Operational Programme 2007-2013, as well with the financial and logistic support from the Research Center of System Ecology, Eco-Diversity and Sustainability, University of Bucharest that are kindly acknowledged.

REFERENCES

ADAMESCU A. 2004. *Dinamica structurii şi rolul funcţional al fitoplanctonului din ecosistemele acvatice ale zonei inundabile/Dunărea inferioară.* Teză de doctorat, Universitatea din Bucureşti. Bucureşti. 221 pp.

BOTNARIUC N., VADINEANU A., IGNAT GH., DIACONU I. 1985. *Fauna bentonică ca transportor de energie în ghiolurile Matiţa-Merhei.* Studii şi comunicări de ecologie. Muzeul "Deltei Dunării". Tulcea. **1**: 231-234.

BOTNARIUC N., IGNAT GH., DIACONU I., VĂDINEANU A. 1987. *L'évolution de l'état trophique des ecosystèmes aquatiques caractéristiques au Delta du Danube: 5. La structure et la dynamique de la faune benthonique.* Revue Roumaine. Biology Animale. Edit. Academiei. Bucharest. **32**(2): 121-127.

CHALONER D. T., HERSHEY A. E., LAMBERTI G. A. 2009. *Benthic Invertebrate Fauna*, In: Editor-in-Chief: Gene E. Likens. Editor(s)-in-Chief. Encyclopedia of Inland Waters. Academic Press. Oxford: 157-172.

COVICH A. P., PALMER M. A., CROWL T. A. 1999. *The Role of Benthic Invertebrate zoobenthic species influence energy flows and nutrient cycling.* BioScience (February). University of California Press. United States. **49**(2): 119-127.

CRISTOFOR S., VĂDINEANU A., SÂRBU A., POSTOLACHE C., DOBRE R., ADAMESCU M. 2003. *Long-term changes of submerged macrophytes in the Lower Danube Wetland System.* Hydrobiologia. Netherlands. Elsevier Science. Amsterdam. **506-509**(1-3): 625-634.

GODEANU S. 2002. *Diversitatea lumii vii – determinator ilustrat al florei şi faunei României (Volumul II – apele continentale).* Edit. Bucura Mond. Bucureşti. **2**(1, 2). 315 pp.

IGNAT GH., CRISTOFOR S., VĂDINEANU A., RÎŞNOVEANU G., NAFORNIŢA G., FLORESCU C. 1997. *Structura şi dinamica faunei bentonice din apele Dunării Inferioare şi Delta Dunării.* Analele Ştiinţifice ale Institutului de Cercetare şi Proiectare Delta Dunării. Edit. AVES. Tulcea. **4**(1): 133-142.

POPESCU-MARINESCU VIRGINIA. 1992. *Structura zoocenozelor bentonice din Dunăre, în sectorul românesc în perioada 1971-1986.* Hidrobiologia. Netherlands. Elsevier Science. Amsterdam. **20**: 111-143.

PENNAK, R. W. 1953. *Fresh-water invertebrates of the United States.* The Ronald Press Company. Publisher: Wiley. New York. 769 pp.

RÎŞNOVEANU GETA, IGNAT G., VĂDINEANU A., CRISTOFOR S., CIUBUC C., NAFORNIŢA G., POPESCU M. 1997. *The state of the benthic community of the Danube Delta Lakes – a consequence of eutrophication.* Revue Roumaine de Biologie – Serie de Biologie Animale. Edit. Academiei. Bucharest. **42**(2): 227-235.

RÎŞNOVEANU GETA & VĂDINEANU A. 2002. *Observations on the population dynamics of Potamothrix hammoniensis (Michaelsen, 1901) (Tubificidae, Oligochaeta) in Lake Isacova in the Danube Delta.* Hydrobiologia. Netherlands. Elsevier Science. Amsterdam. **479**(1-3): 23-30.

RÎŞNOVEANU GETA & VĂDINEANU A. 2003. *Long-term functional changes within the Oligochaeta communities in the Danube Delta.* Hydrobiologia. Netherlands. Elsevier Science. Amsterdam. **506/509**: 394–405.

RÎŞNOVEANU GETA 2006. *Structure and function of the Oligochaeta communities in lentic ecosystems of the Danube Delta.* In: Tudorancea C. and Tudorancea M. M. (Eds.). Danube Delta – Genesis and Biodiversity. Backhuys Publishers. Leiden: 237-260.

RUSSEV B. 1998. *Das Makrozoobenthos der Donau - Dynamik der Veränderungen durch anthropogenen Einfluß.*- In: Plankton und Benthos der Donau, Ergebnisse der Donauforschung. IAD der SIL. Wien. **4**: 257-364.

STRAYER D. L. 2009. *Benthic Invertebrate Fauna, Lakes and Reservoirs.* In: Gene E. Likens Lake (Ed.). Ecosystem Ecology: A Global Perspective, Cary Institute of Ecosystem Studies Millbrook. NY: 27-40.

TUDORANCEA C. 2006. *Benthic fauna of the Danube Delta.* In: Tudorancea C. and Tudorancea M. M. (Eds.). Danube Delta – Genesis and Biodiversity. Backhuys Publishers. Leiden: 211-236.

VĂDINEANU A., CRISTOFOR S., IGNAT GH. 1992. *Phytoplankton and submerged macrophytes in the aquatic ecosystems of the Danube Delta during the last decade.* Hydrobiologia. Belgium. Elsevier Science. Bruxelles. **243/244**: 141-146.

VĂDINEANU A. 1998. *Dezvoltare durabilă (Sustainable Development).* Edit. Universităţii din Bucureşti. **1**. 247 pp.

VĂDINEANU A., CRISTOFOR S., IGNAT GH., CIUBUC C., RÎŞNOVEANU G., BODESCU F., BOTNARIUC N. 2000. *Structural and functional changes within the benthic communities of Danube delta lakes.*Verhandlungen Internationale Vereinigung Limnologie. Stuttgart. **27**: 2571-2576.

VĂDINEANU A., CRISTOFOR S., IORDACHE V. 2001. *Biodiversity changes in the Lower Danube river system.* In: Gopal B., Junk J. W. and Davis A. J. (Eds.), Biodiversity in Wetlands: Assessment, Function and Conservation, Backhuys Publishers. Leiden. **2**: 29-65.

VĂDINEANU A., ADAMESCU M., VĂDINEANU R. S., CRISTOFOR S., NEGREI C. 2003. *Past and future management of the Lower Danube Wetlands System: a bioeconomic appraisal.* Journal of Interdisciplinary Economics. Great Britain. London. **14**: 415-447.

VĂDINEANU A. 2009. *Deterioration and Rehabilitation of the Lower Danube Wetlands System.* The Wetlands Handbook, 1st edition. Edited by E. Maltby and T. Barker, Blackwell Publishing. NY: 876-907.

WHILES M. R. & GRUBAUGH J. W. 2009. *Benthic Invertebrate Fauna, River and Floodplain Ecosystems.* In: Editor-in-Chief: Gene E. Likens, Editor(s)-in-Chief, Encyclopedia of Inland Waters. Academic Press. Oxford: 205-215.

***. *Rolul Funcţional al Biodiversităţii în Sistemul Dunării Inferioare* (RFB). 1999. Raport anual pentru perioada 1998-1999. Departamentul de Ecologie Sistemică şi Dezvoltare Durabilă. Universitatea Bucureşti. Bucureşti. 84 pp.

***. *Reţeaua Ecologică a Dunării Inferioare* (REDI). 2001. Raport anual pentru perioada 2000-2001. Departamentul de Ecologie Sistemică şi Dezvoltare Durabilă. Universitatea Bucureşti. Bucureşti. 191 pp.

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ZOOBENTHIC STRUCTURE OF THE TOPOLOG RIVER

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Abstract. The paper presents data referring to the comparative structure of the benthic invertebrate fauna of the Topolog River in five sampling site. On the basis of relative abundance, the dominancy of the invertebrate groups is highlighted. In particular, it is analysed the community structure of the mayflies larvae being presented the list of the taxa, ecological spectrum, relative abundance, frequency and other ecological characteristics of the mayflies fauna.

Keywords: benthic invertebrate fauna, Topolog River, mayflies.

Rezumat. Structura zoocenozei bentonice a Râului Topolog. Lucrarea prezintă date referitoare la structura faunei de nevertebrate bentonice a Râului Topolog în cinci staţii de cercetare. Sunt evidenţiate grupele dominante pe baza abundenţei relative din macrozoobentos. În mod particular este analizată structura comunităţilor de efemeroptere, fiind prezentată lista taxonilor, spectrul ecologic, abundenţa relativă, frecvenţa şi alte caracteristici ecologice ale faunei de efemeroptere din Râul Topolog.

Cuvinte cheie: fauna de nevertebrate bentonice, Râul Topolog, efemeroptere.

INTRODUCTION

Situated in the Olt hydrographic basin, the Topolog river springs from the southern slope of Făgăraş Mountains, crosses the counties of Argeş and Vâlcea, having a length of 88.8 km and flows into the Olt river, in Galicea, being one of its main left tributaries (ROŞU, 2007). The Topolog hydrographic basin is situated in the central-southern region of the country, in the Carpathians EcoRegion, with a length of 547 km² and an average width of 6.5 km. The Topolog is considered a mountain stream due to the high average altitude of about 772 m and steep average slope of 20.4‰, falling within the typology of water-courses in the mountains, piedmont and highlands (RO01) (P.M.B.H.O., 2009).

The anthropogenic impact on the Topolog river is particularly felt in the upper and middle course, by building a chain of five micro-hydropower stations (MHS) and creating a water feed pipe to additionally supply Vidraru Dam, leading to significant changes in both hydromorphological parameters of the water-course and the structure of water biocoenosis.

The research conducted and presented in this paper aimed to highlight the impact of hydro-technical harnessing on the structure of benthic zoocoenosis by making the inventory of important taxa of benthic invertebrate fauna in the Topolog River, highlighting the dominant groups based on their relative abundance, identifying Ephemeroptera species and determining the water quality of the Topolog River based on Ephemeroptera species distribution.

MATERIAL AND METHODS

In the period August 2010 – April 2011, zoobenthic samples were taken periodically in August, November and April. To determine the structure of benthic zoocoenosis, there were established four sampling stations in the sector Vadul Frumos – Galicea. Vadul Frumos station (S1) is situated upstream of micro-hydropower stations, in an area with minimal anthropogenic impact. Sălătrucul de Jos station (S2) is situated in the middle chain of micro-hydropower stations, upstream of Şuici Dam. Poienari de Argeş (S3) and Galicea (S4) stations were situated downstream of hydro-technical harnessing, the latter being situated at the river mouth (Fig. 1).

On each sampling site, the benthos samples were taken using a Surber–sampler, which covered a surface of 0.16 m² (mesh-size: 200 μm). The stones were washed in the stream and brushed. The samples were preserved on the field in 8% formalin solution. The retained material was separated into groups by a Zeiss stereomicroscope in the Hydrobiology lab of the University of Pitesti and removed in ethanol 70%. European identifications keys were used (ELLIOTT *et al.*, 1988; BAUERNFEIND & HUMPESCH, 2001; GODEANU, 2002).

RESULTS AND DISCUSSIONS

As far as the benthic invertebrate fauna is concerned, in the research period representatives from eight taxa groups were identified. The analysis of the resulted data reveals that the mayflies are the best represented in all the sample stations, followed by stoneflies. In the upstream stations the chironomids are dominant, especially in the samples taken in April, while the caddisflies are relatively constant in number.

The structure of benthic zoocoenosis in August (Fig. 2) showed a clear dominance of Ephemeroptera, Plecoptera and Chironomida species. Ephemeroptera maximum number of individuals/m² was recorded in station 2 (1,733 ind./m²); the other three stations had approximately equal values (950 ind./m² on average). The maximum density of Plecoptera was recorded in station 3 (1,449 ind./m²), the other values being below 600 ind./m², with a minimum of 273 ind./m² in station 4. As Plecoptera, Chironomida species were best represented in station 3 (1,049 ind./m²), the other values being below 300 ind./m².

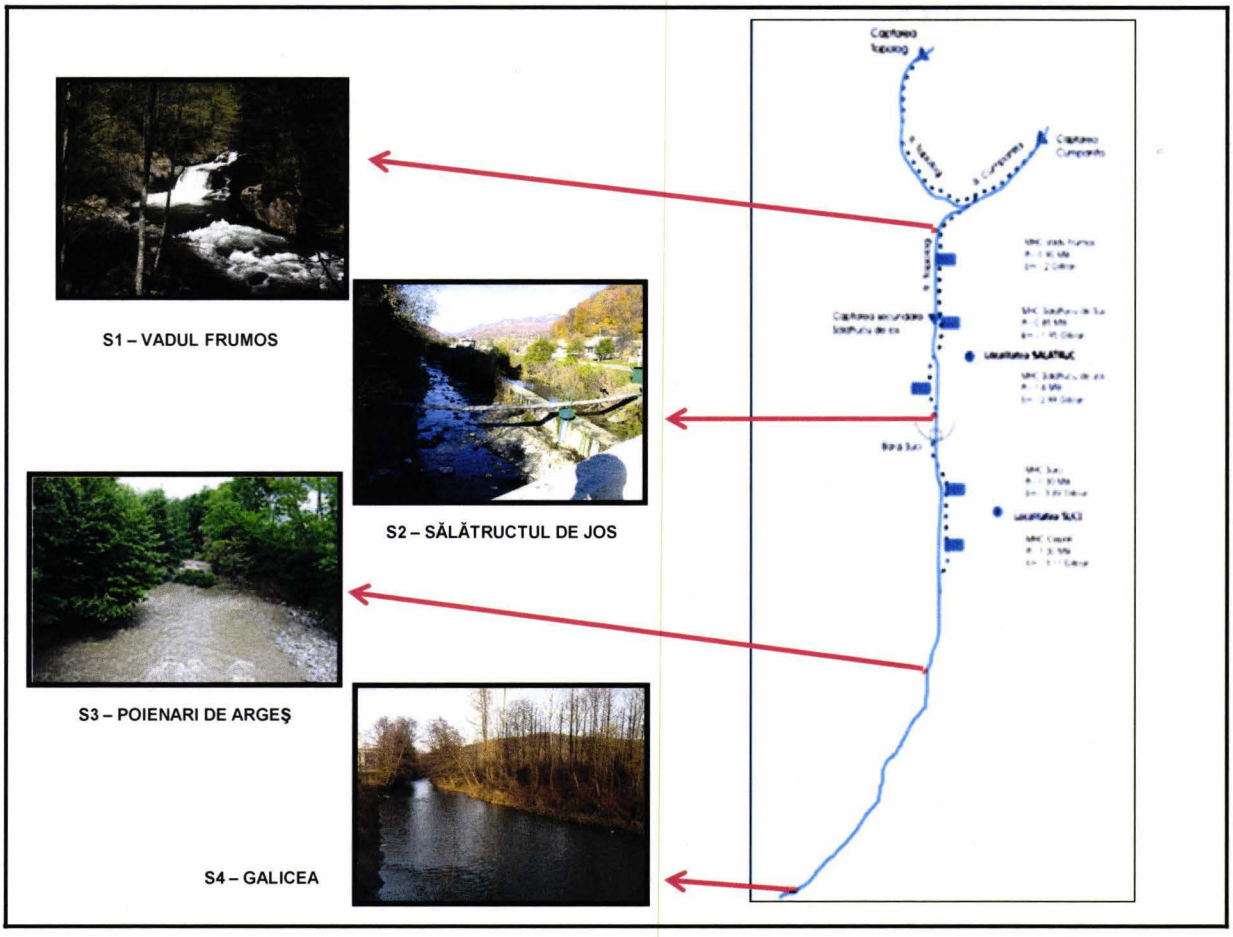

Figure 1. Location of the sampling sites (original photos).
Figura 1. Localizarea staţiilor de prelevare (foto originale).

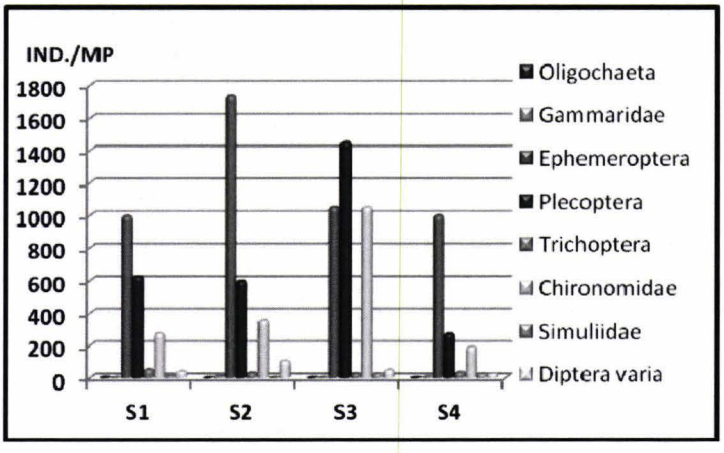

Figure 2. The zoobenthical structure of the Topolog River – August 2010.
Figura 2. Structura zoocenozei bentinice a Râului Topolog – August 2010.

The analysis of benthonic zoocoenosis structure in November (Fig. 3) highlighted the clear dominance of Ephemeroptera in all four stations, followed by Plecoptera, the other groups being underrepresented. Numerical density of ephemeroptera ranged between 425 ind./m^2 in station 2, and 744 ind./m^2 in stations 3 and 4. The maximum number of ind./m^2 for Plecoptera was 306 ind./m^2 in station 3, the other values being comparable and much lower. Chironomida recorded low values, below 50 ind./m^2.

April recorded an extraordinarily high numerical density for Chironomida group, in all stations, with values ranging between 246 ind./m^2 in station 3 and 2,671 ind./m^2 in station 2 (Fig. 4). The maximum number of individuals/m^2 for ephemeroptera was recorded in station 4 (2,163 ind./m^2), maintaining high values in all stations. For Plecoptera, the situation was similar to Ephemeroptera, with no high differences in all four stations, from a minimum of 775 ind./m^2 (station 2), to a maximum of 1,075 ind./m^2 (station 4).

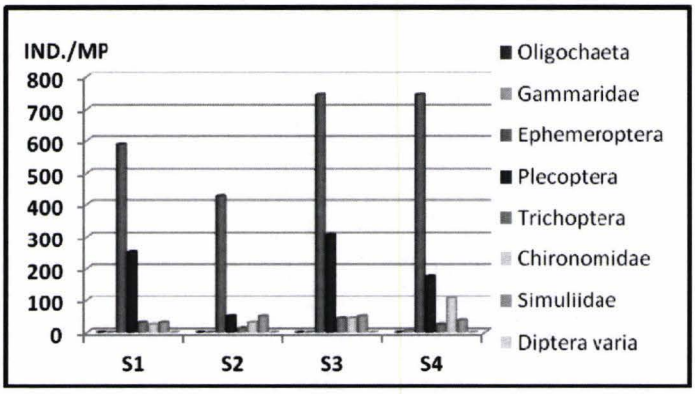

Figure 3. The zoobenthical structure of the Topolog River – November 2010.
Figura 3. Structura zoocenozei bentinice a Râului Topolog – Noiembrie 2010.

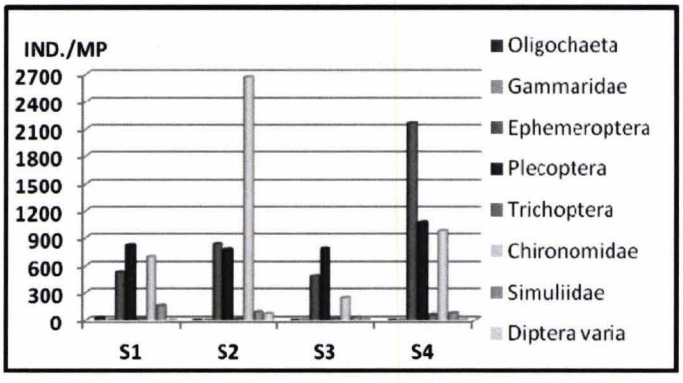

Figure 4. The zoobenthical structure of the Topolog River - April 2011.
Figura 4. Structura zoocenozei bentinice a Râului Topolog - Aprilie 2011.

In the case of mayflies, in the samples taken we identified fourteen species from seven genera belonging to six families from all the three suborders. Station 1 was the least rich in species, but with a considerably higher number of ind./m^2, on average, for each species (Table 1).

Baëtis alpinus (PICTET 1843–1845) was present in all samples, the number of ind./m^2 decreasing progressively from upstream to downstream, with decreasing flow speed, knowing that it is a rhitron species, an indicator for the waters in the oligosaprobic category; in most cases, the situation is similar to *Rhithrogena semicolorata* (CURTIS 1834); *Epeorus* EATON 1881 genus was present in all sampling stations, with a small number of individuals/m^2. *Ecdyonurus dispar* (CURTIS 1834), *Ephemera danica* MÜLLER 1764 and *Caenis macrura* STEPHENS 1835 appeared only in station 4, being relatively eurybiont species, which bear a slightly higher degree of organic load. *Baëtis muticus* (LINNAEUS 1758) and *Paraleptophlebia submarginata* STEPHENS 1835) were present only in station 3; *Ecdyonurus torrentis* KIMMINS 1942 was present sporadically in stations 1 and 3, as a water indicator in the rithron with high flow speed; *Ephemerella ignita* (PODA 1761) was permanently present in stations 3 and 4, as a water indicator in β – mesosaprobic category (Fig. 5).

Table 1. The distribution of the mayfly fauna of the Topolog River.
Tabel 1. Distribuţia faunei de efemeroptere a Râului Topolog.

Taxa	Sampling site			
	Vadul Frumos	Sălătrucul de Jos	Poienari de Argeş	Galicea
Baëtis alpinus (PICTET 1843 – 1845)	X	X	X	X
B. lutheri MÜLLER – LIEBENAU 1967	-	X	-	X
B. muticus (LINNAEUS 1758)	-	-	X	-
B. rhodani (PICTET 1843 – 1845)	-	X	X	X
B. vernus CURTIS 1834	-	X	X	-
Rhithrogena semicolorata (CURTIS 1834)	X	X	X	X
Ecdyonurus dispar (CURTIS 1834)				X
E. torrentis KIMMINS 1942	X	-	X	-
E. venosus (FABRICIUS 1775)	-	X	X	-
Epeorus sp. EATON 1881	X	X	X	X
Paraleptophlebia submarginata (STEPHENS 1835)	X	X	X	-
Ephemera danica MÜLLER 1764	-	-	-	X
Ephemerella ignita (PODA 1761)	-	-	X	X
Caenis macrura STEPHENS 1835				X

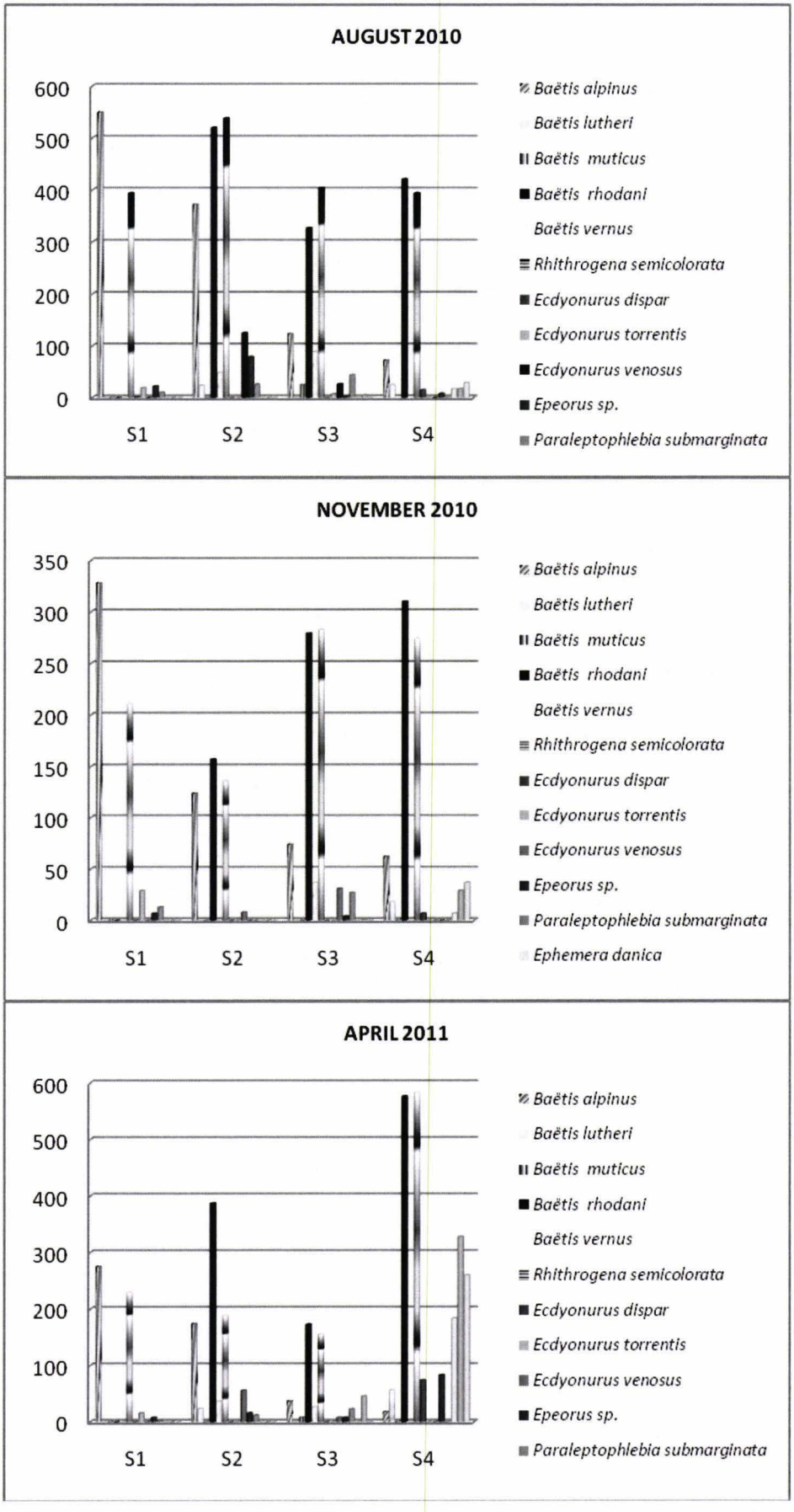

Figure 5. Numerical density of the mayfly fauna and its seasonal variation in the Topolog River.
Figura 5. Densitatea numerică a faunei de efemeroptere şi variaţia sezonieră a acesteia în Râul Topolog.

In terms of ecological spectrum (Fig. 6), it can be seen that Ecdyonuriidae family is best represented in upstream stations, having a weight of 60% in Vadul Frumos, but decreasing progressively to 31% in Galicea. Baetidae are well represented in Poenarii de Arges, where they are dominant (49%), maintaining high weight in the other downstream stations. *Leptophlebia* represent 20% of the ephemerofauna in Vadul Frumos station, their weight decreasing downstream to values below 13%. The other families have a weight below 10% in all stations.

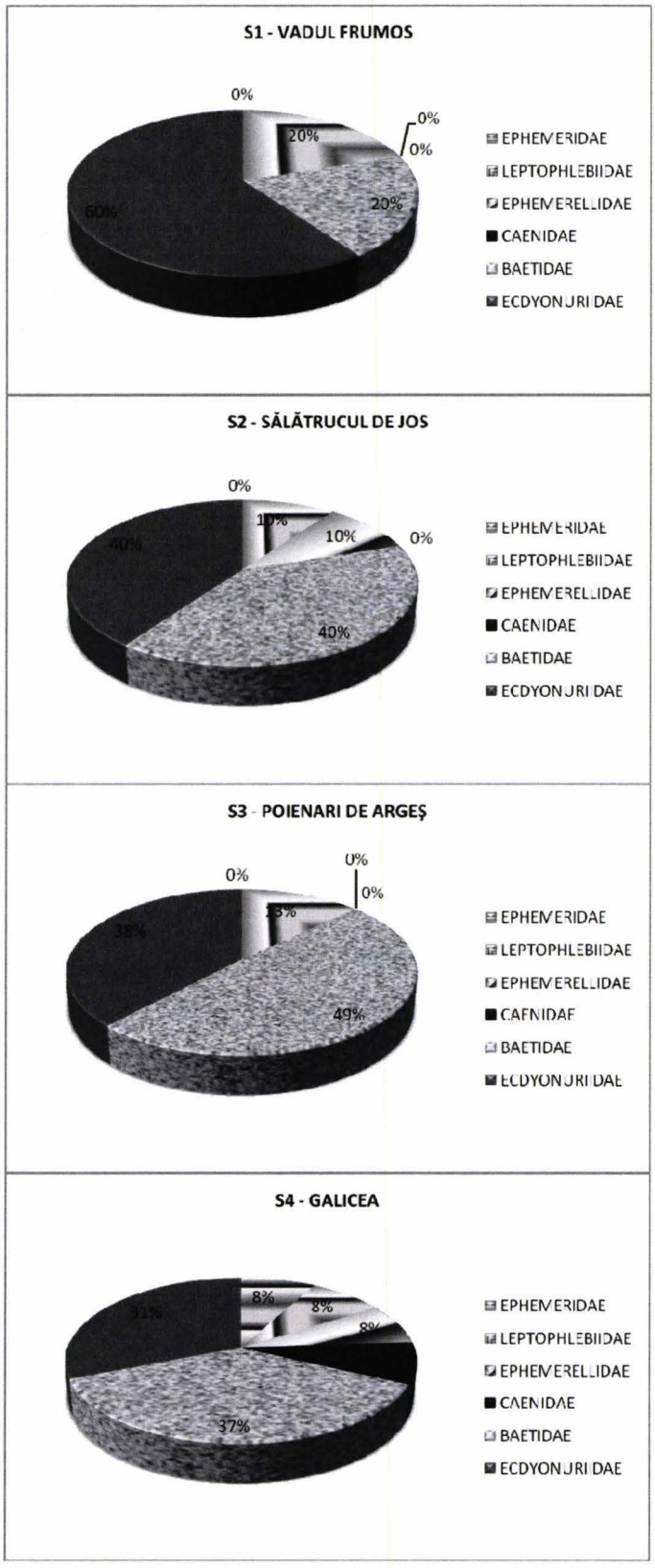

Figure 6. Ecological spectrum of the mayfly population in the Topolog River.
Figura 6. Spectrul ecologic al populaţiei de efemeroptere din Râul Topolog.

CONCLUSIONS

From the ecological zonation point of view (GÂLDEAN, 1992), the presence of the identified species points at the idea that the river where the research was undertaken is part of the area where the erosion phenomenon is predominant, alternating with small areas of sedimentation.

From the quality of the water, the identified species are indicators of the waters from the oligosaprobic and β – mezosaprobic categories (BREZEANU *et al.*, 2011).

The hydrotechnical lay out did not significantly modify the structure of the benthic zoocoenosis; it has been reformed over the years.

REFERENCES

BAUERNFEIND E. & HUMPESCH U. H. 2001. *Die Eintagsfliegen Zentraleuropas (Insecta:Ephemeroptera): Bestimmung und Ökologie.* Verlag des Naturhistorichen Museums Wien. 240 pp.

BREZEANU GH., CIOBOIU OLIVIA, ARDELEAN A. 2011. *Ecologie acvatică: Hidrobiologie.* „Vasile Goldiş" University Press. Arad. 406 pp.

ELLIOTT J. M., HUMPESCHE U. H., MACAN T. T. 1988. *Larvae of the British Ephemeroptera: A key with ecological notes.* Scientific Publications of the Freshwater Biological Association. London. **49**. 145 pp.

GÂLDEAN N. 1992. *Utilisation of mayflies (Insecta, Ephemeroptera) for divising some romanian running watwrs into zones.* Travaux du Museum d'Histoire Naturelle „Grigore Antipa". Bucureşti. **32**: 215-222.

GODEANU S. 2002. *Diversitatea lumii vii. Determinatorul ilustrat al florei si faunei Romaniei. Apele continentale.* Edit. Bucura Mond. Bucureşti. **2**. 694 pp.

ROŞU A. 2007. *Bazinul hidrografic al râului Topolog.* Edit. Tiparg. Piteşti. 432 pp.

***. Planul de Management al Bazinului Hidrografic Olt (P.M.B.H.O.). 2009 //www.rowater.ro/daolt (accessed: March, 25, 2012).

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PARTICULARITIES OF THE EPIGEIC INVERTEBRATES POPULATIONS ON THE ROCKY HABITATS FROM THE DOFTANA VALLEY (PRAHOVA COUNTY)

PURICE Dorina, CIOBOIU Olivia

Abstract. Rocky habitats are considered ecological structures with particular characteristics, sometimes with extreme environmental conditions in comparison with other terrestrial habitats. Between 2008 and 2011 the rocky habitats were studied to identify the population structure of epigeic invertebrates and also the pattern of variations between years. The observations show obvious differences between the structural elements (numerical abundances, structure of dominance, constancy classes, specific diversity) of the invertebrate populations from rocky habitats and those of other terrestrial habitats (forests, meadows) but also the patterns of variations from year to year. It was also noticed that the local microclimatic factors have an extreme influence on the invertebrate populations, making the differences between the invertebrate populations inhabiting in the same climatic region. There are discussed the characteristics of the communities of epigeic invertebrates in each study area, there are compared the variations and differences between the studied areas and also, those between the studied areas and of the invertebrate populations from other terrestrial habitats of the Doftana Valley.

Keywords: rocky habitats, epigeic invertebrates, population structure, the Doftana Valley.

Rezumat. Particularităţi ale populaţiilor de nevertebrate epigee pe stâncării de pe Valea Doftanei (judeţul Prahova). Stâncăriile sunt considerate structuri ecologice cu caracteristici aparte, uneori cu condiţii de mediu extreme în comparaţie cu alte habitate terestre. În perioada 2008-2011 s-a realizat un studiu care a avut ca obiectiv indentificarea caracteristicilor structurale ale populaţiilor de nevertebrate epigee şi modelul variaţiilor multianuale. S-a observat că există diferenţe evidente între elementele structurale (abundenţe numerice, structura dominanţei, clase de constanţă, diversitate specifică) ale populaţiilor nevertebratelor epigee din habitate stâncoase şi cele ale populaţiilor din alte habitate terestre (păduri, pajişti) dar şi din punctul de vedere al modelelor lor de variaţie multianuală. De asemenea, s-a remarcat că factorii microclimatici locali au o influenţă extrem de importantă asupra populaţiilor de nevertebrate, făcând diferenţieri între populaţiile de pe stâncării aflate în aceeaşi zonă climatică. Sunt discutate caracteristicile comunităţilor de nevertebrate epigee din fiecare zonă studiată, sunt comparate tipurile de variaţii ale situsurilor studiate precum şi ale acestora în raport cu cele din alte habitate terestre de pe Valea Doftanei.

Cuvinte cheie: stâncării, nevertebrate epigee, structura populaţiilor, Valea Doftanei.

INTRODUCTION

The rocky habitats are very important ecological structures in the terrestrial landscape, with geomorphological and also (micro) climatic particularities determining special coenoses with special dynamics and heterogeneity noticed at various scales of time and space.

There are only a few studies on the epigeic invertebrates inhabiting the rocky habitats. The study undertaken in the last years on the rocky areas of the Doftana Valley started from the need determined by the lack of information in this domain (PURICE & CIOBOIU, 2011).

MATERIAL AND METHOD

The studied sites are located in Brebu gorges (the Doftana Valley) (N: 45° 12' 31,1"; E: 25° 44' 23,5") at 537 m altitude. There were chosen two slopes (northern and southern) due to their microclimatic differences. Vegetation was represented by different types of elements: Euro-Asian: *Rubus saxatilis*, *R. caesius*, *Hippophae rhamnoides*, *Populus tremula*, *Salix caprea*, *Salvia glutinosa*, *Campanula sibirica* (44,18%); European: *Valeriana montana*, *Crategus monogyna*, *Berberis vulgaris*, *Taxus baccata* (18,6%); central-european: *Centaurea stoebe*, *Cornus sanguinea*, *Cytisus nigricans* (9,3%); Carpathian: *Sesleria heuflerana*, *Thymus pullcherimus*, *Silene nutans* subsp. *dubia* (11,62%); Mediterranean: *Cnidium silaifolium*, *Hedera helix*. The highest representation had mesophytes species (42%), followed by xeromesophytes (37%) and mezohygrophytes (9%), and finally xerophytes (7%). More than 20% are pioneer species, as *Cytisus nigricans*, *Rosa canina* and *Hippophaë rhamnoides*.

Soils are classified in three classes: clayey till argillaceous on the moderate and strongly inclined peaks, which are serious affected by erosion; brown eumesobasic to pseudogleyic, which have a mineral component formed at soil surface, connected to a thin humified organic matter layer; typically alluvial soil.

The epigeic invertebrate fauna was sampled with pitfall traps. We used plastic jars with 100 ml mixture of 4% formalin and ethylene glycol (1:1 vol.). Ten sample units were placed in each studied area, at a distance of 5 meters and the fauna was collected seasonally. The dataset covers the years 2010 and 2011 to emphasize the structure and the dynamics of the local epigeic invertebrate populations.

RESULTS

The invertebrate fauna collected in the two years of study belongs to 24 groups of invertebrates identified in the epigeic populations of the northern slope and 21 respectively, in the southern one (Tables 1 and 2).

The epigeic invertebrates population of the **northern slope of Doftana rocky habitat** had the maximum number of taxa during the summer of 2010 and autumn of 2011 respectively (Table 1); the same pattern of variation in number of taxa was noticed to the local population of epigeic invertebrates inhabiting the southern slope of Doftana rocky habitat (Table 2).

The seasonal variations of the average numerical densities in the population from the northern slope were maximum in summer 2010 and during the spring 2011 respectively. The trend was to decrease the annual values in 2011. On the southern side of Doftana rocky habitat, in both years, the highest densities of epigeic invertebrates were recorded during the summer season but as in the previous case, the average annual numerical density was lower in 2011.

Table 1. Structural characteristics of the epigeic invertebrates in 2010-2011 on northern slope of the Doftana Valley (%-relative abundances, F%-frequencies, N/s.u. average numerical densities). / Tabel 1. Caracteristicile structurale ale nevertebratelor epigee de pe versantul nordic al Văii Doftana în perioada 2010-2011 (%-abundenţa relativă, F%-frecvenţa, N/s.u. densitatea medie numerică

TAXA	spring 2010			summer 2010			autumn 2010			spring 2011			summer 2011			autumn 2011		
	%	F%	N/s.u.	%	F%	N/s.u.	%	F%	N/s.u.	%	F%	N/s.u.	%	F%	N/s.u.	%	F%	N/s.u.
GASTEROPODA	1.96	28.57	0.43	0.6	22.2	1.33	0.28	11.11	0.11	0.15	16.66	0.14	1.21	30	0.55	3.04	66.67	1.56
OLIGOCHAETA				0.1	11.1	0.11							0.24	10	0.11	1.73	55.56	0.89
ACARINA	24.2	85.71	5.28	16	99.9	35	50.4	100	19.78	14.53	83.3	13.28	22.46	90	10.33	13.5	44.44	6.89
OPILIONES	1.96	28.57	0.43	1.3	77.79	2.77	0.56	22.2	0.22				6.04	80	2.78	3.68	66.67	1.89
PSEUDOSCORPIONES				4.1	88.89	9.11	0.28	11.11	0.11	0.94	66.67	0.86	0.24	10	0.11	0.43	22.22	0.22
ARANEAE	4.57	57.14	1				3.12	66.67	1.22	5.62	100	5.14	1.69	50	0.77	2.38	66.67	1.22
ZYGENTOMA	1.31	28.57	0.28	0.8	77.78	1.66				0.47	33.3	0.43	2.41	60	1.11	2.6	55.56	1.33
CRUSTACEA Isopoda	0.65	14.28	0.14	0.6	33.3	1.33				0.47	33.3	0.43	2.41	60	1.11	2.6	55.56	1.33
COLLEMBOLA	36.6	100	8	31	88.89	69.33	15.9	88.89	6.22	27.41	100	25.1	14.25	90	6.56	14.3	100	7.33
THYSANOPTERA				0.4	33.3	0.78				0.15	16.66	0.14						
MYRIAPODA-Diplopoda				0.5	77.78	1.11				0.78	66.67	0.71	1.45	40	0.67	1.08	44.44	0.55
MYRIAPODA-Chilopoda				0.5	55.56	1				0.15	16.66	0.14	0.48	10	0.22	4.33	77.78	2.22
HETEROPTERA				0.4	100	0.89	0.28	11.1	0.11	15.29	100	14				0.43	22.22	0.22
HOMOPTERA -Aphididae	6.53	71.43	1.42	0.8	66.67	1.78	1.42	33.3	0.55				0.24	10	0.11	0.43	22.22	0.22
HOMOPTERA - Cicadoidea	1.31	28.57	0.28	0.5	66.67	1	1.42	55.56	0.55	0.15	16.66	0.14				0.21	11.11	0.11
HYMENOPTERA var	1.96	14.28	0.43	7.1	88.89	15.67	2.26	66.67	0.89	6.4	100	5.85	1.45	10	0.67	8.46	55.56	4.33
HYMENOPTERA - Formicidae	1.31	28.57	0.28	14.1	100	31.22	0.85	33.3	0.33				12.8	80	5.88	17.9	88.89	9.11
ORTHOPTERA var.										26.87	100	24.57						
ORTHOPTERA - Gryllidae										0.47	16.66	0.43						
COLEOPTERA	5.23	57.14	1.14	7.7	100	17	15.6	100	6.11				14.5	90	6.67	9.11	88.89	4.67
DIPTERA	9.8	71.43	2.14	13.4	88.89	29.67	7.65	66.67	3				18.1	100	8.33	13.9	77.78	7.11
MECOPTERA										0.15	16.66	0.14						
MEGALOPTERA	2.61	42.85	0.57															
LEPIDOPTERA				0.1	11.1	0.11												
TOTAL	**100**		**21.82**	**100**		**220.87**	**100**		**39.2**	**100**		**91.5**	**100**		**45.98**	**100**		**51.2**

Table 2. Structural characteristics of the epigeic invertebrates in 2010-2011 on southern slope of the Doftana Valley (%-relative abundances, F%-frequencies, N/s.u. average numerical densities). / Tabel 2. Caracteristicile structurale ale nevertebratelor epigee de pe versantul sudic al Văii Doftana în perioada 2010-2011 (%-abundenţa relativă, F%-frecvenţa, N/s.u. densitatea medie numerică).

