`

TRANSYLVANIAN REVIEW OF SYSTEMATICAL AND ECOLOGICAL RESEARCH

13

The Cefa Nature Park

Editors

Angela Curtean-Bănăduc, Doru Bănăduc & Ioan Sîrbu

Sibiu - Romania

2012

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Angela Curtean-Bănăduc, Doru Bănăduc & Ioan Sîrbu

„Lucian Blaga” University of Sibiu,
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IN MEMORIAM

Victor Preda
(1912 - 1982)

Victor Preda was a Romanian biologist and also a doctor.

He was born in Bucharest on 20 November 1912. He achieved his secondary education, crucial to his later very active life, in the effervescent atmosphere of that time in the "Gheorghe Lazăr" High School of Sibiu, where he also took the baccalaureate in 1929.

For higher education he decided to attend Faculty of Medicine of Cluj-Napoca University. At this university, he later obtained a doctorate in medicine in 1930.

He carried out intensive specialization in cytochemistry and histology in Vienna and Paris during the period 1938-1939.

Between 1951 and 1952 he acted as University Professor of general biology at the Faculty of Natural Sciences of Cluj-Napoca University.

He was awarded the title of Reader in medical science in 1956.

Elected a member of the Romanian Academy in 1974, he became President of the Cluj-Napoca branch of the Romanian Academy in 1975.

His professional recognition results from his membership of various professional associations: Polish Anatomists Association (1958), International Society of Cell Biology (1969), New York Academy of Sciences (1969), etc.

His research focused mainly on the field of anthropology (physical and social anthropology) and experimental histology and embryology.

The diligent studies resulted in the publication of over 280 scientific papers and publications. He published numerous treatises and monographs on theoretical and general biology, of which the most important are: "Biologia teoretică" (Theoretical Biology) published in 1944; "Probleme moderne de biologie" (Modern problems of biology) 1946; "Biologia" (Biology) 1963; "Biochimia dezvoltării embrionare la vertebrate" (The biochemistry of embryonic development in vertebrates) 1969; "Determinarea şi diferenţierea sexuală la vertebrate" (Determination and sexual differentiation in vertebrates) 1968; "Evoluţia indicelui cefalic în raport cu vârsta" (Evolution of cephalic index on age) 1943; "Beiträge zur Kenntnis des Wachstums und Regenerationsprozesses" (Contributions to the knowledge of growth and regeneration processes) 1944; "Rolul trofic al sistemului nervos embrionar" (Trophic role of the embryonic nervous system) 1956-1961; "Biochimia dezvoltării embrionare la peşti" (The biochemistry of embryonic development in fish) 1959; "Bazele nervoase ale procesului regenerativ şi biochimismului procesului regenerativ" (Fundamentals of the nerve regenerative process and regenerative biochemistry process) 1959; etc.

He died on 10 April 1982 in Cluj-Napoca, leaving the results of his hard work, a man worthy of respect.

The Editors

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Preface

The richness, diversity, complexity and mosaic distribution of habitats and ecosystems in the Tisa River basin, and particularly the basin of the Criş rivers (Crişul Alb, Crişul Negru and Crişul Repede), represent the most important proof and indicator of the remarkable level of biological diversity that has been maintained in this part of the Pannonic Biogeographical Region.

The various forms of current human exploitation of land and natural resources embody the way that human communities have evolved throughout the time, using the values of their region's natural assets, taking advantage of each area's specific morphological and functional characteristics. Cefa-Biharugra transboundary region, situated on both sides of the Romanian-Hungarian national border, illustrates and epitomizes this process. Humid areas within this region have been used and turned by local communities, in response to the area's natural particularities, into wide stretches of waters, wet meadows, forested areas and agricultural lands that have preserved the area's initial natural values which are essential for the preservation of a high level of the local and regional biodiversity.