TAXA	spring 2010			summer 2010			autumn 2010			spring 2011			summer 2011			autumn 2011		
	%	F%	N/s.u.	%	F%	N/s.u.	%	F%	N/s.u.	%	F%	N/s.u.	%	F%	N/s.u.	%	F%	N/s.u.
GASTEROPODA	0.32	10	0.14	0.1	11.1	0.11	0.27	11.11	0.11	4.54	66.67	0.28						
OLIGOCHAETA				0.64	33.3	0.67							0.23	11.1	0.22			
ACARINA	58.26	80	25.71	25.1	33.3	2.56	49.4	100	19.78	9.09	33.33	0.57	77.93	77.8	52.33	26.46	77.78	13.56
OPILIONES	0.32	10	0.14	1.62	44.4	1.67	0.55	22.22	0.22	4.54	33.33	0.28	1.88	33.3	1.78	2.38	55.56	1.11
PSEUDOSCORPIONES	0.32	10	0.14	0.42	33.3	0.44	0.27	11.11	0.11							0.65	22.22	0.33
ARANEAE	0.65	20	0.28	5.44	44.4	5.56	3.04	66.67	1.11	38.63	66.67	2.43	1.53	88.9	1.44	3.25	55.56	1.67
ZYGENTOMA				2.39	44.4	0.22	2.22	66.67	0.89									
CRUSTACEA Isopoda	0.32	10	0.14	1.85	44.4	1.89				4.54	33.33	0.28				0.65	33.33	0.33
COLLEMBOLA	24.6	70	10.86	25.1	44.4	48.56	15.5	88.89	6.22	25	33.33	1.57	1.17	88.9	22.44	15.83	77.78	8.11
THYSANOPTERA													0.23	11.1	0.22			
MYRIAPODA-Diplopoda	0.97	10	0.42	0.64	44.4	0.67				4.54	33.33	0.28				0.86	33.33	0.44
MYRIAPODA-Chilopoda	4.21	70	1.86	0.1	11.1	0.11				2.28		0.14				1.08	33.33	0.55
HETEROPTERA	0.65	20	0.28	0.22	11.1	0.22	0.27	11.11	0.11	2.28	33.33	0.14	0.47	33.3	0.44	0.86	22.22	0.44
HOMOPTERA -Aphididae				2.5	44.4	2.56	1.38	33.3	0.55				0.7	44.4	0.67	0.21	11.11	0.11
HOMOPTERA - Cicadoidea				0.95	11.1	1	1.38	55.56	0.55				0.35	33.3	0.33	0.43	11.11	0.22
HYMENOPTERA var				8.06	55.6	8.22	2.22	66.67	0.89	2.28	33.33	0.14	2.11	55.6	2	1.3	88.89	0.67
HYMENOPTERA - Formicidae	6.79	50	3				0.83	33.3	0.33	2.28	33.33	0.14	1.06	44.4	1	28.85	88.89	14.78
ORTHOPTERA var.				0.1	11.1	0.11												
BLATTODEA				0.22	11.1	0.22												
COLEOPTERA	1.62	40	0.71	5.55	44.4	5.67	15.2	100	6.11				12.34	88.9	11.67	11.49	77.78	5.89
DIPTERA	0.97	30	0.42	19	44.4	19.33	7.48	66.67	3							5.7	88.89	2.89
TOTAL	**100**		**44.1**	**100**		**99.79**	**100**		**39.98**	**100**		**6.25**	**100**		**94.54**	**100**		**51.1**

At Doftana North, the structure of invertebrates population is dominated numerically by Acarina and Collembola in both years, and with a few more groups in summer (Diptera for instance) and autumn (Coleoptera,

Formicidae etc., see table 1). The euconstant groups of invertebrates were Gasteropoda and Acarina in both years, Collembola, Homoptera, Coleoptera and Diptera also in 2010, and in 2011 – Pseudoascorpiones and Chilopoda. It is noticed a raise of the invertebrate numerical densities in spring and autumn of 2011, but drastic lower values in summer 2011, as the average temperature raised and the humidity decreased in comparison with the previous year.

Doftana South has a similar structure of the invertebrate population: Acarina and Collembola are eudominant numerically all the year 2010 and also in 2011 (Acarina / Collembola, but not both groups, see table 2). Euconstant in both years were Acarina, Opiliones, Araneae, Collembola, Heteroptera and moreover, some other groups, varying seasonally (Table 2). The same trend of raising the numerical densities in spring and autumn 2011 is noticed also on the southern slope, but during the summer, the average numerical densities are quite similar to those of 2010.

The taxonomical composition but also the structure of dominance and constancy of classes of Coleoptera fauna vary seasonally in both studied areas (Table 3).

As the taxonomic composition, the beetles fauna shows seasonal changes in both years of study and differences from one year to another. It is not noticed a pattern or a trend of variations in composition of beetles communities: in 2010 the number of Coleoptera families raised from spring to autumn in both populations, and the same happened in 2011 on the southern slope, even if the number of families was lower than in the previous year.

Table 3. The presence and numerical relative abundances (%) of Coleoptera families in the studied areas. / Tabel 3. Prezenţa şi abundenţa numerică relativă (%) a familiilor de coleoptere din zonele studiate.

COLEOPTERA	Doftana North						Doftana South						Lunca Mare		
	spring 2010	summer 2010	autumn 2010	spring 2011	summer 2011	autumn 2011	spring 2010	summer 2010	autumn 2010	spring 2011	summer 2011	autumn 2011	spring	summer	autumn
Staphylinidae	0.65	2.31	3.4	1.2	2.93	3.34		1.74	3.06		0.35	1.73	0.66	6.71	3.32
Silphidae	0.65	0.6	0.28	0.75	0.73	0.89		0.33	0.28			1.73	4.6	1.43	0.28
Scarabaeidae	0.65	0.2	3.12					0.43	1.38		0.59	0.22		2.38	3.05
Curculionidae		0.9		0.75	1.22	0.45			1.66		0.23	1.3		0.23	
Carabidae		0.75	5.97	0.3	6.84	3.34	1.62	1.41	1.94		1.6	0.65		6.44	5.81
Tenebrionidae	3.28		1.7	0.3		0.89		0.24	1.38			0.65		1.91	0.83
Chrysomelidae		2.93	0.85	2.28	2.44			0.54	2.21		1.52	4.34			
Elateridae			0.28	0.3	0.49	0.45		0.87	1.66		0.94	0.43		0.23	0.28
Cantharidae				0.15							1.65	0.22		2.15	
Mycetophagidae				0.15					1.66		1.41			0.48	0.83
Nitidulidae				0.15							1.41	0.22		0.95	0.83

The ground beetle fauna (Family Carabidae) is represented in both populations mainly by predator species. *Carabus violaceus* LINNAEUS 1758, *Carabus coriaceus* LINNAEUS 1758 are the big predator species present in both populations of the Doftana Valley, while *Carabus glabratus* PAYKULL 1790 was found at Lunca Mare. Other predator ground beetle species found in all the studied sites and with important densities in populations is *Abax parallelipipedus* (PILLER & MITTERPACHER 1783).

The relative numerical abundances of the beetle families are low in relation with integrating invertebrate populations.

During this study, 6 species of gastropods were identified in the rocky habitats (Table 4). Inside the integrating food webs, one of their predator group is represented by the predator ground beetles (especially *Carabus* species, known as consumers of slugs and snails) (CIOBOIU, 2004; GROSSU, 1987, 1993).

Table 4. Gastropod species of rocky habitats on the Doftana Valley. / Tabel 4. Specii de gastropode pe stâncării de pe Valea Doftanei.

FAMILY	SPECIES
Enidae WOODWARD 1903	*Ena montana montana* (DRAPARNAUD 1801)
Clausillidae SCHMIDT 1857	*Alopia (Alopia) doftanae* (NORDSIECK 1977)
Zonitidae MORCH 1864	*Vitrea jetschini* (KIMAKOWICZ 1890)
	Nesovitrea petronella (L. PFEIFFER 1853)
	Oxychilus (Cellariopsis) orientalis (CLESSIN 1887)
Helicidae RAFINESQUE 1815	*Helix pomatia* LINNAEUS 1758

Alopia (*A.*) *doftanae* (NORDSIECK 1977) is an endemic species, found only on the Doftana Valley (at Brebu and Lunca Mare).

The species of the Family Zonitidae are hygrophilous species, well adapted to high humidity and cool climate, with preference for the areas of higher altitude.

Vitrea jetschini (KIMAKOWICZ 1890), a species of 4 - 4.5 mm length, is an endemic species; it inhabits the humid litter layer of the deciduous forests, under stones, at the base of rocks and sometimes, on the ground.

Oxychilus (Cellariopsis) orientalis (CLESSIN 1887), a species of 5.5 - 10 mm, is quite common in the mountain areas, especially in humid litter layer and logs of the deciduous forests.

Nesovitrea petronella (L. PFEIFFER 1853) is a rare species, sporadically collected in Europe. In Romania, it is found only in the mountain areas, especially in Bucegi Massif; it prefers open areas, meadows and pastures (among the roots of the herbaceous species, in the litter layer, under stones).

Helix pomatia LINNAEUS 1758 is a common, eurytopic species, of 38 - 40 mm, found in many habitats (gardens, forests, etc.), in humid and shadowed places. It is an oviparous species (it lays eggs in June-July) (NEACŞU & CIOBOIU, 1999, 2000).

DISCUSSIONS

To have a better image about the seasonal variations in the structure of the epigeic invertebrates populations of rocky habitats, we took into account (for comparison), the invertebrate population of Lunca Mare (an alluvial shrub land of *Salix purpurea*, situated also on the Doftana Valley, at 485 m altitude) that we studied during 2008 (Table 5).

Table 5. Seasonal variations of air temperature (T - °C) and humidity (Humid. - mm) and average densities (n/s.u.) of epigeic invertebrates at Câmpina meteorological station. Doftana (northern and southern slopes) and Lunca Mare. / Tabel 5. Variaţiile sezoniere ale temperaturii aerului (T - °C) şi umidităţii (Umidit. – mm) şi densitatea medie a nevertebratelor epigee la staţia meteorologică Câmpina. Doftana (versanţii nordici şi sudici) şi Lunca Mare.

	Spring			Summer			Autumn		
	T	Humid.	N/s.u.	T	Humid.	N/s.u.	T	Humid.	N/s.u.
Câmpina	19.06	0.71	0	21.56	0.64	0	12.33	0.77	0
Doftana-N	18.64	72.8	21.86	21.03	67.63	220.88	12.71	73.38	39.22
Doftana-S	19.81	72.91	44.14	22.01	19.39	102	15.67	73.13	40.11
Lunca Mare	16.67	0.7	21.68	21.36	0.64	46.52	12.3	0.77	40.09

A simple view on the seasonal variations of the main climatic parameters (air temperature and humidity) shows obvious differences at local level between the northern and southern slope. Thus, related to temperature, the highest differences are noticed in autumn (on the southern slope the average temperature is about 3°C higher) and during the summer, also on the southern slope, the air humidity is about 3.5 times lower than on the northern side.

In comparison with this situation, we notice that at Lunca Mare, the seasonal values of air temperature and humidity are very close to those of Campina meteorological station.

The relationships between the invertebrates and the abiotic factors are reflected by the values of r and show a positive correlation of invertebrates with temperature and a negative one with humidity; gastropods seem not to be very much influenced by temperature (maybe the amplitude of the air temperature variations are not so high to influence the gastropods).

As prey-predators relationships, on the northern slope of Doftana was noticed a negative connection between gastropods and spiders (r=-0. 504). On the southern slope, it seems that it does not exist a relationship gastropods-spiders (r=0.115) because these predators access their prey (Diptera and Isopoda) in a positive relationship (r=0.901 Araneae-Diptera and r=0.942 Araneae-Isopoda respectively) (see also Fig. 1).

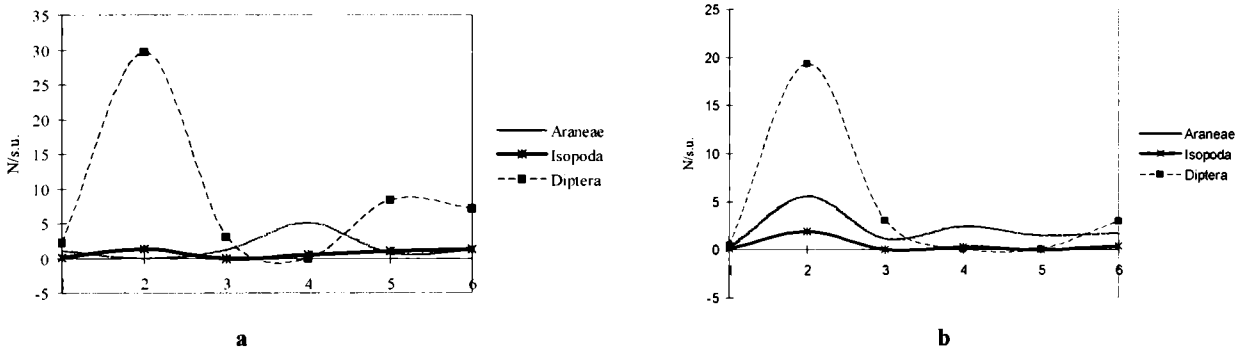

Figure 1. The variations of average densities (N/s.u.) of Araneae and of two groups of prey within Doftana study sites (a – Northern slope, b – Southern slope). / Figura 1. Variaţiile densităţii medii (N/s.u) la Araneae şi două grupuri de pradă din zone studiate de pe Doftana (a – versantul nordic, b – versantul sudic).

Pseudoscorpiones have a positive relationship with Acarina and Collembola on the northern slope (r=0.977 Pseudoscorpiones-Collembola and r=-0.85 for Pseudoscorpiones-Acarina) and also with collembolan on the southern slope (r=0.621), while with Acarina it is almost a negative correlation (r=-0.476).The variations of average numerical densities of Pseudoscorpiones, Acarina and Collembola are illustrated in figure 2.

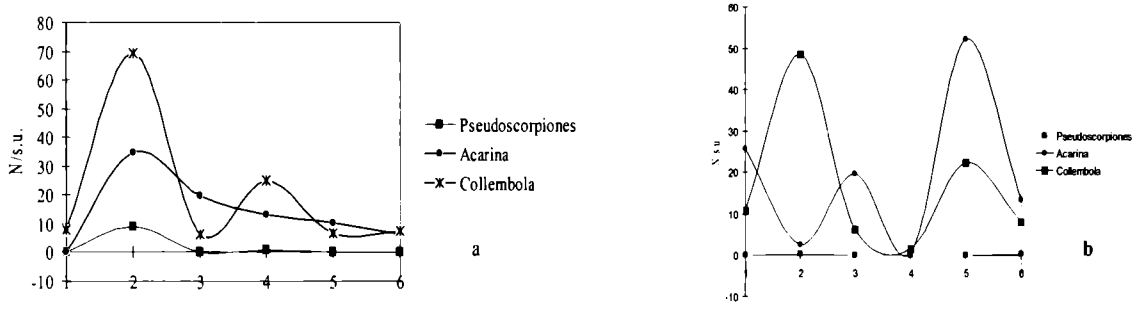

Figure 2. The variations of average densities (N/s.u.) of Pseudoscorpiones, Collembola and Acarina within Doftana study sites (a – Northern slope, b – Southern slope). / Figura 2. Variaţiile densităţii medii (N/s.u) la Pseudoscorpiones. Collembola şi Acarina din zone studiate de pe Doftana (a – versantul nordic, b – versantul sudic).

We also noticed that between the predator groups, between Araneae and Chilopoda it is an ''attempt'' of negative correlation in the population of the northern slope of Doftana (r=-0.47) , while on the southern slope, Araneae-Carabidae seem to become negative correlated (r=-0.534) (see also Fig. 3).

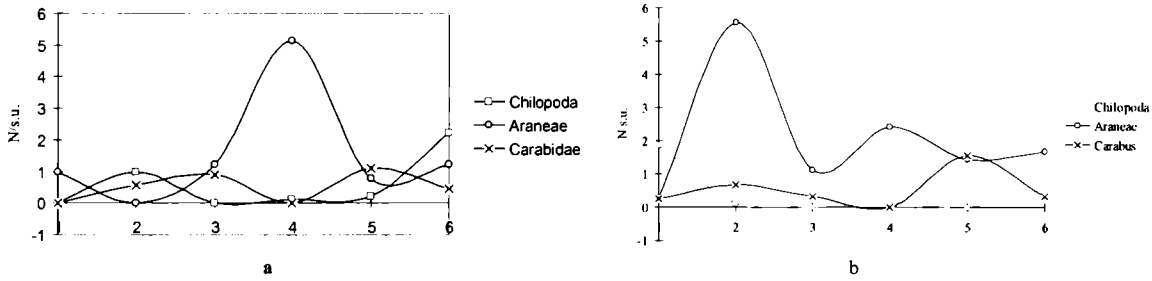

Figure 3. The variations of average densities (N/s.u.) of some predator invertebrates within Doftana study sites (a – Northern slope, b – Southern slope). / Figura 3. Variaţiile densităţii medii (N/s.u) ale unor nevertebrate prădătoare din zone studiate de pe Doftana (a – versantul nordic, b – versantul sudic).

The increased numerical abundances of epigeic invertebrates during the summer are due to the increase of phytophagous densities as vegetation develops. This situation occurs also in shrub lands and forests we studied in the same climatic region (the Doftana Valley) (MANU, 2008; PAUCĂ *et al.*, 2008 a, b; VASILIU-OROMULU *et al.*, 2008).

The beetle fauna, with its high diversity, is an important part of any coenotic structure. The qualitative and quantitative characteristics of the beetle populations reflect their involvement in the coenotic dynamics and plasticity.

At Lunca Mare, Pseudoscorpiones and Acarina seem to be negatively correlated with air temperature(r=-0.95 and r=-0.998 respectively). Araneae, Collembola and Diptera – negatively correlated with air humidity (r= -0.816, -0.892 and -0.856 respectively), while Acarina and Pseudoscorpiones are positively correlated with humidity (r=0.768 and 0.577 respectively).

As in the populations of Doftana slopes, there is a correlation between gastropods and predators (*Carabus* sp. and Araneae), a negative one this time, and between the predator groups - a positive correlation. Spiders feed on Diptera and Isopoda – an abundant source of food (r has positive values in both cases) and Pseudoscorpiones feed on Acarina (r positive) and Collembola (r negative).

CONCLUSIONS

Seasonal variations in the composition of epigeic invertebrates populations are similar in all studied areas; the presence/absence of some groups of invertebrates are determined by vegetation (composition, degree of development of primary producers (e.g. during summer – a higher number of phytophagous groups of invertebrates) and also by the main abiotic factors (temperature, humidity) influencing the invertebrates phenology.

The quantitative characteristics of invertebrate populations (numerical densities for instance) are also reflected in the populations structure. The presence of the predator invertebrates is conditioned in all habitats by the source of food and the proportions between the predator groups – by their prey abundance.

If as populations structure we have realized an image with the actual data, the pattern of a multi-annual variations is far from being clear with actual data; it seems to be necessary further studies to define in which way the

abiotic factors, with their particular variations in these particular habitats, affect the epigeic invertebrates populations at a larger scale of time.

ACKNOWLEDGEMENT

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REFERENCES

CIOBOIU OLIVIA. 2004. *The molluscs from Alexandru V. Grossu's collection, a parameter of the spreading assessment in the current conditions of the anthropic impact.* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. Edit. Sitech. Craiova. **20**: 319-339 [In Romanian].

MANU M. 2008. *The influence of some abiotical factors on the structural dynamics of the predatory mite populations (Acari: Mesostigmata) from an ecosystem with Myricaria germanica from Doftana Valley (Romania).* Travaux du Museum d'Histoire Naturelle "Grigore Antipa". Bucharest. **51**: 463-471.

NEACŞU P. & CIOBOIU OLIVIA. 1999. *Contribuţii asupra ecologiei speciei Hclix pomatia L. (Gastropoda Pulmonata) din Oltenia.* Oltenia. Studii şi comunicări. Ştiinţcle Naturii. Muzeul Olteniei. Craiova. **15**: 62-66.

NEACŞU P. & CIOBOIU OLIVIA. 2000. *Contributions to the knowing of the microhabitats of the garden snail – Helix pomatia* L. (Gastropoda Pulmonata). Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei. Craiova. **16**: 203-205 [In Romanian].

PAUCĂ-COMĂNESCU MIHAELA, ONETE MARILENA, HONCIUC VIORICA, VASILIU-OROMULU LILIANA, STĂNESCU MINODORA, FIEREA CRISTINA, PURICE DORINA, FALCĂ M., MAICAN SANDA, ŞINCU D., ION MIHAELA, MUNTEANU CRISTINA. 2008a. *Structura unor componente ecosistemice din tufărişurile aluviale colinare.* Protecţia şi restaurarea bio şi ecodiversităţii. Lucrările Conferinţei Naţionale de Ecologie Mamaia 2007. Edit. Ars Docendi: 165 -169.

PAUCĂ-COMĂNESCU MIHAELA, PURICE DORINA, ONETE MARILENA, DIHORU G., MOUNTFORD O., HONCIUC VIORICA, VASILIU-OROMULU LILIANA, STĂNESCU MINODORA, FIEREA CRISTINA, FALCĂ M., MAICAN SANDA, ION MIHAELA, MUNTEANU CRISTINA. 2008b. *Alluvial Salix purpurea and Hyppophae rhamnoides collinear shrubs in Prahova and Doftana zone.* Romanian Journal of Biology-Plant Biology. Edit. Academiei Române. Bucharest. **53**(2): 97-122.

PURICE DORINA & CIOBOIU OLIVIA. 2011. *Structura şi dinamica populaţiilor de nevertebrate epigee din habitate stâncoase de pe Valea Prahovei.* Rezumat. A 51-a Sesiune Anuală de Comunicări Ştiinţifice a Institutului de Biologie. Edit. Ars Docendi. Bucureşti: 65.

VASILIU-OROMULU LILIANA, PAUCĂ-COMĂNESCU MIHAELA, ONETE MARILENA, SANDA V., NICOLAE C., ŞTEFĂNUŢ S., ŞINCU D., HONCIUC VIORICA, STĂNESCU MINODORA, FALCĂ M., FIEREA CRISTINA, PURICE DORINA, MAICAN SANDA, MUNTEANU CRISTINA, ION MIHAELA. 2008. *Biocoenotic differentiation of Quercus petraea and of mixed Quercus petraea and Fagus sylvatica decidous forests from the lower Doftana Valley (Prahova county).* Romanian Journal of Biology – Zoology. Edit. Academiei Române. Bucharest. **52-53**: 79-105.

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STRUCTURAL PARTICULARITIES OF CERTAIN SPRINGS WITHIN THE LOWER HYDROGRAPHIC BASIN OF THE JIU RIVER

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Abstract. The lower hydrographic basin of the Jiu River is characterized by a complex ecosystem structure (springs, rivulets, and reservoirs). Each category is defined by geomorphologic, hydrologic, and structural-biocoenotic particularities. Thus, we mention springs and streams, which, within the Preajba Valley hydrographic basin, can be considered the representative factor for the geographical space of Oltenia Plain.

Keywords: springs, biodiversity, the Preajba Valley, the Oltenia Plain.

Rezumat. Particularităţile structurale ale unor izvoare din bazinul hidrografic inferior al Jiului. Bazinul hidrografic inferior al râului Jiu se caracterizează printr-o structură ecosistemică complexă (izvoare, mici râuri şi lacuri de baraj). Fiecare categorie se defineşte prin particularităţile geomorfologice, hidrologice şi structural-biocenotice. În acest sens se disting izvoarele şi pâraiele, care în ansamblul bazinului hidrografic Valea Preajba constituie factorul reprezentativ pentru spaţiul geografic al Câmpiei Olteniei.

Cuvinte cheie: izvoare, biodiversitate, Valea Preajba, Câmpia Olteniei.

INTRODUCTION

The lower hydrographic basin of the Jiu is characterized by a complex ecosystem structure (springs, streams, and reservoirs). Along its lower sector, the Jiu River receives a small tributary – the Preajba Valley stream. Located within a plain area, the hydrographic basin of the Preajba Valley is mainly characterized by the presence of a large number of springs, which generates and determines the configuration and functioning both of the stream itself and of the small reservoirs built along its course. An important factor for the physical-geographic structuration of the area is represented by the presence of more than 40 springs (BREZEANU & GRUIŢĂ, 2002; BREZEANU *et al.*, 2011; CIOBOIU, 2002; CIOBOIU & BREZEANU, 2002).

These springs supply small rivulets, which are biotopes that ensure the development of certain specific biocoenosis. Consequently, when globally analysing the structural features of the entire Preajba Valley basin, we consider that the springs and the small rivulets they supply are a representative factor for the entire basin (Fig. 1).

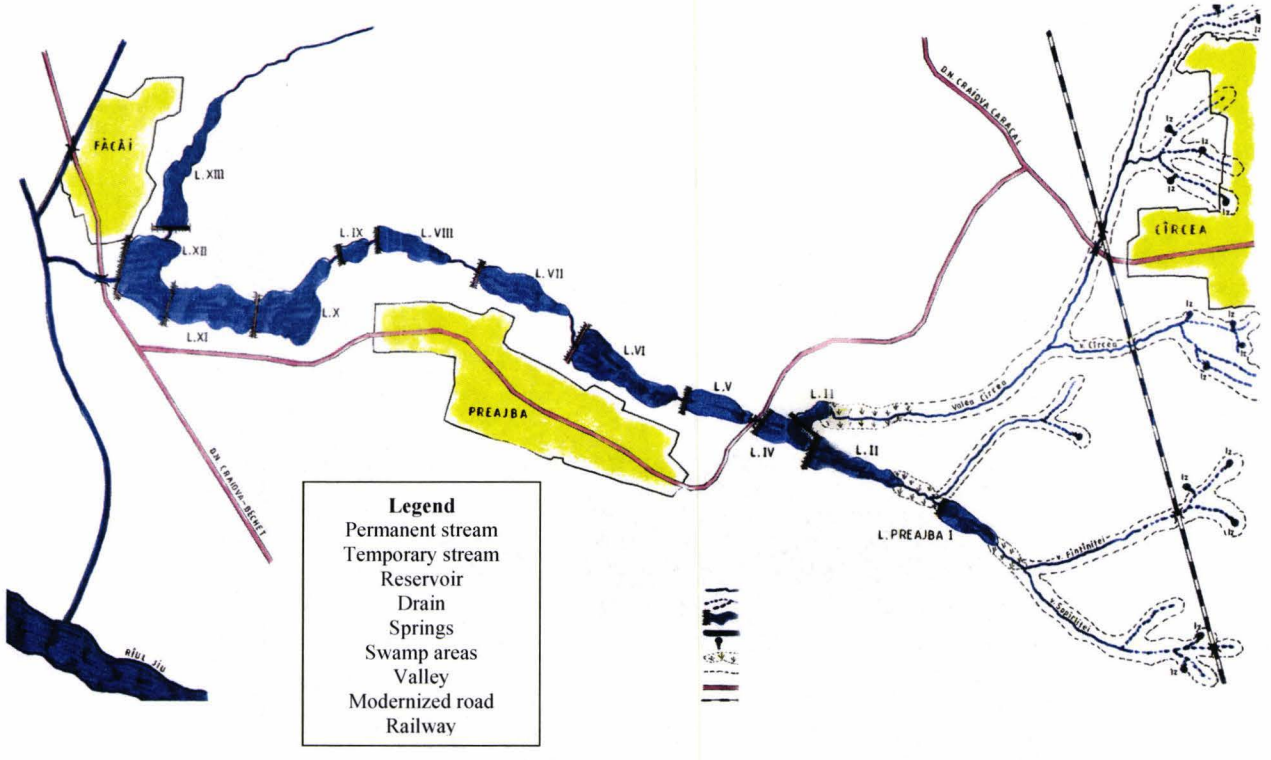

Figure 1. The plan of the Preajba Valley Hydrographical Basin (after CIOBOIU, 2002).
Figura 1. Schiţa bazinului hidrografic Valea Preajba (după CIOBOIU, 2002).

MATERIAL AND METHOD

According to the geomorphologic and hydrologic specificity of these types of ecosystems, there were adapted and used corresponding materials. Thus, in order to gather the water samples, there were sampled one-litter recipients from the established points. The determination of planktonic and benthic structures was made based on the collection of qualitative and quantitative samples by means of planktonic net and limnological netting (BREZEANU & ENĂCEANU, 1964; CIOBOIU, 2011).

RESULTS AND DISCUSSIONS

From the ecological point of view, the springs that are to be found on a surface of only 10-15 ha are grouped into two main categories: reocrene and limnocrene and their combination, namely limno-reocrene. In case of reocrene springs, the physical-chemical features are distinct from those of other types. Thus, the values of fixed residues, chlorine, sulphites and nitrates are two times higher than those of other springs. These higher quantities may be induced by the fact they wash a greater surface of the substratum they cross and, consequently, dissolve and carry greater quantities of the aforementioned elements. The other categories, the limnocrene and limno-reocrene ones, display relatively similar values of the analysed elements. The concentrations are for limno-reocrene springs (Fig. 2).

The springs are characterized by very small concentrations of nitrates and phosphates (NO_3^- - 62.04 mg./l, NO_2^- - 0.03 mg./l, NH_4^+ - 0.11 mg./l, PO_4^{3-} - 0.28 mg./l). These are mainly induced by different anthropogenic pollution factors, which have a more reduced influence on springs (CIOBOIU, 2003; ZUBCOV *et al.*, 2002) (Table 1).

Table 1. Physical-chemical composition of springs.
Tabel 1. Compoziţia fizico-chimică a izvoarelor.

Analysed indicators	Cârcea			Analysis method
	Reocrene spring	Limnocrene spring	Limno-reocrene spring	
Conc. of hydrogen ions (pH), unit. pH	7.21	8.04	7.43	STAS 6325-75
Electric conductivity (µs)	1250	670	4	STAS 7722-84
Fixed residue mg/l	620	335	495	STAS 9187 - 84
Alkalinity ml HCl 0,1	10.8	8.1	11.5	-
Oxidable organic substances CCOCr mgO_2/dm^3	21.6	25	22	SR ISO 6060- 96
Total hardness, German degrees	34.1	31.6	31.2	STAS 3026-76
Ammonia (NH_4), mg/l	0.06	0.11	0.05	STAS 6328-85
Calcium (Ca^{2+}), mg/l	172.8	156.8	120	STAS 3662-62
Magnesium (Mg2+), mg/l	44.8	43.9	63.9	STAS 6674-77
Nitrates (NO_3), mg/l	62.04	45.32	25.6	STAS 3048-90
Nitrites (NO_2), mg/l	SLD	0.03	SLD	STAS 3048- 77
Chlorides (Cl), mg/l	81.6	42.6	31.9	STAS 3049- 86
Phosphates (PO^3_4), mg/l	0.19	0.28	0.23	STAS 3265-66
Sulphates (SO_4), mg/l	89	44	37	STAS 3002-87
Sodium mg/l	79	36	59	STAS 3223-52
Potassium mg/l	1.7	1.1	1.5	STAS 3223-52

Figure 2. The area of limno-reocrene springs supplying the streams in the upper sector of the Preajba Valley hydrographical basin.
Figura 2. Zona izvoarelor limnoreocrene care alimentează pâraiele din sectorul superior al bazinului hidrografic Valea Preajba (original).

From the qualitative viewpoint, the water of the springs belongs to the first category. It is freshwater and the water table they come from is a valuable resource used for the water supply of Craiova city.

Springs, most of them reocrene, form small pools on the clayish-sandy soil. The clean and transparent water presents a 12 – 13°C temperature even during summer (LUNGU & DUŢOIU, 1996).

The rivulets that appear on the slopes eroded the clayish soil developing up to one meter deep beds. The water speed is of about 0.50 m/sec. and it gathers at the foot of the slope forming the upper sector of the stream Bătrâna Valley and the Preajba Valley. The slow speed of the stream even along this sector determines the presence of a silty-sandy bottom. Water temperature during summer reaches 18 – 20°C in the upper sector and more than 24°C in the lower sector, in the proximity of the first reservoir.

Around the springs, pools, and rivulets there were identified the following macrophytes: *Mentha aquatica* LINNAEUS 1758, *Heleocharex palustris* LINNAEUS 1758, *Polygonium amphibium* LINNAEUS 1758, *Carex riparia* LINNAEUS 1758. On the surface of the plants stems and leaves, as well as on the substratum around them, it was noticed the almost exclusive presence of diatomeae that love lower temperatures, clean and rich in silicates water (NICOLAESCU *et al.*, 1999).

The taxonomic structure of zooplankton is reduced: a ciliate species (*Vorticella microstoma)*, four of testaceae (*Arcella arenaria, Centropyxis discoides, C. aculeata, Diflugia globulosa*) and one species of rotifers (*Rotaria magna*) (PARPALĂ *et al.*, 2002).

The benthonic fauna is made up of the following groups: ostracods, gamarids, gastropods, bivalves, chironomids, ephemeropteres, heteropteres. Molluscs are on the first place due to their numerical density and ecological role in the fauna of the streams. We mention that their presence was mainly noticed in the lower sector of the streams that are characterized by a great floristic and faunistic diversity.

The numerical and biomass density place the gastropods on the first place; they are mainly represented by the following species: *Valvata (Cincina) piscinalis* O. F. MULLER, 1774, *Esperiana esperi* (A. FERUSSAC 1823), *E. (Microcolpia) daudebardii acicularis* (FERUSSAC 1823), *Physa fontinalis* (LINNAEUS 1758), *Aplexa hypnorum* (LINNAEUS 1758), *Stagnicola palustris* (O. F. MULLER 1774), *Radix labiata* (ROSSMASSLER 1835), *Galba truncatula* (O. F. MULLER 1774), *Planorbis planorbis* (LINNAEUS, 1758) (Table 2).

Table 2. Gastropod species present in the lower sector of the Preajba Valley hydrographical basin.
Tabel 2. Speciile de gastropode întâlnite în pârâiele din sectorul superior al bazinului hidrografic Valea Preajba.

Class **GASTROPODA** CUVIER 1798 Subclass PROSOBRANCHIA MILNE EDWARD 1848 Order MESOGASTROPODA THIELE 1925	
Family Valvatidae THOMSON 1840	*Valvata (Cincina) piscinalis* O. F. MULLER 1774
Family Thiaridae TROSCHEL 1857	*Esperiana esperi* (A. FERUSSAC 1829) *E. (Microcolpia) daudebardii acicularis* (A. FERUSSAC 1823)
Subclass PULMONATA CUVIER 1917 Order BASOMMATOPHORA A. SCHMIDT 1855	
Family Physidae FITZINGER 1833	*Physa fontinalis* (LINNAEUS 1758) *Aplexa hypnorum* (LINNAEUS 1758)
Family Lymnaeidae RAFINESQUE 1815	*Stagnicola palustris* (O. F. MULLER 1774) *Radix labiata* (ROSSMASSLER 1835) *Galba truncatula* (O. F. MULLER 1774)
Family Planorbidae RAFINESQUE 1815	*Planorbis planorbis* (LINNAEUS 1758)

Esperiana (Microcolpia) daudebardii acicularis (A. FERUSSAC 1823) is a common species of streams forming large populations together with *Esperiana esperi* (A. FERUSSAC 1829). Their dimensions range between 15 and 20 mm high, 5 and 8 mm wide, a conic shell and oval aperture.

Aplexa hypnorum (LINNAEUS 1758) is senestre, displaying a fusiform-elongated, transparent, brown-yellowish, shiny shell of 9-13 mm. It prefers streams, living in numerous populations, but it can be also found in springs and pools.

Stagnicola palustris (O. F. MULLER 1774), even if it is characteristic to slow waters, it is quite frequent in streams and springs in the plain area, as it is the case of the studied ecosystems. Its dimensions range between 20 and 30 mm high and 10 and 15 mm wide.

Radix labiata (ROSSMASSLER 1835), a small gastropod, (h = 20-21 mm, w = 12 mm) has an oval, yellow-reddish and resistant shell. It prefers highly eutrophic lakes, but, sometimes, it can be found in rocky-bottom streams.

Galba truncatula (O. F. MULLER 1774) is a typically reophile species identified in springs, small waters, swamps, holes, marshes directly on silt or rocks, often in numerous populations. It has a small, elongated-oval, reddish-brown and thick aspect shell with a well-developed spire.

Planorbis planorbis (LINNAEUS 1758) is characterized by its discoidal shell (h = 3.5 mm, l = 15-17 mm). It lives in stagnant waters with silty bottom, as well as in the streams with rich vegetation; it is often found in lacustrine ecosystems from Romania (CIOBOIU, 2002; GROSSU, 1986, 1987, 1993).

Unio pictorum LINNAEUS 1758 is a species frequently met in the studied ecosystems. Even if it is not too numerous, it plays an important role in the coenotic bioeconomy of the area due to its high capacity of filtering the water (NEGREA *et al.*, 2004).

CONCLUSIONS

Through their geographical position, the springs and streams represent a very important segment in the assembly of the Preajba Valley hydrographical basin. The 40 springs are the characteristic element of the area as, within a limited geographical space (10-15 ha), they are the representative factor of Oltenia Plain. It is well-known that this area displays a dry climate and the presence of the springs and streams represents a characteristic feature of Oltenia Plain from the ecological viewpoint.

REFERENCES

BREZEANU GH. & ENĂCEANU VIRGINIA. 1964. *Studiul hidrobiologic al bazinului inferior al Cernei (Cerna, Belareca şi Mehadica).* Hidrobiologia. Edit. Academiei R. S. R. Bucureşti. **5**: 51-65.

BREZEANU GH. & GRUIŢĂ S. ALEXANDRA. 2002. *Limnology generale.* Edit. H.G.A. Bucureşti. 287 pp. [In Romanian].

BREZEANU GH., CIOBOIU OLIVIA, ARDELEAN A. 2011. *Aquatic Ecology.* „Vasile Goldiş" University Press. Arad. 406 pp. [In Romanian].

CIOBOIU OLIVIA. 2002. *Gasteropodele lacurilor mici de baraj din Câmpia Olteniei.* Edit. Sitech. Craiova. 120 pp.

CIOBOIU OLIVIA. 2003. *The Hydro- chemical characteristics of some Springs, Rivers and Lakes from the inferior Basin of the Jiu river.* Lucrările Institutului de Hidrologie. Edit. H.G.A. Bucureşti: 52-53.

CIOBOIU OLIVIA. 2011. *Biodiversity of a protected lacustrine complex within the lower hydrographical basin of the Jiu.* International Journal of Ecosystems and Ecology Sciences (IJEES). Tirana. Albania. **1**(1): 56-62.

CIOBOIU OLIVIA & BREZEANU GH. 2002. *Hidrobiological Peculiarities of some small Eutrophic Reservoirs within the Hydrographical Basin of the Jiu.* Limnological Reports. Proceedings of the 34th Conference IAD. Tulcea. Romania. **34**: 275-287.

GROSSU AL. V. 1986. *Gastropoda Romaniae. 1. Subclasa Prosobranchia şi Opistobranchia.* Edit. Litera. Bucureşti. 525 pp.

GROSSU AL. V. 1987. *Gastropoda Romaniae. 2. Subclasa Pulmonata I. Ordo Basommatophora II. Ordo Stylommatophora.* Edit. Litera. Bucureşti. 445 pp.

GROSSU AL. V. 1993. *The catalogue of the molluscs from Romania.* Travaux Museum d'Histoire Naturelle „Grigore Antipa". Bucureşti. **33**: 291-366.

LUNGU AURA & DUŢOIU E. 1996. *Evolution of physicochemical and biological factors in some reservoirs of Argeş catchment as a results of water development works.* Study and Researches Biology. University Bacău. **1**: 123-128.

NEGREA ŞT., NEGREA ALEXANDRINA, ARDELEAN A. 2004. *Biodiversitatea în mediile subterane din România.* „Vasile Goldiş" University Press. Arad. 248 pp.

NICOLAESCU N., CIOBOIU OLIVIA, BREZEANU GH. 1999. *Date preliminare asupra structurii comunităţilor algale fitoplanctonice din lacuri mici de acumulare din Câmpia Olteniei.* Lacurile de acumulare din România. Edit. Universităţii „A. I. Cuza". Iaşi: 135-142.

PARPALĂ LAURA, ZINEVICI V., CIOBOIU OLIVIA. 2002. *Contributions to the Study of the Zooplankton within the small Basins from the Oltenia Plain.* Proceedings of the Institute of Biology. Annual Scientific Session. Bucharest. **4**: 115-120.

ZUBCOV N. I., BOICENCO N. I., MUNJIU OXANA, BILEŢCHI LUCIA, BOGONIN Z. S. 2002. *Dynamics of the Hydrochemical Index of the Prut river.* Limnological Reports. Proceedings of the 34th Conference IAD. Tulcea. Romania. **34**: 95-100.

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GASTROPODS DIVERSITY IN CONACU-NEGREŞTI VALLEY

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Abstract. Conacu - Negreşti Valley is located in the south-eastern part of Romania, particularly in an area with excessive continental climate. The valley is characterized by a series of specific habitats, of which the most important are the dry steppe meadows, exposed limestone rocks and Conacu-Negreşti Lake. The biodiversity of the valley is very interesting, characterized by a number of rare and endemic species, specific to Dobrogea province. This paper presents the data concerning gastropod diversity identified in this area so far. The data represent the results of the research activities developed within the framework of a project from April 2003-August 2005, a continuation of the project from 2009-2010.

Keywords: gastropod diversity, bioelements, endemic species, xerophilous species.

Rezumat. Diversitatea gastropodelor din Valea Conacu-Negreşti. Valea Conacu-Negreşti este localizată în sud-estul României, într-o zonă cu climat continental excesiv. Prezintă o serie de habitate specifice, mai importante fiind pajiştile stepice uscate, pereţii calcaroşi cu calcare la zi şi lacul cu acelaşi nume, cu o biodiversitate extrem de interesantă, cu multe specii rare şi endemice caracteristice provinciei Dobrogea. Lucrarea prezintă datele privind diversitatea gastropodelor cunoscute până în prezent din această vale. Aceste date reprezintă rezultatele cercetărilor desfăşurate în cadrul proiectelor din perioada aprilie 2003-august 2005, respectiv 2009-2010.

Cuvinte cheie: diversitatea gastropodelor, bioelemente, specii endemice, specii xerofile.

INTRODUCTION

Conacu-Negreşti Valley is located in the extreme south-eastern part of Romania, in the centre of Cobadin Plateau, subunit of Negru Vodă Plateau, South Dobrogea. Cobadin Plateau landscape consists of large and almost flat interfluves. There start a series of short valleys discharging into the Danube River.

The studied region has an old Proterozoic foundation, composed of crystalline and one sedimentary suprastructure that is characterized by the existence of two types of Palaeozoic-Mesozoic and Neozoic formations (AXINI, 2006, 2009, 2012; BREZEANU, 1997; COTEŢ, 1969).

Here develops a temperate-continental climate, with hot, dry summers and cold winters with strong blizzards because of the movement of cold continental air from north-eastern and eastern parts Europe or the Arctic air.

The landscape of the valley consists of gorges with limestone walls, with "limestones to day", Conacu-Negreşti Lake being located within this area (BASARABEANU, 1969; GÂŞTESCU & BREIER, 1969; GODEANU, 2002), canyons, ravines, xerophyte steppe grasslands, grassy hills and bushes.

Conacu-Negreşti Valley (Figs. 1, 2, 3), part of South Dobrogea, is distinguished by spectacular landscape beauty and is characterized by rich and diverse assemblage, with many rare or endemic species specific to Dobrogea Province. Its significance also is derived from its geological, geomorphologic, and paleontological characteristics (AXINI, 2012).

Figure 1. Map of Europe (from Google Earth) emphasizing the position of Dobrogea and Conacu-Negreşti Valley in Europe.
Figura 1. Harta Europei (după Google Earth) cu poziţionarea Dobrogei şi a Văii Conacu-Negreşti în Europa.

MATERIAL AND METHODS

During the projects carried out between 2004 and 2010, different stations were established for field observations, identification of species and sampling both from the lake and the valley.

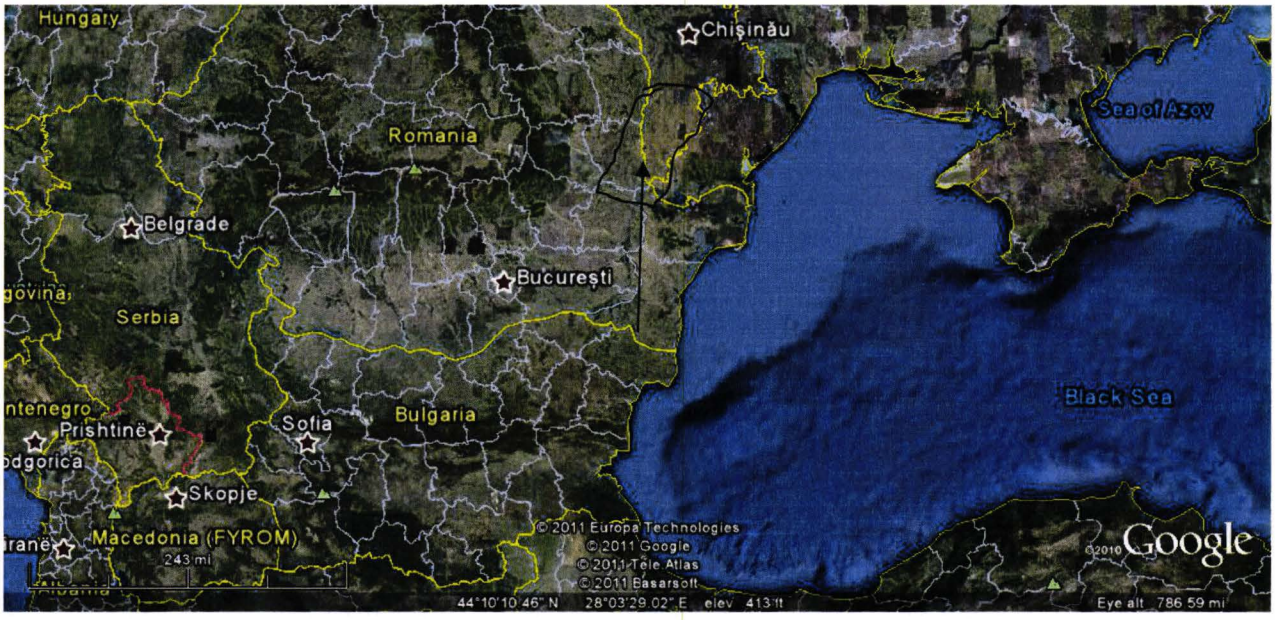

Figure 2. Geographical position of Conacu-Negreşti Valley in Dobrogea region (area circled in black) (image from Google Earth).
Figura 2. Aşezarea geografică a Văii Conacu- Negreşti în regiunea Dobrogea (suprafaţa marcată cu negru) (imagine după Google Earth).

Figure 3. Conacu-Negreşti Valley (from Google Earth).
Figura 3. Valea Conacu-Negreşti (după Google Earth).

10 stations were established at different points in the lake, taken differently depending on the nature of the substrate, lake depth and the existence of marsh, aquatic and floating vegetation. From these stations, samples were collected monthly. All samples were taken from the shore area of the lake.

Samples were collected by dredging on the distance of two meters. Subsequently, they were stored in plastic containers with lids - in formalin. They were then examined in the Laboratory of Invertebrate Zoology, Faculty of Natural and Agricultural Sciences, Ovidius University, Constanţa. Each sample taken from the field was washed through a set of four sieves, each with different mesh. Species were determined by means of IOR binocular magnifier and specimens of each species were counted.

For the terrestrial species, 12 stations were established depending on the type of the existing habitats in the valley: limestone walls with "rocks to day", grassy hills, canyons, plateaus, ravines, debris walls, limestone walls with fossil mollusks. For species identification, it was widely used field observations and photographs taken monthly by the team, during the field trips.

The nomenclature of taxa and data processing is according to data from literature as well as to national and international legislation.

RESULTS AND DISCUSSIONS

Conacu-Negreşti Valley hosts many species of invertebrates, of which, so far, we have identified a total of 101 terrestrial and aquatic species, belonging of 17 orders and 57 families (AXINI, 2006, 2009). Of these, gastropods are second after the insects that hold the highest numerical proportion.

Of the gastropods identified thus far, the 22 species include both terrestrial and aquatic taxa among which 9 families grouped in 3 orders (AXINI, 2012; GROSSU, 1986, 1987; MÜLLER, 2002; NEGREA, 2002) (Table 1).

Within the lake basin (43^{0}59`15.94``N, 28$^0$09`24.52``E), benthic invertebrate fauna found in 2004-2005, is dominated by species of gastropods (*Planorbarius corneus*, *Esperiana esperi*, *E. acicularis*, *Valvata piscinalis*, *Physa acuta*), followed by Diptera and Heteroptera, of insects (GOMOIU & SKOLKA, 2001).

Gastropod populations occupy an important place in the lake biocoenoses structure, by the specific and numerical diversity and biomass (CHIRIAC & UDRESCU, 1965; CIOBOIU, 1998, 2002). They are the first organisms to be investigated when examining stagnant water. They indicate the oxygen content of the water of these basins. Their occurrence in surface water shows low levels of oxygen in water.

The presence of gastropod *Planorbarius corneus* with 464 specimens (indicator species for mesotrophic-eutrophic waters) shows that there is not a pronounced disturbance of the lake (ŢIGĂNUŞ & SAMARGIU, 2003). The presence of this species indicates the existence of high levels of calcium ions in lake water.

The Danubian and Pontic species of gastropods (*Esperiana esperi*, *E. acicularis*) shows that the valley is a former branch of the Danube River. This is demonstrated by geology and geography data, as well as by our field observations (the form of the canyons in the south - west of the valley). They are Pontian-Southeast European relicts.

Table1. The taxonomic analysis of identified gastropod species.
Tabel 1. Analiza taxonomică a speciilor de gastropode identificate.

Order	Family	Species
Mesogastropoda	Thiaridae	*Esperiana esperi* (FÉRUSSAC 1823)
		Esperiana acicularis (FÉRUSSAC 1829)
	Valvatidae	*Valvata piscinalis* (O. F. MÜLLER 1774)
	Bithynidae	*Bithynia leachi* (SCHEPPARD 1823)
		Bithynia tentaculata (LINNAEUS 1758)
Basomatophora	Physidae	*Physa acuta* (DRAPARNAUD 1805)
		Physa fontinalis (LINNAEUS 1758)
	Planorbiidae	*Planorbarius corneus* (LINNAEUS 1758)
		Gyraulus albus (O. F. MÜLLER 1774)
	Lymneidae	*Radix ovata* (DRAPARNAUD 1805)
		Radix peregra (O. F. MÜLLER 1774)
		Galba truncatula (O. F. MÜLLER 1774)
		Stagnicola palustris (O. F. MÜLLER 1774)
Stylomatophora	Enidae	*Chondrula tridens* (O. F. MÜLLER 1774)
		Zebrina detrita (syn. *Helix detrita*) (MÜLLER 1774)
		Zebrina varnensis (L. PFEIFFER 1847)
	Helicidae	*Helicella obvia dobroudschae* (CLESSIN 1886)
		Cepaea vindobonensis (A. FÉRUSSAC 1821)
		Helix pomatia (LINNAEUS 1758)
		Helix lucorum (O. F. MÜLLER 1774)
	Limacidae	*Limax cinereo-niger* (WOLF 1803)
		Limax flavus (LINNAEUS 1758)

On limestone slopes with "rocks to day", on plateaus, hills and canyons in the south-west of the valley (43^{0}57`58.97``N, 28$^0$10`14.88``E) is worth mentioning many individuals of the gastropods *Cepaea vindobonensis* (44^{0}00`20.83``N, 28$^0$08`32.99``E) (common snail in the whole Dobrogea, widespread in our country) and *Helicella obvia dobroudschae* (43^{0}59`44.28``N, 28$^0$10`25.59``E) (xerophilous species, endemic to Dobrogea).

Chondrula tridens, *Zebrina detrita* (syn. *Helix detrita*), and *Z. varnensis* are found on the limestone walls with "rocks to day", in less numerous specimens.

The presence of two species - *Zebrina detrita*, large snail, and *Chondrula tridens* (44^{0}00`20.83``N, 28$^0$08`32.99``E) (relatively common species in the foliage of oak forests) previously confirmed the existence of pubescent oak forest (*Quercus pubescent*); however, it is no longer found in Conacu-Negreşti Valley today. These are xerophilous species belonging to the genera of West Asian origin.

Zebrina varnensis (43^{0}59`44.28``N, 28$^0$10`25.59``E) is a xerophilous species, highly resistant to drought, found on sunny slopes covered with herbaceous vegetation, in sandy areas (SKOLKA, 2008; SKOLKA *et al.*, 2005). This species is a regional endemism spread of the Black Sea coast of Romania and Bulgaria. This demonstrates once again that the valley is a former branch of the Danube River connecting it and the Black Sea.

The analysis of the geographical elements of gastropods from Conacu-Negreşti Valley (ZOLTÁN *et al.*, 2004; HUBENOV, 2007; ANIMALBASE, 2011) shows that the North Mediterranean-Turanian elements dominate with 3 species, followed by West Palearctic, Caspian Relict, Pontian-Southeast European, Holarctic, Holopalearctic, West and Central Eurosiberian and European elements, each with 2 species (Table 2).

Table 2. The zoogeographical elements, ecological data and conservation status of gastropods from Conacu-Negreşti Valley.
Tabel 2. Elementele zoogeografice, informaţii ecologice şi statutul de conservare al gastropodelor din Valea Conacu-Negreşti.

Species	Zoogeoelements	Ecological data/conservation status
Bithynia leachi	WP	L, PO, RH, SW, β
Bithynia tentaculata	WP	L, B, PO, SW, PH, NE, o-β
Cepaea vindobonensis	PM	T, XPH
Chondrula tridens	ET, NMT	T, XPH-ME
Esperiana acicularis	RC, PSEE	L, CR, RH, PO, LI
Esperiana esperi	RC, PSEE	L, CR, PO, LI, DD
Galba truncatula	H	L, EU, PE, PH, o-β
Gyraulus albus	WCES	L, B-8‰, PO, RH, SW, PH, R, N
Helicella obvia dobroudschae	ED	T, XPH
Helix lucorum	NMT	T, ME-HG
Helix pomatia	E	T, XPH-ME, EU, E, ESC, BC-3, HD-V
Limax cinereo-niger	E	T, ME
Limax flavus	RP, P, NM	T, ME, N
Physa acuta	NMT, SET	L, EU, PC, TX, NE, α-β
Physa fontinalis	TP	L, PH, R, N, α-β
Planorbarius corneus	WCES	L, B-8‰, SW, PO, NE, α-β
Radix ovata	HP	L, B-2,5‰, SW
Radix peregra	HP	L, EU, PH, PE
Stagnicola palustris	H	L, EU, PH, PC
Valvata piscinalis	WCP	L, RH, PO, SW, PH, NE, β
Zebrina detrita	CSEAN	T, XPH, CA, E
Zebrina varnensis	ER	T, XPH, CA, W

Abbreviation used:
Zoogeoelements: CESEAN-Central and South European-Anatolian, E-European, ED-Dobrogean Endemic, ER-Regional Endemic, ET-European-Turanian, H-Holarctic, HP-Holopalearctic, NM-North Mediterranean, NMT-North Mediterranean-Turanian, ML-Mediterranean-Lusitanian, P-Pontian, PM-Ponto-Mediterranean, PSEE-Pontian-Southeast European, RC-Caspian Relict, RP-Preglacial Relict, SET-South European-Turanian, TP-Transpalaearctic, WCES-West and Central Eurosiberian, WCP-West and Central Palearctic, WP-West-Palearctic.
Ecological data, conservation status (COUNCIL DIRECTIVE, 1992; IUCN, 2011): B-brackish, B-‰-limiting freshwater level for marine and salinity level for the freshwater form, BC, 3-Bern Convention, CA-calciphilous, CR-crenobiont, DD-data deficient (IUCN), E-European importance, ESC-the Red List of Threatened Animals and Plants in Europe, EU-eurybiont, HD, V-Habitats Directive, HG-hygrophilous, L-freshwater, LI-lithophilous, ME-mesophilous, NE-not-evaluated, PE-pelophilous, PH-phytophilous, PO-pomatophilous, R-rare, RH-rhithrophilous, SC-stenoepibathic, SW-stagnant water, T-terrestrial, TX-trogloxene, XPH-xerophilous, W-world importance, α-β - α-β-mesosaprobic, β - β-mesosaprobic, o-β - o-β-mesosaprobic.

Across the valley, fossil marine species are present (*Mactra* sp.) (in the rocks from the lake, the canyons and ravines, on limestone walls and coasts with "limestone rocks to day", Sarmatian) and unidentified species so far.

CONCLUSIONS

Data presented in this work were compiled from field and laboratory studies conducted in 2003 - 2010. This research is part of a program developed by the Monachus Group for Research and Environmental Education in Constanţa in partnership with the Faculty of Natural and Agricultural Sciences, Ovidius University in Constanţa,

Romania; it aimed at identifying the biodiversity of Conacu-Negreşti Valley, the biology and ecology of which have not been well-known until 2003.

A total of 22 species of gastropods was identified in this time. Of these Mollusca, two are endemic, seven are relicts, and two are rare. One species (*Helix pomatia*) is of European importance and included on the Habitats Directive and Bern Convention lists.

At present, the valley does not have designated conservation status. Human impacts on different aspects may contribute to future declines and even disappearance of some gastropods species in Conacu-Negreşti Valley, many species important to science and human well-being, some of which have not been described yet.

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REFERENCES

AXINI MONICA. 2006. *Lake and Conacu - Negreşti Valley – Study made to their proposal for entry in the list of protected areas in Romania.* Thesis, Faculty of Agricultural Sciences and Natural Sciences. Ovidius University Constanţa. Romania. 128 pp. [In Romanian].

AXINI MONICA. 2009. *Conacu-Negreşti Valley. The ecological reevaluation.* Dissertation, Faculty of Natural Sciences and Agricultural Sciences. Ovidius University Constanţa. Romania. 130 pp. [In Romanian].

AXINI MONICA. 2012. *Rare and Endemic Species in Conacu - Negreşti Valley, Dobrogea, Romania.* In: Stevens (Ed.) Global Advances in Biogeography. Tech Published House. California: 219-254.

AXINI MONICA. 2012. *Rare and Endemic Species in Conacu - Negreşti Valley, Dobrogea, Romania.* Available online at: http://www.intechopen.com/books/global-advances-in-biogeography (accessed: March 25, 2012).

BASARABEANU N. 1969. *Rolul apelor torenţiale asupra modelării reliefului actual din Dobrogea.* Studii Geografice asupra Dobrogei. Lucrările Primului Simpozion de Geografie a Dobrogei. Edit. Pontica. Constanţa: 65-70.

BREZEANU D. G. 1997. *Monografia Comunei Cobadin.* Primăria Comunei Cobadin. Judeţul Constanţa. Edit. Pontica. Constanţa. 95 pp.

CHIRIAC E. & UDRESCU M. 1965. *Ghidul Naturalistului în Lumea Apelor Dulci.* Edit. Ştiinţifică. Bucureşti: 126-141.

CIOBOIU OLIVIA. 1998. *Structura şi dinamica unor populaţii de gasteropode din lacuri mici de acumulare din Câmpia Olteniei. 1 - Viviparus acerosus Bourg.* Argessis. Studii şi comunicări - Seria Ştiinţele Naturii. Edit. Universităţii Piteşti: 23-28.

CIOBOIU OLIVIA. 2002. *Gasteropodele lacurilor mici de baraj din Câmpia Olteniei.* Edit. Sitech. Craiova. 120 pp.

COTEŢ P. 1969. *Dobrogea de Sud - Geneză şi Evoluţie.* Studii Geografice asupra Dobrogei, Lucrările Primului Simpozion de Geografie a Dobrogei. Edit. Pontica. Constanţa: 51-56.

GÂŞTESCU P. & BREIER A. 1969. *Lacurile din Dobrogea.* Studii Geografice asupra Dobrogei. Lucrările Primului Simpozion de Geografie a Dobrogei. Edit. Pontica. Constanţa: 97-104.

GODEANU S. 2002. *Apele continentale, prezentare generală.* In: Godeanu (Ed.) Diversitatea lumii vii. Determinatorul ilustrat al florei şi faunei României. Vasile Goldiş University Press. Arad. **2**: 1-24.

GOMOIU M. T. & SKOLKA M. 2001. *Ecologie. Metodologii pentru studii ecologice.* Ovidius University Press. Constanţa: 62-64.

GROSSU AL. V. 1986. *Gastropoda Romaniae. 1. Subclasa Prosobranchia şi Opistobranchia.* Edit. Litera. Bucureşti. 525 pp.

GROSSU AL. V. 1987. *Gastropoda Romaniae. 2. Subclasa Pulmonata I. Ordo Basommatophora II. Ordo Stylommatophora.* Edit. Litera. Bucureşti. 445 pp.

HUBENOV Z. 2007. *Fauna and zoogeography of marina, freshwater and terrestrial mollusks (Mollusca) in Bulgaria.* In: Fet & Popov (Eds.). Biogeography and ecology in Bulgaria. Springer: **82**: 141-198. Available from the world wide web: http://www.springerlink.com/content/n36xj8q7g70v3842/ (accessed: March 25, 2012).

MÜLLER G. I. 2002. *Phylum Mollusca. Moluşte.* In: Godeanu (Ed.) Diversitatea lumii vii. Determinatorul ilustrat al florei şi faunei României. Vasile Goldiş University Press. Arad. **2**: 334-337.

NEGREA ALEXANDRINA. 2002. *Class Gastropoda. Melci.* In: Godeanu (Ed.). Diversitatea lumii vii. Determinatorul ilustrat al florei şi faunei României. Vasile Goldiş University Press. Arad. **2**: 338-343.

SKOLKA M. 2008. *Invertebrate diversity in the western part of Black Sea coast: Cape Midia - Cape Kaliakra.* In: Făgăraş (Ed.) Volum cu lucrările Conferinţei de la Constanţa „Studii comparative privind biodiversitatea habitatelor costiere, a impactului antropic şi a posibilităţilor de conservare şi restaurare a habitatelor de interes comunitar dintre Capul Midia (România) şi Capul Kaliakra (Bulgaria)". Mamaia: 153-157.

SKOLKA M., FĂGĂRAŞ M., PARASCHIV GABRIELA-MIHAELA. 2005. *Biodiversitatea Dobrogei.* Ovidius University Press, Constanţa: 140-152.

ŢIGĂNUŞ V. & SAMARGIU MANUELA. 2003. *Principiile metodelor biologice de evaluare a stării calitative a apelor.* In: Tofan (Ed.) Noi Profesiuni de Mediu - Educaţie Ecologică. Ovidius University Press. Constanţa: 37-58.

ZOLTÁN F., MAJOROS G., VARGA A. 2004. *A scoring method for the assessment of rarity and conservation value of the Hungarian freshwater molluscs*. Acta Oecologica. Heldia. Hungary. **6**: 1-14.

***. ANIMALBASE. 2011. http://www.animalbase.uni-goettinger.de/... (accessed: April 30, 2011).

***. COUNCIL DIRECTIVE 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Available online at: http://ec.europa.eu/environment/nature/legislation/habitatsdirective (accessed: April 30, 2011).

***. IUCN 2011. http://iucn.org/ (accessed: April 30, 2011).

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RELATIONSHIP OF SAZANI AND IONIAN ZONES BASED ON BIOSTRATIGRAPHICAL DATA AND TECTONIC FACTS

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Abstract. Karaburun-Sazan-Zvernec region is a part of a tectonic area with very intensive activity due to the collision of two tectonic zones, Ionian and Apulia (Sazani). New geological data obtained in seismic exploration and well drilling in the Albanian offshore are giving a much better explanation about the relationships between Sazani and Ionian zones. The identified micropaleontologic associations from studied areas indicate deposits from Middle Eocene-Upper Eocene to Lower Oligocene-Upper Oligocene and in this paper a special attention is accorded to Oligocene carbonate section belonging to Sazani Zone. The Sazani Zone is represented by two tectonic blocks with different orientations: a northern block dipping to east and a southern block dipping towards the west where the Oligocene carbonate deposits are emerging.

Keywords: Microfacies, Sazani Zone, Apulia Platform, transversal fault, monocline, structures, biostratigraphical data.

Rezumat. Relaţia dintre zonele Sazani şi Ionică pe baza datelor biostratigrafice şi a dovezilor tectonice. Karaburun-Sazan-Zvernec este o regiune caracterizată de o activitate tectonică foarte intensă ca urmare a coliziunii a două zone structurale, Ionică şi Apulia (Sazani). Date geologice noi obţinute în explorare seismică şi de foraj în largul coastelor albaneze oferă o mult mai bună explicaţie cu privire la relaţiile existente între zonele structurale Sazani şi Ionică. Asociaţiile micropaleontologice identificate depozitele carbonatice din zonele studiate indică depozite de varstă Eocen mediu-Eocen superior Eocen şi Oligocen inferior-Oligocen superior. În această lucrare, o atenţie specială este acordată depozitelor carbonatice oligocene aparţinând zonei Sazani. Această zonă este reprezentată de două blocuri tectonice, cu orientări diferite, un bloc nordic scufundat spre est şi unul sudic-scufundat spre vest, unde depozitele de carbonatice oligocene au fost emerse.

Cuvinte cheie: microfacies, zona Sazani, platforma Apulia, falie transversală, monoclin, structuri, date biostratigrafice.

INTRODUCTION

Sazani Zone is the westernmost geological zone in Albania and extends parallel to the Preapulian or Paxos Zone of Hellenides (Greece) and at east to Apulian Platform (Italy) and is formed by two main structures: the anticlinal structure of Sazani-Karaburni and the monocline of Mali e Kanali (Kanali Mountain). A general feature of Sazani Zone is the predominance of an oppressive and intense overthrust tectonics in transversal direction from east to west and a total dipping of all structural lines toward the northeast. The Ionian Zone is an adjacent zone, occupying a large part in Albania, exceeding other external zones in the area and is characterized by a series of anticlines and synclines belt parallel and sub-parallel through almost the entire length of the zone in a sub-meridional position.

The relationship between Sazani and Ionian zones has been subject of many geological, geophysical and paleontological studies focusing on identifying the unconformities in carbonate deposits.

Issues that need clarification are: setting the unconformity of Burdigalian sediments on the Late Cretaceous carbonate sediments (Sazani-1/s, Zverneci-3, Falcon-1, A4-1X well); the placement of Serravalian deposits on those of the Late Cretaceous (A4-2X well); the placement of Messinian deposits on those of Burdigalian (A4-1X well); the placement of Tortonian deposits on those Burdigalan (Falcon-1 well); the placement of Pliocene deposits with unconformity in almost all land-sea region (MEZINI *et al.*, 2001).

These facts are closely related to the tectonic development of the region and show that this development has been the effect of gradual and sudden impulses that led to the phenomena described above and to the relationship between Sazani Zone and Ionian Zone. All tectonics phases have controlled the sediment distribution in the basin. During the cycle of sedimentation, in Sazani Zone, the transgression phase begins with the Oligocene deposits represented by thick-bedding massive brecciated limestones and becomes more intense in Burdigalian, which is represented by interbeddings of marly and terrigenous deposits. These deposits are present almost anywhere in the area of the platform slope and lie discordantly on the carbonate deposits. During the Late Miocene, the regressive phase is marked by the end of sedimentation of the evaporate formation. Then, the Pliocene transgression phase covers the entire northern part of the region.

Geological setting of Sazani Zone

In the framework of the External Albanides, the Sazani Zone outcrops in southwestern part and includes Sazani Island, Karaburuni Peninsula and Kanali Mountain (Mali Kanalit). This zone refers to two monoclines separated from each other by a longitudinal fault (FILI & XHAFA, 1982).

The principal extension of this zone in the Albanian (Ionian and Adriatic) offshore is completely covered by molassic Miocene-Pliocene deposits. This zone represents an eastern continuation of the Apulia platform (part of the Adriatic plate).

The different geological studies regarding the Sazani Zone have demonstrated the existence of a typical neritic platform at least since Late Triassic until Oligocene (BRAHIMI *et al.*, 1992; SOTA *et al.*, 1980).

Surface geological observations show that the Burdigalian deposits (*Globigerinoides bisphaericus* Zone) lays transgressively over the Karaburuni carbonate ("Rrëza" Channel, "Shën Jani" Bay, and "Sazani" Island, Fig. 1) deposits. This phenomenon shows an older folding phase of Apulia Zone and also the later folding phase of Çika belt anticline (Western part of Ionian Zone).

In surface, the Sazani eastern border serves as overthrusting tectonic contact with the Ionian zone, which is very evident in Dukati "Qafa e Llogarase" region up to Palasa (Fig. 1) (XHOMO *et al.*, 2002).

Eastward, it dips under the Ionian Sea and extends up to the north of Corfu, where it is deviated nearly 25-35 km westward. This deviation probably has been caused by the rifting phase through a transversal fault, putting in front of each other completely different facies.

The two structures, which are well distinguished on land mainly, consist of Early Cretaceous-Late Cretaceous carbonate deposits and very rare Paleogene ones. In the Sazani-Karaburni, the eastern flanks weakly dip at 20-40 degrees and are overridden on the Apulian platform, while the flank of Mali Kanalit monocline dips at angles between 30 to 50 degrees.

The passage of these deposits from the east to the west dipping is done through a transversal passing sinistral sideways displacement with a north-northwest to east-southeast strike developed.

Stratigraphy

The stratigraphy of this zone was treated in different studies and papers. The principal aim of this study is to present new data on the stratigraphy of Paleogene and especially Oligocene deposits. The geological and micropaleontological data are very representative in the regions where these deposits are fair cropping out (BRAHIMI *et al.*, 1992).

Based on the mapping data of these zones, it is noticed that the extension of the Paleogene deposits is along the western slope of Kanali Mountain up to Arusha Bay, at Gjuza Cape and Rreza Channel. It is important to specify that the Paleogene section in all mentioned above regions is incomplete. According to the stratigraphical data (BRAHIMI & SADUSHI, 1993), the oldest Paleogene deposits outcropping there belong to Middle Eocene, which is successively followed by the Upper Oligocene deposits (SOTA *et al.*, 1980).

Our aim consists in clearing up the time of the arrival of detritic sedimentation in Sazani Zone. The outcrop of Gjuheza Cape, situated in the northeastern extreme edge of Karaburuni Peninsula (Fig. 1), is the single outcrop where the oldest terrigenous can be observed (Plate IV, Photo 17).

Middle Eocene-Upper Eocene

The Middle-Upper Eocene deposits are laying unconformably on the Maastrichtian deposits (Fig. 1). At the base of these deposits, a conglo-breccia layer of about 2-3 m thick is present. It is constituted of angular and sub angular pebbles and boulders with different sizes reaching about 5-6 cm up to 0.5 m. In some cases, the boulders reach the size of 0.5÷2 m and are not all rounded. There are blocks deposited in place. In many outcrops, the Eocene carbonate section seems to be as a very rough breccious mass, mainly represented by micritic limestones, dolomitic limestones and rarely by bioclastic limestones.

Generally, the section consists of thick-bedded wackestones and mudstones. The rock fragments are about of 1 mm in size and only in some cases, there are bigger blocks, reflecting in this way a great irregularity during the depositional time. The most frequent fauna present in these deposits is represented by *Discocyclina nummulitica* GUMBEL, *Chapmanina gassinensis* SILVESTRI, *Melobesioidea*, *Alveolina fusiformis* SOWERBY, *Nummulites* sp. Besides them, corals are reported as well. The thickness of deposits reaches up to 130-170 cm.

Oligocene

The Oligocene is represented by Lower Oligocene-Upper Oligocene deposits exposed in "Rreza e Kanalit" and in some restricted areas in "Gjuhza Cape" region.

Lower Oligocene

The Lower Oligocene deposits are present only in the southernmost extreme of Karaburuni monocline (Rreza e Kanalit) and are exposed in a tectonic block in contact with the Upper Cretaceous deposits (Fig. 1). They are cavernous rocks without any stratification, represented by limestones of beige colour of wackstone type. The limestone fragments show different composition and sizes up to 2-3cm. The microfaunal assemblage refers to *Lepidocyclina* (*Nephrolepidina* sp.), *Lepidocyclina* (*Eulepidina* sp.), *Spiroclypeus* sp., *Amphistegina* sp., *Austrotrillina* sp., *Microcodium elegans* GLUECK and *Subterraniphyllum thomasi* ELLIOT, confirming Lower Oligocene age (Plate I, Photos 3-6. Plate II, Photos 7-12. Plate III, Photo 13).

Upper Oligocene

These deposits are present on restricted area only at Gjuza Cape and are lying unconformably on the Middle-Upper Eocene deposits where an evident angular unconformity is also visible.

The base of Upper Oligocene deposits is characterized by a conglo-breccious layer of 0.5-1.0 m thick. The constituent clasts are semi-rounded and cemented by a marly-carbonate mass of grey-yellow colour. Toward the top, the section becomes more clayey and is interbedding with some breccious limestone layers, whose thickness increases gradually upward (Plate IV, Photos 18, 19, 20). In all the previous works, these deposits had been considered to be Aquitanian (SOTA 1980). The micropaleontological analyses (microfauna and especially calcareous nannofossils) performed recently in the terrigenous section samples and cementing material of the lowermost bed, show the presence

of *Globigerina gr. ciperoensis, G. trilocularis, G. venezueliana, Globorotalia kugleri* BOLLI, *Globorotalia pseudokugleri* Blow, *G. opima nana, Globigerinoides* sp., *Miogypsinoides* sp., *Sphenolithus ciperoensis* BRAMLETTE & WILCOXON , *S. conicus, S. moriformis, C. eopelagicus, H. euphratis, T. carinatus, P.hermosus, P. ovat, E. fenestrata*, etc., confirming the Late Oligocene.

The other part of the following terrigenous section consists of micritic limestones and conglo-breccias layers belonging to the Chattian-Aquitanian up to Burdigalian (*Globigerinoides trilobus* subzone, Plate III, Photos 14, 15, 16). The presence of *Globigerinoides trilobus* in the upper part of the terrigenous section should be carefully interpreted due to the presence of some Quaternary deposits above.

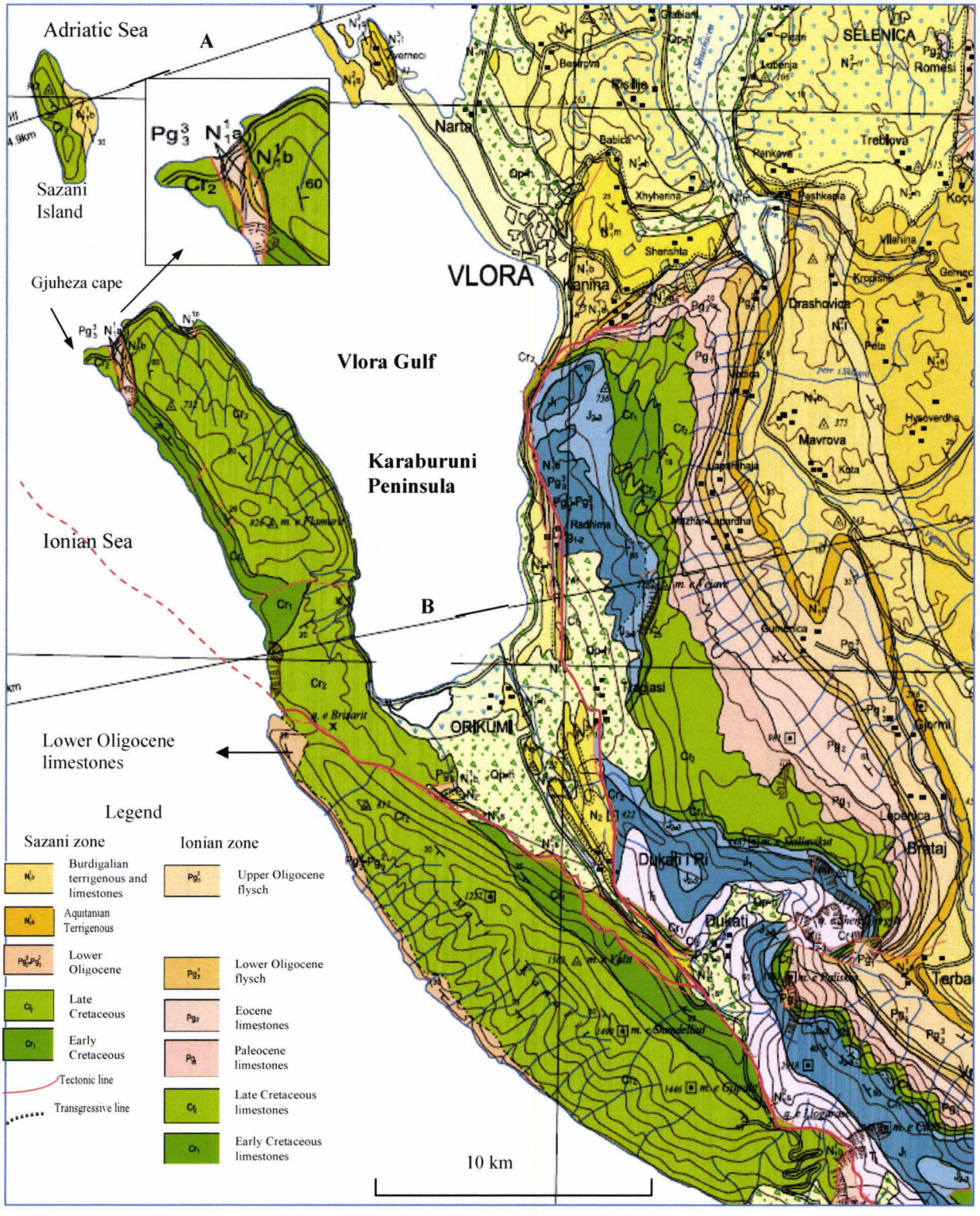

Figure 1. Geological map of Karaburuni-Vlora region (based on geological map of Albania, 1:200.000).
Figura 1. Harta geologică a regiunii Karaburuni-Vlora (după Harta geologică a Albaniei, 1:200.000).

Based on the geological and micropaleontological data it is fully confirmed that the terrigenous cycle in the Sazani Zone begun with the Upper Oligocene subduction. The same situation was also evidenced even in a long distance from Sazani Zone, in northwest (MEZINI *et al.*, 2001). These results show that this zone should be included in a transitory zone in comparison with the Apulia platform or Paxos Zone, where the carbonate deposits are considered to be of Aquitanian or Burdigalian age.

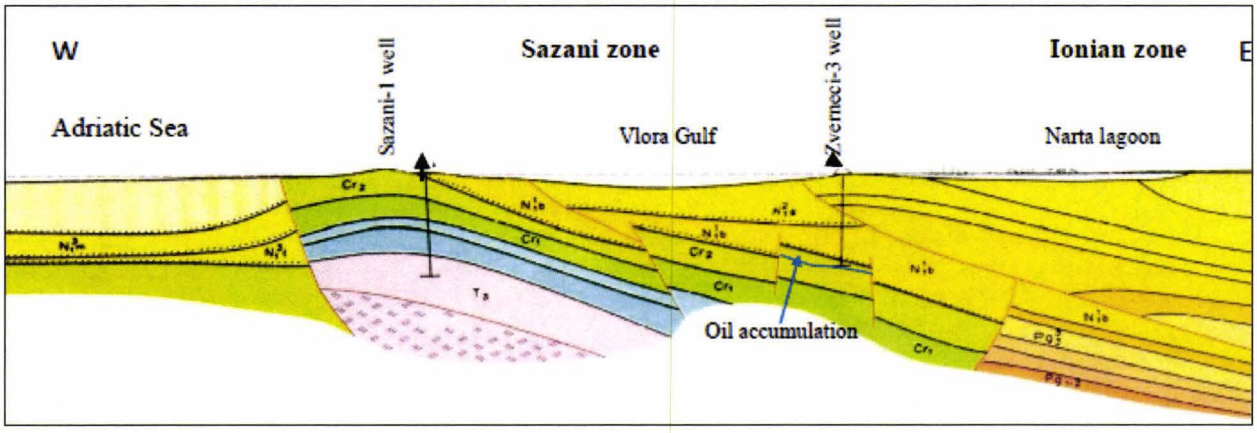

Figure 2. Geological section "A", between Sazani-1 and Zverneci-3 wells (Geological map of Albania, 1:200,000).
Figura 2. Profil geologic între Sazani 1 şi Zverneci 3 (Harta geologică a Albaniei, 1:200.000).

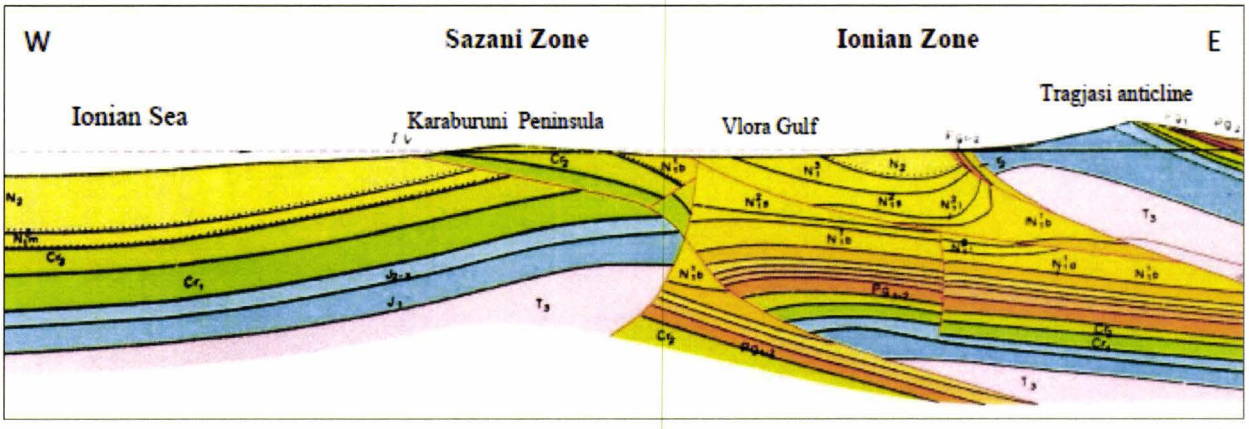

Figure 3. Geological section "B" on southern part of Vlora Gulf (Geological map of Albania, 1:200,000).
Figura 3. Profil geologic al părtii sudice a golfului Vlora (Harta geologică a Albaniei, 1:200.000).

Tectonic and basin geodynamic

The Sazani Zone was underthrusted during the compressional phases taking place especially in Upper Cretaceous-Early Paleogene. This zone situated between the Apulia platform (represented by deposits of nearly horizontal dipping) and the orogene of the eastern zones underwent a fracturing of the deposits (Figs. 2 and 3).

Karaburun-Sazan-Zvernec region is included in a tectonic area with a very intensive activity due to the collision of two tectonic zones: Ionian and Apulia (Sazani). The eastern part of the region (Vlora) belongs to the Ionian zone while its western edge is represented by Sazani (Apulia) tectonic zone. The lithofacies features and the tectonic style vary from one area to another or from east to west. In Vlora region limestones have been found covered by a thick Oligocene flysch (Pg3). In the Zverneci-3well is confirmed the transgressively placement of Burdigalian sediments (N_1 b) on the eroded limestone of the Late Cretaceous. This fact indicates a different tectonic regime (between the two tectonic zones). The Sazani Zone has been emerged above the sea level and eroded, while the eastern part has been submerged below sea level and where the sedimentary rocks of Oligocene, Aquitanian and Burdigalian have been settled.

From Late Cretaceous to Burdigalian, the region had the appearance of a monocline, which retreated from the west to the east. Moving from east to west, this monocline was gradually covered by younger deposits from Oligocene (Vlore), Aquitanian and Burdigalian. Taking into account these data, the region represents the area of platform-slope transition in the Ionian zone (Fig. 4).

The Karaburuni peninsula appears as a regional backthrust over the transition zone from the platform to slope-basin.

South of Vlora, it is visible the development of a triangular zone, where the Dukati syncline (Ionian zone) is entirely covered from the Karaburuni backthrust and Cika overthrust. This backthrust starts from Eastern side of the Sazani Island and continues toward the South.

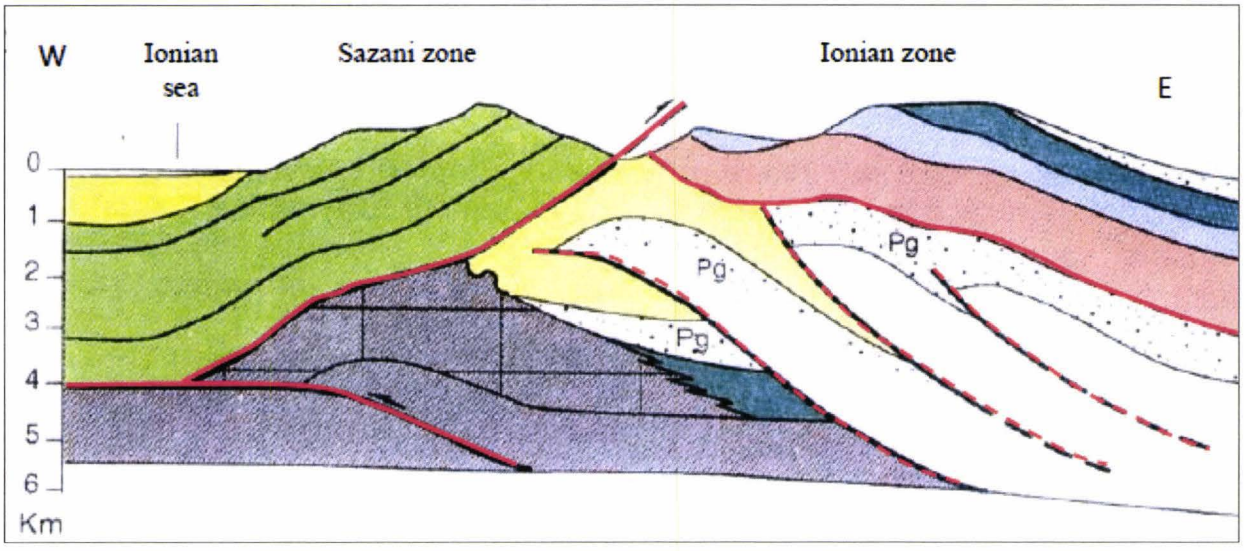

Figure 4. Geological section - the contact between Sazani and Ionian zones (Geological map of Albania, 1:200,000).
Figura 4. Secţiune geologică - contactul dintre zonele Sazani şi Ionică (Harta geologică a Albaniei, 1:200.000).