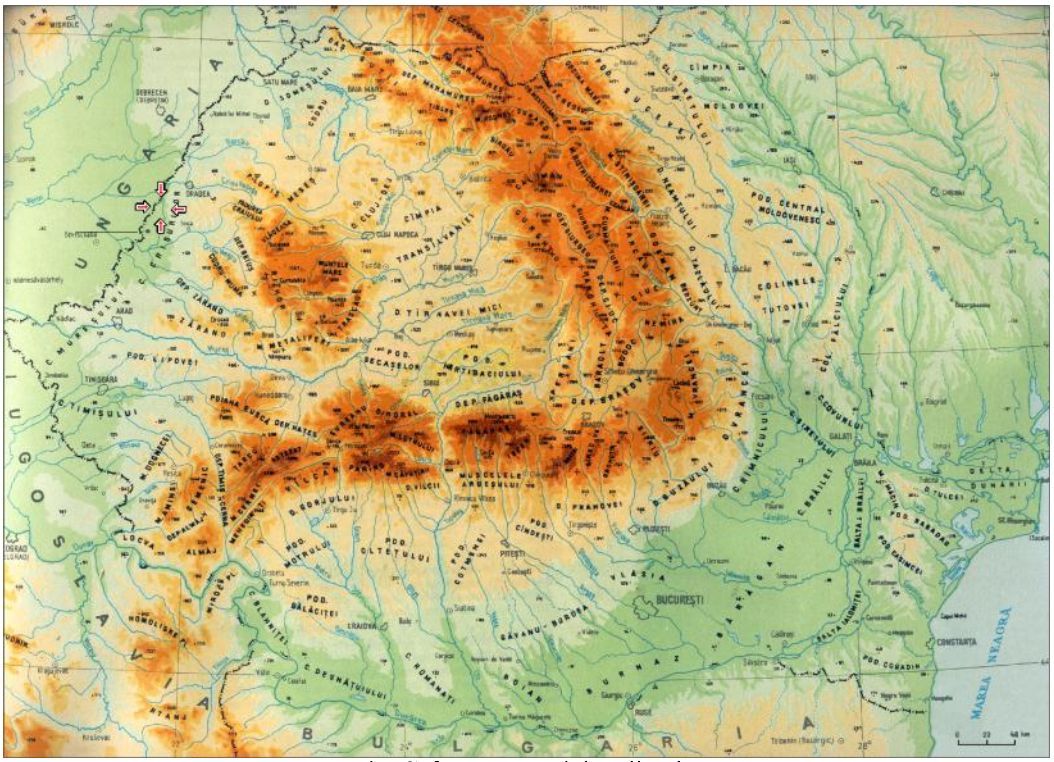
The maintenance of this landscape within the Pannonic-Bulgarian bird migration corridor, representing one of the most important areas in western Romania for feeding, refuge and nesting for a remarkable variety of birds per unit of area, shows that interaction between man and nature has not eroded the area's initial biodiversity values. On the contrary, it has contributed to preserving them. This formula for co-existence should be maintained and extended to the whole region in order to assure the maintenance of favorable conservation status of both habitats and species, which is essential at European level.

The constant activities of professionals to preserve the area's nature values have led to the declaration of a first protected area in Hungary, the Kis Sarret-Biharugra area, as a component of Körös-Maros National Park, at the end of the 1990s, and after that of Cefa Nature Park in Romania in 2000.

Cefa Nature Park is the direct result of fruitful Romanian-Hungarian collaboration within the framework of the PHARE CBC project „Romanian-Hungarian Corridor for Biodiversity Conservation", carried out by the Apuseni Nature Park Directorate from Romania in collaboration with the Körös/Criş-Maros/Mureş National Park Directorate from Hungary, aiming to protect and conserve the whole transborder area, starting from the basic principle that „nature does not take account of national borders".

An intense, complex and long term scientific research program, including also many volunteer activities of the researchers, was conducted under the auspices of this important project and many researchers responded quickly and positively, animated by the desire to be involved in the enhancement of the area's natural values and in the establishment of measures to monitor and maintain these values in the future.

The editors of the *Transylvanian Review of Systematical and Ecological Research* scientific series take this opportunity to support the authors who carried out studies and research in Cefa Nature Park from 2005 to the present, a period that partially coincided with the preparation and campaign stages to obtain certification of the park by the Romanian authorities. The interest shown, the complexity and quality of research activities and particularly the research results have made considerable contributions to the creation of the protected area, as well as to building up the database required for effective management of Cefa Nature Park.



The Cefa Nature Park localization
(Badea et al., 1983 - modified).

Hence, this scientific publication editors believes that it is mandatory to include all the scientific researches in one volume that might represent the starting point of a new perception of this special area, its ecology and its future development and management.

Acknowledgements

The editors of this volume would like to express their gratitude to the authors and the scientific reviewers whose work made the appearance of this publication possible, especially to Mrs. M. Petrovici for her continuous energy and support.

The Editors

A STUDY OF THE BENTHIC DIATOM FLORA OF THE CEFA NATURE PARK (CRIŞANA, ROMANIA)

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KEYWORDS: benthic diatom species, floristic conspectus, fishponds, Cefa Nature Park.

ABSTRACT

The paper presents the results of the qualitative samples analysis of diatoms, as part of the benthos from the fishponds or water supply canals of the fish farm, part of the Cefa Nature Park.

In this initial step the main goal was to establish an unified floristic conspectus. To achieve this benthic diatoms, collected during the periods of the year when diatoms dominate the benthos of water bodies (autumn and spring) were processed samples collected in autumn 2010 and spring 2011.

After processing the samples, 88 specific and intraspecific taxa were identified. Most of them belong to the Bacillariophyceae Class (raphid penate diatoms), of which *Nitschia* genus is best represented (24 species).

ZUSAMMENFASSUNG: Untersuchungen zur benthischen Diatomeenflora des Naturparks Cefa (Crişana, Rumänien).

Die Arbeit befasst sich mit den Ergebnissen der Analyse qualitativer Proben von Kieselalgen Diatomeae als Teil des Benthos aus den Fischteichen oder Wasserzufuhrkanälen der Fischzuchtanlage, die Teil des Naturparks Cefa darstellt.

Dabei handelte es sich, dem Hauptziel entsprechend, in einer ersten Phase um die Zusammenstellung einer einheitlichen, floristischen Aufzählung der benthonischen Kieselalgen/Diatomeen, die innerhalb des Jahres während der Zeiten mit deren dominantem Vorkommen im Wasserkörper (im Frühling und Herbst) entnommen worden. Die Beprobung fand im Herbst 2010 und Frühjahr 2011 statt.

Nach den Bestimmungen wurden 88 spezifische und infraspezifische Taxa festgestellt. Die meisten gehören zur Klasse der Bacillariophyceae (Diatomeae Pennatae Raphidae), von denen die Gattung *Nitschia* mit 24 Arten am besten vertreten ist.

REZUMAT: Studiul florei de diatomee bentonice din Parcul Natural Cefa (Crişana, România).

În lucrare sunt prezentate rezultatele obţinute, în urma analizei unor probe calitative de diatomee, ce constituie o parte a bentosului din heleştee sau canale de alimentare ale fermei piscicole, parte a Parcului Natural Cefa.

S-a urmărit ca principal obiectiv şi într-o primă etapă, stabilirea unui conspect floristic unitar care să reunească diatomeele bentonice, realizat prin prelucrarea probelor colectate în perioadele anului în care diatomeele domină în bentosul corpurilor de apă (toamna şi primăvara). Probele au fost colectate în toamna anului 2010 şi primăvara anului 2011.

În urma determinărilor, au fost identificaţi 88 de taxoni specifici şi intraspecifici. Cei mai mulţi aparţin clasei Bacillariophyceae (diatomee penate rafide), dintre care genul *Nitschia* este cel mai bine reprezentat (24 specii).

INTRODUCTION

The Diatoms are an important part of the algal biomass in lakes, and play an important role in the structure and function of the aquatic food chains. Being primary photoautotrophic organisms, they are directly affected by the changes in the nutrient and light supply and therefore, they are early indicators of environmental changes (Bonnard, 1991; Hall and Smol, 2001; Werum and Lange-Bertalot, 2004; Barinova and Nevo, 2010, 2012; Torrisi et al., 2010).

This study aims to qualitatively assess and characterize the benthic diatom flora, the significant part of algal communities that vegetates in the aquatic habitats of the Cefa Nature Park. Diatom species identified in this area have been mentioned in other papers as well, that covers the algal communities, especially the planktonic ones (Péterfi, 1964, 1969; Momeu et al., 1981), while benthic diatom flora has not yet been treated in a single study.

MATERIALS AND METHODS

The benthic diatom samples (epilithic, epipelic and epiphytic) were taken from five sampling points (Fig. 1), respectively two fishponds (no. 3 and no. 12) and three supply and drain channels (Criş Channel, channel no. 2 and southern drain channel) respectively, in autumn (October) of 2010 and spring (April) of 2011.

Figure 1: The collecting points (1 - 5) in the Cefa Nature Park area (www.googleearth.com, modified).

The epilithic and epiphytic samples were collected by brushing the surfaces of substrata (3-5 rocks or respectively plant fragments, completely covered by water). Epipelic samples were collected by suction with a syringe. Each sample was divided and stored in two labeled recipients and preserved in 4% formaldehyde. Samples were subsequently treated with strong mineral acids (ex. HNO_3), followed by incineration (for six hours). The diatom frustules were mounted in colophony.

The examination, taxonomic identification and the establishment of the floristic composition were done with a trinocular microscope (Olympus BX51), immersion objective (100x), and some up-to-date identification publications like: Süsswasserflora von Mitteleuropa (Krammer and Lange-Bertalot 1997, 2000, 2004, 2008a, 2008b) and Diatoms of Europe Krammer 2000, 2002, 2003; Lange-Bertalot, 2001). The light micrographs were obtained from digital cameras adapted for the microscope (Olympus E330). The checklist of diatom flora was organized according to the system presented by Round et al. (2000).

RESULTS AND DISCUSSION

To the present day, the taxonomic analysis, in the actual systematic context (Guiry and Guiry, 2012) of the benthic diatom flora from the Cefa Nature Park led, until now, to the identification of 88 specific and infraspecific taxa that include 85 species and three varieties, distributed in 23 genera, 17 families, 10 orders and three classes:

Bacillariophyta

Coscinodiscophyceae Round and Crawford 1990

Thalassiosirales Glezer and Makarova 1986

Stephanodiscaceae Glezer and Makarova 1986

1. *Cyclotella bodanica* Eulenstein ex Grunow
2. *Cyclotella meneghiniana* Kützing 1844
3. *Cyclotella planctonica* Brunnthaler 1901
4. *Cyclotella schumanni* (Grunow) Håkansson 1990
5. *Cyclotella stelligera* (Cleve and Grunow) Van Heurck 1882

Melosirales Crawford 1990

Melosiraceae Kützing 1844

6. *Aulacoseira granulata* (Ehrenberg) Simonsen 1979
7. *Melosira varians* Agardh 1827