The central part of the region from Dukati towards the north to Narta represents the deepest part of the syncline separating the transverse anticline of Vlora by raising the Karaburuni unit. The general feature of Sazani Zone is the predominance of a strong onlap in transversal direction from east to west and the total dipping of all structural lines toward the northeast (FILI & XHAFA, 1982)

The eastern part of the Sazani Island and Karaburuni Peninsula (northern part, block I) represents a monocline which dips to east, tectonically complicated with transverse and longitudinal shifts.

In all transverse seismic profiles it is clearly shown the eastern side of Sazani dipping to 30^0-35^0 degrees, which close to Zverneci slowly becomes nearly horizontal or creates a sharped block.

Based on the regional seismic lines in the Albanian offshore it was outlined the orogenic front of the External Albanides. In the Albanian onshore, this front continues between the Karaburuni and Kanali mountains and to southern part to Llogara, outcropping as a "pop up" structure.

If during the structural balancing Sazani Island and Karaburuni peninsula were displaced toward SSW, after the displacement, these structures have formed an anticlinal structure because the Kanali Mountain has western dipping (~70° W), while Karaburuni Peninsula and Sazani Island have eastern dipping (~30° E), (MEZINI *et al.*, 2001).

The reservoir qualities of these rocks are adequate for the hydrocarbons. The problem consists in finding the stratigraphical type of the traps in these deposits, sealed by a certain sedimentary cover presence.

CONCLUSIONS

The deposits participating to the geological architecture of the region have been studied from data of complex geological studies where the main role is played by the micropaleontological studies.

The oldest deposits are those of Late Triassic-Early Jurassic (T3-J1), while the carbonate deposits are Oligocene.

The micropaleontological studies show microfauna from Eocene, Upper Eocene-Lower Oligocene and Upper Oligocene. In Sazani Zone, the Zverneci-3 well drilled about 730m depth in limestones shows a sedimentary succession starting from the Late Cretaceous (Cr2), Early Cretaceous (Cr1) and stopping in the Upper Jurassic deposits (J_3, Tithonian) this order being peculiar for drilling data.

Tectonically, the Sazani Zone is represented by two tectonic blocks with different orientations: the northern block dips to east, while the southern one dips towards the west and where Oligocenene carbonate deposits are emerging. The relationship between these two blocks is tectonic.

REFERENCES

BRAHIMI Q., SADUSHI P., KOLA A., KANANI J., DODONA E., PIRDENI A., MYFTARI A. 1992. *Stratigrafia e depozitimeve karbonatike ne brezin antiklinal te Çikes dhe zonen e Sazanit nga Trasiku i siperm deri ne Eocen.* Archive of National Agency of Natural Resources. Fier: 82-98.

BRAHIMI Q. & SADUSHI P. 1993. *Zonimi biostratigrafik i Oligocenit te poshtem deri ne Burdigalian sipas studimit mikrofacial.* In: Albanian oil magazine. Fier. **3**: 33-47.

FILI I. & XHAFA Z. 1982. *Tektonika e Albanideve te Jashtme.* Archive of National Agency of Natural Resources. Fier: 26-39.

MEZINI A., FEJZULLAU F., GJONI K., TAHIRI XH., PRIFTI I., HASANI L., TRIFONI E. 2001. *Pergjithesimi kompleks gjeologo - gjeofizik i rajonit Vlore - Zvernec pas kryerjes se punimeve sizmike nga kompani te huaja.* Archive of National Agency of Natural Resources. Fier: 35-52.

SOTA T., GORA H., BEDINI L. 1980. *Ndertimi gjeologjik dhe perspektiva naftegazmbajtese e rajonit Karaburun.* Archive of National Agency of Natural Resources. Fier: 17-28.

XHOMO A., DIMO LL., XHAFA, NAZAJ SH., NAKUCI V., YZEIRAJ D., LULA F., SADUSHI P., SHALLO M., VRANAJ A., MELO V., KODRA A., BAKALLI F., MECO S. 2002. *Gjeologjia e Shqiperise, Stratigrafia, Magmatizmi, Metamorfizmi, Tektonika dhe Evolucioni Paleogjeografik dhe Gjeodinamik (Geology of Albania ,text of geological mapo f Albania), scale 1:200 000).* Archive of National Agency of Natural Resources. Fier: 147, 170-171, 185.

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PLATE I / PLANŞA I

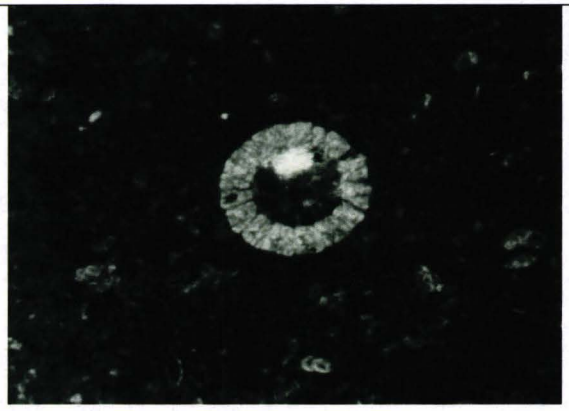

Photo 1. Mudstone with Characeae and Discorbidae (X60), Late Cretaceous, "Mali Kanalit" block. / Foto 1. Calcar micritic cu Characeae şi Discorbidae (X60), Cretacic superior, blocul "Mali Kanalit" (original).

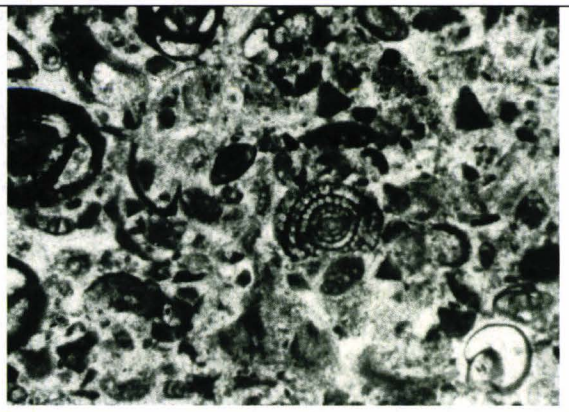

Photo 2. Packstone with *Borelis* sp., *Austrotrillina* sp. And Miliolidae (X20), Upper Eocene-Lower Oligocene, "Reza e Kanalit" block. / Foto 2. Packestone cu *Borelis* sp., *Austrotrillina* sp. and Miliolidae (X20). Eocen superior-Oligocen inferior, blocul "Reza e Kanalit" (original).

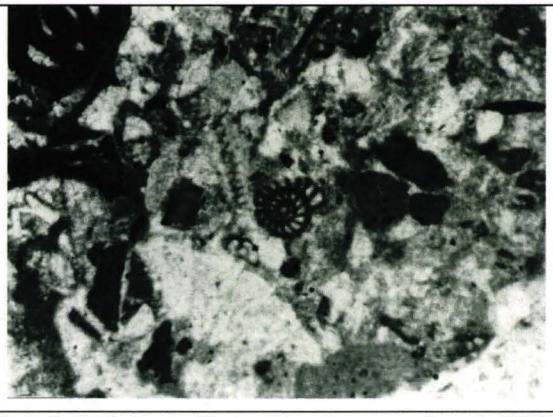

Photo 3. Packstone with *Amphistegina* sp. and corals (X60), Lower Oligocene, "Reza e Kanalit" block. / Foto 3. Packestone cu *Amphistegina* sp. şi corali (X60), Oligocen inferior, blocul "Reza e Kanalit" (original).

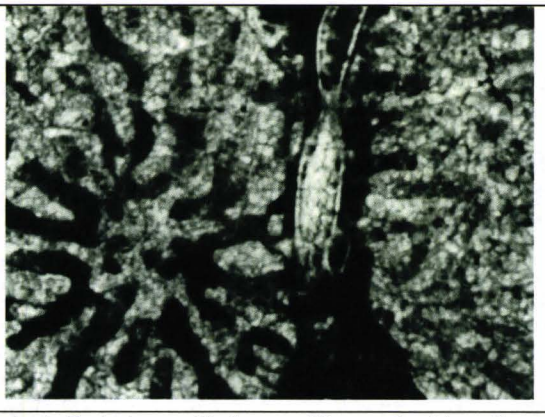

Photo 4. Grainstone with *Austrotrillina* sp, *Lepidocyclina* sp. and *Pseudocyclamina sphaeroidea* (resedimented) (X60), Lower Oligocene, "Reza e Kanalit" block. / Foto 4. Gresie cu *Austrotrillina* sp., *Lepidocyclina* sp. şi *Pseudocyclamina sphaeroidea* (resedimentate) (X60). Oligocen inferior, blocul "Reza e Kanalit" (original).

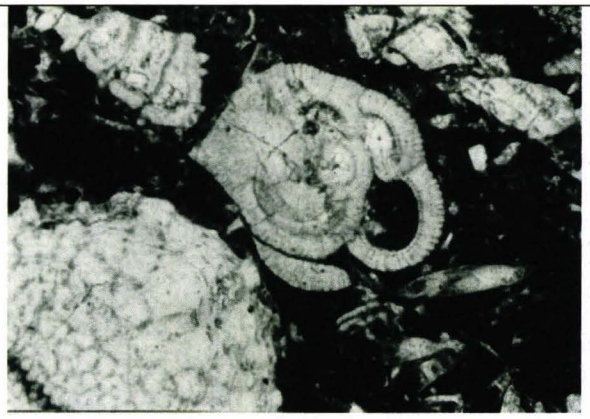

Photo 5. Packstone with *Victoriella* sp. and *Lepidocyclina* sp. (X20), Lower Oligocene, "Reza e Kanalit" block. / Foto 5. Packestone cu *Victoriella* sp. and *Lepidocyclina* sp. (X20), Oligocen inferior, Blocul "Reza e Kanalit" (original).

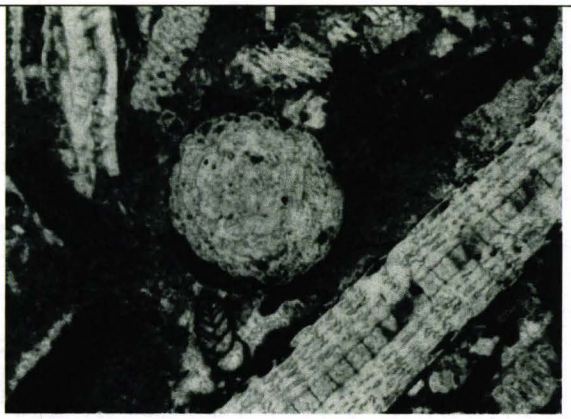

Photo 6. Packstone with *Phaerogypsina* sp., *Lepidocyclina* sp. and Textularidae (X20), Lower Oligocene, "Reza e Kanalit" block. / Foto 6. Packestone cu *Phaerogypsina* sp., *Lepidocyclina* sp. şi Textularidae (X20),Oligocen inferior, blocul "Reza e Kanalit" (original).

PLATE II / PLANŞA II

Photo 7. Packstone with Peneroplidae (X20) Lower Oligocene, "Reza e Kanalit" block. / Foto 7. Packstone cu Peneroplidae (X20) Oligocen inferior, blocul "Reza e Kanalit" (original).

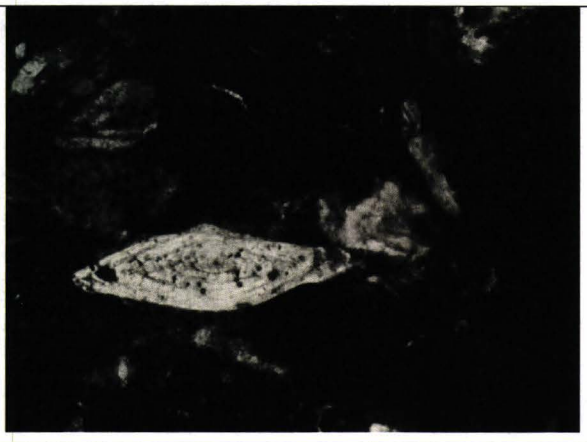

Photo 8. Packstone with *Amphistegina* sp. and *Lepidocyclina* sp. (X40) Lower Oligocene, Gjuza Cape. / Foto 8. Packstone *Amphistegina* sp. şi *Lepidocyclina* sp. (X40) Oligocen inferior, Gjuza Cape (original).

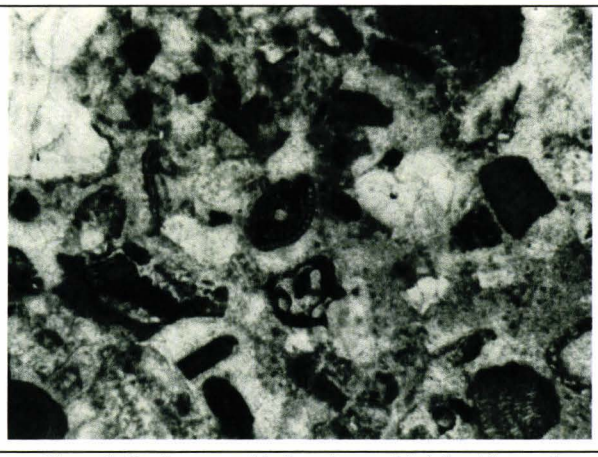

Photo 9. Packstone with *Borelis* sp., Melobesidae and *Subteranyphyllum thomasi* ELLIOT (X40), Lower Oligocene, "Reza e Kanalit" block. / Foto 9. Packstone cu *Borelis* sp., Melobesidae şi *Subteranyphyllum thomasi* ELLIOT (X40), Oligocen inferior, blocul "Reza e Kanalit" (original).

Photo 10. Packstone with *Eulepidina* sp. (X40), Upper Oligocene, Gjuza Cape. / Foto 10. Packstone cu *Eulepidina* sp. (X40), Oligocen inferior, Gjuza Cape (original).

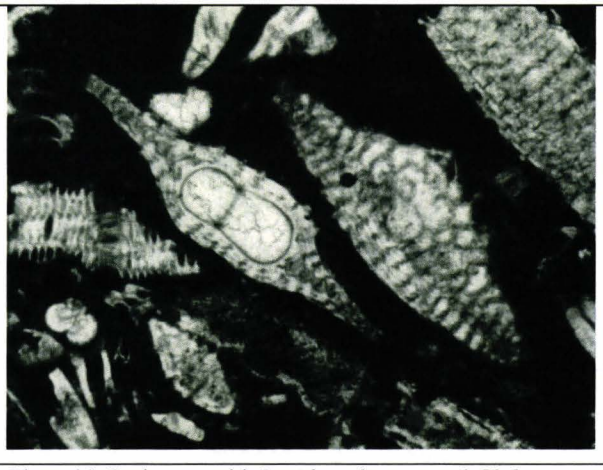

Photo 11. Packstone with *Lepidocyclina* sp. and *Globigerina* (X60), Lower Oligocene, "Reza e Kanalit' block. / Foto 11. Packstone cu *Lepidocyclina* sp. şi *Globigerina* (X60), Oligocen inferior, blocul "Reza e Kanalit" (original).

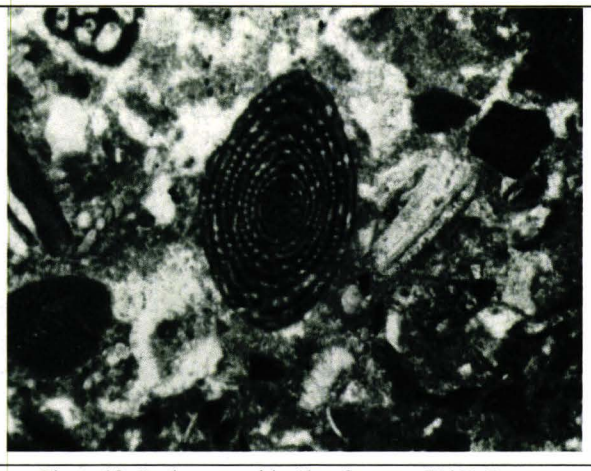

Photo 12. Packstone with *Alveolina* sp. (X40), Lower Oligocene, "Reza e Kanalit' block. / Foto 12. Packstone cu *Alveolina* sp. (X40), Oligocen inferior, blocul "Reza e Kanalit (original).

PLATE III / PLANŞA III

Photo 13. Bioclastic mudstone with *Pararotalia* sp., *Heterostegina* sp., *Amphistegina* sp. and Melobesidae (X60) Lower Oligocene "Reza e Kanalit" block. / Foto 13. Calcar micritic bioclastic cu *Pararotalia* sp., *Heterostegina* sp., *Amphistegina* sp. şi Melobesidae (X60), Oligocen inferior, blocul "Reza e Kanalit" (original).

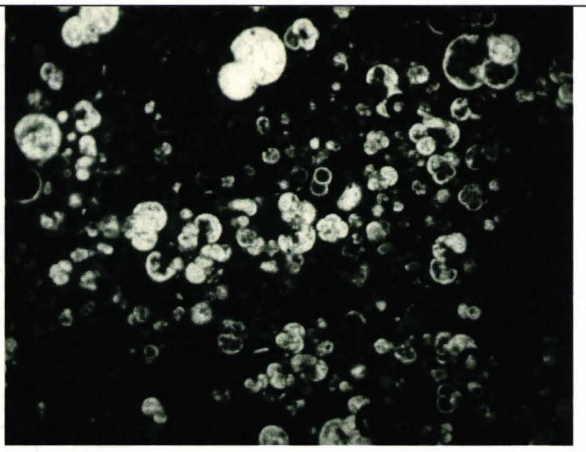

Photo 14. Marls with *Globigerinoides trilobus* REUSS, *Globigerinoides* sp. and Globigerinidae (X60), Burdigalian, Llogara. / Foto 14. Marne cu *Globigerinoides trilobus* REUSS, *Globigerinoides* sp. şi Globigerinidae (60X), Burdigalian, Llogara (original).

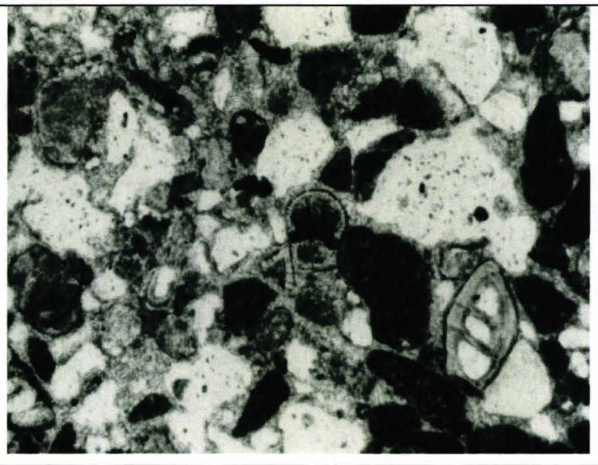

Photo 15. Grainstone with *Globigerinoides trilobus* REUSS, *Globigerinoides* (X40), Burdigalian, Gjuza Cape. / Foto 15. Gresie cu *Globigerinoides trilobus* REUSS, *Globigerinoides* (X40), Burdigalian, Gjuza Cape (original).

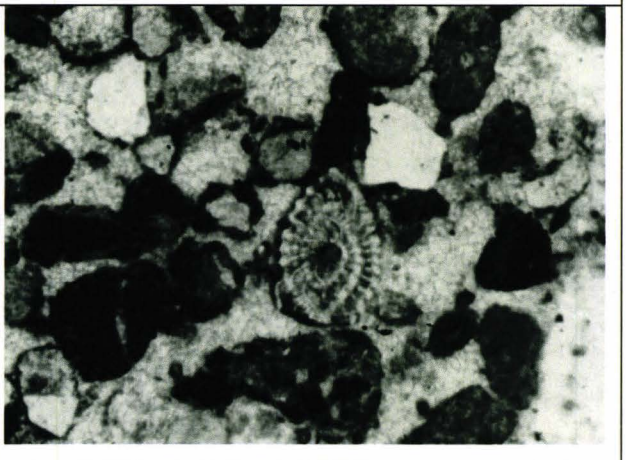

Photo 16. Sandstone with *Elphidium* sp. (X40), Burdigalian, Gjuza Cape. / Foto 16. Gresie cu *Elphidium* sp. (X40), Burdigalian, Gjuza Cape (original).

PLATE IV / PLANŞA IV

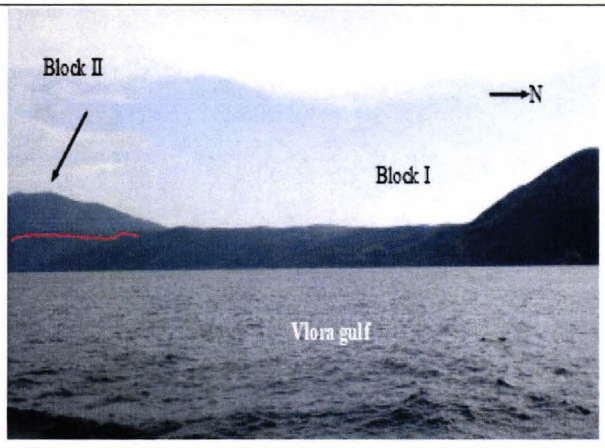

Photo 17. Two blocks of Sazani Zone placed on Karaburuni Peninsula - eastern side. / Foto 17. Peninsula Karaburuni – Două blocuri aparţinând zonei Sazani - partea estică (original).

Photo 18. Late Cretaceous limestones - Gjuza Cape. / Foto 18. Calcare Cretacic superioare - Gjuza Cape (original).

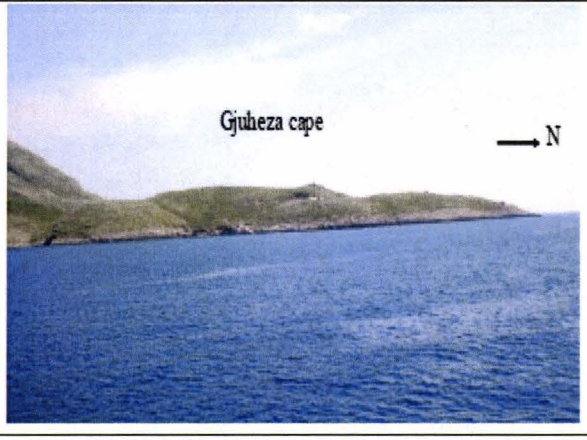

Photo 19. Early Cretaceous-Late Cretaceous bioclastic mudstones from "Mali e Kanalit" - western side. / Foto 19. Calcare aparţinând Cretacicului inferior - Cretacic superior - Mali e Kanalit - partea vestică (original).

Photo 20. Lower Oligocene bioclastic mudstonepackestones eroded by the waves of Ionian Sea. / Foto 20. Calcar micritic -packestone bioclastice Oligocen inferioare erodate de apele marii Ioniene (original).

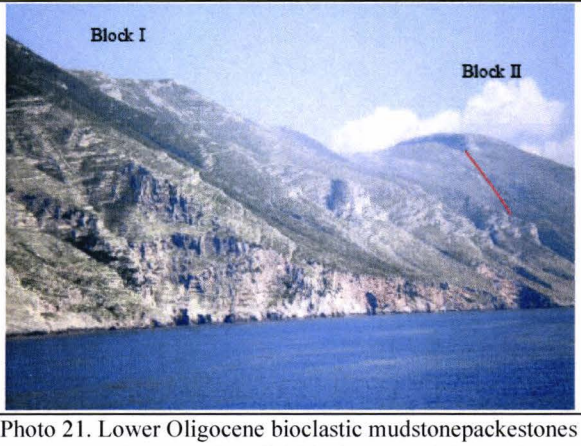

Photo 21. Lower Oligocene bioclastic mudstonepackestones to west of "Reza e Kanalit" block - toward the north. / Foto 21. Calcar micritic-packestone bioclastice Oligocen inferioare la vest de blocul "Reza e Kanalit" - vedere spre nord (original).

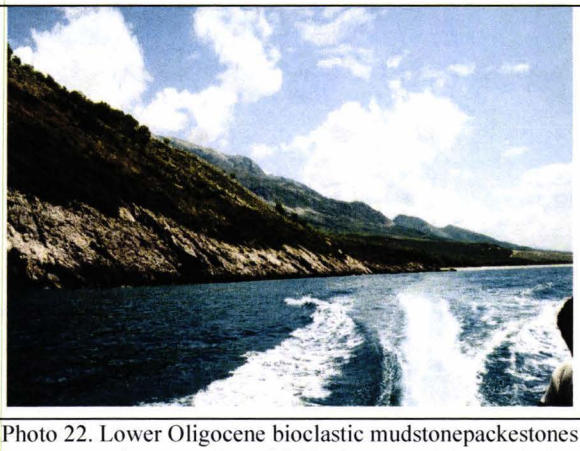

Photo 22. Lower Oligocene bioclastic mudstonepackestones to west of "Reza e Kanalit" block - toward the south. / Foto 22. Calcar micritic-packestone bioclastice Oligocen inferioare la vest de blocul "Reza e Kanalit" - vedere spre sud (original).

MAASTRICHTIAN CONTINENTAL GASTROPODS FROM FĂRCĂDEANA (RUSCA MONTANĂ BASIN, ROMANIA)

VASILE Ştefan, CSIKI-SAVA Zoltán

Abstract. The Maastrichtian deposits are widespread in the Rusca Montană Basin, and yielded paleofloristic, palynological and vertebrate assemblages similar to those of the neighbouring Haţeg Basin. Although gastropods were mentioned from this area, they were only noted as co-occurrences of palynomorphs or vertebrates. This paper describes the freshwater and terrestrial gastropods recovered from the gray-blue mudstones of the Fărcădeana site. The gastropod assemblage includes representatives of Lymnaeidae, Planorbidae, Physidae, Bithyniidae and Cyclophoridae, again, all taxa being common to those previously mentioned from the coeval deposits of Haţeg Basin. The ecological preferences of the described taxa suggest that the deposits containing them accumulated in a poorly-drained floodplain or pond environment, supporting previous conclusions based on sedimentology and composition of the vertebrate assemblage.

Keywords: Pulmonata, microgastropods, Late Cretaceous.

Rezumat. Gastropode continentale maastrichtiene de la Fărcădeana (Bazinul Rusca Montană, România). Depozitele maastrichtiene au o răspândire largă în Bazinul Rusca Montană şi au furnizat asociaţii paleofloristice, palinologice şi de vertebrate similare celor din Bazinul Haţeg, situat în vecinătate. Deşi gastropodele au mai fost menţionate din această zonă, ele au fost doar notate ca ocurenţe alături de palinomorfe sau de vertebrate. Această lucrare descrie gastropodele dulcicole şi pe cele terestre recuperate din siltitele cenuşiu-albăstrui ale sitului Fărcădeana. Asociaţia de gastropode include reprezentanţi ai familiilor Lymnaeidae, Planorbidae, Physidae, Bithyniidae şi Cyclophoridae, toţi taxonii fiind comuni cu cei menţionaţi anterior din depozitele sincrone ale Bazinului Haţeg. Preferinţele ecologice ale taxonilor descrişi sugerează că depozitele care îi conţin s-au acumulat într-un mediu de câmpie inundabilă slab drenată sau de baltă, susţinând concluziile bazate pe sedimentologie şi pe compoziţia asociaţiei de vertebrate.

Cuvinte cheie: Pulmonata, microgastropode, Cretacicul târziu.

INTRODUCTION

The Rusca Montană Basin is an elongated intramountainous depression, located in the northwestern part of the Southern Carpathians, south of the Rusca Montană Massif and north of the Bistra Valley. It evolved as an active sedimentation area beginning with the Middle Jurassic, when marine sediments, today cropping out mostly in the western part of the basin, accumulated until the Campanian, with a short continental episode during the Albian, when the area was emerged, allowing the accumulation of bauxites (DINCĂ, 1977; BUCUR *et al.*, 1983). The overlying Maastrichtian strata make up the thickest and the widest spread lithostratigraphic units of the basin, and are represented by continental deposits, occurring under two different lithofacies: a coarse, unfossiliferous, stratigraphically lower unit, which crops out west of the Rusca Valley, and an upper unit consisting of detritic-volcaniclastic deposits that dominates the area east of the Rusca Valley (Fig. 1) (DINCĂ, 1977; GRIGORESCU, 1990, 1992). The age of the latter unit was estimated based on palynological data, the recognized palynomorphs belonging to the *Pseudopapilopollis praesubhercynicus* zone (BALTEŞ, 1966; ANTONESCU *et al.*, 1983). The deposits of this unnamed upper unit yielded a diverse compressive flora, including monocots (several species of *Pandanus*, "*Palmophyllum*" *longirachis*) and subtropical dicots (*Ficus, Credneria, Platanus, Myrtophyllum, Lindera*), as well as rare ferns (*Asplenium, Gleichenia*) (e. g. TUZSON, 1913; GIVULESCU 1966, 1968; PETRESCU & DUŞA, 1985), associated with a few thin coal beds (see DUŞA, 1987, for a review). The first Maastrichtian vertebrate remains in the region were reported by CODREA *et al.* (2009) from red, fine-grained overbank deposits and gray channel sandstones cropping out in the eastern part of the basin, and include chelonians, crocodylians, sauropods, ornithopods, theropods and multituberculates (for details see FEIGI *et al.*, 2010; CODREA *et al.*, 2012). VASILE & CSIKI (2011) described a microvertebrate assemblage from the Fărcădeana site, in the area of Negoiu village, containing anuran, albanerpetontid, crocodylian, lacertilian and theropod remains, as well as eggshell fragments.

The first to note the existence of gastropods in the coal-bearing deposits from Rusca Montană was BALTEŞ (1966), who recorded their presence, but without giving any taxonomical details. CODREA *et al.* (2009, 2012) also mentioned the occurrence of rare gastropods in the fine overbank deposits, alongside the vertebrate remains. More information is given by VASILE & CSIKI (2011), documenting the presence of freshwater and terrestrial gastropods including lymnaeids, helicids, planorbids and cyclophorids, but without describing the figured material. Part of that material, as well as other specimens, collected in 2010 and 2011, is described in more detail in this paper.

MATERIAL AND METHODS

Several red- or grey-coloured mudstone beds were sampled from the slopes of Fărcădeana Brook, a tributary of Negoiu Creek, in search of Maastrichtian microvertebrate remains. One of the red mudstone layers only yielded a few gastropod opercula, so it was not sampled any further. Most of the specimens come from the same 2 m thick layer of gray-blue mudstone that produced the fossil microvertebrate remains and fruits described by VASILE & CSIKI (2011).

The gastropod specimens, including fossilized shells, inner moulds, and isolated opercula, were obtained by screen-washing about 500 kilograms of sediment, using 0.71 mm and 2 mm mesh size sieves. The fossil material was sorted from the remaining sediment under a Zeiss-Stemi binocular microscope.

The images used in this paper were taken using a Hitachi S-2600N scanning electron microscope belonging to the Hungarian Natural Sciences Museum in Budapest.

Given the small size of the specimens, the numerical parameters were measured on the pictures, using the ImageJ 1.45s software. Each parameter was measured on all the available specimens, the description of the material including the range of the parameters, followed in brackets by the arithmetic mean of the measurements.

The classification and nomenclature follows that of BOUCHET & ROCROI (2005).

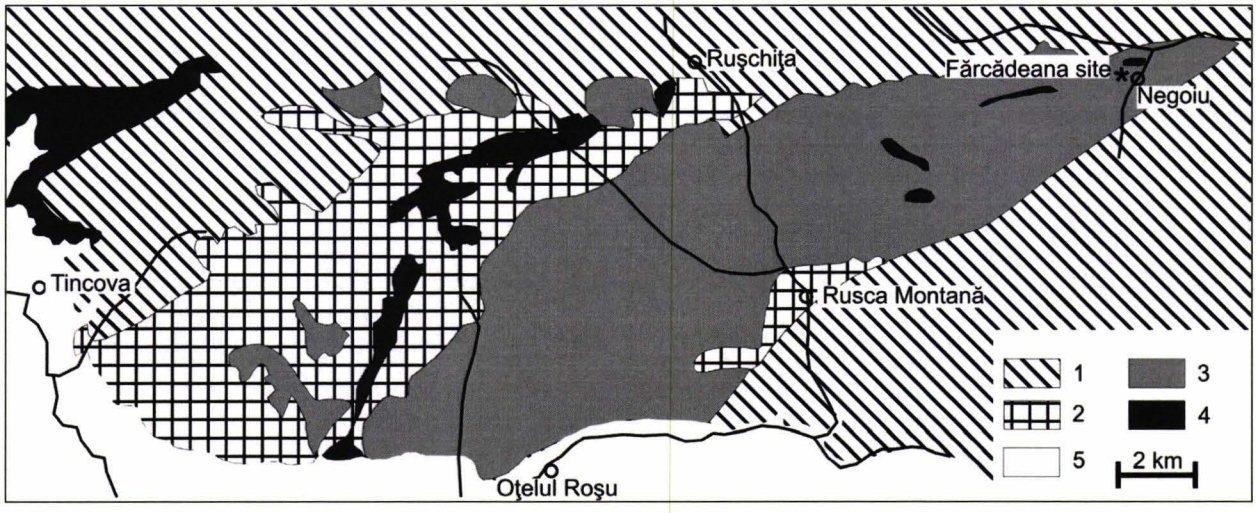

Figure 1. Simplified geological map of the Rusca Montană Basin. 1. Metamorphic units; 2. Pre-Maastrichtian Mesozoic sedimentary deposits; 3. Maastrichtian continental deposits; 4. Volcanic intrusions; 5. Neogene and Quaternary deposits. Limits of units based on STRUTINSKI *et al.* (1983). / Figura 1. Harta geologică simplificată a Bazinului Rusca Montană. 1. Unităţi metamorfice; 2. Depozite sedimentare mezozoice pre-maastrichtiene; 3. Depozite continentale maastrichtiene; 4. Intruziuni vulcanice; 5. Depozite neogene şi cuaternare. Limitele dintre unităţi sunt bazate pe cele indicate de STRUTINSKI *et al.* (1983).

RESULTS AND DISCUSSIONS

Informal group Pulmonata CUVIER 1817
Clade Hygrophila FÉRUSSAC 1822
Superfamily Lymnaeoidea RAFINESQUE 1815
Family Lymnaeidae RAFINESQUE 1815
Lymnaeidae indet. (Fig. 2a)

Material: 1 specimen.

Measurements: shell height (estimated): 1.59 mm; maximum width: 0.998 mm; apical angle: 50°.

Description: Ovate-oblong sinistral shell made of 2.5 rapidly increasing rounded-convex whorls. The apex is rounded. Short spire and inflated last whorl, slightly larger than half of the shell. The suture line is moderately deep, inclining to 18-20° from horizontal. Faint growth lines can be seen in some of the specimens. The aperture area is not preserved, therefore its shape and size could not be estimated. These morphological features are most similar to those reported for the genus *Lymnaea*, with the notable difference that most extant species of this genus have a dextral shell. BAKER (1911) notes, however, that even among the extant American species of *Lymnaea*, there are some that have a dextral shell. Given these information, it is not impossible for the material described above to belong to a sinistral-shelled species of the genus *Lymnaea*.

Paleogeographical distribution: *Lymnaea* is known from the Lower Cretaceous of North America (BAKER, 1911; YEN, 1951), the Albian-Aptian of China (PAN & ZHU, 2007) and the Maastrichtian of France (OPPENHEIM, 1895; FABRE-TAXY, 1969). In Romania, the genus was mentioned from the Maastrichtian continental deposits of the Densuş-Ciula Formation, being represented by two species, *L. dilatata* and *L. maastrichta*, the latter announced as new species (PANĂ *et al.*, 2002), but not yet formally described.

Ecology: Recent lymnaeids inhabit diverse plant-rich water bodies, from transient water pools and oligotrophic swamps, to large lakes or shallow streams, preferring stagnant waters, where they can be found floating at the surface, or in the near-shore area, many times just out of the water (BOWDICH, 1822; ZITTEL, 1887; GROSSU, 1955). Although the lymneids are usually vegetarian, consuming stems of water plant, algae or vegetal detritus, they can switch to a carnivorous and detrivorous diet based on the available food resources, thus feeding on small fish, newts, animal carcasses, insect larvae, other gastropods, or even their own eggs (BAKER, 1911). Recent lymnaeids are the major prey item for some fish, bird or insect species (BAKER, 1911).

Superfamily Planorboidea RAFINESQUE 1815
Family Planorbidae RAFINESQUE 1815
Genus ?*Gyraulus* CHARPENTIER 1837
?*Gyraulus* sp. (Fig. 2b)

Material: 3 specimens.

Measurements: maximum diameter: 2.097-2.958 (2.518) mm.

Description: Plan-spiral dextral shell with 4.5 whorls and sunken spire. Upper side of shell moderately concave and lower side slightly concave. Suture impressed. Surface not ornamented and periphery not carinated. All specimens are damaged, missing the aperture. The size of the spire whorls is increasing gradually, to the contrast with the considerable size increase present at the level of the last whorl, a distinctive character of *Gyraulus* (e.g. MEIER-BROOK, 1983). However, since none of the specimens is complete, lacking the aperture and even fragments from the periphery of the body whorl, the assignment of these specimens to *Gyraulus* is only tentative, a similar morphology occurring in other genera, such as *Bathyomphalus* or *Anisus*. Based on similar material, PANĂ *et al.* (2002) announced a new taxon, *Palaeoanisis septemgiratus*, which was not subsequently formally described.

Paleogeographical distribution: *Gyraulus* was reported from the Lower Cretaceous of Germany (HUCKRIEDE, 1967), China (YANG *et al.*, 1979; PAN & ZHU, 2007) and Japan (ISAJI, 2010), as well as from the Lower? Cretaceous of the United States (YEN, 1951) and the Upper Cretaceous of Mexico (PERRILLIAT *et al.*, 2008), becoming a common occurrence in the Miocene basins of Western Europe and Central Paratethys (e.g. WENZ, 1923, 1942; HERZHAUSER & KOWALKE, 2002; BINDER, 2004; BULIĆ & JURIŠIĆ-POLŠAK, 2009). Recent representatives of the genus are among the most widespread planorbids in the world, occurring in Europe, Asia, Africa, Australia and Tasmania, respectively North America (BAKER, 1945; MEIER-BROOK, 1983).

Planorbidae indet. (Fig. 2c)

Material: 5 specimens (1 shell and 4 inner moulds).

Measurements: maximum diameter: 2.187-3.083 (2.67) mm; shell height: 1.2 mm;

Description: Dextral discoidal shell with 2.5 whorls. Upper side convex because of the slightly raised spire. Lower side convex. Whorls gradually increasing in size from the protoconch to the last whorl, one of the important features in which this taxon differs from *Gyraulus*. The aperture is oval, wider than high. A conspicuous peripheral carina can be seen in the only specimen where the shell is preserved, but this is not visible on the inner moulds.

Paleogeographical distribution: Among the planorbids, the genus *Planorbis* was reported e. g. from the Upper Cretaceous of southern France (ZITTEL, 1887; OPPENHEIM, 1895). In the Cretaceous of Romania *P. planorbis* (LINNAEUS, 1758) was mentioned from the Haţeg Basin (PANĂ *et al.*, 2002).

Ecology: Recent planorbids live near the shores of slow-flowing or stagnant waters, and are rarely found in waters exceeding two meters in depth (BAKER, 1945; GROSSU, 1955). Some small-sized planorbids, such as *Gyraulus*, are abundant in small pools, which sometimes dry out completely. Planorbids prefer vegetal food, while also ingesting small grains of sand, useful in the mechanical digestion of the food (BAKER, 1945). Planorbids are a source of food for many animals that live or feed in water-logged areas, like freshwater fish, water birds, turtles, frogs, newts, leeches, odonate nymphs or crayfish (BAKER, 1945).

Family Physidae FITZINGER 1833
Genus *Physa* DRAPARNAUD 1801
cf. *Physa* sp. (Fig. 2d)

Material: 1 specimen.

Measurements: shell height: 1.63 mm; maximum width: 1.28 mm; spire height: 0.6 mm; height of last whorl: 1.03; apical angle 70.5°.

Description: Oval-shaped sinistral shell with three rounded, slightly convex whorls, separated by deep sutures, rapidly increasing in size. The conical spire is short and it has a rounded-obtuse apex. The last whorl is globular and twice the size of the spire. The inner moulds are ornamented by narrow longitudinal troughs, increasing in number with the size of the whorl they appear on. The aperture is poorly preserved; it appears to have been of a rounded triangular shape. The small size of the recovered specimens suggests they might belong to *P. pygmaea* (NICOLAS, 1890), described from the Cretaceous of Provence. The assignment of the specimen to the genus *Physa* is only tentative, given the large size of the platforms placed at the level of the suture, a feature not common in this genus.

Paleogeographical distribution: Cretaceous *Physa* has been reported from the Aptian-Albian of China (PAN & ZHU, 2007), from the Campanian of Mexico (PERRILLIAT *et al.*, 2008), throughout the Cretaceous of the United States (YEN, 1951; HARTMAN, 1989, 1998) and from the Upper Cretaceous of France (ZITTEL, 1887; OPPENHEIM, 1895; FABRE-TAXY, 1959). In the Cretaceous of Romania, the species *P. patula* is present in the Maastrichtian continental deposits of the Haţeg Basin (at Sânpetru, Tuştea, Fântânele, Budurone) (PANĂ *et al.*, 2002).

Ecology: Recent lymnaeids inhabit stagnant (ponds, lakes, or marshes) or slowly flowing plant-rich waters, usually floating at the water surface (GROSSU, 1945).

Clade Littorinimorpha GOLIKOV & STAROBOGATOV 1975
Superfamily Rissooidea GRAY 1847
Family Bithyniidae GRAY 1857 (syn. Bulimidae GUILDING 1828)
Genus *Gastrobulimus* WENZ 1940
Gastrobulimus sp. (Fig. 2e)

Material: 1 specimen (inner mould).