Fragilariophyceae Round 1990

Fragilariales Silva 1962

Fragilariaceae Greville 1833

8. *Diatoma vulgaris* Bory de St.-Vincent 1824
9. *Diatoma vulgaris* Bory de St.-Vincent 1824 var. *capitulata* Grunow 1862 (Fig. 2)
10. *Fragilaria capucina* Desmazières 1925
11. *Fragilaria capucina* Desmazières 1925 var. *gracilis* (Oestrup) Hustedt 1950
12. *Fragilaria construens* (Ehrenberg) Grunow 1862
13. *Fragilaria dilatata* (Brébisson) Lange-Bertalot 1986
14. *Fragilaria subsalina* (Grunow) Lange-Bertalot 1991
15. *Fragilaria virescens* Ralfs 1834
16. *Synedra ulna* (Nitzsch) Ehrenberg 1832

Bacillariophyceae Haeckel 1878 em. Mann 1990
Eunotiales Silva 1962
Eunotiaceae Kützing 1844
17. *Eunotia formica* Ehrenberg 1843
18. *Eunotia tenella* (Grunow) Hustedt 1913
Cymbelalles Mann 1990
Rhoicospheniaceae Chen and Zhu 1983
19. *Rhoicosphaenia abbreviata* (Agardh) Lange-Bertalot 1980
Anomoeoneidaceae Mann 1990
20. *Anomoeoneis sphaerophoria* (Ehrenberg) Pfitzer 1871
Cymbellaceae Greville 1833
21. *Cymbella affinis* Kützing 1844
22. *Cymbella laevis* Nägeli 1849
23. *Cymbella lanceolata* (Agardh) Kirchner 1878
24. *Cymbella minuta* Hilse 1862
25. *Cymbella proxima* Reimer 1975 (Fig. 3)
26. *Cymbella silesiaca* Bleisch 1864
27. *Cymbella tumida* (Brébisson) van Heurck 1880
28. *Cymbopleura anglica* (Lagerstedt) Krammer 2003
Gomphonemataceae Kützing 1844
29. *Gomphonema acuminatum* Ehrenberg 1832
30. *Gomphonema clavatum* Ehrenberg 1832
31. *Gomphonema minutum* (Agardh) Agardh 1831
32. *Gomphonema parvulum* (Kützing) Kützing 1849
33. *Gomphonema truncatum* Ehrenberg 1832
Achnanthales Silva 1962
Achnantaceae Kützing 1844
34. *Achnanthes exigua* Grunow 1880
35. *Achnanthes lanceolata* (Brébisson ex Kützing) Grunow 1880
Cocconeidaceae Kützing 1844
36. *Cocconeis pediculus* Ehrenberg 1838
37. *Cocconeis placentula* Ehrenberg 1838
38. *Cocconeis placentula* Ehrenberg var. *lineata* (Ehrenberg) van Heurck 1885
Naviculales Bessey 1907
Amphipleuraceae Grunow 1862
39. *Frustulia vulgaris* (Thwaites) De Toni 1891
Pinnulariaceae Mann 1990
40. *Caloneis bacillum* (Grunow) Cleve 1894
41. *Caloneis silicula* (Ehrenberg) Cleve 1894
Naviculaceae Kützing 1844
42. *Hippodonta capitata* (Ehrenberg) Lange-Bertalot, Metzeltin, Witkowski 1996
43. *Navicula angusta* Grunow 1860
44. *Navicula capitatoradiata* Germain 1891
45. *Navicula cryptotenella* Lange-Bertalot 1985
46. *Navicula gastrum* (Ehrenberg) Kützing 1844
47. *Navicula menisculus* Schumann 1867
48. *Navicula placentula* (Ehrenberg) Kützing 1844
49. *Navicula radiosa* Kützing 1844

50. *Navicula tripunctata* (Müller) Bory 1822

Pleurosigmataceae Mereschkowsky 1903

51. *Gyrosigma acuminatum* (Kützing) Rabenhorst 1853
52. *Gyrosigma nodiferum* (Grunow) Reimer 1966

Thalassiophysales Mann 1990

Catenulaceae Mereschkowsky 1902

53. *Amphora ovalis* (Kützing) Kützing 1844
54. *Amphora pediculus* (Kützing) Grunow ex A. Schmidt 1875
55. *Amphora veneta* Kützing 1844

Bacilariales Hendey 1937

Bacillariaceae Ehrenberg 1831

56. *Nitzschia acicularis* (Kützing) W. Smith 1853
57. *Nitzschia amphibia* Grunow 1862
58. *Nitzschia angustata* (W. Smith) Grunow 1880
59. *Nitzschia capitellata* Hustedt 1922
60. *Nitzschia constricta* (Kützing) Ralfs 1861
61. *Nitzschia fonticola* Grunow 1879
62. *Nitzschia fossilis* (Grunow) Grunow 1881
63. *Nitzschia frustulum* (Kützing) Grunow 1880
64. *Nitzschia gracilis* Hantzsch 1860
65. *Nitzschia heufleriana* Grunow 1862
66. *Nitzschia intermedia* Hantzsch ex Cleve and Grunow 1880
67. *Nitzschia levidensis* (W. Smith) Grunow 1881
68. *Nitzschia linearis* (Agardh) W. Smith 1853 (Fig. 4)
69. *Nitzschia modesta* Hustedt 1950
70. *Nitzschia paleacea* (Grunow) Grunow 1881
71. *Nitzschia palea* (Kützing) W. Smith 1856
72. *Nitzschia pusilla* Grunow 1862
73. *Nitzschia sigma* (Kützing) W. Smith 1853
74. *Nitzschia sociabilis* Hustedt 1957
75. *Nitzschia solita* Hustedt 1953
76. *Nitzschia subacicularis* Hustedt 1922
77. *Nitzschia subtilis* (Kützing) Grunow 1880
78. *Nitzschia thermaloides* Hustedt 1955
79. *Nitzschia tubicola* Grunow 1880

Surirellales Mann 1990

Surirellaceae Kützing 1844

80. *Cymatopleura solea* (Brébisson) W. Smith 1851
81. *Surirella angusta* Kützing 1844
82. *Surirella bifrons* Ehrenberg 1843 (Fig. 5)
83. *Surirella biseriata* Brébisson 1835
84. *Surirella brébissonii* Krammer and Lange-Bertalot 1987
85. *Surirella constricta* W. Smith 1851
86. *Surirella minuta* Brébisson 1849
87. *Surirella suecica* Grunow 1881
88. *Surirella tenera* W. Gregory 1856

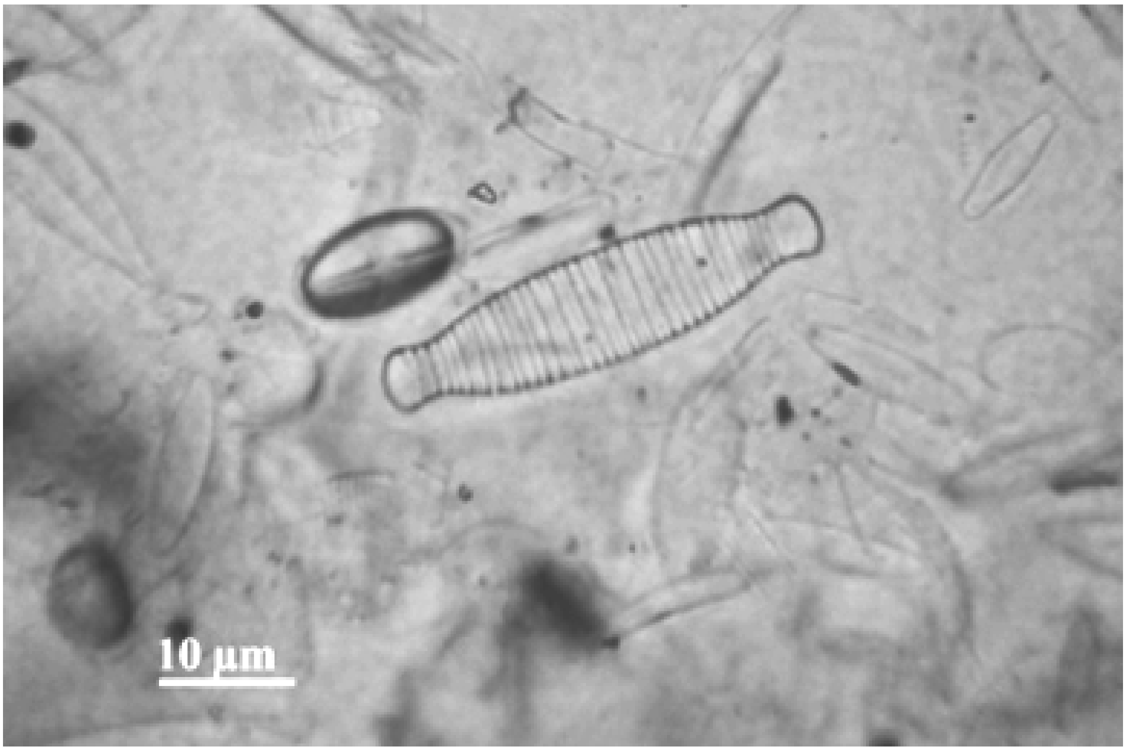

Figure 2: *Diatoma vulgaris* var. *capitulata*.