Measurements: height (save for the missing protoconch): 2.468 mm; maximum width: 1.4 mm; height of spire (save for the protoconch): 0.547 mm; height of the last whorl: 1.92 mm; apical angle: 56°.

Description: Oval-conical dextral shell, slightly inflated, consisting of four whorls. The spire is short, representing about a quarter of the height of the shell. The whorls are separated by deep horizontal suture lines. The last whorl is very high. The aperture area is damaged, but it appears to have been of a laterally compressed oval or falciform shape. No impressions of possible ornamentation or growth lines can be seen on the inner mould.

Paleogeographical distribution: The occurrence of *Gastrobulimus* in the continental Maastrichtian of the Haţeg Basin was mentioned by PANĂ *et al.* (2002), from the Pui site, and also by ANTONESCU *et al.* (1983) from Vălioara and Sânpetru. Other Cretaceous occurrences of the genus include those from the Maastrichtian of France (OPPENHEIM, 1895; FABRE-TAXY, 1959) and from the Santonian-?Campanian of Hungary (BANDEL & RIEDEL, 1994). Bulimids are common in the Paleogene of Western and Central Europe, subsequently extending their distribution eastward, as they occur in the Neogene of Central-Eastern and Eastern Europe (WENZ, 1928; 1942).

Informal group Architaenioglossa HALLER 1890
Superfamily Cyclophoroidea GRAY 1847
Family Cyclophoridae GRAY 1847
Genus *Rognacia* OPPENHEIM 1895
Rognacia sp. (Fig. 2f)

Material: 13 specimens.

Measurements: shell height: 1.13-1.74 (1.349) mm; spire height: 0.744-1.199 (0.894) mm; height of last whorl: 0.362-0.748 (0.492) mm; maximum width: 0.715-1 (0.88) mm; apical angle: 25.5-42.5° (32.2°).

Description: The conical dextral shell is high, and has six convex whorls that are separated by deep sutures. The protoconch is rounded, and the subsequent whorls gradually increase in size up to the last one, which makes up about one-third of the entire shell height. The whorls are set with numerous axial ribs. The aperture is not preserved in any of recovered specimens and thus its shape could not be reliably estimated.

Paleogeographical distribution: *Rognacia* was described for the first time from Upper Cretaceous continental deposits of southern France (OPPENHEIM, 1895). The taxon was mentioned from the Maastrichtian of Romania by PANĂ *et al.* (2002), from Fântânele, Budurone and Pui, in the continental deposits of the Haţeg Basin.

Genus *Ischurostoma* BOURGUIGNAT 1874
Ischurostoma sp. (Fig. 2g)

Material: 4 specimens.

Measurements: shell height: 2.49-3.09 (2.87) mm; spire height: 2.02-2.37 (2.19) mm; height of last whorl: 0.47-0.8 (0.68) mm; apical angle: 16.5-23.3° (19.62°).

Description: The conical dextral shell is high and consists of seven whorls separated by deep sutures. The whorls increase in size gradually up to the last one, which makes up for almost one-third of the shell. The aperture is subcircular, slightly higher than wide. No traces of a possible ornamentation can be seen on the surface of the shell.

Paleogeographical distribution: *Ischurostoma* was described for the first time from, and occurs commonly in, the Eocene of France (BOURGUIGNAT, 1891), where it is present throughout the Paleogene (NOULET, 1868; WENZ, 1926; FAURÉ, 2007). In Romania, the taxon was reported by PANĂ *et al.* (2002) from the Maastrichtian Fântânele, Tuştea, Sânpetru and Pui sites in the Haţeg Basin.

Ecology: Cyclophorids are terrestrial gastropods, living in humid environments, in shaded areas, under fallen trees or among the fallen leaves (ZITTEL, 1877).

Indeterminate (cyclophorid?) opercula (Figs. 2h, i)

Material: around 1,600 isolated opercula.

Two inner moulds of low and wide-shelled gastropods were found with attached opercula. The opercula outline is circular and both the inner and outer sides are concave. The inner side is smooth, while the outer side shows a dexterous plane spiral pattern, each spiral arm being made of tightly packed prisms, arranged parallel to each other, and oriented obliquely to the spiral arms. These opercula also occur isolated, as the most abundant fossil remains, representing more than 95% of all the fossils (gastropod, vertebrate and fruits) yielded by the Fărcădeana site. The two inner moulds still having attached opercula are poorly preserved, leaving insufficient information for a taxonomical assessment.

Isolated opercula similar to those described here were assigned by PANĂ *et al.* (2002) to cyclophorids, and are common in the continental Maastrichtian of the Haţeg Basin (being recorded at Pui, Fântânele, Budurone, Tuştea,

General Berthelot 1 & 2, Crăguiş; see also VASILE *et al.*, 2011). Cyclophorids are the only terrestrial gastropods recovered so far from the Fărcădeana site. Among the aquatic gastropods currently known from Fărcădeana, only the bithyniids have opercula. Unlike the opercula described here, the bithyniid opercula grow around eccentric nodes (ZITTEL, 1887). Recent planorbids are known to secrete an operculum during arid periods, when the water bodies dry out, but such opercula are parchment-like (GROSSU, 1955), and hence not likely to be preserved and fossilized. Therefore, until new data from the site becomes available, these opercula are assigned to cyclophorids.

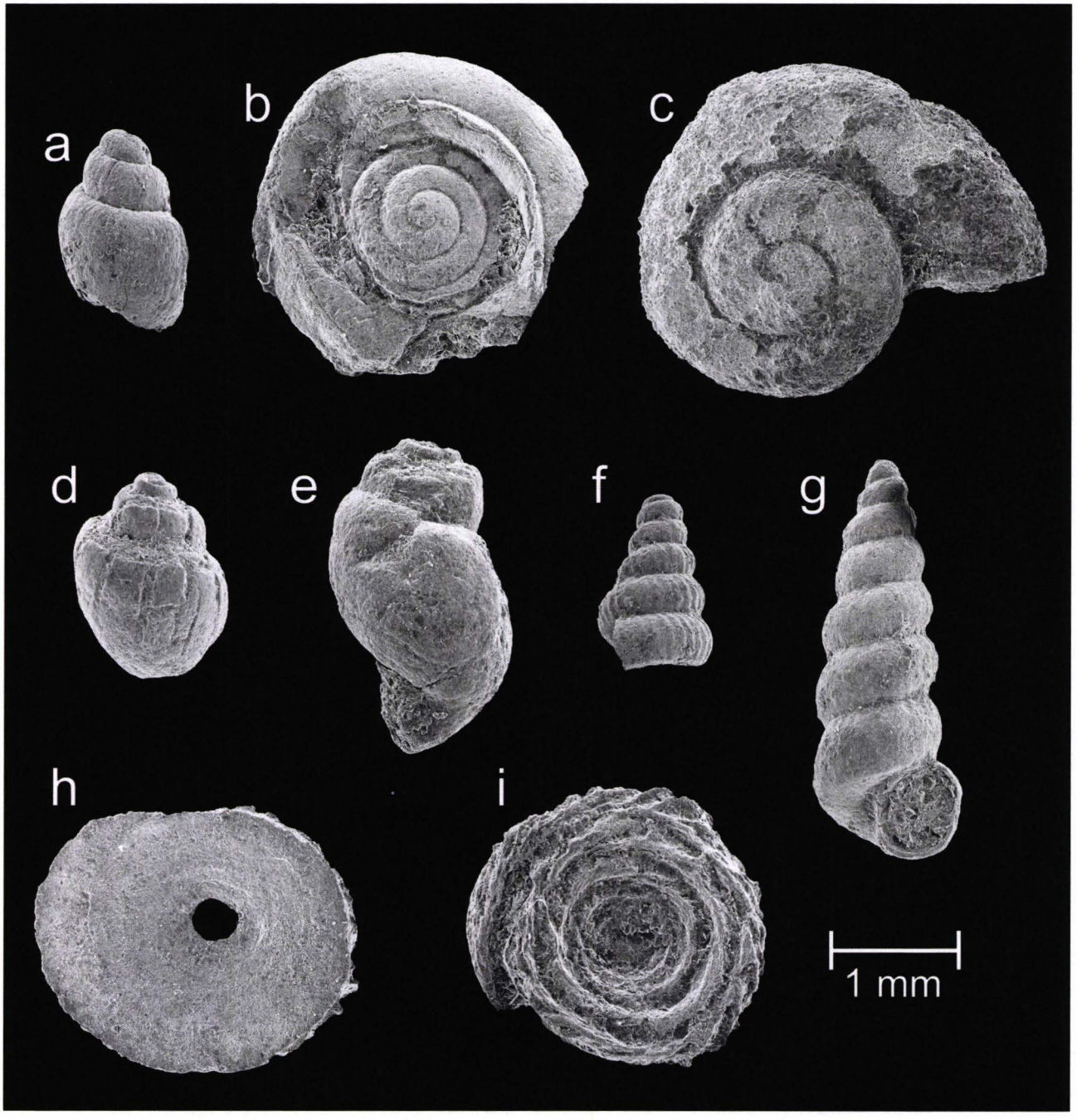

Figure 2. Maastrichtian fresh-water and terrestrial gastropods from Fărcădeana. Rusca Montană Basin. a. Lymnaeidae indet., abapertural view; b. ?*Gyraulus* sp., apical view; c. Planorbidae indet., apical view; d. cf. *Physa* sp., abapertural view; e. *Gastrobulimus* sp., abapertural view; f. *Rognacia* sp., abapertural view; g, *Ischurostoma* sp., apertural view; h. Undetermined (cyclophorid?) operculum, inner view; i. Undetermined (cyclophorid?) operculum, outer view (original). / Figure 2. Gastropode maastrichtiene dulcicole şi terestre de la Fărcădeana, Bazinul Rusca Montană. a. Lymnaeidae indet., vedere abaperturală; b. ?*Gyraulus* sp., vedere apicală; c. Planorbidae indet., vedere apicală; d. cf. *Physa* sp., vedere abaperturală; e. *Gastrobulimus* sp., vedere abaperturală; f. *Rognacia* sp., vedere abaperturală; g, *Ischurostoma* sp., vedere aperturală; h. Opercul nedeterminat (cyclophorid?), vedere internă; i. Opercul nedeterminat (cyclophorid?), vedere externă (original).

CONCLUSIONS

The Maastrichtian gastropod assemblage from Fărcădeana, Rusca Montană Basin, is fairly diverse, including both freshwater (lymnaeids, planorbids, physids, bithyniids) and terrestrial (cyclophorids) taxa.

All the freshwater gastropod families identified in the fossil material recovered from Fărcădeana have recent representatives that inhabit stagnant or slowly flowing waters. The terrestrial taxa recovered from the same site also prefer humid microhabitats, such as the vicinity of ponds. These ecological preferences support previous conclusions reached based on sedimentological and vertebrate assemblage information. The fossiliferous mudstones from Fărcădeana are gray-coloured, suggesting a poorly-drained paleoenvironment, in which oxygen supply was insufficient for the available iron to combine into ferrous compounds. On the other hand, ferric compounds are present, represented by ferric oxide yielding the green-gray colour of the sediments, respectively by sulphide, occurring as fine pyrite crystals. The microvertebrate assemblage is dominated by water-dwelling taxa, such as the amphibians (anurans, albanerpetontids). Altogether, the available information suggests that accumulation of sediments took place in a hydrodinamically quiet waterlogged environment, such as a pond, or an abandoned secondary channel from a poorly-drained area of the floodplain. Since chances of transport are low in such an environment, the fossil assemblage must be autochthonous or, at most, para-autochthonous, thus closely reflecting the composition of the original biocoenosis.

The gastropods here reported represent an important addition to the Maastrichtian fauna of the Rusca Montană area. Most of them belong to herbivorous taxa, and thus sat near the base of the food chain in aquatic to peri-aquatic environments. If not exactly the major food source, gastropod surely represented an important addition to the diet of small vertebrates, or that of other invertebrates (insects, insect larvae) that inhabited these biotopes. The large number of isolated opercula (around 1,600) shows that, even though they were small, gastropods compensated in numbers and transferred important amounts of mass and energy from the primary producers to predators placed higher in the trophic chain.

All the gastropod taxa identified so far in the Maastrichtian of Rusca Montană Basin were also reported from coeval continental deposits of the neighbouring Haţeg Basin (see PANĂ *et al.*, 2002). The similarities between the palynomorph (ANTONESCU *et al.*, 1983), plant (e.g. MĂRGĂRIT & MĂRGĂRIT, 1967; PETRESCU & DUŞA, 1983), vertebrate (e.g. CODREA *et al.*, 2009, 2012; GRIGORESCU, 2010; VASILE & CSIKI, 2011), and now the gastropod assemblages described from the Maastrichtian continental deposits of the two sedimentary basins suggest that these underwent a similar evolution during this time interval, with land connections in place, allowing the different taxa to spread between and to colonize both areas.

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REFERENCES

ANTONESCU E., LUPU DENISA, LUPU M. 1983. *Corrélation palinologique du Crétacé terminal du sud-est des Monts Metaliferi et des Dépressions de Haţeg et de Rusca Montană.* Anuarul Institutului de Geologie şi Geofizică. Institutul de Geologie şi Geofizică. Bucureşti. 59: 71-77.

BAKER F. C. 1911. The *Lymnaeidae of North and Middle America. Recent and Fossil.* The Chicago Academy of Sciences Special Publication. Chicago. 3: 1-539.

BAKER F. C. 1945. *The Molluscan Family Planorbidae.* The University of Illinois Press. Urbana. 530 pp.

BANDEL K. & RIEDEL F. 1994. *The Late Cretaceous gastropod fauna from Ajka (Bakony Mountains, Hungary): a revision.* Annalen des Naturhistorischen Museums in Wien. Naturhistorischen Museum Verlag. Wien. **96 A**: 1-65.

BALTEŞ N. 1966. *Remarques sur la microflore de certains depots charbonneaux Daniens du Bassin de Rusca Montană, Roumanie.* Pollen et spores. Muséum national d'Histoire naturelle. Paris. **8**(1): 213-221.

BINDER H. 2004. *Terrestrial, freshwater and brachyhaline Gastropoda from the Lower Miocene deposits of Oberdorf (Styria, Austria).* Annalen des Naturhistorischen Museums in Wien. Naturhistorischen Museum Verlag. Wien. **105 A**: 189-229.

BOUCHET P. & ROCORI J.-P. 2005. *Classification and Nomenclator of Gastropod Families.* Malacologia. ConchBooks. Hackenheim. **47**(1-2): 1-397

BOURGUIGNAT J.-R. 1891. *Coquilles fossiles terrestres et fluviales trouvées dans les depots de phosphorites du department du Tarn-et-Garonne.* In: Servain (Ed.) Oeuvres scientifiques de M. J.-R. Bourguignat. Imprimerie D. Dumoulin. Paris. 31 pp.

BOWDICH, T. E. 1822. *Elements of conchology including the fossil genera and the animals. Part I. Univalves.* J. Smith. Paris. 73 pp.

BUCUR I., STRUTINSKI C., CUCURUZAN ILEANA. 1983. *Formaţiunile Mezozoice din sud-vestul Bazinului Rusca Montană.* Dări de Seamă ale Institutului de Geologie şi Geofizică. Institutul de Geologie şi Geofizică. Bucureşti. **69**(4): 57-76.

BULIĆ J. & JURIŠIĆ-POLŠAK ZLATA. 2009. *Macropalaeontology and stratigraphy of lacustrine Miocene deposits at Crnika beach on the Island of Pag (Croatia).* Geologia Croatica. Croatian Geological Survey. Zagreb. **62**(3): 135-155.

CODREA V., GODEFROIT P., SMITH T., JIPA-MURZEA C. 2009. Maastrichtian land vertebrates in Rusca Montană Basin (Romania). In: Godefroit & Lambert (Eds.) Tribute to Charles Darwin and Bernissart Iguanodons: New Perspectives on Vertebrate Evolution and Early Cretaceous Ecosystems. Brussels. 29 pp.

CODREA V., GODEFROIT P., SMITH T. 2012. *First Discovery of Maastrichtian (Latest Cretaceous) Terrestrial Vertebrates in Rusca Montană Basin (Romania).* In: Godefroit (ed.) Bernissart Dinosaurs and Early Cretaceous Terrestrial Ecosystems. Indiana University Press. Bloomington: 571-587.

DINCĂ A. 1977. Geologia Bazinului Rusca Montană. Partea de vest. Anuarul Institutului de Geologie şi Geofizică. Institutul de Geologie şi Geofizică. Bucureşti. 52: 99-173.

DUŞA A. 1987. *Zăcăminte de huile din Cretacicul superior.* In: Petrescu, Nicorici, Biţoianu, Ţicleanu, Todros, Ionescu, Mărgărit, Nicorici, Duşa, Pătruţoiu, Munteanu, Buda (Eds.) Geologia zăcămintelor de cărbuni,. Editura Tehnică. Bucureşti. **2**: 74-81.

FABRE-TAXY SUZANNE. 1959. *Faunes Lagunaires et Continentales du Crétacé supérieur de Provence. III – Le Maestrichtien et le Danien.* Annales de Paléontologie. Elsevier. Amsterdam. **45**: 55-124.

FAURÉ P. 2007. *Le Tertiaire du Castrais et de l'Albigeois. Ses Mollusques Fossiles. Un état des connaissances.* Revue du Tarn. Castres. **208**: 1-22.

FEIGI, Ş. V., JIPA C., SOLOMON A. 2010. *Paleomedii maastrichtiene în Bazinul Rusca Montană.* Lucrările celui de-al X-lea Simpozion Naţional Studenţesc "Geoecologia". Petroşani. Editura Universitas. Petroşani. **1**: 33-36.

GIVULESCU R. 1966. *Sur quelques plantes fossiles du Danien de Roumanie.* Comptes Rendus de l'Académie des Sciences de Paris. Académie des Sciences. Paris. **262**(D): 1933-1936.

GIVULESCU R. 1968. *Nouvelles plantes fossils du Danien de Roumanie.* Comptes Rendus de l'Académie des Sciencecs de Paris. Académie des Sciences. Paris. 267(D): 880-882.

GRIGORESCU D. 1990. *Nonmarine formations connected with the Laramian tectogenesis (Post-Early Maastrichtian formations in the Haţeg and Poiana Ruscă basins).* In: Grigorescu, Avram, Pop, Lupu, Anastasiu, Rădan (Eds.) Guide to excursions A + B. Institute of Geology and Geophysics. Bucharest: 18-23.

GRIGORESCU D. 1992. *Nonmarine Cretaceous Formations of Romania.* In: Matter & Chen (Eds.) Aspects of Nonmarine Cretaceous Geology. China Ocean Press. Beijing: 142-164.

GROSSU A. V. 1955. *Fauna Republicii Populare Romîne. Mollusca. Volumul III, Fascicula 1: Gastropoda, Pulmonata.* Editura Academiei Republicii Populare Romîne. Bucureşti. 518 pp.

HARTMAN J. H. 1989. *Stratigraphy of the uppermost Cretaceous and Paleocene nonmarine Mollusca in the Crazy Mountains Basin, south-central Montana.* In: French & Grabb (Eds.) 1989 Field Conference Guide Book, Montana Centennial Edition. Geologic Resources of Montana. Montana Geological Society. Billings. **1**: 163-172.

HARTMAN J. H. 1998. *The Stratigraphy of Mesozoic and Early Cenozoic Nonmarine Mollusks of Colorado.* Proceedings of the Denver Museum of Natural History, Series 3. Denver Museum of Natural History. Denver. **14**: 1-16.

HARZHAUSER M. & KOWALKE, T. 2002. *Sarmatian (Late middle Miocene) Gastropod Assemblages of the Central Paratethys.* Facies. Springer. Berlin & Heidelberg. **46**: 57-82.

HUCKRIEDE R. 1967. *Molluskenfaunen mit limnischen und brackishen Elementen aus Jura, Serpulit und Wealden NW-Deutschlands und ihre paläogeographische Bedeutung.* Beihefte zum Geologischen Jahrbuch. Amt für Bodenforschung. Hannover. **67**: 1-263.

ISAJI S. 2010. *Terrestrial and freshwater pulmonate gastropods from the Early Cretaceous Kuwajima Formation, Tetori Group, Japan.* Paleontological Research. Palaeontological Society of Japan. Tokyo. **14**(4): 233-243.

LINNAEUS C. 1758. *Systema Naturae per Regna Tria Naturae, Secundum Classes, Ordines, Genera, Species, cum Characteristibus, Differentiis, Synonymis, Locis. Editio Decima, Reformata.* Laurentii Salvii. Holmiae. Tomus **I**: iv + 823 p.

MEIER-BROOK K. 1983. *Taxonomic studies on Gyraulus (Gastropoda: Planorbidae).* Malacologia. ConchBooks. Hackenheim. **24**(1-2): 1-113.

NICOLAS H. 1890. *Faune malacologique du Danien (Saint-Remy et les Baux).* Association française pour l'Avancement des Sciences. Paris. 351p.

NOULET J.-B. 1868. *Mémoire sur les coquilles fossils des terrains d'eau douce du Sud-Ouest de la France.* Editions Delboy. Toulouse. 103 pp.

OPPENHEIM, P. 1895. *Beiträge zur Binnenfauna der provençalischen Kreide.* In Zittel (Ed.) Palaeontographica. Beitraege zur Naturgeschichte der Vorzeit. E. Schweizerbart'sche Verlagsbuchhandlung. Stuttgart. **42**: 309-378.

PAN H. & ZHU X. 2007. *Early Cretaceous non-marine gastropods from the Ziazhuang Formation in North China.* Cretaceous Research. Elsevier. Amsterdam. **28**: 215-224.

PANĂ IOANA, GRIGORESCU D., CSIKI Z., COSTEA C. 2002. *Paleo-ecological significance of the continental gastropod assemblages from the Maastrichtian dinosaur beds of the Haţeg Basin.* Acta Palaeontologica Romaniae, Editura Vasiliana. Iaşi. **3**: 337-343.

PERRILLIAT MARÍA DEL CARMEN, VEGA F. J., ESPINOSA BELINDA, NARANJO-GARCIA EDNA 2008. *Late Cretaceous and Paleogene freshwater gastropods from Northeastern Mexico.* Journal of Paleontology. The Paleontological Society. Boulder. **82**(2): 255-266.

PETRESCU I. & DUŞA A. 1985. *Paleoflora din Senonianul Bazinului Rusca Montană.* Dări de Seamă ale Institutului de Geologie şi Geofizică. Institutul de Geologie şi Geofizică. Bucureşti. **69**(3): 107-124.

STRUTINSKI C., PAICĂ MARIA, BUCUR I. 1983. *The Supragetic Nappe in the Poiana Ruscă Massif – an argumentation.* Anuarul Institutului de Geologie şi Geofizică. Institutul de Geologie şi Geofizică. Bucureşti. **60**: 221-229.

TUZSON J. 1913. *Adatok Magyarország fosszilis flórájához (Addindamenta ad floram fossiliem Hungariae III.).* A Magyar Király Földtani Intézet Évkönyve. Franklin-Társulat Könyvnyomdája. Budapest. **21**(8): 209-233.

VASILE Ş., CSIKI Z. 2011. *New Maastrichtian microvertebrates from the Rusca Montană Basin (Romania).* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Tipography SITECH Craiova. Craiova. **27**(1): 221-230.

VASILE Ş., CSIKI Z., GRIGORESCU D. 2011. *Reassessment of the spatial extent of the Middle Member, Densuş-Ciula Formation (Maastrichtian), Haţeg Basin (România).* Acta Palaeontologica Romaniae. Cluj University Press. 7: 335-342.

WENZ W. 1923. *Pars 22: Gastropoda extramarina tertiaria VI.* In: Pompeckj (Ed.) Fossilium Catalogus I: Animalia.. Kugler: 1421-1862.

WENZ W. 1928. *Pars 38: Gastropoda extramarina tertiaria VIII.* In: Pompeckj (Ed.) Fossilium Catalogus I: Animalia.. Kugler: 2231-2502.

WENZ W. 1942. *Die Mollusken des Pliozäns der rumänischen Erdöl-Gebiete als eitverstrinerungen für die Aufschluß-Arbeiten.* Senkenbergiana. Druck von Kramer & Co. Frankfurt am Main. **24**: 1-293.

YANG H., WANG Z., LI M., HUANG B. 1979. *Stratigraphic Subdivision, Correlation, Paleofaunas, and Floras of South China Mesozoic to Early Tertiary Red Beds.* Mesozoic and Cenozoic Red Beds of South China, Selected Papers from the "Cretaceous-Tertiary Workshop", Nanxiong, Guangdong Province. Nanjing Institute of Paleontology Science Press. Nanjing: 58-78.

YEN T.-C. 1951. *Fresh-Water Mollusks of Cretaceous Age from Montana and Wyoming.* Shorter Contributions to General Geology. United States Government Printing Office. Washington: 1-20.

ZITTEL K. A. 1887. *Traité de Paléontologie. Tome II: Paléozoologie. Partie I: Mollusca et Arthropoda.* Imprimérie R. Oldenbourg. München. 897 pp.

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ADDITIONAL PROBOSCIDEAN FOSSILS FROM MAVRODIN (TELEORMAN COUNTY, ROMANIA)

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Abstract. This paper describes proboscidean fossil remains (partial mandibles, isolated molars) recently discovered in the Pleistocene deposits from Mavrodin (Teleorman County). Based on dentition characters, the remains have been assigned to *Mammuthus meridionalis* and *M. trogontherii*, mammoth species previously reported from the same locality. The age of death of the animals has also been estimated, when the preservation state of the material allowed it. The microscopic study of the enamel is in agreement with the taxonomic assignment based on the morphological parameters, also allowing the assessment of more fragmentary material. The evolution stage of the specimens belonging to each species has been discussed preliminarily.

Keywords: Mammoths, Pleistocene, Southern Romania, *Mammuthus meridionalis*, *M. trogontherii*.

Rezumat. Noi resturi de proboscidieni de la Mavrodin (judeţul Teleorman, România). Această lucrare descrie resturile fosile de proboscidieni (mandibule parţiale, molari izolaţi) descoperite recent în depozitele pleistocene de la Mavrodin (judeţul Teleorman). Pe baza caracterelor dentiţiei, resturile au fost atribuite la *Mammuthus meridionalis* şi *M. trogontherii*, specii de mamuţi menţionate şi anterior din aceeaşi localitate. Vârsta morţii animalelor a fost de asemenea estimată, atunci când starea de conservare a materialului a permis-o. Studiul microscopic al emailului este în concordanţă cu determinarea taxonomică făcută pe baza parametrilor morfologici, permiţând şi determinarea materialului fragmentar. Stadiul evolutiv al specimenelor aparţinând fiecărei specii a fost discutat în mod preliminar.

Cuvinte cheie: mamuţi, Pleistocen, sudul României, *Mammuthus meridionalis*, *M. trogontherii*.

INTRODUCTION

The village of Mavrodin is located in the central area of Teleorman County, about 10 km northwest from Alexandria (44°01'43"N, 25°14'07"E). From the geomorphologic point of view, the locality belongs to the Găvanu-Burdea Plain, a subunit of the Romanian Plain, with a relatively flat relief in this sector, interrupted only by small creeks or by the terraces of a few rivers. The inhabited area of the village is crossed, from north to south by Câinelui Creek, which flows into the Vedea, the main river in this area, just south of the village. The area is covered by fertile soil, extensively used in agriculture, the only outcrops occurring along the two main valleys mentioned above, and along the banks of Tinoasa Creek, a small tributary of Câinelui Creek.

The sedimentary deposits covering the Moesian Platform are around 2,500 meters thick, and belong to four cycles (Permian-Triassic, Middle Jurassic-Barremian, Albian-"Senonian", Miocene-Holocene) (BANDRABUR *et al.*, 1967). The only deposits cropping out in Mavrodin area belong to the last cycle, namely to the Pleistocene. The Lower Pleistocene deposits consist of a basal subunit, the Cândeşti Formation, reported from boreholes from the northeastern part of the Moesian Platform, covered by the Frăteşti Formation, cropping out along the main valleys that cross the Romanian Plain (for the definition of the Cândeşti and Frăteşti Formations, as well as the Plio-Pleistocene stratigraphic units of the Dacian Basin, see ANDREESCU *et al.*, *in press*). The latter unit is represented by a succession of gravels covered by fine or coarse sand beds and it is better exposed further east, in Giurgiu County, where it has yielded numerous remains assigned by APOSTOL (1974) to "*Archidiskodon meridionalis*" (NESTI, 1825). In the interfluvial area between the Vedea and Teleorman rivers, the Lower Pleistocene Frăteşti Formation is 15-25 m thick, and is covered by a thinner Middle Pleistocene succession (1-4 meters of marls, clays and sands) capped by Middle-Upper Pleistocene loessoid deposits 10-20 m thick. The deposits presented above as forming the Pleistocene succession of the plain between the Vedea and the Teleorman have been cut by the Vedea River, whose terrace deposits accumulated during the Middle and Late Pleistocene and are represented by gravels and sands, capped by loess, the entire succession measuring from 9 to 12 meters (BANDRABUR *et al.*, 1967).

The only large mammal fossils described so far from Mavrodin have been found west of the inhabited area of the village, in the banks of Tinoasa Creek, near its junction with Câinelui Creek. The faunal assemblage described by APOSTOL & CACOVEANU (1980) included bovids, cervids, and the proboscideans "*A. meridionalis*" and "*Mammuthus chosaricus*" (DUBROVO, 1966). The two taxa will be referred to in this paper as belonging to the genus *Mammuthus*, following the chosen nomenclature mentioned below.

MATERIAL AND METHODS

The fossil material described here was collected along Câinelui Creek between 2005 and 2011 either by the authors, who found it scattered along the creek bed, or by the locals, when excavating for sand and gravel to use locally in construction. Even if some of the specimens accidentally discovered by the locals were found *in situ*, their precise stratigraphical position was not noted.

The deposits cropping out along the banks of Câinelui Creek consist of gravels and sands that show parallel, oblique and crossed bedding and are interrupted by thin layers of brown clay. The precise age of these deposits remains uncertain, but some other vertebrate remains belonging to equids, cervids and bovids (other than those mentioned above as being described by APOSTOL & CACOVEANU, 1980), found *in situ*, might offer more useful information in this respect, after their taxonomical assessment will be complete.

The proboscidean fossils are housed in Bucharest, at the University of Bucharest Laboratory of Paleontology (provisional working numbers preceded by MV) and at the Primary School no. 156 "The Great Martyr Saint George" (provisional numbers beginning with Sc.156).

Morphometric parameters have been measured according to MAGLIO (1973) – for the grinding teeth – and according to MASCHENKO (2002) – for the mandibles – using a digital calliper, and the measuring tape for the larger specimens.

The systematics and nomenclature follow LISTER (1996), emended by LISTER & VAN ESSEN (2003) and LISTER *et al.* (2005) by the separation of *M. rumanus* (ŞTEFĂNESCU, 1924) as the basalmost Eurasian representative of the *Mammuthus* phylogenetic line.

The nomenclature of grinding teeth follows SHOSHANI (1996) in naming deciduous premolars (dP) distinctly from the molars (M). For an alternative opinion see, for example, LAWS (1966). The upper teeth have their position written as superscript (e.g. M^{1-3}) and the lower teeth as subscript (e. g. dP_4, M_3).

The evolution of the three main layers of the molar enamel in the case of the Eurasian mammoth lineage could represent a useful diagnostic character for intrageneric systematics. During the transition from *M. rumanus* to *M. primigenius*, the relative thickness of the middle enamel layer increased, while the inner and outer layers were thinned (FERRETTI, 2003). Thin sections were prepared in order to analyze the microstructure of the specimens from Mavrodin with the following method: detached molar plates were sectioned horizontally (perpendicular to the occlusal-basal axis) with a circular diamond saw. The samples were then embedded in a low-viscosity two-component epoxy adhesive system (Araldit AY 103 with Hardener HY 956) diluted with one drop of ethanol for every 10 ml of the mixture to prevent further fragmentation. The samples were polished with wet aluminium oxide powder from coarser to finer (grit numbers 400, 800, and 1000) and then the polished surfaces were glued on glass slides using the above mentioned two component epoxy glue. The samples were thinned further to achieve the optimal expression of examined features. Photomicrographs of the sections were taken with a Nikon Eclipse E600 microscope using ×2 to ×40 objective lenses with trans-illumination. Glycerol was used between the objective and the section when viewed under magnifications above ×20.

Thickness measurements of the enamel layers were taken along a line perpendicular to the enamel-dentine junction (i.e. the boundary plane between dentine and enamel). As the thickness may vary locally along the enamel section, a minimum of 10 measurements was taken at different sites on each section, and then a mean value was calculated for each specimen.

The difference map shown on figure 3 d was made with a layer-based image-editing software (Adobe Photoshop).

RESULTS AND DISCUSSIONS

Class Mammalia LINNAEUS, 1758
Order Proboscidea ILLIGER, 1811
Family Elephantidae GRAY, 1821
Subfamily Elephantinae GRAY, 1821
Genus *Mammuthus* BROOKES, 1828
M. meridionalis NESTI, 1825

The material assigned to *M. meridionalis* consists in one juvenile partial mandible and two isolated partial molars.

The mandible (Sc.156/3, Figs. 1 a - c) preserves the mandibular body almost entirely. The anterior process of the symphysis is broken off, as are the lingual walls, posterior to the two grinding teeth. Both ascending rami are broken off. Both left and right deciduous teeth (dP_4) are in place. In buccal view (Fig. 1 a), the lower border of the corpus is concave, just posterior to the downward-pointing symphysis. The anterior border is almost vertical, with a slight concavity in its middle part. In anterior view (Fig 1 b), the mandible outline is V-shaped, showing a wide symphysis and a high pre-alveolar depth. In occlusal view (Fig. 1 c), the mandible appears to be wide and antero-posteriorly short. The dP_3 alveoli are not entirely resorbed. The dP_4 are in use, their entire occlusal surface, counting 8 plates each, being equally worn. Posterior to them, the lingual part of the corpus is broken, but the inner side of the buccal wall shows plate impressions from the M_1, which was fairly developed, yet not in use. The left dP_4 detaches from its socket, so all its parameters could be measured (Table 2). Measurements of the mandible are listed in Table 1.

The co-occurrence of dP_3 sockets anterior to dP_4s in full use and signs of a well developed yet not erupted M_1 is comparable to a state between age groups VI and VII described by LAWS (1966) for the extant African bush elephant, which gives an approximate age at death of 4-6 African elephant years for the juvenile mammoth whose mandible is described above. JACHMANN (1985, 1988) showed that LAWS' (1966) estimation of age based on the progression of

teeth is not entirely precise, overestimating the age of young individuals distributed to age groups IX-XVIII. Since our specimen shows tooth progression outside this age group interval, the estimation based on LAWS (1966) remains plausible and does not fall under the age interval rightfully criticized by JACHMANN (1985, 1988). ROTH & SHOSHANI's (1988) evaluation of Indian elephant age based on the type of grinding teeth in use and the degree of wear, gives an approximate age at death of 5-6 Indian elephant years for the present juvenile mammoth.

The broken symphyseal process does not allow a gender determination of this individual using the data from AVERIANOV (1996) employed below for the more complete MV01, and, even for the fragmentary MV02.

A fragmentary molar (MV31) preserves the posteriormost four plates and one platelet (Figs. 2 a - b) of an M^3. The fragment is damaged, showing obvious signs of transport: the interplate cement is mostly eroded, and parts of enamel are broken off from the occlusal and lateral sides.

Sc.156/2 designates a partial left M_2 that preserves the posteriormost six plates and talon (Figs. 2 c - d). The plates are widely spaced by cement-filled intervals, and show advanced wear. The enamel forms a continuous loop for each of the anteriormost two plates preserved, dividing into three or four islets. Enamel is thicker on the posterior side of each plate (2.17-2.38 mm posteriorly compared to 2.3-3.3 mm anteriorly; see Table 2 for an average of all measurements). The cement intervals are 4-5 mm lower than the level of the plates.

M. meridionalis is a common occurrence in the Pleistocene deposits from the Romanian area located between the Carpathians and the Danube (e.g. APOSTOL, 1968, 1974b), reports from outside this area being rare and based on doubtful material (e. g. JURCSÁK, 1973; CZIER, 2002).

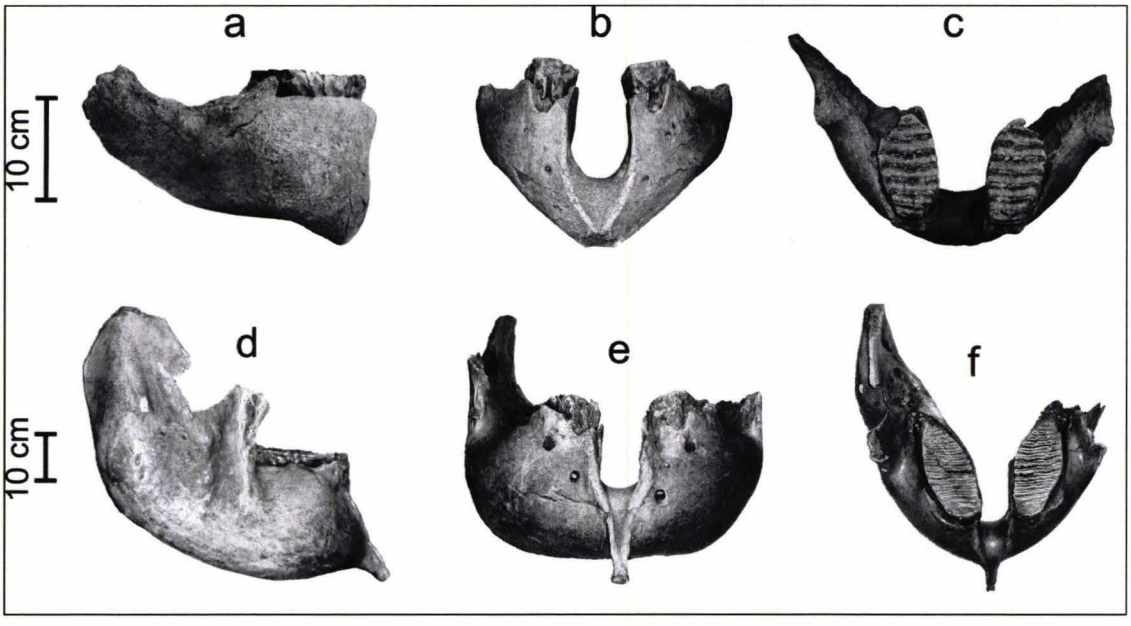

Figure 1. Proboscidean partial mandibles from Mavrodin. a - c. *M. meridionalis*, Sc.156/3, in right buccal, anterior, and occlusal views; d-f. *M. trogontherii*, MV01, in right buccal, anterior, and occlusal views.

Figura 1. Mandibule parţiale de proboscidieni de la Mavrodin. a - c. *M. meridionalis*, Sc.156/3, în vedere bucală dreaptă, anterioară şi oclusală; d - f. *M. trogontherii*, MV01, în vedere bucală dreaptă, anterioară şi oclusală.

Table 1. Dimensions of mandibles (in mm) / Tabel 1. Dimensiunile mandibulelor (în mm).

Inventory number	Sc.156/3	MV01	MV02
Greatest length of the lower jaw	+230	+490	-
Height of the horizontal branch under a functional tooth	101	260	-
Length of interalveolar crest	-	220	+245
Greatest width of horizontal branches	+288	667	-
Symphysis length	76	166	195
Greatest symphysis width	55	56	68
Distance between the horizontal branches at the level of anterior edge of alveoli of functional teeth	88	130	-
Distance between the horizontal branches at the level of anterior edge of alveoli of functional teeth	112	265	-

MAGLIO (1973) tentatively splits the *M. meridionalis* recorded from western and southern Europe into three stages of evolution, from the more primitive state (with less plates, thicker enamel and lower lamellar frequency of M3s) assigned to the "Laiatico Stage"; to the typical *M. meridionalis* as described by NESTI (1825), assigned to the "Montevarchi Stage" (originally misspelled "Montavarchi" by MAGLIO, 1973); and ending with the more evolved state, the transitional form to *M. trogontherii* (with more plates, thinner enamel and higher lamellar frequency of M3s), assigned to the "Bacton Stage". A

similar distinction between different stages of evolution of *M. meridionalis* has been proposed based on the material found and described from Eastern Europe. Different subspecies of "*Archidiskodon*" *meridionalis* have been designated to describe up to four stages of evolution of the genus: "*A. m. rumanus*", "*A. m. gromovi*", "*A. m. meridionalis*" and "*A. m. tamanensis*" (for a review see BAYGUSHEVA & TITOV, 2001; or DUBROVO, 1977 for a different opinion). Clarifying the validity of different genera or subspecies is beyond the purpose of this paper. Although the preferred nomenclature (use of *Mammuthus* over *Archidiskodon*) was stated in the previous section, and although we consider the separation of subspecies not fully supported yet, reference to subspecies of "*A. meridionalis*" is made in the present text in order to facilitate comparison with Eastern European material, whereby the terms used by researchers of this area are employed. The separation of *M. meridionalis* into stages of evolution is mostly based on the morphometric analysis of M3 parameters. Therefore the only specimens from Mavrodin that can be analysed in this respect are the fragmentary M^3 (MV31) described above, and the M^3 described by APOSTOL & CACOVEANU (1980). Compared to the data sets and graphs plotted by DUBROVO (1977), LISTER (1996), and BAYGUSHEVA & TITOV (2012), the two molars fall within the limits of the typical *M. meridionalis* ("Montevarchi Stage"), the fragmentary M^3 (MV31) showing affinities towards the more basal form ("*A. m. gromovi*"). This assignment is, however, only tentative, given the low number of available samples, the fragmentary character of MV31, or the fact that the specimen from APOSTOL & CACOVEANU (1980) has only been analysed based on indirect measurements, its whereabouts being so far unknown to the authors.

Mammuthus trogontherii POHLIG, 1888

One partial mandible, one broken symphysis, and two partial isolated molars have been assigned to *M. trogontherii*.

The best preserved specimen recovered so far from Mavrodin is represented by an almost complete mandible (MV01, Fig. 1. d.-f.), which only misses the left ramus and the condylar part of the right one. The thin rostral part of the right ramus is also partially broken, in the area of the masseteric fossa.

In buccal view, the corpus appears as massive, especially in its rostral part (Fig. 1. d). The ventral border of the corpus is dorsally curved and forms a rounded mandibular angle. The ramus is anteroposteriorly wide, thicker caudally but thinning rostrally in the area of the wide and shallow masseteric fossa. The angle between the mandibular corpus and ramus is acute. In anterior view the ventral and lateral borders of the mandible give it a wide U-shaped outline (Fig. 1. e). The symphyseal process (rostrum) is well developed. In occlusal view, the two very well preserved M_3s can be seen in place (Fig. 1. f). No remaining sockets of previous teeth can be seen in front of the molars. The occlusal surface is moderately worn, the cement between the plates being worn only to a slightly lower level than that of the enamel crests, except for the area around mid-length, where the cement is extremely worn, especially on the lingual sides, where it was reduced to a level 15-20 mm below the enamel crest. The mesial and distal ends of the grinding surface are higher than the mid-length area, and give the occlusal surface a slightly concave outline, when seen in lateral view. On the left M_3 the grinding surface comprises 14 plates and the anterior talonid, while 16 plates and the talonid appear on its right counterpart. The mandibular body is broken posterior to the left M_3, so that five more plates and the posterior talon are exposed, none of which is in use. The parameters that could be measured on the molars (given their implanted state) are given in table 2. Mandible parameters are listed in table 1.