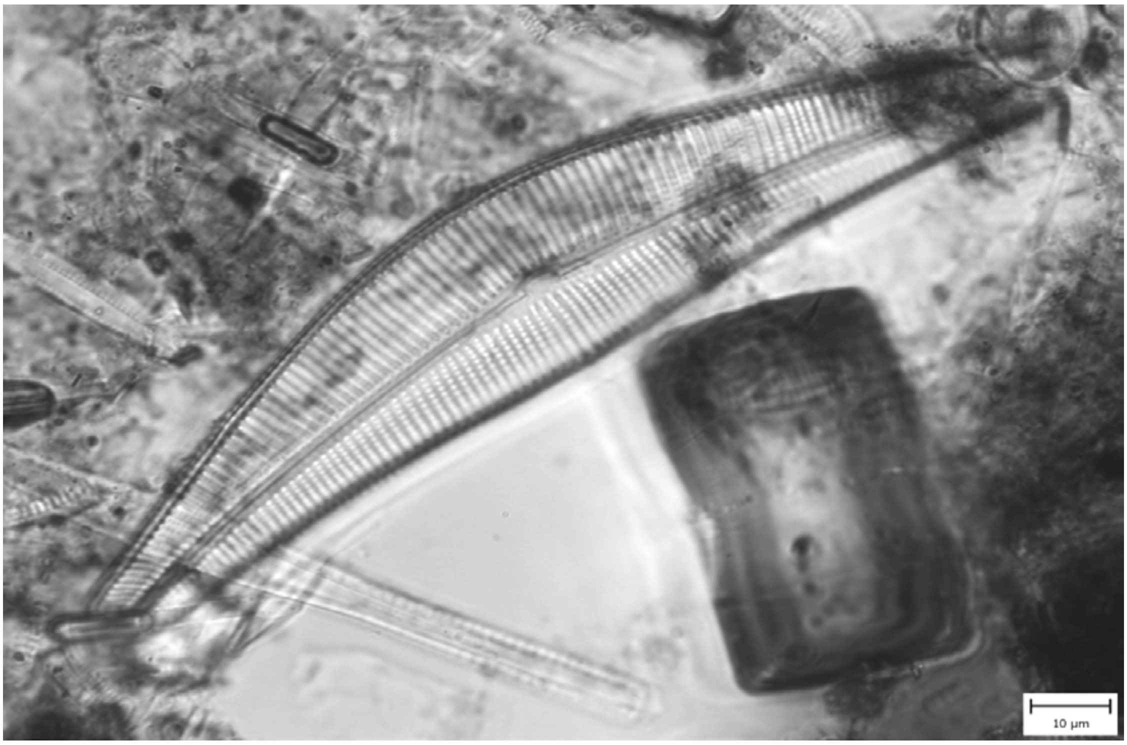

Figure 3: *Cymbella proxima*.

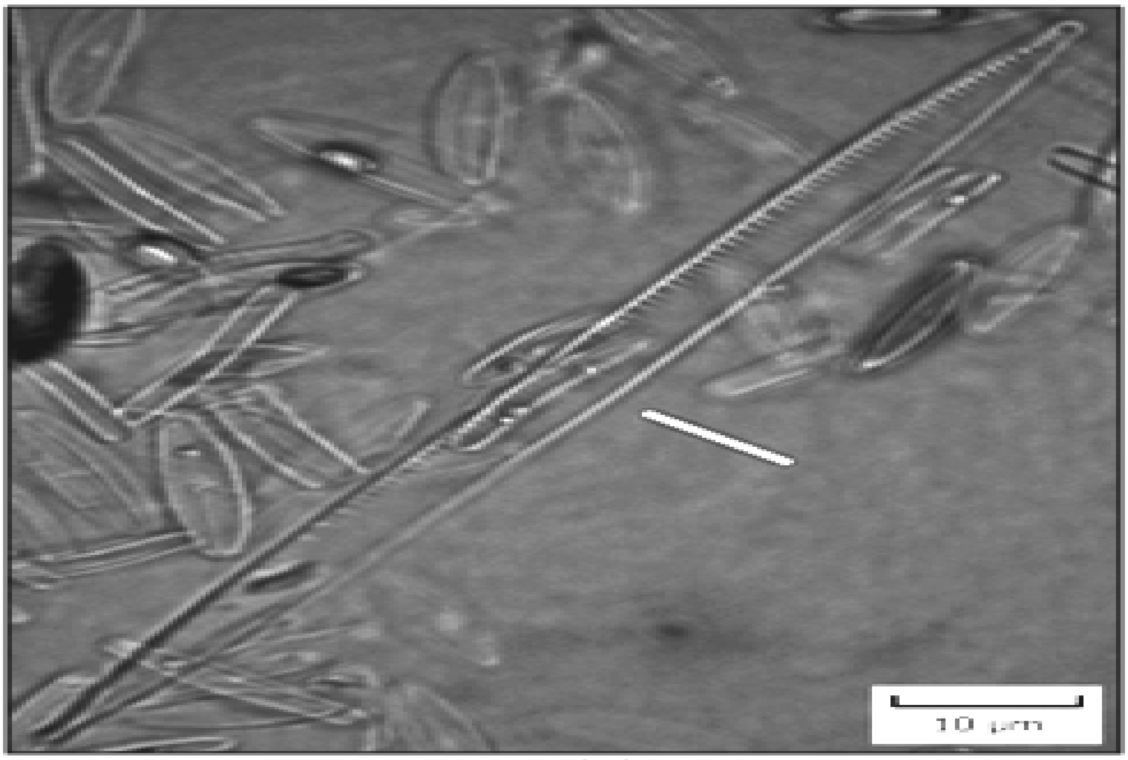

Figure 4: *Nitzschia linearis*.

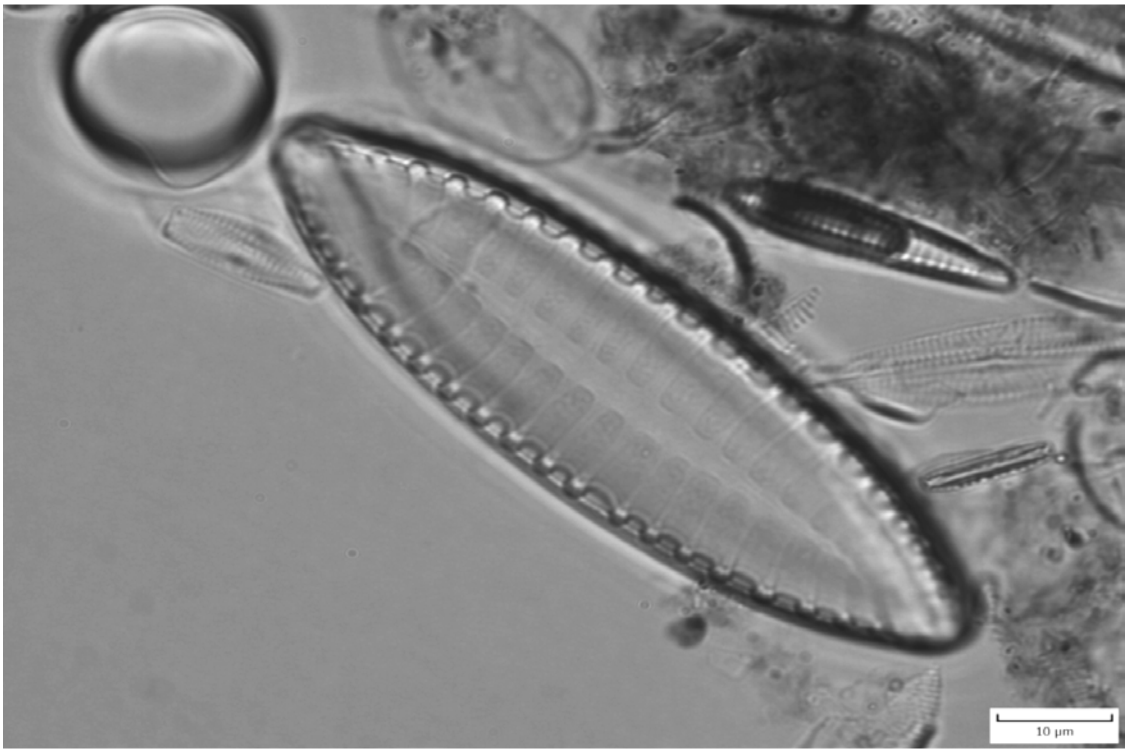

Figure 5: *Surirella bifrons*.

It was found that the dominant family is Bacillariaceae, and the dominant genus is *Nitzschia*, comprising 24 specific taxa. The other genera in descending order are as follow: *Cymbella*, *Navicula* and *Surirella* (each having eight taxa), *Fragilaria* (six taxa), *Cyclotella* and *Gomphonema* (each with ive taxa). Others are represented by less taxa, many of which have one species (Fig. 6).

According to the characterization of the identified taxa in different bibliographic sources (Kramer 2000, 2002, 2003; Krammer and Lange-Bertalot, 1997, 2000, 2004, 2008a, 2008b; Lange-Bertalot, 2001; Round et al., 2000), most taxa (90%) are characterized as cosmopolitan (e.g. *Aulacoseira granulata, Diatoma vulgaris, Synedra ulna, Rhoicosphaenia abbreviata, Cymbella affinis, Gomphonema parvulum, Achnanthes lanceolata, Cocconeis placentula, Navicula capitatoradiata, Gyrosigma acuminatum, Amphora ovalis, Nitzschia amphibia, Surirella bifrons*). In our case, far fewer are the taxa with presumably cosmopolitan distribution (*Navicula placentula, Amphora pediculus, Nitzschia fonticola*), and others have vaguely characterized distribution or are less (incompletely) known.