The sole presence of the M_3s, as well as their wear stage corresponds to age stage XXV as described by LAWS (1966), allowing the age of death to be estimated at around 47 African elephant years, outside the interval which according to JACHMANN (1985, 1988) presents significant errors. When compared to the scheme presented by ROTH & SHOSHANI (1988), the wear stage of the M_3s show that the steppe mammoth whose mandible is described here died around the age of 50 Indian elephant years. These estimations are supported by the data presented by ATHANASSIOU (2012), who estimated the age at death of the Loussiká mammoth to around 45 years, based not only on dental wear stage, but also on the stage of epiphyseal synostosis. Since the Loussiká *M. trogontherii* still had the posterior parts of its M_2s with the remaining three plates in wear, the mammoth described here was most probably older; hence the age of 47-50 years is considered a good approximation for the time of its death. A broken symphysis that entirely preserves the rostrum, has been tentatively assigned to *M. trogontherii* because its resemblance to the same portion of MV01. The size of the rostrum, as well as the greatest width of the symphysis, is significantly larger than in MV01. The data presented by AVERIANOV (1996) shows that a well developed symphyseal process is usually associated with the remains of male mammoths. Both MV01 and MV02 have a well developed rostrum and probably belonged to males. The larger size in MV02 accounts for a larger and probably older individual, given that male elephants (both living and fossil) are known to be larger than females, and to grow slowly through their entire life (AVERIANOV, 1996; HAYNES, 1993). The gender assessment based on the relative size of the rostrum is, however, doubtful, a thorough statistical analysis of the morphometric parameters of woolly mammoth mandibles giving inconclusive results when it comes to sexual dimorphism (ÁLVAREZ-LAO & MÉNDEZ, 2011).

MV55 designates an extremely high, hence upper molar that probably represents a left M^3 (Fig. 2 e-f). The grinding surface counts 15 plates, all in use, the posterior convergence of the lateral edges and the presence of enamel islets on the posteriormost preserved plate suggest that the molar only lacks two or three more plates. It is however possible that such wear figures, albeit more elongated, also occurred on the next four posterior preserved plates, but the buccal thirds of these plates are broken. The measured parameters (e.g. the lamellar frequency, enamel thickness) fall within the interval corresponding to the overlap between *M. trogontherii* and *M. primigenius*. The specimen has been assigned to *M. trogontherii* mostly based on the large size of the tooth. It is, however, not definitive that this specimen represents a highly evolved *M. trogontherii* or a primitive *M. primigenius*.

Another partial upper molar assigned to *M. trogontherii* (Sc.156/1) only preserves eight plates and the basal halves of two more plates, all from the posterior part of the possible right M_3 (Fig. 2. g-h). Only the anterior two of the complete plates show wear figures, and the posteriormost plates barely show initial wear.

Remains of the steppe mammoth in Romania are rare both inside (see CODREA, 2008 for a review) and outside (e.g. APOSTOL 1968, 1971, 1974a; SIMIONESCU, 1930) the Carpathian arch.

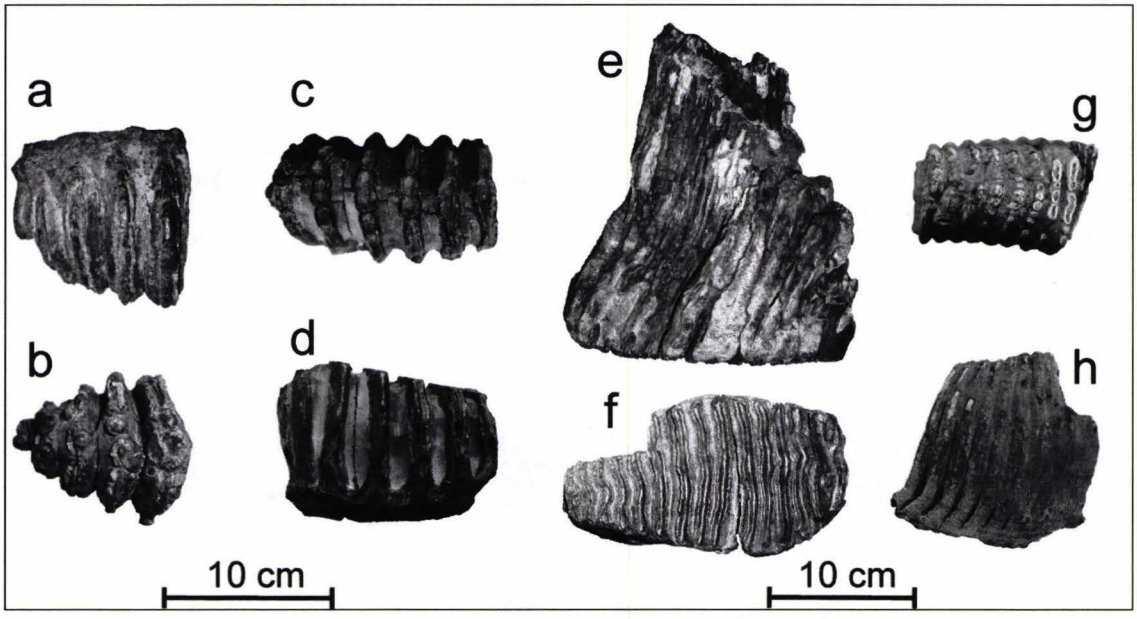

Figure 2. Isolated proboscidean molars from Mavrodin. *M. meridionalis*: a - b. MV31, M^3, in lateral and occlusal views; c - d. Sc.156/2, M_2 sin, in occlusal and lingual views. *M. trogontherii*: e - f. MV55, M^3 sin, in lingual and occlusal views; g - h. Sc.156/1, M_3 dex, in occlusal and buccal views. Posterior is to the left – images b and g have been flipped horizontally to fit this arrangement.
Figura 2. Molari izolaţi de proboscidieni de la Mavrodin. *M. meridionalis*: a - b. MV31, M^3, în vedere laterală şi oclusală; c - d. Sc.156/2, M_2 sin, în vedere oclusală şi linguală. *M. trogontherii*: e - f. MV55, M^3 sin, în vedere linguală şi oclusală; g - h. Sc.156/1, M_3 dex, în vedere oclusală şi bucală. Partea posterioară spre stânga imaginii - b şi g reprezintă imaginile în oglindă ale vederilor respective, pentru a se potrivi acestui aranjament.

Table 2. Dimensions of proboscidean teeth from Mavrodin / Tabel 2. Dimensiunile dinţilor de proboscidieni de la Mavrodin.

Taxon	Tooth type	Inventory number	L (mm)	H (mm)	W (mm)	HI (H/W)	P	LF (10P/L)	ET (mm)
M. meridionalis	dP_4 sin	Sc.156/3	104.33	62.14	56.46	1.1	8	7.66	1.46
	dP_4 dex	Sc.156/3	98.34	-	55.57	-	8	8.13	1.43
	M_2 sin	Sc.156/2	+127.84	92.5	79	1.17	+6, x	4.69	2.5
	M^3	MV31	+106.1	110.6	98	1.12	+4, x	4.69	3.9
	M^3 sin*	-*	257*	125*	120*	1.04*	14*	4-5*	3*
M. trogontherii	M_3 sin	MV01	320	-	105.07	-	19, x	6.46	2.31
	M_3 dex	MV01	+241.88	-	107.8	-	17+	7.03	2.91
	M^3 sin	MV55	+185	215	93.6	2.29	15+	8.1	1.9
	M_3 dex	Sc.156/1	+131	158	89	1.77	+10	7.63	2.28
	M^3 dex*	-*	243*	160*	100*	1.6*	18*	7*	3-4*

Legend: L – maximum length; H – maximum height; W – maximum width; HI – hypsodonty index; P – plate number; LF – lamellar frequency; ET – enamel thickness; + designates incomplete teeth; x – talonid or platelet. * - data taken from APOSTOL & CACOVEANU (1980).
Legendă: L – lungimea maximă; H – înălţimea maximă; W – lăţimea maximă; HI – indicele de hypsodontie; P – numărul de lofe; LF – frecvenţa lamelară; ET – grosimea emailului; + indică un dinte incomplet; x – talonid sau lofidă. * - date preluate din APOSTOL & CACOVEANU (1980).

As in *M. meridionalis*, and indeed, in all European species of *Mammuthus*, the transition from *M. trogontherii* to *M. primigenius* seems to have followed the same pattern, supposedly in steps, with the more advanced types evolving in the Oriental part of Eurasia (either China or Siberia), subsequently migrating westward to Europe, where it gradually replaced the more primitive forms (LISTER & SHER, 2001; LISTER *et al.*, 2005). DUBROVO (1966) assigned the more advanced molars to a separate species, *M. chosaricus*, because of their smaller size, the increase in the number of plates and, hence, of the lamellar frequency, along with a decrease in enamel thickness. Subsequently, she considered that the differences between *M. trogontherii* and "*M. chosaricus*" are not that significant, and cannot sustain the separation of the later taxon as a different species, but rather as a subspecies, and names two *M. trogontherii* subspecies: the more primitive "*M. t. trogontherii*" and the more evolved "*M. t. chosaricus*" (DUBROVO, 1977). It is to this latter taxon that APOSTOL & CACOVEANU (1980, Fig. 16) assign one of the molars found along Tinoasa Creek. Other isolated molars from Romania have been assigned to this taxon, mainly based on their small size (GARRUT *fide* APOSTOL, 1968).

Comparing the measurements of the "*M. chosaricus*" from Mavrodin to the data presented by DUBROVO (1977), one can indeed consider that the size of the M^3 corresponds to that of the more evolved form, "*M. t. chosaricus*", but this conclusion is premature, since the number of plates, the lamellar frequency and the enamel thickness are well outside the limits of that form, fitting well within the limits of the typical "*M. t. trogontherii*". The M_3s from the MV01 mandible also seem to fit within the limits of the measurement interval of the typical *M. trogontherii*, even if they are close, in some respects (lamellar frequency, enamel thickness) to "*M. t. chosaricus*". The MV55 M^3 is, in its measured parameters, the closest to *M. primigenius*, to such degree that it might very well have belonged to a primitive representative of this species. The number of specimens is again two small to draw firm conclusions in respect to the primitive or evolved state of the *M. trogontherii* coming from Mavrodin, but the affinities towards a more evolved "*M. t. chosaricus*" stage are present.

According to FERRETTI (2003), the optic fibre effect of the enamel prisms (bundles of apatite crystallites) allows the rapid and coarse identification of the relatively large enamel portions under light microscopy. The innermost layer of the enamel adjacent to the enamel-dentine junction (EDJ) is irregular. The middle layer makes up almost 50-60 percent of the total enamel thickness. The outermost layer is marked by a sudden flattening of the inclination of the enamel prisms which become parallel to the occlusal plane. The latter change causes a slight difference in the optical properties of the aforementioned layer when viewed under crossed nicols. An additional thin prismless enamel layer is often visible near the outer enamel surface. The boundary plane between the enamel and cement (ECJ = enamel-cement junction) is wrinkled. The enamel can be seen to bulge along the ECJ.

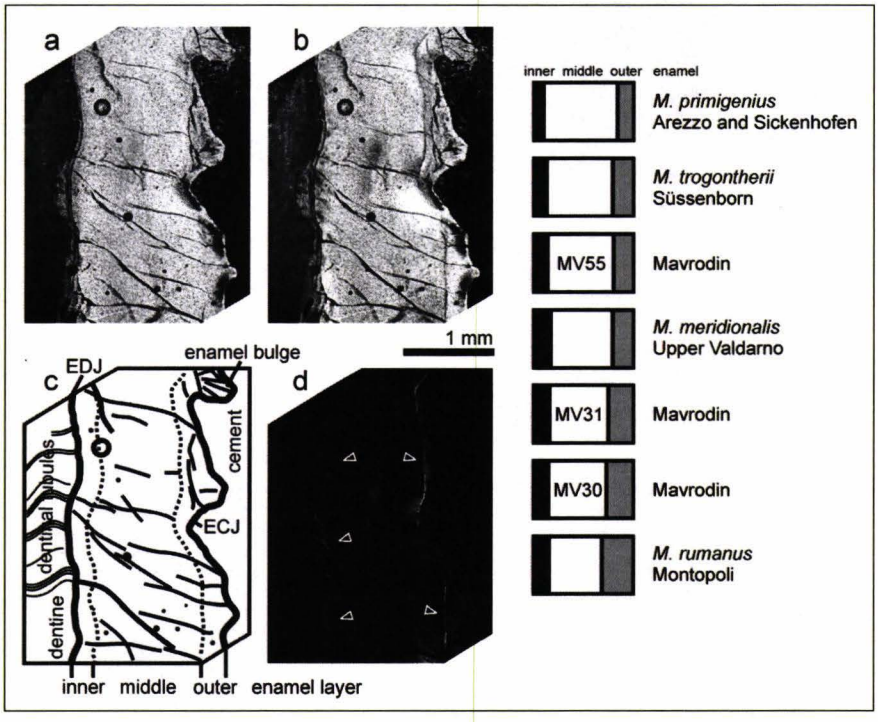

Figure 3. Horizontal section of the MV55 molar enamel (a: without crossed nicols, b: with crossed nicols) and the schematic representation of the depicted slice (c). Lighter tones on image d represent greater differences between image a and b. Abbreviations: EDJ = enamel-dentin junction, ECJ = enamel-cement junction. To the right: the enamel properties of the Mavrodin mammoths related to taxa from other localities. Data in addition are from FERRETTI (2003).

Figura 3. Secţiune orizontală prin emailul molarului MV55 (a: cu un singur nicol, b: cu nicoli încrucişaţi) şi reprezentarea schematic a secţiunii figurate (c). Tonurile mai deschise din imaginea d reprezintă diferenţe mai accentuate între imaginile a şi b. Abrevieri: EDJ = joncţiunea email-dentină. ECJ = joncţiunea email-ciment. În partea dreaptă: proprietăţile emailului mamuţior de la Mavrodin alături de taxoni din alte localităţi. Datele suplimentare din FERRETTI (2003).

Table 3. The enamel properties of the Mavrodin mammoths/ Tabelul 3.Proprietăţile emailului mamuţilor de la Mavrodin.

Specimen	Relative enamel thickness			ET (mm)
	inner enamel	middle enamel	outer enamel	
MV30	15	58	27	4.0
MV31	16	59	25	3.9
MV55	14	66	20	1.9

The above-mentioned layers are distinguishable in the case of the samples from the MV30, MV31 and MV55 specimens, although the enamel was poorly preserved and fragmented in the first two cases. The results are shown on figure 3 and summarized in Table 3. On the basis of the mean percentage thickness of the main layers relative to the whole enamel thickness, MV30 and MV31 belong to primitive *M. meridionalis*, while MV55 is most plausibly referable to *M. trogontherii*.

CONCLUSIONS

The morphometric parameters have shown that the proboscidean fossil remains from Mavrodin belong to two species: *M. meridionalis* and *M. trogontherii*. The abundant sample adds to the previously described one (APOSTOL & CACOVEANU, 1980), but the precise age of the fossil-bearing deposits is not thoroughly documented, so it is not clear if the two types of mammoth were contemporaneous.

Observations of the worn teeth present in the two partial mandibles, as well as their wear stages, allowed an estimation of the time of death for the two individuals, and documented the presence of a *M. meridionalis* juvenile and a fully grown, mature *M. trogontherii*. The features of the mandibles further suggest that two of the remains come from male steppe mammoths.

The preliminary data shows that the *M. meridionalis* M3s belong to the typical or even basal stage in the evolution of the species, whereas the *M. trogontherii* remains show an evolved stage, which dismisses the possibility that the fossil record samples a mixed population of the two species. It is not clear if *M. meridionalis* remains were reworked in the Middle Pleistocene, or if both *M. meridionalis* and *M. trogontherii* remains were reworked and re-deposited in the Upper Pleistocene terrace deposits. Further research (land mammal assemblage, palynology, freshwater mollusc assemblage, etc.) is needed in order to assess what stratigraphical levels have yielded the proboscidean remains. An increase of the sample, by the addition of more new material, as well as a revision of the material housed in the local museums (from Alexandria and Roşiorii de Vede), will make assessments of the evolutionary stages of the two species found at Mavrodin much more reliable and will show whether or not they occurred in this area simultaneously.

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REFERENCES

ÁLVAREZ-LAO D. J. & MENDEZ M. 2011. *Ontogenetic changes and sexual dimorphism in the mandible of adult woolly mammoths (Mammuthus primigenius).* Geobios. Elsevier Masson France. Issy-les-Moulineaux. **44**: 335-343.

ANDREESCU I., CODREA V., LUBENESCU VICTORIA, MUNTEANU T., PETCULESCU A., ŞTIUCA E., TERZEA ELENA. 2012. *New developments in the Upper Pliocene-Pleistocene stratigraphic units of the Dacian Basin (Eastern Paratethys), Romania.* Quaternary International, doi:10.1016/j.quaint.2012.02.009 (In press).

APOSTOL L. 1968. *Particularité morphologiques des molaires des proboscidiens fossiles quaternaires de Roumanie, conservées dans la collection du Musée d'Histoire Naturelle "Grigore Antipa".*Travaux du Muséum d'Histoire Naturelle "Grigore Antipa". Bucureşti. **9**: 581-616.

APOSTOL L. 1971. *Donées sur le squelette de* Mammuthus trogontherii *(Pohlig) découvert dans la plaine roumaine.* Travaux du Muséum d'Histoire Naturelle "Grigore Antipa". Bucureşti. **11**: 459-472.

APOSTOL L. 1974a. Mammuthus trogontherii *(Pohlig) dans la region Feteşti (Stelnica-Vlaşca), Département Ialomiţa.* Travaux du Muséum d'Histoire Naturelle "Grigore Antipa". Bucureşti. **14**: 481-491.

APOSTOL L. 1974b. *Étude sur l'éspèce* Archidiskodon meridionalis *(Nesti) de la region Giurgiu, Dépt. Ilfov.* Travaux du Muséum d'Histoire Naturelle "Grigore Antipa". Bucureşti. **15**: 393-406.

APOSTOL L. & CACOVEANU IOANA. 1980. *L'étude des restes fossils Quaternaires d'eléphantidés, de bovidés et de cervidés conserves dans les musées des villes d'Alexandria et de Roşiorii de Vede (Département de Teleorman, Roumanie).* Travaux du Muséum d'Histoire Naturelle "Grigore Antipa". Bucureşti. **22**: 587-607.

ATHANASSIOU A. 2012. *A skeleton of* Mammuthus trogontherii *(Proboscidea, Elephantidae) from NW Peloponnese, Greece.* Quaternary International. Elsevier Ldt. and INQUA. Amsterdam. **255**: 9-28.

AVERIANOV A. O. 1996. *Sexual dimorphism in the mammoth skull, teeth, and long bones.* In: Shoshani & Tassy (Eds.) The Proboscidea: Evolution and Palaeoecology of Elephants and their Relatives. Oxford University Press. Oxford: 260-267.

BANDRABUR T., PATRULIUS D., GHENEA ANA. 1967. *Harta geologică scara 1:200 000, L-34-XXXII, 43. Neajlov. Notă explicativă.* Comitetul de Stat pentru Geologie. Institutul Geologic. Bucureşti. 47 pp.

BAYGUSHEVA VERA & TITOV V. 2012. *The evolution of Eastern European merionaloid elephants' dental characteristics*. Quaternary International. Elsevier Ldt. and INQUA. Amsterdam. **255**: 206-216.

CODREA V. A. 2008. *Fossil proboscideans in Inner Carpathian area (Romania)*. Sargetia. Acta Musei Devensis. Series Scientia Naturae. Qual Media & Mediamira Publishing House. Deva. **21**: 31-40.

CZIER Z. 2002. *Archidiskodon meridionalis cf. ürömensis din Biharianul de la Subpiatră**. Armonii naturale. Complexul Muzeal Arad. Secţia de Ştiinţe naturale. Arad. **4**: 50-64. (*title corrected according to the errata)

DUBROVO IRINA ALEKSANDROVNA. 1966. *On systematic position of fossil elephant from Khozarsky faunal complex*. Bulletin Comisii po izuch, chetvert perioda. **32**: 63-74.

DUBROVO IRINA ALEKSANDROVNA. 1977. *A history of elephants of the* Archidiskodon-Mammuthus *phylogenetic line on the territory of the USSR*. Journal of the Palaeontological Society of India. Jurij Alexandrovich Orlov Memorial Number. Lucknow. **20**: 33-40.

FERRETTI M. P. 2003. *Structure and evolution of mammoth molar enamel*. Acta Palaeontologica Polonica. Warszawa. **48**(3): 383-396.

HAYNES G. 1991. *Mammoths, Mastodons, & Elephants. Biology, Behavoir, and the Fossil Record*. Cambridge University Press. New York. 413 pp.

JACHMANN H. 1985. *Estimating age in African elephants*. African Journal of Ecology. Blackwell Publishing Ltd. Oxford. **23**: 199-202.

JACHMANN H. 1988. *Estimating age in African elephants: a revision of Laws' molar evaluation technique*. African Journal of Ecology. Blackwell Publishing Ltd. Oxford. **26**: 51-56.

JURCSÁK T. 1983. *Archidiskodon meridionalis (Nesti) din Villafranchianul de la Oradea*. Nymphaea. Folia naturae Bihariae. Muzeul Ţării Crişurilor. Oradea. **10**: 87-142.

LAWS R. M. 1966. *Age criteria for the African elephant, Loxodonta a. africana*. East African Wildlife Journal. Blackwell Publishing Ltd. Oxford. **4**: 1-37.

LISTER A. M. 1996. *Evolution and taxonomy of Eurasian mammoths*. In: Shoshani & Tassy (Eds.) The Proboscidea: Evolution and Palaeoecology of Elephants and their Relatives. Oxford University Press. Oxford: 203-213.

LISTER A. M. & VAN ESSEN H. 2003. *Mammuthus rumanus (Ştefănescu), the earliest mammoth in Europe*. In: Petculescu & Ştiucă (Eds.) Advances in Vertebrate Paleontology "Hen to Panta". Romanian Academy Institute of Speleology "Emil Racoviţă". Bucharest: 47-52.

LISTER A. M. & SHER A. V. 2001. *The Origin and Evolution of the Woolly Mammoth*. Science. American Association for the Advancement of Science. Washington. **294**: 1094-1097.

LISTER A. M., SHER A. V., VAN ESSEN H., WEI G. 2005. *The pattern and process of mammoth evolution in Eurasia*. Quaternary International. Elsevier. Amsterdam. **126-128**: 49-64.

MAGLIO V. J. 1973. *Origin and Evolution of the Elephantidae*. Transactions of the American Philosophical Society. New Series. The American Philosophical Society. Philadelphia. **63**(3): 1-149.

MASCHENKO E. N. 2002. *Individual development, biology and evolution of the woolly mammoth*. Cranium. Werkgroep Pleistocene Zoogdieren. Culemborg. **19**(1): 4-120.

NESTI F. 1825. *Sulla nuove species de elephante fossile del Valdarno all 'Illustrissimo sig. Dott. Prof. Ottaviano Targioni Tozzetti (Letere sopra alcune ossa fossili de Valdarno non per anco descritte)*. Nuovo Giornale dei Letterati. Presso Sebastiano Nistri. Pisa. **11**(24): 195-216.

POHLIG H. 1888. *Dentition und Kraniologie des Elephas antiquus Falc. mit Beiträgen uber Elephas primigenius Blum. und Elephas meridionalis Nesti, I*. Nova Acta Leopoldina. E. Blochmann et Filii Dresden. **53**(1): 1-279.

ROTH V. L. & SHOSHANI J. 1988. *Dental identification and age determination in* Elephas maximus. Journal of Zoology. London. **214**: 567-588.

SHOSHANI J. 1996. *Skeletal and other basic anatomical features of elephants*. In: Shoshani & Tassy (Eds.). The Proboscidea: Evolution and Palaeoecology of Elephants and their Relatives. Oxford University Press. Oxford: 9-20.

SIMIONESCU I. 1930. *Elephas trogontherii Pohl. in România*. Memoriile Secţiunii Ştiinţifice. Seria III. Academia Română. Bucureşti. **7**: 25-31.

ŞTEFANESCU S. 1924. *Sur la presence de l'Elephas planifrons et de trois mutations de l'Elephas antiquus dans les couches géologiques de Roumanie*. Comptes Rendus de l'Académie de Sciences de Paris. **179**: 1418-1419.

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INVESTIGATIONS TO DETECT ECOSYSTEM DISTURBANCES UNDER THE INFLUENCE OF ANTHROPOGENIC FACTORS

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Abstract. The extractive and energetic industries determined the change of the soil surface in the middle Jiu river basin, as well as the setting up of sterile and ash waste dumps, with a higher heavy metal and radionuclide content. A methodology for the investigation of the affected areas was discussed in order to limit the negative effects of these anthropogenic pollutants. This includes: the quantitative and qualitative analysis of the heavy metals and radionuclides in soil and plants; the establishment of the pioneer and indicator species, as well as of the species tolerant and resistant to the stress factor action, species used for the recovery of the affected ecosystems; methods for the detection of species with a role in the phytoremediation process, as well as methods for the analysis of the stress factor effects, which permit their maintenance at a tolerable level. Among the analysis methods, we mention: growth tests (especially in the laboratory experiments), cytogenetic analysis (structural and metabolic modifications of the chromosomes and of the division spindle), structural and ultrastructural investigations for the evidence of the stress factor effect, the induced lesions and the interaction of the eukaryote cell with the stress factors, the entrance pathways and the accumulation place of the pollutant particles in the eukaryote cell (important aspect in the phytoremediation species), a/o. Bioindicators for the evidence of anthropic pollutant factors (heavy metals and radionuclides in this study) are represented by biological species, or certain features of theirs, altered under the action of the two anthropic factors (alteration of the genetic material, of the nucleus ultrastructure, a/o).

Keywords: heavy metals; radionuclides; biological effects; Jiu river basin.

Rezumat. Investigaţii pentru detectarea perturbării ecosistemelor sub influenţa factorilor antropici. În bazinul mijlociu al Jiului, industria extractivă şi energetică, au contribuit la modificarea suprafeţei solului şi la formarea haldelor de steril şi cenuşă, cu un conţinut ridicat în metale grele şi radionuclizi. Pentru a limita efectele negative ale acestor poluanţi antropici, a fost analizată o metodologie de investigaţie a suprafeţelor afectate. Aceasta implică: analiza cantitativă şi calitativă a prezenţei radionuclizilor şi metalelor grele în sol şi plante; stabilirea speciilor pionier şi a speciilor indicator, precum şi a speciilor rezistente şi tolerante la acţiunea factorilor de stres, specii utilizate în refacerea ecosistemelor afectate; metode de depistare a speciilor cu rol în fitoremediere, precum şi metode de analiză a efectelor acestor factori de stres, care permit menţinerea lor la un nivel tolerabil. Dintre metodele de analiză, se remarcă: testele de creştere (în special la experimente din laborator), analize citogenetice (modificări structurale şi metabolice ale cromosomilor şi ale fusului de diviziune), analize structurale şi ultrastructurale pentru a evidenţia efectul factorilor de stres, leziunile induse şi interacţiunea celulei eucariote cu factorii de stres; căile de pătrundere şi locul de stocare a particulelor poluante în celula eucariotă (aspect important în cazul speciilor cu rol în procesul de fitoremediere), ş.a. Bioindicatori pentru evidenţierea efectului factorilor de stres antropic (metale grele şi radionuclizi) pot fi reprezentaţi prin specii biologice, sau prin anumite caracteristici ale acestora, care sunt modificate specific sub acţiunea celor doi factori de stres antropic consideraţi (alterări la nivelul materialului genetic, caracteristici ultrastructurale ale nucleului ş.a.).

Cuvinte cheie: metale grele; radionuclizi; efecte biologice; bazinul Jiului.

INTRODUCTION

The human society development represented both by its numerical increase and the rise in social necessities, leads to intensive exploitation of natural resources, as well as to the release of different matters in the environment, which adulterate the biocoenosis composition. The research performed under natural or experimental conditions proved the existence of numerous species indicating the presence of different toxic substances in the environment, as well as some species with the capacity of catching different toxic substances. They contribute to the 'cleaning' of the environment (CORNEANU *et al.*, 2008). The pollution sources can come from different industries (energetic, extractive, chemical, a/o), transportation, agriculture, human agglomerations, a/o.

The extractive and energetic industries from the middle Jiu river basin represent a major pollution source, because large areas are affected by the destruction of the arable level from the soil surface, by bringing and depositing on the soil surface an immense amount of underground matter with a high heavy metal and radionuclide content. The sterile waste dumps resulted from the coal exploitation shape and modify the soil surface, as they have a high heavy metal and radionuclide content, and they are an improper ground for the spontaneous and forest vegetation, for agriculture, for the animal and human health. Moreover, as a result of the working of the two power stations from Rovinari and Turceni, ash sterile waste dumps with a high heavy metal and radionuclide content appear, which also affect the environment and animal or human health.

Different papers pointed out the effects of a high amount of heavy metals or an enhanced activity of different radionuclides on the living organisms. LEHMANN & REBELE (2004) evaluated the tolerance towards some heavy metals (Cu, Zn, Pb and Cd) of the *Calamagrostis epigejos* and *Elymus repens* species, from the neighbourhood of some copper smelters in Poland, farm sewage in Berlin and an unpolluted control. These experiments revealed a different tolerance depending on the species and the considered heavy metal and in all cases a constitutional tolerance towards Pb, more pronounced in *C. epigejos*. Other investigations were performed by BANASOVA *et al.*, 2007; CONESA *et al.*, 2007;

FROUZ *et al.*, 2008; GOPALAN, 1999; KRISTEN, 1997; LEHMANN & REBELE, 2004; LINDENMAYER *et al.*, 2000; RAJAKARUNA et *al.*, 2011; REMON *et al.*, 2005, a/o

This study was developed on the basis of the experimental results obtained in the POLMEDJIU grant, regarding the heavy metal and radionuclide effect on the biocoenoses from the middle Jiu river basin. The installation of vegetation on sterile and ash waste dumps with a high heavy metal and radionuclide content was analysed. The investigations performed in the natural biocoenoses, in the crops, or in the experiment with tester species for stress conditions are also discussed, and an investigation method of the anthropogenic affected areas is proposed. In the bioindicator group, some cytogenetic and structural features are included (*bodyguard* and *NAB's*).

INVESTIGATION TECHNIQUES AND BIOINDICATORS OF POLLUTION

The mutagenic action of the environment can be established and studied in different investigations.

A. Studies performed on biocoenoses, or in crops. A particular case is the pioneer species study.

B. Studies performed under experimental conditions, when the effect of some pollutant factors is analysed. These investigations are usually performed on tester species for mutagenesis.

A. INVESTIGATIONS PERFORMED ON BIOCENOSES AND IN CROPS. PIONEER SPECIES.

As a result of the anthropogenic activity (mining industry, oil derrick eruption, waste sterile and ash dump building, domestic waste dumps, geological activity, a/o), or as a result of natural incidents (landslides, earthquakes, volcanic activity, a/o), the amount of mutagenic agents rises (heavy metals and radionuclides, a/o).

Adulterations of the biocoenosis composition, or changes of biocoenoses (desertification process in Oltenia, a/o) take place, or areas without vegetation, named 'terrenum nudum', can result. Moreover, the presence of a mutagenic factor exceeding a certain value is perceived by sensitive species, or by indicator species. Phenotypical mutations, as well as genetic mutations take place and they can be analysed in the laboratory. The vegetal models, which are sensitive for the detection of the environment agent genotoxicity, can be used as primordial indicators for their detection in soil, water and air (GOPALAN, 1999). Thus, the meristematic and sporogenous tissues of plants generally represent models of response to genotoxicity, similar to those of the embryogenic and spermatogenous tissues of the vertebrates (KRISTEN, 1997).

The evaluation of the environment mutagenesis depends on the stress factor, the affected area, climate, degree of contamination with mutagenic factors, a/o. If a catastrophic situation is not present, the following investigation techniques must be considered.

***Investigations on the soil surface**, to establish the pollution degree, the affected area size and the environment features, possible mutations induced by the stress factors, a/o. If possible, some mutants in the plant and animal populations from the affected area will be identified. In this case an *albino* mutant in *Cardaria draba* (L.) DESV. (Fam. Brassicaceae) was identified on a ground of 'terrenum nudum' type (with a great amount of salts, heavy metals and radionuclides), with revegetation after an oil derrick explosion. On an ash waste dump near CET-Turceni (with a great amount of radionuclides and heavy metals) there were antennal mutants (the antennal article number was affected) in three *Thysanoptera* (Insecta) species: *Neohydatothrips gracilicornis*, *Thrips tabaci* and *Fankliniella intonsa* (BĂRBUCEANU & VASILIU-OROMULU, 2011a, 2011b). The mutants recognized in the first two *Thysanoptera* species represent the first results in the scientific literature.

***The heavy metal content and radionuclide activity** were established in soil (the sterile and ash waste dumps near Rovinari and Turceni power stations, as well as in Control, Argineşti, the 5-20 and 20-40 cm levels), as well as in the main crop plants cultivated on them. The heavy metal content was determined by a spectrophotometer of atomic absorption, in the version with solution atomization in air-acetylene. The radionuclide activity was determined by the Duggan method, in the soil and vegetation samples, which were analysed by a gamma-spectrophotometer with an HPGe detector, with a plane crystal and a Be window (DUGGAN, 1988). The time of sample measuring ranged between 20000s – 40000s. The obtained values were related to 1 kg of soil or 1 kg of green mass.

The recorded values indicated a higher amount of radionuclides in the waste dumps from the Rovinari Station (especially on the ash waste dump) as compared to the values recorded in the Control area (Table 1). The mining excavation brings to the ground surface great amounts of soil with heavy metals and radionuclides. The ash waste dumps (formed from the residues resulted from the lignite combustion) have a higher amount of radionuclides. The presence of high values as compared to the average values for the natural radionuclides and the high values for Cs-137 (usually over 10 Bq/Kg soil) points out an artificial radioactive pollution with different contamination degrees.

***Pioneer species of superior plants. Pioneer species** are species which colonize previously uncolonized land, usually leading to ecological succession. They are the first organisms to start the chain of events leading to a liveable biosphere or ecosystem. The ash and sterile waste dumps are primary ecosystems, 'terrenum nudum' respectively. Since uncolonized land may have thin, poor quality soils with few nutrients, pioneer species are often vigorous plants with adaptations such as long roots, root nodes containing nitrogen-fixing bacteria, and leaves that employ transpiration. Pioneer species will die creating plant litter, and break down as 'leaf mould' after some time, making new soil for secondary succession, and nutrients for small fish and aquatic plants in adjacent bodies of water.

After a period of time, through natural processes, there are changes in the biotope. At the same time, the ash and sterile waste dumps are a permanent source of pollution for the nearby places, because they have a high heavy metal and radionuclide a/o content. The pioneer species developed on waste dumps present a natural resistance to radioactivity and to the high amount of heavy metals. In Table 3, some pioneer species from the ash waste dump from Ceplea, near CET-Turceni, with some genetic features, are presented. The degree of polyploidy is a diversification and adaptation to the environment, a reaction to stress factors including. It is natural that all polyploidy species do not have resistance to stress factors. According to RAMSEY *et al.* (1998) "polyploidy is widely acknowledged as a major mechanism of adaptation and speciation in plants". In a recent synthesis, TE BEEST *et al.* (2012) also point out that: "polyploidy has been proposed as an important determinant of invasiveness in plants" (a characteristic of the pioneer species).

Table 1. The soil radionuclide activity (in Bq/kg sol: mean ± SE). in some sites from the middle Jiu river basin (Control and ash or sterile waste dumps from CET-Rovinari, 5-20 cm level). / Tabel 1. Activitatea radionuclizilor din sol (în Bq/kg sol: media ± SE) în unele locuri din bazinul mijlociu al Jiului (Control şi halde de steril şi cenuşă de la Rovinari, orizontul 5-20 cm).

Radionuclide	Control (Argineşti)	Sterile waste dump, Rovinari Station	Ash waste dump, Rovinari station
U-238 (Th-234)	32.09 ± 3.58	30.86 ± 3.53	97.7 ± 10.6
Ra-226	15.9 ± 1.0	22.1 ± 1.31	92.0 ± 4.0
Pb-210	55.8 ± 3.83	36.6 ± 3.29	88.5 ± 6.0
Bi-214	13.0 ± 0.92	29.2 ± 1.42	66.2 ± 4.0
Pb-214	18.9 ± 1.27	25.1 ± 1.31	77.7 ± 3.75
U-235	3.00 ± 0.29	2.15 ± 0.47	5.78 ± 1.67
Ac-228 (Th-232)	25.1 ± 4.21	29.9 ± 2.02	53.48 ± 3.82
Pb-212	31.1 ± 1.13	34.4 ± 1.26	81.67 ± 3.16
K-40	455.8 ± 21.9	401.5 ± 27.6	299.5 ± 3.59
Be-7	< 13.1	< 11.5	< 22.8
Cs-137	19.7 ± 2.93	13.6 ± 1.27	75.8 ± 3.44

For most heavy metals, the recorded values in ash waste dumps were generally higher as compared to similar values from Control and sterile waste dumps (Table 2).

Table 2. The heavy metals content (limits of variability) in some cultivated areas situated on sterile and ash waste dumps and in Control (mg/kg, 5-20 cm level). Tabel 2. Conţinutul în metale grele (limite de variabilitate) în terenuri agricole situate pe halde de steril şi cenuşă şi la Control (mg/kg sol, orizontul 5-20 cm).

Situs	Zn	Cu	Fe	Mn	Pb	Ni	Cr	Co	Cd
Control Argineşti	20.5-61.2	16.4-35.2	25334-36108	578-996	24.7-36.9	42.6-85.8	22.1-46.0	12.4-16.2	Udl
Rovinari-sterile dump	54.8-95.3	16.1-35.4	21912-30207	374-436	19.0-22.0	21.2-55.0	22.0-32.6	9.6-11.5	Udl
Rovinari-ash dump	66.6	52.8	26705	215	38.3	42.6	39.4	11.4	Udl
Turceni-sterile dump	66.0-284	16.6-36.1	12854-30188	550-797	5.1-30.2	17.5-54.6	25.9-47.0	5.2-11.5	0.6-1.8
Turceni-ash dump	45.0-54.7	31.9-36.1	39507-41876	269-321	26.2-36.2	92.1-133.2	10.8-15.5	12.3-16.8	0.2-0.3

Udl – under detection limit.

The analysis of these pioneer species developed on the ash and sterile waste dumps from the middle Jiu river basin (CORNEANU *et al.*, 2010a) points out the predominance of the polyploidy forms and/or polyploidy series (*Convolvulus arvensis, Erophila verna, Stelaria media, Thlaspi perfoliatus*, a/o), species with specific genetic features (diffuse centromere in *Juncus inflexus*), as well as species with a natural resistance determined by the presence of some genes involved in the phytoremediation process, through synthesis of bioactive substances, a/o (*Plantago lanceolata, Taraxacum officinalis, Thlaspi perfoliatum*), a/o. These waste dumps are subsequently colonized with shrubs and trees (*Salix* sp., *Populus* sp., a/o), the cuttings being brought by the wind or birds.

The same species were also met on another nude terrene of about 80 ha (resulted from oil derrick mud and other petroliferous products), caused by an oil derrick explosion at Moşneni-Almăj (Dolj district; POPESCU *et al.*, 1998), as well as around the oil derrick from the Moreni Oil Extraction Site (Dâmboviţa district; DUMITRU *et al.*, 2000).

The pioneer species present some biological features which ensure their resistance on *soils* with a high amount of heavy metals and radionuclides (as well as to other stress factors), such as: small size chromosomes, sometimes with a diffuse centromere; the presence of a polyploidy series, or other ploidy forms (aneuploidy, a/o); the presence of protective substances (traps for free radicals, substances involved in the annihilation of some chemical mutagens, a/o); specific genes involved in the synthesis of some substances with a chelating role which bind with the pollutant factor (*phytochellatine, metalthioneine*), a/o. The research performed by WOŹNIAK *et al.* (2005) in the Upper Silesia, Poland, regarding the vegetation development on coal mine heaps, points out pioneer species of similar plants. LEI and DUAN (2008) studied the restoration potential of the pioneer plants developed on lead-zinc mine tailings in China.

The main investigations performed in the pioneer species analysis are similar to the investigations performed in the experiments with genetic tester species (presented in section B). They are of a different nature: phenotypic and biometrical (growth tests), cytogenetic, biochemical, flow-cytometry, structural and ultrastructural investigations, a/o. The vegetation succession on soils contaminated with heavy metals was performed by RIEMON *et al.* (2005) on a former metallurgical landfill in France; CONESA *et al.* (2007) in mine tailings from Cartagena, Spain; FROUZ *et al.* (2008) in a coal exploitation from the Czech Republic, a/o.

Table 3. Pioneer species of plants, met on ash and sterile waste dumps, resistant to a high heavy metal and radionuclide content. / Tabel 3. Specii pionier de plante, întâlnite pe haldele de cenuşă şi steril, rezistente la un conţinut înalt de metale grele şi radionuclizi.

Genotype	Family	Basic chromosome number (x)	Somatic chromosome number (2n)	Observations
Arenaria serpyllifolia	*Caryophyllaceae*	8	2n=4x=32	-
Atriplex patula	*Chenopodiaceae*	9	2n=4x=36	-
Berteroa incana	*Brassicaceae*	8	2n=2x=16	Bioactive stuff
Calamagrostis epigeios	*Chenopodiaceae*	7	2n=4x=28	Risomes
Carduus acanthoides	*Asteraceae*	11	2n=2x=22	Flavonoids
*Convolvulus arvensis***	*Convolvulaceae*	5	2n=10x=50	-
Cynodon dactylon	*Poaceae*	9	2n=4x=36	-
Capsella bursa-pastoris	*Brassicaceae*	8	2n=4x=32	-
Descurainia Sophia	*Brassicaceae*	7	2n=4x – 8x	-
Erophila verna	*Brassicaceae*	6, 7, 8	2n=2x - 10x	Cytotypes
*Juncus inflexus**	*Juncaceae*	10	2x, 4x, 8x	Aneuploids
*Lepidium ruderale***	*Brassicaceae*	8	2x, 4x	Aneuploids
*Medicago lupulina***	*Fabaceae*	7, 8	2n=4x=28-32	-
*Mentha pulgerina***	*Lamiaceae*	5	2n=4x=20	-
Phytolacca americana	*Phytolaccaceae*	18	2n=2x=36	Bioactive stuff
*Polygonum aviculare***	*Polygonaceae*	10	2n=6x=60	-
*Pimpinella saxifraga***	*Apiaceae*	9, 10	2n=4x=36-40	-
Solanum nigrum	*Solanaceae*	12	2n=6x=72	
Stelaria media	*Caryophyllaceae*	10,11,12,13,14	2n=40,42,44	Aneuploids
Taraxacum officinalis	*Asteraceae*	8	2n=3x=24	Bioactive stuff
Thlaspi perfoliatum	*Brassicaceae*	7	2x, 6x, 10x	Specific genes

Legend: *- diffuse centromere; ** - facultative halophyte

***Indicator species, tolerant and resistant to pollution.**

An '**indicator species** is any biological species that defines a trait or characteristic of the environment' (FARR, 2002). Regarding the modification of the abiotic conditions and/or changes in ecological processes, an indicator species is an indicator of environmental changes, such as modification of the climate, the presence of a toxic element, a/o (modified after LINDENMAYER *et al.*, 2000). According to MCGEOCH (1998), 'a **bioindicator** can be loosely defined as a species or a species group, that reflect the abiotic or biotic state of the environment, represent the impact of environment change on a habitat, community or ecosystem, or indicate the diversity of other species' (reproduced after AVGIN & LUFF, 2010). Thus, in present (2012 year) is considered that, **bioindicator** is a species whose death or unusual behaviour may indicate the presence of toxic substances which were not detected by test instruments. The investigations performed by different authors pointed out that every individual manifested a certain response to stress factors and in some cases induced characteristic adulterations. For these reasons, the 'indicator' term can be re-defined. Thus, **bioindicator** represents a species or its different biological features (structural or ultrastructural, cytogenetic, biochemical, a/o), which offer information about the presence of some stress factors in the environment, as well as the active response (defence, survival, a/o) of the considered organism.

Tolerance is the property of an organism to identically react to the action of some mechanical, physical, chemical, medical, a/o factors in increased doses. The medical tolerance is the capacity of an organism to support increased doses of drugs, or of other exogenous factors, obtaining the same effect.

Shade-tolerant species are species that are able to thrive in the shade and in the presence of natural competition by other plants. **Shade-intolerant species** require full sunlight and little or no competition. **Intermediate shade-tolerant** trees fall somewhere in between the two.

Resistance is the degree in which an organism is unaffected by different stress factors from internal or external environment. Resistance is dependent on the genetic constitution of the organism, as well as on other factors, such as biochemical factors, the degree of adaptation to the environmental conditions, a/o. The plant resistance to different stress factors can be a breeding factor. As a result of selection of the most resistant individuals from the crops on the sterile waste damps, for 30 years, landraces were obtained in: *Phaseolus vulgarius*, *Pisum sativum*, *Lycopersicon esculentum*, *Capsicum annuum*, *Allium sativum*, *Cucurbita pepo*, *Cucurbita pepo oblonga*, *Cucumis sativus*, *Zea mays*, *Avena sativa*, *Ocimum basilicum*, a/o (CORNEANU *et al.*, 2011). They present a high resistance to heavy metals and radionuclides.

***Mushrooms,** especially in their mycorrhizal habitat, are involved in long-term accumulation of radionuclides and their transfer from the alimentary chain, regulating their accumulation in host plants (DIGHTON et al., 2008). The radioresistance of some mushroom species is linked to the melanin presence, which can absorb all types of

electromagnetic radiations (MEREDITH & SARNA, 2006). The melanised mushroom species around Chernobyl reactor responded to the ionizing radiation presence through accelerated growth (DADACHOWA & CASADEWALL (2008). Their resistance in an environment with a high heavy metal and/or radionuclide content, as well as their involvement in the phytoremediation process, are a result of the presence of genes from the phytochelatin and metallothionein group. The research performed by COLLIN-HANSEN *et al.* (2007) pointed out the presence of phytochelatines in the *Boletus edulis* mushroom. On the sterile and ash waste dumps around Rovinari and Turceni power stations, the *Agaricus arvensis, Boletus edulis, Coprinus comatus, Macrolepiota procera, Pleurotus eryngii, Suillus luteus*, a/o species of macromycetes were met. They have the capacity of accumulating heavy metals and/or radionuclides (DOĞAN *et al.*, 2006; BUSUIOC *et al.*, 2008; FALANDYSZ *et al.*, 2008; MICHELOT *et al.*, 1999, a/o).

Lichens vegetating on a substrate extract different substances from it and from the air, pollutant elements including (NIEBOER *et al.*, 1972; PUCKET *et al.*, 1973; BANASOVA *et al.*, 2007, a/o). Thus, some lichen species adapted on media with a high heavy metal, radionuclide and other abiotic pollutant content, becoming indicator species for their presence in the environment (ASLAN *et al.*, 2011; RAJAKARUNA *et al.*, 2011; STATE *et al.*, 2010; ZSIGMOND & URAK, 2011, a/o).

Insecta, Thysanoptera. Investigations performed in this polluted area led to the establishment of some *Thysanoptera* (Insecta) species with an indicator, tolerant or resistant capacity (BĂRBUCEANU *et al.*, 2011b). Some differences regarding the Thysanoptera species with a specific role in the two polluted areas were also remarked. Thus, on the sterile waste dumps from the power station Turceni, the indicator species were *Frankliniella intonsa* and *Neohydatothrips gracilicornis*, whereas on the waste dumps from the power station Rovinari, there was a single indicator species, *Haplothrips leuchanthemi*. The resistant species were *Chirothrips manicatus* and *Thryps physapus* on the waste dumps from the power station Rovinari, whereas on the waste dumps from the power station Turceni, there were three resistant species: *Chirothrips manicatus*, *Thryps physapus* and *Thrips validus* (BĂRBUCEANU & VASILIU-OROMULU, 2011a).

Investigations of some stress factors affecting the vegetal communities must be completed by the publication of a **Catalogue with indicator, tolerant and resistant superior plant species** to these stress factors. This catalogue must be put at the disposal of the authorized bodies from the affected area (prefect's office, town halls, cadastre offices, environment protection agencies, ROMSILVA, a/o). On the basis of this Catalogue, the plant and animal communities in the affected areas will be restored, using new species as well. Interspecific relations of the news components of the biocoenosis must be established. The features of "tolerant" and "resistant" species in the new environmental conditions (under the action of stress factors) must also be analysed.

B. INVESTIGATIONS PERFORMED UNDER EXPERIMENTAL CONDITIONS.

These investigations and techniques can be applied both to organisms harvested from the affected area and in *ex situ* experiments. These experiments can be performed with ordinary species, or with radiobiological tester species, in experimental culture (on soil surface), or in the mutagenesis laboratory.

In the laboratory, the species are exposed to an abiotic stress factor, or they are cultivated under some conditions from the environment, being cultivated on soil and wetted with water from the affected area, or which reflect a stress factor (a concentration of heavy metals or radionuclides, a/o).

As radiobiological tester species, annual species are recommended, which are sensitive to stress factor action ('a species, sensitive to a stress factor, also manifests sensitivity to other stress factors'), and have a small number of chromosomes in the somatic cells (preferably up to 2n=20), the division cycle quite synchronous, such as: *Vicia faba* (2n=12), *Hordeum vulgare* (2n=14), *Nigella damascena* (2n=12), *Tradescantia* sp. (2n=24), *Allium cepa* (2n=16) or *Allium sativum* (2n=16), **the *Allium* test** (FISKEJÖ, 1985) being used in the environmental mutagenesis analysis. The tester species, *Allium test* particularly, present some advantages as compared to microbial and animal cells, as being more sensitive to pollutants from the environment (FISKEJÖ, 1985), heavy metals (PANDA *et al.*, 1996; PALACIO *et al.*, 2005), radionuclides including (CORNEANU *et al.*, 2005; CORNEANU *et al.*, 2008, 2009), and being also used for the monitoring of the synergic effects of several pollutants, hydrophilic or lipophilic chemical substances including.

Investigations performed under experimental conditions are of different types.

1. Growth tests, conducted according to the recommendation of authorized bodies (IAEA-VIENNA), 14 days after the germination beginning (for monocotyledonous plants), 21 days for *Allium test*, and 28 days (for dicotyledonous species). In all cases, real leaf length must exceed cotyledonous leaf length. Phenotypical mutants will be also remarked. The individual observations are statistically interpreted.

2. Analysis of cell cycle and of DNA amount (flow-cytometry) performed in the laboratory enables the analysis of the genetic stability of some genetic material resulting from field or laboratory experiments. By this method, it can be established if a potential mutagenic agent affects the genetic stability of a genotype, if different genetic mutations are induced (at chromosomal and genomic level), respectively.

3. Analysis of cytogenetic modifications (chromosomal aberrations, metabolic chromosome modifications, abnormalities of the division spindle, micronucleus presence in the next interphase) is usually conducted in the first mitotic divisions in the radicular meristematic tissue. Investigations are performed in the meristematic tissue of the radicel top, with squash preparations, CARR stain, analysed by an optical microscope.

3.a. Chromosomal aberrations are analysed in all the cell cycle stages, and usually in anaphase and telophase. The main chromosomal aberrations are: **acentric fragments, minutes** (very small acentric fragments, up to 1 μm in diameter), **acentric rings, bridges** (single, double, parallel or crossed), **arches, centric rings**, a/o. In the next interphase, all the acentric fragments and other chromosomal matter without centromere are amalgamated, and micronuclei result. Their numeric analysis offers information about the mutagen process, the efficiency of an anticarcinogen treatment a/o. 'Retarded chromosomes' can result from mistakes during performed of the chromosomal preparations. "Gaps" must be also analysed with much caution: there can be real modifications, uncoloured regions on the chromosome length, or secondary chromosomal constrictions.

3.b. Metabolic modifications of the genetic matter, usually visible in prophase, prometaphase and metaphase, but also in anaphase and telophase (CORNEANU *et al.*, 2010b). They are especially determined by the adulteration of the condensation degree of the chromatin fibres, the modification of the division spindle orientation, the centromere and/or kinetochore inactivation, a/o. They are represented through: **PCC (premature chromatin condensation), DCC (delay in chromatin condensation), PCD (premature centromeric division)**, the presence of some chromosomes or the whole **chromosome set with banding aspect, multipolar division spindle**, or its **wrong orientation** (the division spindle in the same cell half, as a result of the mitotic division, sometimes tetraploid cells a/o can result. (CORNEANU *et al.*, 2010b).

4. Biochemical analysis of the main substance groups involved in the active response to modified environment conditions, having as a result the organism survival.

5. Analysis of structural and ultrastructural modifications of different cell organelles (chloroplast, mitochondria, Golgi complex, peroxisome presence, a/o) conducted with a transmission electron microscope (TEM). It can offer information regarding the induced adulterations, the pollutant particles interaction with cell organelles, their spread in the organism, and/or their accumulation place, a/o (CORNEANU *et al.*, 1999). The main structural adulterations of the nucleus induced by stress factors are represented by: invaginations of the nuclear envelope in which cytoplasm can be present, with or without cellular organelles; lysis areas in nucleus or nucleolus, adulteration of the ultrastructural shape of nucleolus, a/o.

6. Analysis of the metabolic and ultrastructural modifications of the nucleus, conducted with a TEM. The metabolic modifications represented by **bodyguard** and **NAB's** are involved in the resistance to the action of some strong stress factors. **Bodyguard** is represented by large heterochromatin blocks, disposed on the inner surface of the nuclear envelope (CORNEANU *et al.*, 1999). Just some genes involved in the cell survival remain active in the rest of euchromatin. Bodyguard is the cell response to the action of a strong stress factor. **NAB's (nucleolus associated bodies)** are spherical corpuscles, with a diameter of about 0.5 μm, situated near the nucleolus or in intimate association with it. They are made of chromatin fibres with a diameter of about 24-26 nm (CRĂCIUN *et al.*, 1996). Their presence indicates an intense metabolic activity, normal (meristem or secretor cells, a/o), or pathological (stress factor action). In Fig. 1, there is a nucleus with **NAB's** in *Typha latifolia*, developed on a sterile waste dump from Olari.

7. Environmental pollution and human infertility. In the studied area from the middle Jiu river basin, with a high amount of heavy metals and radionuclides, there were numerous cases of human infertility (female). The cytogenetic analysis of some young women proved some cytogenetic adulterations involved in human infertility: **chromatidal and chromosomal breaks,** anomalous elongation of the secondary constriction from the 1q chromosome (+1q), probably a premature expulsion of supplementary heterochromatin in metaphase, a/o. Some abnormalities in ovogenesis also determined the presence of an ectopic pregnancy, a/o.

8. Soil surface decontamination can be performed by the use of plant species involved in the phytoremediation process. These genotypes extract the excess of heavy metals and radionuclides from the environment. In the POLMEDJIU grant, investigations in herbaceous plants, shrubs and trees were conducted. These investigations identified some new species with a phytoremediation role, not mentioned before in the scientific literature, such as *Taraxacum officinale*, *Quercus rubra*, *Robinia pseudoacacia* var. *oltenica*, a/o. Moreover, these investigations discovered the entrance pathways of pollutant particles in the plant (leaf or root), their spread (mainly through the plant conducting system and through the aeriferous conducting system of the leaf) or penetration of the cell wall (Fig. 2), as well as the interaction of the pollutant particles with the cell organelles. In some species, the pollutant particles are accumulated in the intercellular spaces or are complexed with some chelating substances (synthesized in plants, by some specific genes; Fig. 3) and are neutralized (CORNEANU *et al.*, 2012). Syntheses on the field crops involved in the phytoremediation of contaminated metals were elaborated by many researchers (CORNEANU *et al.*, 2011; VAMERALI *et al.*, 2010; a/o). Sometimes exogenous particles are present inside some organelles, in nucleus including (Fig. 4). SEREGIN & KOZHEVNIKOVA (2008) also conducted investigations in some plants with a natural resistance to a great amount of heavy metals (*Zea mays*, *Lupinus* sp., *Thlaspi perfoliatum*, *T. caerulescens* and *Amaranthus retroflexus*). They analysed the role of root and offshoot tissues in the transport and accumulation of some heavy metals (Cd, Pb, Ni and Sr). The specific features of transport and distribution of metals in the roots of different plant species are essential determinants for the ability of plants to accumulate metals in their organs.

CONCLUSIONS

The coal extractive and energetic industries are the main sources for the environment pollution with heavy metals and radionuclides. They affect the environment quality, human and livestock health. The research performed in the middle Jiu river basin contributed to establish some indicators for pollution with heavy metals and radionuclides. The analysis of the environment pollution must include several investigations.

1. The establishment of heavy metal and radionuclide content in the environment (soil, vegetation, water, air).
2. The vegetation analysis to establish the pioneer species installed on the affected areas, as well as the tolerant, resistant and sensitive plant species.
3. The use of tolerant and resistant species, together with pioneer species for the revegetation (or reforestration) of the affected areas.
4. The establishment of indicator, resistant and tolerant species from other organism groups: mushrooms, lichens, some animals (Insecta, Thysanoptera, in this paper).
5. The use of different methods of analysis of the pollutant effects on the natural biocoenosis, crops or experimental investigations.
6. The main work methods for the analysis of the stress factor effect in the affected areas, are: the analysis of the morphological and structural adulterations of the organisms; growth tests; cytogenetic investigations (numeric, structural and metabolic modifications of the chromosomes, as well as the spindle division activity, a/o), structural, ultrastructural and metabolic adulterations of the nucleus or different cell organelles; analysis of the interaction of the eukaryote cell with pollutant particles; modifications in the human population (the fertility state of women), a/o.
7. The results of these researches must be put at the disposal of the authorized bodies in the affected area.
8. The experimental investigations led to redefining the bioindicator term. Bioindicator is represented both by individuals, and by some of their features, which indicate the presence of a stress factor in the external or internal environment, even without discovering it.

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REFERENCES

ASLAN A., ÇIÇEK A., YAZICI K., KARAGÖZ Y., TURAN M., AKKUŞ F., YILDIMIR O. S. 2011. *The assessment of lichens as bioindicator of heavy metal pollution from motor vehicles activities.* African Journal of Agricultural Research, Academic Journals. **6**(7): 1698-1706.

AVGIN S. S. & LUFF M. L. 2010. *Ground bettles (Coleoptera: Carabidae) as bioindicators of human impact.* Munis Entomology & Zoology, University of Ege, Bornova-Izmir. **5**(1): 209-215.

BANASOVA V., ČIAMPOROVÁ M., NADUBINSKA M. 2007. *Heavy metal localities and their vegetatiopn in Slovakia.* 8 pp. http://www.metaltolerantplants.sav.sk.Publications/HM_sites_Slovakia.pdf.

BĂRBUCEANU DANIELA, VASILIU-OROMULU LILIANA, CORNEANU MIHAELA, CORNEANU C. G. 2011a. *Structural characteristics of the thrips fauna on the ash and sterile waste dumps from Rovinari (Gorj District).* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **27**(1): 74-80.

BĂRBUCEANU DANIELA & VASILIU-OROMULU LILIANA. 2011b. *Influenţa poluării mediului asupra faunei de tripşi (Insecta: Thysanoptera) în zona bazinului mijlociu al Jiului.* In: M. Corneanu (Ed.) Bazinul mijlociu al Jiului. Impacte de mediu şi sociale ale industriei extractive şi energetice. Studiu monografic. Edit. Universitaria, Craiova: 179-190.

BUSUIOC G., STIHI C., DUMITRU M. 2008. *Researches concerning the capacity of some macromycetes species for accumulating heavy and rare metals.* Bulletin of Agricultural Sciences and Veterinary Medicine UASVM, Agriculture. Edit. Academica, Cluj-Napoca. **65**(2): 13-17.

COLLIN-HANSEN C., PETERSEN S. A., ANDERSEN R. A., STEINNES E. 2007. *First report of phytochelatins in a mushroom: induction of phytochelatins by metal exposure in Boletus edulis.* Mycologia, Mycological Society of America, Orono-Maine. **99**(2): 161-174.

CONESA H. M., GARCÍA G., FAZ Á., ARNALDOS R. 2007. *Dynamics of metal tolerant communities' development in mine tailing from the Cartagena-La Unión Mining diastrict (SE Spain) and their interest for further revegetation purpose.* Chemosphere, Elsevier. Amsterdam. **68**: 1180-1185.

CORNEANU C. G., CRĂCIUN C., CRĂCIUN V., CORNEANU MIHAELA. 1999. *Nucleus ultrastructure in different genotypes of Lycopersicon esculentum Mill. and cell metabolic activity.* Acta Horti Botanici Bucurestiensis, 1998. Edit. Alo, Bucureşti. **27**: 59-68.

CORNEANU G. C., COJOCARU L., CORNEANU MIHAELA. 2005. *Quick methods of the environment mutagen capacity with the possibility to use them in schools and hospitals units.* Journal Environm. Protection & Ecology. Balkan Environmental Association Protection (B.En.A.), Thessaloniki. **6**(1): 31-34.

CORNEANU G. C., CRĂCIUN C., CORNEANU MIHAELA. 2012. *Procesul de fitoremediere şi interacţiunea celulei vegetale cu particulele poluante.* In: CORNEANU MIHAELA (Ed.), Bazinul mijlociu al Jiului. Impact de mediu şi socio-economic al industriei extractive şi energetice. Studiu monografic. Edit. Universitaria Craiova: 220-235.

CORNEANU MIHAELA, CORNEANU C. G., COJOCARU L., NEŢOIU C. 2008. *Genotoxicity environment evaluation in the Dolj district (Romania).* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. 24: 191-198.

CORNEANU MIHAELA, CORNEANU C. G., COJOCARU LUMINIŢA, GĂMĂNECI GH. 2009. *The evaluation of soil genotoxicity by modified Allium test.* Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **25**: 235-242.

CORNEANU MIHAELA, RĂDUŢOIU D., CORNEANU G. C., LĂCĂTUŞU A., COJOCARU LUMINIŢA. 2010a. *Refacerea naturala a vegetaţiei pe haldele de steril de la exploatări carbonifere.* In: Cândea V., D.-S. Delion (Eds.). Sesiunea ştiinţifică de primăvară a AOŞR, Neptun Comorova, 20-22 mai 2010. Edit. Academia Oamenilor de Ştiinţă din România, Bucureşti: 245-254.

CORNEANU MIHAELA., CORNEANU G., JURESCU N., TOPTAN C. 2010b. *Evaluation of the genotoxicity of water bottled in PET.* Environmental Engineering and Management Journal. **9**(11): 1531-1537.

CORNEANU MIHAELA, RĂDUŢOIU D., CORNEANU G., LĂCĂTUŞU A., COJOCARU LUMINIŢA. 2010. *Refacerea naturala a vegetaţiei pe haldele de steril de la exploatări carbonifere.* In: Cândea V., D.-S. Delion (Eds.), 2010 – Sesiunea ştiinţifică de primăvară a AOSR, Neptun Comorova, 20-22 mai 2010. Edit. Academia Oamenilor de Ştiinţă din România, Bucureşti. **1**(1): 245-254.

CORNEANU MIHAELA (Ed.). 2011. *Bazinul mijlociu al Jiului. Impact de mediu şi socio-economic al industriei extractive şi energetice. Studiu monografic.* Edit. Universitaria Craiova. 300 pp.

CORNEANU MIHAELA, DANCI O., PETCOV A. A., GĂMĂNECI G., SĂRAC I. 2011. *Populaţiile locale – sursă de germoplasmă pentru rezistenţa la stresul abiotic.* În: Corneanu M. (Ed.), Bazinul mijlociu al Jiului. Impact de mediu şi socio-economic al industriei extractive şi energetice. Studiu monografic. Edit. Universitaria Craiova: 261-276.

CRĂCIUN C., CORNEANU G. C., BOJU V., CRĂCIUN V., CORNEANU MIHAELA, CRĂCIUN L. 1996. *The presence of the NAB's corpuscles in different metabolic stages of the nucleus.* In: C. Crăciun, A. Ardelean (Eds.) Current Problems and Techniques in Cellular and Molecular Biology. Edit. Mirton, Timişoara: 143-148.

DADACHOVA E. & CASADEVALL A. 2008. *Ionizing radiation: how fungi cope, adapt, and exploit with the help of melanin.* Current Opinion in Microbiology, Elsevier, Amsterdam. **1**(6): 525-531.

DIGHTON J., TUGAY T., ZHDANOVA N. 2008. *Fungi and ionizing radiation from radionuclides.* FEMS Microbiology Letters, John Wiley & Sons, Hoboken, N. J. **281**(2): 109-120.

DOĞAN H. H., ŞANDRA M. A., UYANÖZ R., ÖZTÜRK C., ÇETIN Ü. 2006. *Contents in metals in some wild mushrooms. Its impact in human health.* Biological Trace Element Research, Humana Press Inc., Springer Link, Heidelberg, **106**(1): 79-94.

DUGGAN L. J. 1988. *Laboratory investigations in nuclear science.* Tennelec-The Nucleus. Oak Ridge, Tennessee. 208 pp.

DUMITRU M., CORNEANU C. G., CORNEANU MIHAELA, COJOCARU LUMINIŢA, MOCANU A. M., SMARANDACHE O.-C. 2000. *Natural recovery processes of the vegetation in the area of the oil derrick at Moreni (Dâmbovita district).* Acta Horti Botanici Bucurestiensis. Edit. Alo, Bucureşti. **28**: 223-242.

FALANDYSZ J., KUNITO T., KUBOTA R., GUCIA M., MAZUR A., FALANDYSZ J. J., TANABE S. 2008. *Some mineral constituents of parasol mushroom (Macrolepiota procera).* Journal of Environmental Science and Health, Part B - Pesticides, Food Contaminants and Agricultural Wastes, Taylor & Francis, London. **43**(2): 187-192.

FARR D. 2002. Indicator species. In: Enciclopedia of Environmetrics (Eds. A.E. Sharawi & W.W. Piegorsch. John Wiley et Sons, Hoboken, N. J.: 1-2.

FROUZ J., PRACH K., PIŽL V., HÁNĚL L., STARÝ J., TAJOVSKÝ K., MATERNA J., BALÍK V., KALČÍK J., ŘEHOUNKOVÁ K. 2008. *Interactions between soil development, vegetation and soil fauna during spontabneous succesion in post mining sites.* European Journal of Soil Biology. Elsevier Masson SAS, Amsterdam. **44**: 109-121.

GOPALAN H. N. B. 1999. *Ecosystem health and human well being: the mission of the international programme on plant bioassays.* Mutation Research. Elsevier B. V., Cambridge, a/o. **426**(2): 99-102.

FISKESJÖ G. 1985. *The Allium test as a standard in environmental monitoring.* Hereditas. John Wiley & Sons, Lund. **102**: 99-112.

KRISTEN U. 1997. *Use of higher plants as screens for toxicity.* Toxicology In vitro. Elsevier B. V., Cambridge, a/o. **11**(1): 181-191.

LEHMANN C. & REBELE F. 2004. *Evaluation of heavy metal tolerance in Calamagrostis epigejos and Elymus repens revealed copper tolerance in a copper smelter population of C. epigejos.* Environmental & Experimental Botany. Elsevier, Amsterdam. **51**: 199-213.

LEI D. & DUAN C. 2008. *Restoration potential of pioneer plants growing on lead-zinc mine tailings in Lanping, southwest China.* Journal of Environmental Sciences. **20**: 1202-1209.

LINDENMAYER D. B., MARGULES C. R., BOTKIN D. 2000. *Indicators of forest sustainability biodiversity: the selection of forest indicator species.* Conservation Biology. Elsevier, Amsterdam. **14**(4): 941–950.

MCGEOCH M. A. 1998. *The selection, testing and application of terrestrial insects as bioindicat*ors. Biological Reviews of the Cambridge Philosophical Society, Cambridge University, Cambridge. **73**: 181-201.

MEREDITH P. & SARNA T. 2006. *The physical and chemical properties of eumelanin.* Pigment Cell Research, John Wiley & Sons, Hoboken, N. J. **19**: 572-594.

MICHELOT D., POIRIER F., MELENDEZ-HOWELL L. M. 1999. *Metal content profiles in mushroom collected in primary forest of Latin America.* Archives of Environmental Contamination and Toxicology, Springer-Vlg., Heidelberg. **36**: 256-263.

NIEBOER E., AHMED H. M., PUCKETT K. J., RICHARDSON D. H. S. 1972. *Heavy metal content in lichens in Sudbury, Ontario.* Lichenologist. British Lichen Society, Cambridge. **5**: 292-304.

PALACIO S. M., ESPINOSA QUINONES P. R., GALANTE R. M., ZENATTI D. C., SCOLATTO A. A., LORENZ E. K., ZAKARKIM C. E., ROSSIM., RIZZUTTO M. A., TABACNIKS M. H. 2005. *Correlations between heavy metals ions (Cu, Zn, Pb) concentrations and root length of Allium cepa L., in polluted river water.* Brazilian Archives of Biology and Technology. Technology Institute of Paraná (TECPAR), Curitiba. **48**(4): 191-196.

PANDA K. K., PATRA J., PANDA B. B. 1996. *Induction of sister chromatid exchanges by heavy metal salts in root meristem cells of Allium cepa L.* Biologia Plantarum. Springer, Heidelberg, Prague, a/o. **30**(4): 555-561.

POPESCU G. G., CORNEANU G. C., COSTACHE I., BĂBEANU C., MARINICĂ I., CORNEANU MIHAELA. 1998. *The renovation of a terrestrial plant communities affected by derrick mud from Almaj-Mosneni (jud. Dolj).* Acta Horti Botanici Bucurestiensis. Edit. Alo, Bucureşti. **26**: 155-168.

PUCKET K. H., NIEBOER E., GORZYNSKI M. J., RICHARDSON D. H. S. 1973. *The uptake of metal ions by lichens: A modified Ion-Exchange Processes.* NEW Phytologist, John Willey & Sons, Hoboken, N. J. **62**(2): 1329-1342.

RAJAKARUNA N., HARRIS T. B., CLAYDEN S. R., DIBBLE A.C., OLDAY F. 2011. *Lichens of the Callacan Mine, a copper- and zinc-enriched superfund site in Brooksville, Maine, USA.* Rhodoa. New England Botanical Club, College of the Atlantic, Bar Harbor, ME. **113** (953): 1-31.

RAMSEY J. & SCHEMSKE D.W. 1998. *Pathyways, mechanisms, and rates of polyploid formation in flowering plants.* Annuar Review of Ecology and Systematics, Michigan State University, Michigan. **29**: 469-501.

REMON E., BOUCHARDON J.-L., CORNIER B., GUY B., LECLERC J.-C., FAURE O. 2005. *Soil characteristics, heavy metal availability and vegetation recovery at a former metallurgical landfill: implicatyions in risk assessment and site restoration.* Environmental Pollution. Elsevier, Amsterdam. **137**: 316-323.

SEREGIN I. V. & KOZHEVNIKOVA A. D. 2008. *Roles of root and shoot tissues in transport and accumulation of cadmium, lead, nickel, and strontium.* Russian Journal of Plant Physiology, Springer-Vlg., Heidelberg. **55** (1): 3-26.

STATE G., POPESCU I. V., GHEBOIANU A., RADULESCU C., DULAMA I., BANCUTA I., STIRBESCU A. 2010. *Lichens as biomonitors of heavy metal air pollution in the Targoviste area.* Journal Science and Arts, Walachia University, Târgovişte. **1**(12): 119-124.

TE BEEST M., LE ROUX J. J., RICHARDSON D. M., BRYSTING A. K., SUDA J., KUBEŠOVÁ M., PYSĚK P. 2012. *The more the better? The role of polyploidy in facilitating plant invasions.* Annales of Botany, Oxford University. **109**: 19-45.

VAMERALI T., BANDIERA M., MOSCA G. 2010. *Filed crops for phytoremediation of metal-contaminated land.* Environmental Chemistry Letters. Springer Vlg., Heidelberg. **8**: 1-17.

WOŹNIAK G., PASIERBIŃSKI A., ROTAŃSKI A. 2005. *Spontaneous woodland vegetation on coal mine heaps of Silesian industry region (Upper Silesia, Poland).* V International Conference "Anthropization and environment of rural settlements. Flora and Vegetation". Proceedings, Kyiv: 259-272.

ZSIGMOND A.-R. & URAK I. 2011. Assessment of heavy metal content of lichens and soil collected from the Hăşmaş Mountains (Romania). Biharean Biologist, Oradea. Biharean Biology Society, Oradea. **5**(1): 69-72.

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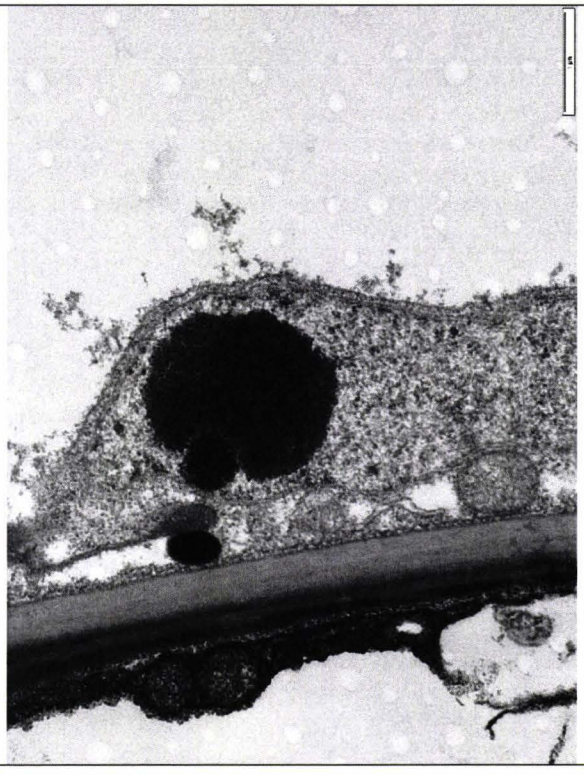

Figure 1. *Thypha latifolia*, sterile waste dump, Olari. Nucleus with NAB's and granular exogenous particles in vacuole Bar = 1 µm. / Figura 1. *Thypha latifolia*, halda steril Olari. Nucleu cu NAB's; particule exogene granulare în vacuolă. Bara = 1 µm.

Figure 2. *Helianthus annuus*, sterile waste dump, Olari. Exogenous acicular particles in cell. Bar = 5 µm. / Figura 2. *Helianthus annuus*, halda de steril, Olari. Particule aciculare exogene în celulă. Bara = 5µm.

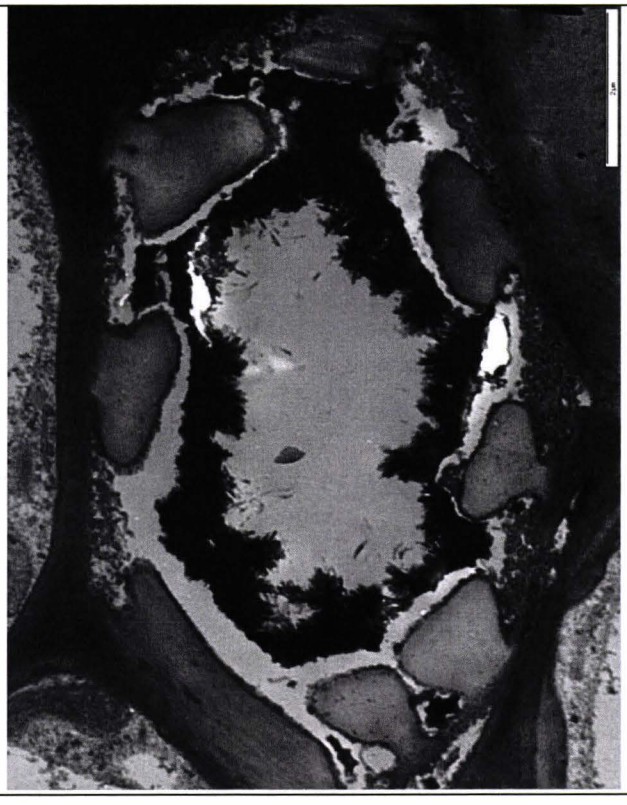

Figure 3. *Quercus rubra*, sterile waste dump, Rovinari. Vacuole with acicular matter and synthesized chelating substance. / Figura 3. *Quercus rubra*, halda steril Rovinari. Vacuolă cu material aciculare acicular şi substanţa chelatoare sintetizată. Bara = 2 µm.

Figure 4. *Helianthus annuus*, sterile waste dump, Olari. Acicular particles among euchromatin fibers in nucleus. Bar = 2 µm. / Figura 4. *Helianthus annuus* halda steril Olari. Particule între fibrele de eucromatină din nucleu. Bara = 2 µm.

PRELIMINARY DATA REGARDING THE EVALUATION OF THE STUDENTS' ENVIRONMENTAL PROTECTION BEHAVIOUR

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Abstract. Ağrı city is the capital of province with the same name located in the eastern part of Anatolia. In 2010, the region counted 542,022 inhabitants. The Murat River (Turkish: Murat Nehri) or the Eastern Euphrates is the major source of the Euphrates. Since September 2011 we have started an activity regarding the scientific works about the Murat River, especially its sector located within the city. There was mainly studied the students' opinion about strict environmental issues - the positive results makes possible future actions, which suppose engaging young generation as volunteers in environmental protection actions and elaboration of educational projects.

Keywords: environmental education, Murat River, Ağrı city.

Rezumat. Date preliminare privind evaluarea conduitei studenţilor faţă de protecţia mediului. Oraşul Ağrı este capitala provinciei cu acelaşi nume localizată în partea de est a Anatoliei. În anul 2010 regiunea număra 542.022 de locuitori. Râul Murat (în limba turcă, Murat Nehri) sau ramura estică a Eufratului este ramura majoră a Eufratului. Din luna septembrie a anului 2011 am iniţiat o activitate ştiinţifică asupra Râului Murat în special asupra sectorului localizat în oraş. A fost analizată mai ales opinia studenţilor privind problemele de protecţie ale mediului. Rezultatele pozitive fac posibile acţiuni viitoare de antrenare a generaţiei tinere ca voluntari în acţiuni de protecţie a mediului şi elaborarea unor proiecte educaţionale.

Cuvinte cheie: educaţie ecologică, râul Murat, oraşul Ağrı.

INTRODUCTION

Ağrı city is the capital of the region with the same name and is located in the eastern part of Anatolia. With a surface of 11,376 km², the region is bordered to the south by Van and Bitlis regions, in the west by Mus and Erzurum, in the north by Kars and Igdir and in the east by Iran. The number of Agri inhabitants was 530,879 in 2007 and increased to 542,022 in 2010 (WIKIPEDIA 1).

Ağrı City is crossed by the Murat River. The Murat River (Turkish: *Murat Nehri*) or the Eastern Euphrates is the major source of the Euphrates. It was also called Arsanias (Armenian: Արածանի) in antiquity. The river originates near Mount Ararat north of Lake Van, in eastern Turkey, and flows westward for 722 km (449 mi) through mountainous area. Before the construction of Keban Dam, the Murat River joined the Karasu 10 km (6.2 mi) north of the dam site and 13 km (8.1 mi) north of the town of Keban (WIKIPEDIA 2).

The number of scientific papers regarding the Murat River is relatively reduced. If the geological structure was quite well studied (DEMIR *et al.*, 2008), there is only little information about the river biodiversity. An interesting paper refers to the parasites of fish living into the Murat Rivers (ASLAN, 2009).

In 2009, it was built a dam in Ağrı region, the costs of the investment reaching 119,856,806 TL. The dam is equipped with three Francis turbines and the production of electric energy is estimated to 129,882 GWh/year. The mean annual temperature of the Murat River is 6.1°C; one third of the year the Murat River is covered by snow. The economy of the region is represented by two bakeries, a sugar factory, two brick workshops; the inhabitants' traditional occupations are agriculture and livestock (EKOREK, 2008).

When the dam was built, there was achieved a well-documented study about the Murat River; although the project stipulated the construction of an experimental facility for wastewater treatment (approximately 150 l/day/inhabitant) (EKOTEK, 2008), our observations in the field have shown that the city sewerage system discharges directly into the Murat River (Photo1). In the urban zone we noticed waste of various origins discharged directly into the river (Photo 2); however, the most concerning issue is the construction of a waste water discharge station in the immediate proximity of the river (Photo 3). Moreover, in some areas of the city, the sewerage pipes discharge directly into the river (Photo 2).

MATERIAL AND METHODS

Since September 2011 we have initiated an extensive documentation activity, which has several directions: one of them is a research study and aims at evaluating the saprobity degree of the Murat River using ciliates; the preliminary data have already been used in the elaboration of a recent scientific paper (KERKMANN *et al.*, 2012).

Another important part of this activity regards the evaluation of environmental education degree of the new generation. We elaborated an original questionnaire, the sets of questions covering a wide range of environmental issues (students' opinion regarding air pollution, the state of roads, few aspects regarding social behaviour, test regarding the students' receptivity towards the European system of waste collection, etc.).

In order to test the students' receptivity regarding environmental pollution issues, there was made a questionnaire of 45 questions about the Murat River and Ağrı city pollution. Two hundred students of the Education

Faculty were interviewed; the age of the subjects varied between 19 and 23 years old, (79 girls and 121 boys). The target group was chosen taking into account that their opinion about environmental protection is complete (they learned about environmental protection in school).

This test was performed in order to achieve an educational project focusing on a correct environmental education and initiation of voluntary activity for waste cleaning of Ağrı streets and the banks of the Murat River. These 45 questions were grouped in few larger subjects (city pollution, the Murat River pollution, testing availability for voluntary actions, some psychological aspects, etc.): the versions of answers were clearly formulated leaving no room for ambiguity. The results are expressed as a percentage.

RESULTS AND DISCUSSIONS

The 45 questions (Table 1, Photo 4) addressed to the students were grouped in a few categories concerning air pollution, the Murat River pollution; there was also tested the students' opinion concerning the possibility to adopt the European system of waste collection. Another group of questions tested the students' availability to act as volunteers for waste collecting from Ağrı streets and the Murat River banks.

The interviewed students are pessimistic when asked about the tourist potential of Ağrı city and its present state (Question 3 – only 15% answered positively!) and also the town future evolution in this direction (Q1, Q32); despite their attitude, they wish a resort in their town (big hotel) built from a project sponsored by the City Hall (Q2-73%).

Another group of questions was made to test the students' capacity of observation regarding the state of Ağrı main streets (Q5,Q7,Q10,Q11).

Only 8.5% of the interviewed students believe that Ağrı streets are clean, considering that a greater frequency of the sanitation is quite necessary (Q10-94%); there should be also mentioned the adherence tendency, at least at mentality level, to the European system of streets cleaning with detergent (Q11-64.5%); the percentage is encouraging and confirms one time more that Turkey certainly goes on the right way towards the integration in the European Union, using the most important element as modernity resort, namely the new generation's mentality.

The important positive answers percentages regarding selective waste collection and their recycling (Q12-96.5%; Q13-94%) support the previous supposition.

A percentage of 71% of the students were open to the possibility of building a bike lane, especially because many of Ağrı's inhabitants use this means of locomotion to cross the city (Q38). The question was introduced by chance because the Project of İbrahim Çeçen University includes such facility in the Campus area (personal communication of the Rector, Professor Dr İrfan Aslan, during the Art and Education Faculty meeting in January 2012).

An important percentage of the interviewed students (71%) believes that Ağrı air is polluted (Q6) and it is necessary to increase the surface of green spaces into the city area, especially into schools gardens (Q39-94.5%) but also on the main arteries of the city (Q37 - 94.5%).The students are sure that organic pollution registered in the city can be the reason for somatic illness (Q43-72%), but also for psychic perturbations like depression or nervosity (Q44 - 81%,Q45 - 94.5%).

The students are flexible and confident in the projects of the City Halls regarding the construction of new residential districts or enlarging the truck park for waste collection (Q35-95.5%, Q23-88.5%) (http://www.agri.bel.tr/).

However, the biggest set of questions (14) was dedicated to the Murat River, especially to the segment crossing the city. The percentage of the students' positive answers emphasizes contradictory results. Moreover, despite the students' ability to recognize a polluted ecosystem like the Murat River (Q18-68.5%, Q19-56.5%), characterized by the necessity of rehabilitating its banks into the urban area (Q20-92%) and of regularizing its course by removing silt, they did not know that the sewerage system discharges directly into the river (Photo 1) (Q25-11%), as well as the sewerage pipes (Photo2) (Q27-9.5%,Q28-42.5%,Q29-29%).

Despite the fact that 35% of the students have no information about the legislation of environmental protection in Turkey (briefly illustrated in Baraj's project EKOTEK, 2008), they consider environmental education study as important (Q16-94%) and are ready to make voluntary work for the sanitation of the main streets (Q31-54%). Moreover, their opinion is favourable to the involvement of categories of inhabitants in the collection of domestic waste from the city and the Murat River banks (Q17-90.5%, Q30-85%). Finally, the students are ready to contribute to the formation of correct environmental protection behaviour of their children (Q33-96%).

Table 1. Questionnaire applied to the target group from the Faculty of Education.
Tabel 1. Chestionar aplicat grupului ţintă de la Facultatea de Educaţie.

No.	Question	Yes number of students	No number of students	I do not know number of students
1	Do you see Ağrı region as a region with tourism potential?	33.5%	62%	4.5%
2	Do you think that the City Hall should make a project for a hotel complex in Ağrı city?	73%	20%	7%
3	Do you think that Ağrı city is ready to receive tourists?	15%	80.5%	4.5%
4	Do you think that Ağrı city is polluted?	78%	19.5%	2.5%

5	Do you consider that the streets of the city are clean?	8.5%	38.5%	53%
6	What do you think about the urban air? Is it clean?	28.5%	68%	3.5%
7	Do you think that there are streets in the city which should be paved?	2%	97%	1%
8	Do you have light industry in your town?	28%	50%	22%
9	Do you think that Ağrı city is affected by the pollution generated by this industry? (sugar factory for example)	11.5%	72%	16.5%
10	Do you consider that the main streets of the city should be hygienized more often?	94%	6%	-
11	Do you think the main streets should be cleaned with detergent as in the European system?	64.5%	30.5%	5%
12	Do you think that waste should be collected separately (paper, plastic, glass and organic household waste) according to the European model?	96.5%	2%	1.5%
13	Do you believe in recycling of some materials like glass and paper?	94%	6%	-
14	Do you think that there must be introduced fines for those citizens who polluted the city?	84.5%	11.5%	4%
15	Do you think that the City Hall must develop projects to reduce pollution in the city?	94.5%	4%	1.5%
16	Do you think that environmental education of students is important?	94%	5%	1%
17	Do you consider it is important to involve pupils in activities raising the city's household garbage? (volunteer for environmental protection?)	90.5%	5.5%	4%
18	Do you think that the Murat River is polluted?	68.5%	7.5%	24%
19	Do you think that the Murat River water can be dangerous for people's health?	56.5%	13.5%	30%
20	Do you think that the river banks located in urban areas should be landscaped?	92%	3.5%	4.5%
21	Do you think the river bed should be cleaned of alluvia? (sediments)	63.5%	18.5%	18%
22	Should there be built a swimming pool /strand for the city residents near the Murat river?	46.5%	40%	13.5%
23	The City Hall has purchased new sanitation trucks. Do you consider the investment necessary?	88.5%	5%	6.5%
24	Is there a sewage network of the city?	20%	80%	-
25	Do you know if the city sewage system discharges in the Murat River?	11%	16%	73%
26	Is there a wastewater treatment station before being discharged into the River Murat?	7%	31%	60%
27	Do you know if in the town there are domestic sewage pipes that discharge directly into the Murat River?	9.5%	17.5%	73%
28	Did you see if there are domestic wastes discarded directly into the river?	42.5%	13.5%	44%
29	Do you consider this detail as important?	29%	6.5%	64.5%
30	Do you think that Ağrı citizens could help to the depollution of the Murat River?	85%	15%	-
31	Would you like to participate as a volunteer to clean Ağrı city?	54%	32%	14%
32	Do you see Ağrı as a tourist town in the future?	36%	52%	12%
33	Are you willing to talk to your children about how important it is to keep the city clean?	96%	3.5%	0.5%
34	Do you know if sometimes there are problems due to the Murat River floods?	16.5%	83.5%	-
35	The City Hall develops a project for the construction of new residential districts. Do you agree?	95.5%	3%	1.5%
36	Do you consider that it is required a larger surface covered by green spaces in the city of Ağrı?	97%	1.5%	1.5%
37	Do you consider as required tree planting along the city main arteries?	94.5%	2%	3.5%
38	Do you consider as useful the construction of bike lanes on the city's arteries? (as the European model, for safety and decongestion of traffic).	71%	17.5%	11.5%
39	Do you considered necessary the arrangement of green spaces in school gardens?	94.5%	4.5%	1%
40	Do you know if there is current legislation for environmental protection?	35%	17%	48%
41	Is there any discharge into the Murat River?	7%	33%	60%
42	Would you like the waters of the Murat River to be cleaner?	93.5%	5%	1.5%
43	Do you think organic pollution may cause diseases in Ağrı city?	72%	15%	13%
44	Do you think environmental pollution in Ağrı may generate stress and depression?	81%	12.5%	6.5%
45	Do you consider that environmental pollution may cause psychological pollution?	94.5%	4%	1.5%

Photo 1. The Murat River – the sewerage system discharges directly into the river. / Foto 1. Râul Murat – sistemul de canalizare deversează direct în râu (original).

Photo 2. Discharge pipe of domestic wastewater in the Murat River (image taken in Ağrı city). / Foto 2. Deschiderea conductei cu ape menajere în râul Murat (fotografie realizată în oraşul Ağrı) (original).

Photo 3. Discharge of wastewater in the Murat River (image taken in Ağrı city). / Foto 3. Deversarea apei uzate în Râul Murat (imagine realizată în oraşul Ağrı) (original).

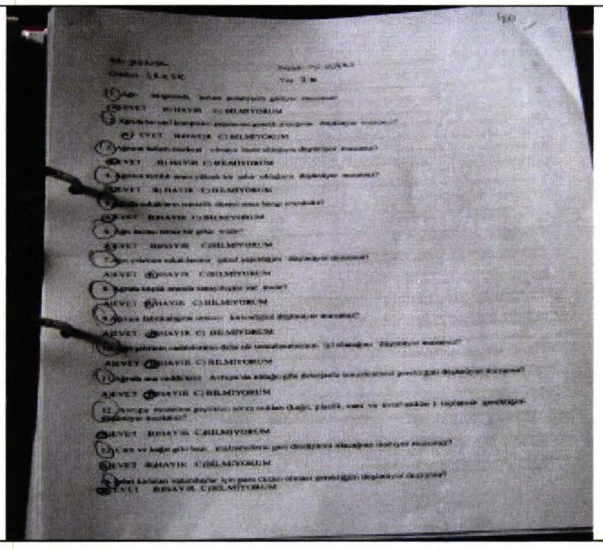

Photo 4. Questionnaire applied to the target group from the Faculty of Education. / Foto 4. Chestionar aplicat grupului ţintă de la Facultatea de Educaţie.

CONCLUSIONS

So, after applying the questionnaire, we can draw some conclusions:

- The students observed some of the main problems regarding the pollution of Ağrı and of the aquatic ecosystem represented by the Murat River.
- The students are open and flexible regarding the adoption of the European system to selective waste collection, waste recycling and street cleaning with detergent, probing a mentality that will certainly ensure the success of Turkey in the process of European integration.
- They demonstrate advanced civic consciousness being ready to take volunteering actions for the sanitation of the city and the Murat River.
- They are aware of the need to transfer gained knowledge to future generations and form a positive attitude towards environmental protection.

We appreciate the results of this questionnaire as encouraging to start an educational project and to take concrete voluntary actions meant to increase the sanitation state of the city and the Murat River banks, to initiate an active dialogue with local authorities in order to sensitize them to environmental issues.

REFERENCES

ASLAN B. 2009. *Ağrı ili Murat Nehri ile Erzurum ili Aras Nehrin'den yakalanan bazı balıkların Endohelmintlerinin araştirilması*. Yüksek Lisans Tezi. Erzurum. 1-59.

DEMIR T., SEYREK A., GUILLOU H., SCEILLET S., WESTWAY R., BRIDGLAND D. 2008. *Preservation by basalt of a staircase of latest Pliocene terraces of the River Murat in eastern Turkey: evidence for rapid uplift of the eastern Anatolian Plateau*. Global and Planetary Change. **68**: 254-269. Available online at: http://www.sciencedirect.com/science/article/pii/S092181810900061 7 (Accessed: Ferbruary 28, 2012).

EKOTEK. 2008. *Yağmur Barajı ve Hes Projesi* 1-81. Available online at: http://www2.cedgm.gov.tr/cedsureci/ced_basvuru_dosyasi/465_ptd.pdf (accessed: Ferbruary 28, 2012).

KERKMANN RALUCA, HATUNOĞLU AŞKIM, HATUNOĞLU Y. 2012. *Preliminnary data regarding anthropogenic impact on the Murat River (Ağrı Region)* (in print). International Journal of Ecosystems and Ecology Science (IJEES). Tirana. Albania.

***. WIKIPEDIA 1. Available online at: http://en.wikipedia.org/wiki/A%C4%9Fr%C4%B1_Province (Accessed: February 28, 2012).

***. WIKIPEDIA 2. Available online at: http://en.wikipedia.org/wiki/Murat_River (accessed: February 28, 2012).

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FORERUNNERS OF THE ECOLOGICAL THINKING (THE 16TH – THE 19TH CENTURIES)

NEACŞU Petre, CIOBOIU Olivia

Abstract. The development of the ecological thinking in the 16th – the 19th centuries is to be assessed on the basis of many forerunners' works, that were to discover, understand and describe the way life mechanisms and processes functioned. Analysing the respective period, one may notice that the researchers from different fields of natural and human sciences understood that items in nature (plants, animals, physical phenomena, etc.) are not isolated and static, but they display dynamic interactions. This knowledge led to the appearance of ecology as a distinct science in the framework of biology in the 20th century.

Keywords: ecological science, forerunners, ecology.

Rezumat. Precursori ai gândirii ecologice (secolele XVI – XIX). Dezvoltarea gândirii ecologice în secolele XVI – XIX se regăseşte în însemnările şi lucrările multor precursori, care urmau să dezvolte şi să descopere, să înţeleagă şi să descrie desfăşurarea macanismelor şi proceselor vieţii. Privind retrospectiv perioada analizată se poate constata că cercetătorii din diverse domenii ale ştiinţelor naturii şi a celor umaniste, au înţeles că lucrurile din natură (plante, animale, fenomene fizice etc.) nu sunt izolate şi statice, ci în interacţiuni dinamice. Aceste cunoştinţe au condus ca în secolul XX să apară ecologia ca ştiinţă biologică de sine stătătoare.

Cuvinte cheie: gândire ecologică, precursori, ecologie.

The development of ecological thinking intensifies between the 16th and the 19th centuries due to the development of all human fields of activity: agriculture, industry, goods market, literature, arts and sciences, highlighting the appearance of a new production pattern, the capitalist one.

In biology, research diversified passing from the simple description of the characteristics of species to multiple physiological, microbiological, soil biology, geographical distribution studies, to the elaboration of ecological concepts and principles.

The understanding germs of the phenomena, structures and functions of plant and animal life, of their relationships to the environments they live in are to be found in the notes and works of many forerunners that were to develop and discover, understand and describe life mechanisms and processes.

In a much or less aleatory succession of their mention in the history of science, of thinking and understanding of life and phenomena related to plant and animal life and not only, the recollection of those scientists who can be considered real forerunners of this science is quite welcome (BOTNARIUC, 1961; IAROSENKO, 1962; NEACŞU, 1984).

The period 1500 – 1900 embraced certain ecological knowledge exposed by scientists from other fields of study. Thus, in the works of some physicists there appeared data about the influence of the environmental factors upon organisms. Robert Boyle tested the behaviour of animals under different conditions of atmospheric pressure. Réaumur made some observations regarding the influence of certain abiotic factors upon organisms (BOTNARIUC, 1961; DELEAGE, 1991; REAUMUR, 1749).

Francis Bacon (1561 – 1626), an English savant and philosopher, in his book entitled "*The New Atlanti*" is against scholastics and a supporter of experimental methods (BOTNARIUC, 1961; WORSTER, 1992).

Henry Hudson, an ornithologist, explained the role of the protection colours in case of birds, as well as their behaviour (BOTNARIUC, 1961; WORSTER, 1992). John Ray (1628 – 1705) is considered the greatest English naturalist before Charles Darwin. He acknowledged the existence of a stable and sustainable order in nature (RAY, 1674).

John Evelin published the work "*Silva*" in 1664 or treatise upon forest trees, where he recommended the rational management of forests (WORSTER, 1992).

Charles Linné (1707 – 1778), 1749, published "*Treatise on the economy of nature*", where he explained through many examples that everything interrelated in nature following a common interest by means of food chain which linked the alive and dead, the predator and prey (BOTNARIUC, 1961; LINNAEUS, 1735; WORSTER, 1992).

Gianluigi Buffon (1707 – 1788) mentioned in his work the succession of forest species and the influence of light and shadow upon this process (BOTNARIUC, 1961; DELEAGE, 1991; IAROSENKO, 1962; WORSTER, 1992).

Gilbert White (1720 – 1793) emphasized the importance of insects and reptiles in the economy of nature. He considered nature was a remarkable organizer (WHITE, 1756; WORSTER, 1992).

Thomas Maltus (1766 – 1834) published in 1798 a brochure entitled "*With regard to the population*", considering that alimentary products increased in arithmetic progression while population increased in geometric progression and, consequently, at a certain moment, population would exceed the available food resources (BOTNARIUC, 1961; REAUMUR, 1749).

Alexander von Humboldt (1769 – 1859), after his research in South America between 1799 and 1804, proved that all the plants present in the world had to be classified not only taxonomically but also from the point of view of geographical conditions. In 1805, he published the work "*Certain ideas upon the geography of plants*" (BOTNARIUC, 1961; SAFONOV & HUMBOLDT, 1962; WORSTER, 1992).

Charles Lyell (1797 – 1875) published the work "*Geology principles*". The ideas exposed in this book contributed to the development of Darwin's evolutionary concepts upon nature. He considered that the human being was a perturbing element of natural balance (DROUIN, 1993; LYELL, 1830; MALTHUS, 1817; MATAGNE, 2002).

George Emerson (1803 – 1882), an American lawyer, held conferences on nature that he also published in 1836 (DELEAGE, 1991; MATAGNE, 2002). Luis Agassiz (1807 – 1873), a zoologist at Harvard University, studied the limnology of Lake Walden (USA) (AGASSIZ, 1859; MATAGNE, 2002; WORSTER, 1992).

Henry Thooreau (1817 – 1862) is a real field ecologist. He observed the succession of plants in nature (WORSTER, 1992). Titman, in Russia, elaborated a study on steppe vegetation in 1837 (IAROSENKO, 1962).

August Grisebach, in 1838, (WORSTER, 1992), introduced the term of formation for identical communities of plants developed under similar climatic conditions, no matter the vegetal species taken as example: humid tropical forests from Africa, South America, Indonesian Archipelago represent a single type of vegetal formation.

J. R. Lorenzo published in 1858 (LORENZO, 1858; IAROSENKO, 1962) a work about the subalpine swamps from Salzburg (Austria). The author described not only the vegetation present in the swamp but also smaller groups such as micro-groups or micro-phytocoenoses.

The Swedish geologist Hampus von Post (IAROSENKO, 1962), 1851-1856, published some works where he remarked that the same plant species may grow differently depending on soil and climatic conditions.

Vladimir M. Bajanov published in 1863 (IAROSENKO, 1962) the paper entitled "*On the artificially cultivated meadows*", which contained numerous geobotanical notions. Kerner published in 1863 the work "*The life of plants in the Danubian countri*", where he subdivided vegetation in formations and thoroughly described each of them (IAROSENKO, 1962).

Ernst Haeckel (1834 – 1919) proposed for the first time in 1866 the term of ecology as the science of the relationships between living organisms and their external environment, habitat (HAECKEL, 1866; NEACŞU, 1984; WORSTER, 1992).

F. I. Ruprechi, in 1866, published the work "*Geobotanical research on chernozem*", where he used the term of geobotanics for the first time (IAROSENKO, 1962).

Karl Moebius defined (1877) biocoenosis as a community of organisms developing within a certain territory, adapted to the environment and one to each other, forming a whole that changes as environment conditions or the number of species changes (DROUIN, 1993; MOEBIUS, 1865; NEACŞU, 1984).

Robert Hult, a Finish researcher published in 1885 a study upon the vegetation in the area of Bleking (Finland) and a study about the alpine vegetation form the north of Finland. Hult's works marked the beginning of research regarding the succession of vegetal groups (IAROSENKO, 1962).

I. K. Pocioski, published the paper (1891) "*Studies regarding the flora development*", where he proposed the separation of the vegetal groups in a distinct science called "*Florology*"; he considered it the science dealing with the genesis, life, development and distribution of vegetal formations. Afterwards, the author renounce at the term of florology replacing it with the term phytocoenology in 1896 (IAROSENKO, 1962).

Charles Darwin (1809 – 1882), an English biologist, set up the evolutionary laws as a result of natural selection (BOTNARIUC, 1961; DARWIN, 1857; NEACŞU, 1984; WORSTER, 1992).

Thomas Huxley (1825 – 1895), another English biologist, published in 1893 the work entitled "*Evolution and ethics*", as he was a partisan of Darwin and his evolutionary theory (BOTNARIUC, 1961; HUXLEY, 1863; WORSTER, 1992).

Eugen Warming published in 1909 "*Oecology of Plants*" (WARMING, 1909). Warming considered that plant ecology had to study:

1 – what are the species associated within the same habitat?

2 – which is the physiognomy of vegetation and landscape?

3 – why do species have a distinct behaviour and habitat?

4 – why do species have a characteristic physiognomy?

5 – which is plant economy, their internal and external structure and their relationship to the environment? (IAROSENKO, 1962; WARMING, 1895; 1909).

Warming is considered the founder of vegetal ecology, in other words of a new biology branch (WARMING, 1895).

P. N. Krilov published in 1898 the work "*Characterization of the vegetation from the Siberian District Tomsk*" (IAROSENKO, 1962).

Retrospectively analysing the aforementioned period one may notice that researchers acting in different fields of natural and human sciences understood that items in nature (plants, animals, physical phenomena, etc.) are not isolated and static but they display dynamic interactions (DELEAGE, 1991; WORSTER, 1992; DROUIN, 1993; MATAGNE, 2002).

It was clearly understood that plants and animals are not distributed at random all over the globe, but they are conditioned and modified by physical factors (temperature, light, humidity, atmospheric pressure), chemical factors (type of soil, water) and biological factors (parasites, predators, human pressure, etc.).

As a conclusion, along the four centuries (16^{th} – 19^{th}), there emerged notions and actions with different degrees of complexity and theorization regarding the living world: succession from dead to alive; water circuit in

nature; succession of plants, etc. There were synthetized different notions, such as vegetal formation, phyto-sociology, biocoenosis, geobotanics, ecology. K. Moebius' work, "*Fauna of Kiel Gulf*" is considered the start of the modern system and methodology in ecology (MOEBIUS, 1865). Charles Darwin advanced the theory about the formation of coral reefs, which, with some modifications, is accepted even nowadays. There appeared the first Laboratory of Marine Biology at Concarneau (France); it can be considered the first research resort in the world. In the United States, the zoologist Louis Agassiz inaugurated the first studies of marine ecology. In London, there was printed the first course on plant ecology.

Consequently, all the accumulated knowledge led to the appearance of ecology as an independent science in the 20th century, as well as of other adjacent branches, such as limnology, hydrobiology, animal ecology, environmental protection.

REFERENCES

AGASSIZ L. 1859. *An essay on classification.* Oxford University Press. London. 381 pp.
BOTNARIUC N. 1961. *Din istoria biologiei generale.* Edit. Ştiinţifică. Bucureşti. 756 pp.
DARWIN CH. 1857. *Originea speciilor.* Edit. Academiei R. P. R. Bucureşti. 313 pp.
DELEAGE J. P. 1991. *Une histoire de l'écologie.* Edit. La Dècouverte. Paris. 478 pp.
DROUIN J. M. 1993. *L'écologie et son histoire.* Edit. Flammarion. Paris. 213 pp.
HAECKEL E. 1866. *Generelle Morphologie der Organismen.* Reimer. Prestel Verlag. Berlin. 241 pp.
HUXLEY T. H. 1863. *Evidence as ta mans place in nature.* Journal of the Proceedings of the Linnean Society of London. D. Appelton and Company. London. 184 pp.
IAROSENKO D. P. 1962. *Geobotanica.* Edit. Academiei R. P. R. Bucureşti. 546 pp.
LINNAEUS C. 1735. *Systema naturae.* Academic Press. Leiden. 1384 pp.
LORENZO J. R. 1858. *Allgemeine Resultate aus der pflanzengeo-graphischen und genetischen Untersuchnagen der Moore im praalpinen Hugellande Salzburgs.* Flora. Allgemeine botanische Zeitung. Regensburg. **41**. 377 pp.
LYELL CH. 1830. *Principles of Geology.* John Murray publisher. London. **1**. 320 pp.
MALTHUS TH. 1817. *Essay on the Population.* John Murray publisher. London. 128 pp.
MATAGNE P. 2002. *Ecologie et son histoire.* Delachaux et Niestlè. Paris. 208 pp.
MOEBIUS K. 1865. *Fauna der Kieler.* W. Engelmann publisher. Leipzig. 88 pp.
NEACŞU P. 1984. *Ecologie şi protecţia mediului.* Tipografia Universităţii Bucureşti. 176 pp.
RAY J. 1674. *Histoire plantarum.* Royal Botanic Society of London. Arno Press London. **3**. 227 pp.
REAUMUR A. F. 1749. *Memoires pour servir a l'histoire des insectes.* Academie Royale des Sciences Frances. Paris. **6**. 1752 pp.
SAFONOV V. & HUMBOLDT VON AL. 1962. *Unele idei despre geografia plantelor.* Edit. Ştiinţifică. Bucureşti. 192 pp.
WARMING E. 1895. *Plantesamfund Grundrak den Okologiske.* Plantegeografi P. G. Philipsen. Copenhaga. 327 pp.
WARMING E. 1909. *Oecology of Plants.* Clarendon Press. Oxford. 422 pp.
WHITE G. 1756. *Ecologie a cent ans.* Ecologie. Biological Sciences. Yale University. New Haven. **26**: 126-158.
WORSTER D. 1992. *Les pionniers de l'écologie.* Edit. Sang de la Terra. Paris. 254 pp.

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IN MEMORIAM
PhD. MIRCEA VLĂDOI
(1946-2011)

CAZAN Oana Mihaela

Although over seven months have passed since my father passed away, I still find it quite hard to accept the idea that the man who had not only a lot of projects to complete but also so much love to offer is no longer among us.

I have decided to write these lines in the memory of a wonderful father and friend, a man who, despite the terrible incurable disease he had to cope with (i.e. cancer), he bravely fought with extraordinary tenacity until the last day of his life, enjoying every moment spent with his beloved family and his friends.

Since childhood my father had been greatly fond of nature – many a time he would tell me about the botany or zoology classes that he, as a schoolboy, had frequently attended in the city's large public gardens, right in the middle of nature.

Another great passion of my father, throughout both high school and university, was chemistry, a science that he made me love from the very first I year I encountered it as a school subject.

In fact, throughout my entire years of school my father was a genuine mentor for me – he carefully guided my first steps in the academic realm and cultivated my love for literature, mathematics, physics, geography and the sciences of nature.

After graduating from university (i.e. Politehnica University of Bucharest) my father pursued a long career of over 40 years in metallurgy, the field in which he also earned his doctorate degree. He co-authored the treatise "Metals and Non-Ferrous Alloys in Metallurgy" (published in 1981) and, as professor of Craiova Mechanics University, he delivered lectures for nearly ten years.

My father's passion for nature began to take clear shape over thirty years ago. It all started one day when my father and I strolled in the park and came across with two boys, who had just caught two Death's Head moths and were urging each other to crush them. Only my father spoiled their fun and took the spectacular moths home, which he used to skilfully create a miniature diorama that I can clearly recollect as though it had happened yesterday. This is how he took up the hobby of hunting and preserving butterflies, whose number rose constantly. I remember with delightful nostalgia all the holidays in my childhood, when my father (Fig. 1), my brother Bogdan and I would go hiking all over the mountains in search for new Romanian butterfly species.

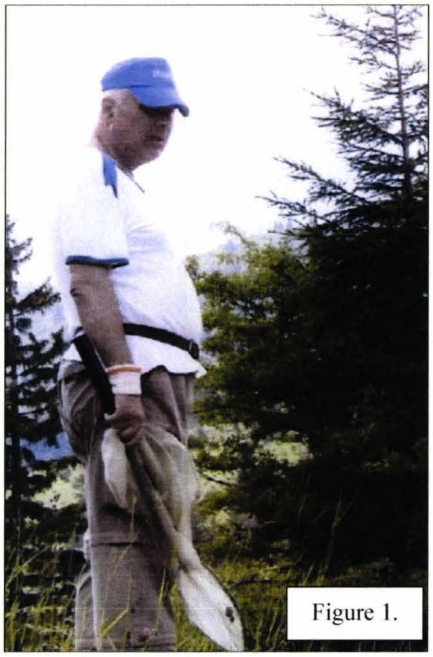

Figure 1.

As the years passed, the assortment of butterflies and moths increased and diversified spectacularly, and my father took great care in minutely arranging and refining his collection. Eventually, he added a great number of exotic species (Fig. 2), to the Romanian ones, as well as an impressive number of members of the insect order of Coleoptera, commonly referred to as beetles (Fig. 3).

My father corresponded with numerous lepidopterists and collectors from all over the world, which enabled him to carry out regular butterfly and moth exchanges and develop the exotic side of his collection. In addition, he was a member of the Romanian Lepidopterology Society and maintained strong ties with the Museum of Natural History in Craiova.

Besides his remarkable collection of Lepidoptera and Coleoptera species, my father accumulated and organized collections of both Romanian and foreign stamps, coins and banknotes, as well as minerals, rocks and corals.

At the moment my father's collection includes dozens of thousands of items representing more than 2,500 various species of Romanian and foreign butterflies, moths and other insects. This collection is the fruit of over thirty years of work, patience and craving for perfection in the fascinating field of entomology, in spite of his completely different professional background and the unforgiving disease he had to struggle with from 2005 until 2011. In the last six years of his life, especially in the last seven-eight months when his condition was seriously worse, my father tenaciously fought against his cancer and never surrendered a single moment.

I would like to say good bye to the one who was my father, mentor and friend for thirty nine years, tear in my eyes and pain in my heart, and end this in memoriam by adding that my father's interest for butterflies, moths, insects in general, stamps, coins and banknotes, minerals, rocks and pebbles, corals and, last but not least, his infinite love for his family motivated him till the last breath of his extraordinary life.

IN MEMORIAM
DR. MIRCEA VLĂDOI
(1946-2011)

CAZAN Oana Mihaela

Cu toate că au trecut şapte luni de când tatăl meu ne-a părăsit pentru totdeauna, îmi vine foarte greu să accept ideea că nu se mai află printre noi omul care mai avea nu doar o mulţime de proiecte de finalizat, ci şi atât de multă dragoste de oferit.

M-am hotărât să aştern aceste rânduri în memoria unui minunat tată şi prieten, un om care s-a luptat curajos şi tenace până în ultima clipă, în ciuda necruţătoarei boli incurabile de care suferea (cancer), bucurându-se de fiecare moment petrecut alături de familia pe care o iubea atât de mult şi de prietenii de-o viaţă.

Tatăl meu a îndrăgit foarte mult natura. Încă din copilărie îmi povestea adeseori despre lecţiile de botanică sau de zoologie pe care, ca şcolar, le petrecea în parcul oraşului, în mijlocul naturii.

O altă mare pasiune a tatălui meu, manifestată de-a lungul anilor de liceu şi a facultăţii, a fost chimia, o ştiinţă pe care m-a făcut s-o iubesc din primul an de studiu al acestei materii.

De fapt, tata mi-a fost un adevarat mentor pe parcursul întregii şcoli – călăuzîndu-mi cu grijă primii paşi într-ale învaţăturii şi cultivându-mi dragostea pentru literatură, matematică, fizică, geografie şi ştiinţele naturii.

După absolvirea facultăţii la Politehnica din Bucureşti, tatăl meu a urmat o lungă carieră de peste 40 de ani în metalurgie, domeniu în care a obţinut şi doctoratul. Este autorul tratului "*Metale şi aliaje non-feroase în metalurgie*" (publicat în 1981) şi a activat timp de aproape zece ani ca lector în cadrul Universităţii de Mecanică din Craiova.

În urma cu mai bine de treizeci de ani, pasiunea tatălui meu pentru natură a început să prindă contur. Totul a pornit într-o zi când mă aflam la o plimbare cu tata prin parc şi am dat întâmplător peste doi baieţi care prinseseră doi fluturi "cap de mort" şi se îndemnau unul pe celălalt care să-i strivească primul. Doar că tata le-a stricat plăcerea şi a dus minunaţii fluturi acasă, folosindu-i cu mare pricepere pentru a crea o diorama în miniatură pe care mi-o amintesc clar, de parcă s-ar fi întâmplat ieri. Aşa s-a nascut hobby-ul său de a prinde şi conseva fluturi, al căror număr a crescut constant. Imi amintesc cu plăcere de toate acele vacanţe din copilărie, când tata, fratele meu, Bogdan şi cu mine băteam munţii în lung şi-n lat, în căutare de noi specii de fluturi româneşti (Fig. 1).

Odată cu trecrea anilor, numărul lor a crescut, colecţia a fost aranjată şi cizelată cu mare migală de catre tata, iar speciilor de fluturi româneşti li s-au alăturat şi din ce în ce mai multe specii exotice (Fig. 2), precum şi numeroase specii de coleoptere (Fig. 3).

Acestea din urmă sunt rezultatul schimburilor efectuate de tata prin corespondente purtate cu numeroşi colecţionari de lepidoptere şi coleoptere din întreaga lume.

A fost de asemenea, membru al Societăţii Lepidopterologice Române şi a avut o buna relaţie de colaborare cu Muzeul de Istorie Naturală din Craiova.

Alături de cu adevarat impresionanta colecţie de lepidoptere şi coleoptere, tata a adunat şi organizat colecţii de timbre- româneşti şi străine – monede şi bancnote din România şi din peste 30 de ţări din lume, corali, roci, minerale şi pietre.

În acest moment, colecţia tatălui meu numără peste 2.500 de specii diferite de fluturi şi alte insecte, româneşti şi exotice (numărul exemplarelor fiind de ordinul zecilor de mii), adunate în peste 30 de ani în care această pasiune a conţinuat să existe şi să fie desăvârşită prin muncă, răbdare şi dorinţă de perfecţiune în domeniul entomologiei, chiar dacă formaţia sa profesională a fost cu totul alta şi chiar dacă începând cu anul 2005 a fost diagnosticat cu această boala cumplită care este cancerul. În ultimii 6 ani, şi în special în ultimele 7-8 luni de viaţă când situaţia s-a înrăutăţit simţitor, tata s-a luptat cu îndârjire cu acest duşman neiertător, nedepunând armele nici un moment.

Închei aici acest articol în memoriam, cu durere în suflet, luându-mi adio cu lacrimi în ochi, de la cel care mi-a fost vreme de aproape 39 de ani tată, mentor şi prieten, concluzionând că pasiunile sale pentru fluturi şi insecte, timbre, monede şi bancnote, corali, diferite tipuri de roci şi pietre, pe lânga dragostea fară margini pentru noi, familia, l-au motivat până în ultima clipă a vieţii sale.

Figure 2. Exotic butterfly from personal collection.
Figura 2. Fluturi exotici din colecţia personală.

Figure 3. Exotic beetles from personal collection.
Figura 3. Coleoptere exotice din colecţia personală.

RECOMMENDATIONS
regarding the elaboration of the papers for the scientific journal
"Oltenia. Studii şi comunicări. Ştiinţele Naturii"

The journal is edited by the Oltenia Museum Craiova and it publishes original papers in the fields of vegetal and animal biology, ecology-environment protection, mineralogy-paleontology, as well as scientific reports, reviews, anniversary or commemoration papers. It appears annually, accredited by CNCSIS as a B+ Journal and content indexing BDI, Zoological Record link la ISI Master Journal List: http://science.thomsonreuters.com/cgi-bin/jrnlst/jlresults.cgi?PC=MASTER&Word=oltenia.

I. Structure, format:

A. Original papers will be structured according to information rendered in the next table:

Table

STRUCTURE OF THE PAPER	CHARACTERISTICS	OBSERVATIONS
TITLE	Capital letters, 12 pt., bold, centered	
two spare rows (12 pt.) between the title and the name of the author/s		
Author/Authors	name, capital letters, first name, non capital, 11 pt., bold, normal, aligned right	between two or many authors, use comma
One spare row, 10 pt.		
Abstract (English)	from the beginning of the line, without tab, 9 pt., bold, normal	the abstract will be written with 9 pt., normal, maximum 300 words
One spare row, 9 pt.		
Keywords (English)	from the beginning of the line, without tab, maximum 5 words, 9 pt., normal	
One spare row, 9 pt.		
Rezumat (Romanian)	from the beginning of the line, without tab, 9 pt., bold, normal	**Complete translation of the title in Romanian** (no capital letters, except for the first letter of the title; 10 pt., bold). The content of the abstract – 9 pt., normal, maximum 300 words
One spare row, 9 pt.		
Cuvinte cheie (Romanian)	from the beginning of the line, without tab, maximum 5 words, 9 pt., normal	
One spare row, 14 pt.		
INTRODUCTION	10 pt. (capital letters, bold)	content – 10 pt., normal
One spare row, 10 pt.		
MATERIAL AND METHODS	10 pt. (capital letter, bold)	content – 10 pt., normal
One spare row, 10 pt.		
RESULTS	10 pt. (capital letter, bold)	content – 10 pt., normal
One spare row, 10 pt.		
DISCUSSIONS	10 pt. (capital letter, bold)	content – 10 pt., normal
One spare row, 10 pt.		
CONCLUSIONS	10 pt. (capital letter, bold)	content – 10 pt., normal
One spare row, 10 pt.		
ACKNOWLEDGEMENTS	10 pt. (capital letter, bold)	content – 10 pt., normal
One spare row, 10 pt.		
REFERENCES	10 pt. (capital letter, bold)	content – see bibliographical references
One spare row, 10 pt.		
Bibliography enumeration	see the detailed explanations at the references heading	
Personal data	Name and surname – 8 pt., bold, normal, centered Institution and e-mail address – 8 pt., normal, centered	

B. Scientific reports will be structured according to the author's (authors') preferences, but it has to include abstract and key words, both in English and Romanian.

C. As for reviews, there will be mentioned: author (authors) of the book (name and first name – SMALL CAPS), comma, the title of the book, non capitals (*Italic*), publishing house, publishing location, year, number of pages. Use a free space and then render the text of the review with as fewer paragraphs as possible and the same characters as in the case of original papers.

- **the materials sent** for publication (printed and in electronic format) has to be between 2 and 8 pages (the number of pages must be even);
- **publishing language:** English;
- **page format –** A4 (21 x 29.7 cm), margins: top – 2.5 cm; bottom – 2.0 cm; left – 2.0 cm; right – 2.0 cm; gutter – 0 cm; header, footer – 1.27 cm. The papers will be elaborated in Microsoft Word, justified; font: Times New Roman, 10 pt., normal; single space;
- latin names (genus, subgenus, species, subspecies) will be written with *italic characters*; **suprageneric names are not written** with italic characters. The same procedure is used when they are mentioned within figures, graphs and tables;
- you have to use the English punctuation signs, namely comma instead of dot and dot instead of comma at numbers in the text, figures, and tables. For example: 54,30 m (in Romanian) = 54.30 m (in English); 2.500 m (in Romanian) = 2,500 m (in English);
- the first mention of a taxon in the text will be followed by the taxon author's name and the publishing year of the description, according to the zoological nomenclature code (e.g.: *Cossus cossus* (LINNAEUS 1758);
- the names of the authors quoted in the text, at references, as well as the authors of the scientific names will be written in SMALL CAPS; **if you do not know** this option, **write normally, not capital letters!**

II. References

➢ **References** in the text (quotation) includes only the author's/authors' names (SMALL CAPS) and publishing year.

Example: IONESCU (1965), STEFĂNESCU, 2008a or (IONESCU, 1965; STEFĂNESCU, 2008a), when it is a single author; IONESCU & WEINBERG (1970), RĂDULESCU & SAMSON (1990) or (IONESCU & WEINBERG, 1970; RĂDULESCU & SAMSON, 1990), when there are two authors; IONESCU *et al.* (1992) or (IONESCU *et al.*, 1992), when there are more than two authors;

- in case there are many papers written by the same author/authors, published in the same year, use the letters a, b, c etc. after the year (e.g.: IONESCU, 2000; IONESCU, 2000a, …, 2000g).

➢ **References** will include **only** the papers quoted in the text (10 pt.), alphabetically rendered, without numbers, as it follows: author (SMALL CAPS), publishing year (normal), (**do not use** comma between the author and the publishing year or between the name and first name of the same author; use comma between different authors, when there are more than two), *the title of the paper* (*italic*), name of the journal, publishing house, volume number (bold), the number of fascicle (normal), number of pages (normal). When there are two authors, use "**&**"; if there are many authors, mention **all** of them. The ladies' first name is completely written; for gentlemen, use only the first letter. The reference titles will be aligned as it follows: the first line from the beginning (no tab), the second at 1.27. Example:

Book reference:

BOŞCAIU N. 1971. *Flora şi vegetaţia Munţilor Ţarcu, Godeanu şi Cernei*. Edit. Academiei R.S.R., Bucureşti: 30-35.

Paper published in a journal:

STAN MELANIA & BACAL SVETLANA. 2006. *New contributions to knowledge of Staphylinidae (Coleoptera: Staphylinidae) of the landscape reserve "Codrii Tigheci" (Moldova)*. Oltenia. Studii şi comunicări. Ştiinţele Naturii. Muzeul Olteniei Craiova. **22**: 155-159.

Reference to a part of a collective paper; volume (with editors):

IFTIME AL. 2005. *Amfibieni şi Reptile*. In: Botnariuc & Tatole (Eds.) Cartea Roşie a Vertebratelor din România. Edit. Academiei Române: 1-325.

Papers presented at scientific manifestations and published in a volume without editors:

CIOCHIA V. & STANCĂ-MOISE CRISTINA. 2001. *Contributions to the knowledge of the Macrolepidoptera from natural complex "Dumbrava Sibiului"*. Sesiunea Ştiinţifică dedicată împlinirii a 75 de ani de la înfiinţarea Staţiunii Biologice Marine "Prof. dr. I. Borcea" Agigea-Constanţa. 19-20 octombrie 2001: 125-131.

Web page: Muzeul Olteniei Craiova. Secţia Ştiinţele Naturii. *Oltenia. Studii şi comunicări. Ştiinţele Naturii* (online). 2008. Publisher: Museum of Oltenia Craiova, Romania. http://olteniastudii.3x.ro/. (accessed: May 8, 2011).

Entire electronic document or service (data base, e-book):

Fauna Europaea: *Chironomidae*. In: Fauna Europaea: Chironomidae, Diptera, Nemathocera (Ed. H. de Jong). Fauna Europaea version 1.5. http://www.faunaeur.org. (accessed: June 23, 2011).

For e-book:

CARROLL L. 1994. *Alices Adventures in Wonderland* (online). Texinfo ed.2.1. (Dortmund, Germany): WindSpiel, November 1994 (cited 30 March 1995). Chapter VII: A Mad Tea-Party. Available from the World Wide Web: http: www germany.eu.net/books/caroll//alice_10.html#SEC 13 (accessed: March 30, 1995).

Electronic publication (papers):

DANILEVSKY M. L. 2007. *A check-list of Longicorn Beetles (Coleoptera, Cerambycoidea) of Europe*. Available online at: http://www.coleoptera-literatura.ic.cz./literatura/checklist_cerambycidae_2007.doc. (accessed: May 20, 2011).

Official publications (laws, decrees, official reports):

*** România. *Legea nr. 13 1993 pentru aderarea României la Convenţia privind conservarea vieţii sălbatice şi a habitatelor naturale din Europa, adoptată la Berna la 19 septembrie 1979*. Monitorul Oficial al României, An. V, nr. 62/25 martie 1993, Bucureşti: 1-20.

Ph.D thesis: COSTACHE I. 2005. *Flora and vegetation Motru River Lower Basin*. Ph.D. Thesis, University of Bucharest: Romania. 290 pp., 8 Pl.

Note: The papers published with other characters than the **Latin** ones, **will be re-written with Latin characters,** both in text and at references.

Example: ALEXANDROVICH O. R. 1995. *Reconstruction of the ways of the ground beetles (Coleoptera, Carabidae) fauna forming at the West of the Russian plain*. In: I. K. Lopatin, Pisanenko A. D., Shklyarov L. P. (Eds.), Fauna and taxonomy: Proceed. Zoology Museum Byel. University Minsk: Nauka I Tekhnika. **1**: 52-68. [In Russian with English abstract]

III. Illustration:

Images (white/black or colour) are inserted into the manuscript, but the original versions have to be also sent separately: original drawing made in ink, good contrast photographs, electronic images in TIFF format at a minimum resolution of 300 dpi.

➢ Tables and graphs will be inserted into the manuscript, but original versions will be sent separately, as well. Tables have to be achieved using the same text editor mentioned above, 8 pt. Graphs must be achieved in Microsoft Word or Microsoft Excel. The table' s legend will be written under the table, 8 pt., normal.

➢ Illustrations references (tables, images) will be made in the text as it follows: (Fig. 1), (Figs. 1a, b), (Figs. 3; 5); (Table 1); to the photos, the source or the photo' s author will be mentioned.

➢ The title of a figure (both in English and Romanian), will be centered below the figure; as for tables, put it above (aligned right), both 9 pt., normal. Examples:

a) Table 1. List of the identified staphylinids from the Lower Dniester. / Tabel 1. Lista faunistică a stafilinidelor identificate în pădurile Nistrului Inferior.

b) Figure 1. Distribution of the butterfly *Papilio machaon* L. / Figura 1. Distribuţia fluturelui *Papilio machaon* L.

➢ **For diagrams, use white, black, grey, different tones and hatches. They will not be published in colours.**

➢ Diacritical marks will be used for the Romanian authors and towns.

The paper will be accepted for publishing if:

➢ it acquires a favourable review from the scientific reviewers of the journal;

➢ it respects the aforementioned requirements;

➢ it is sustained within the framework of the International Conference "*Museum and scientific research*", organized annually in September;

➢ the publication fee is paid;

➢ it is respected the deadline, **March 31** of the current year.

The editorial board has the right to reduce the number of figures and photos (if there are too many as compared to the text of the paper or if they do not correspond to the requirements) and not to accept papers sent after deadline, **March 31, 2013**.

➢ **With all the respect for the authors, papers that do not correspond to the recommendations will be sent back.**

➢ **The responsibility of the scientific content of the papers depends entirely on the authors.** Authors must revise the papers reviewed by the reviewers.

The Editorial Board

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