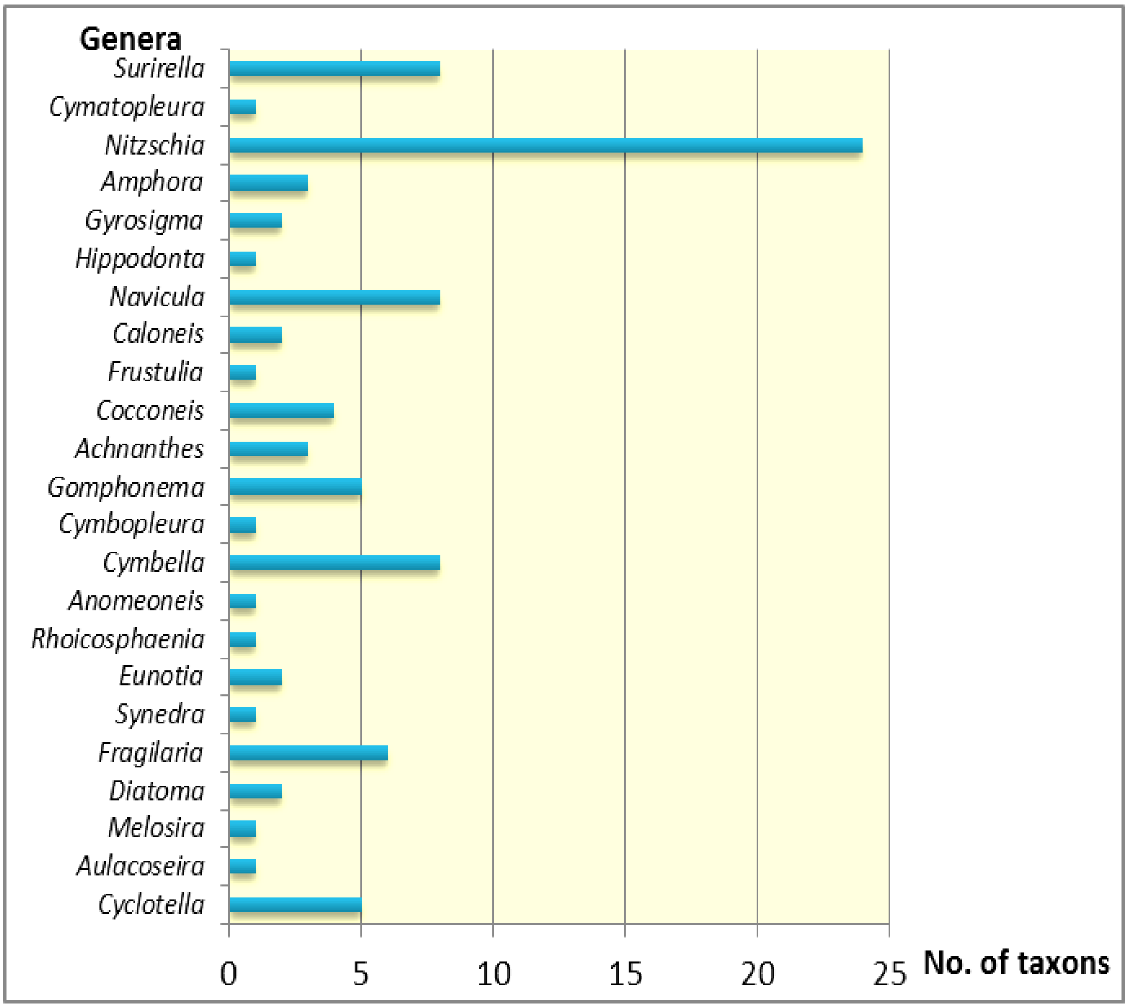

Figure 6: The distribution of identified diatom taxa
within the various genera.

Considering the preferences for the lotic or lentic nature of water, most taxa are adapted to both types of the aquatic habitats. Regarding the salt contents of water, most taxa are found in the brackish water. Many taxa need water having certain amount of electrolytes; most of them prefer water with medium to high electrolyte contents. Considering the water pH, most of the taxa are basophilic and regarding the water trophicity indicators, most taxa live specifically in eutrophic and oligotrophic habitats.

The water quality assessed in this study is based on saprobic categories of diatoms. Benthic diatoms represent some of the best bioindicators among algae, because they are at the base of the food chains and among the first organisms responding to changes that may arise in the environment (Lowe and Pan, 1996). From the saprobic categories circumscribing the identified taxa in the present study, the β-mesosaprobic category is prevailing (38%), being followed by the β-α-mesosaprobic category (24%), α-mesosaprobic category (18%) and oligosaprobic category (16%) while the polysaprobic category is represented by a lower percentage (4%).

ACKNOWLEDGMENTS

The authors of this scientific paper thank to Mrs. M. Petrovici, the coordinator of the scientific voluntary program in the Cefa Nature Park area, who ensured a good progress in the field phase of the present study.

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PLANKTONIC ALGAL COMMUNITIES OCCURRING IN THE WETLANDS OF THE CEFA NATURE PARK (CRIŞANA, ROMANIA)

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KEYWORDS: fishponds, planktonic algae, eutrophication, phytoplankton indices, organic pollution indices.

ABSTRACT

The present paper represents the results of a study on the qualitative structure of plankton algal communities and the assessment of the ecological status of several fishponds located in the Cefa Fishery Complex. The fishponds are situated in the Salonta Plains, part of the low Crişurilor Plain, in the Cefa Nature Park, which is included in a larger protected area stretching across the Hungarian border, in the Körös-Maros/Criş-Mureş National Park..

The main topic of the present paper is the dynamic of planktonic algal communities from fishpond number 12, with special emphasis on summer samples from 1978, 1979, 2007 and 2010. Other four fishponds, numbers 3, 4, 17 and 18, were also considered, based on some research conducted in 1962. 31 algal taxa were identified, belonging to 8 phyla: Cyanoprokaryota, Euglenophyta, Cryptophyta, Dinophyta, Chrysophyta, Xanthophyta, Bacillariophyta and Chlorophyta. Chlorophyta (green algae) had the highest percentage abundance, in all sampled years, but they also revealed a decreasing trend, from 82.19% in 1962 to 35.19% in 2010. Euglenophyta (Euglenoid flagellates) on the other hand increased from 2.74% in 1962 to 26.85% in 2010. These trends can be explained by increasing eutrophication, caused by how the wetlands are managed in the Cefa Fishery complex.

The physical and chemical parameters indicated alkaline waters (the pH ranged between 7.91 and 10), with an eutrophic character. Summer "water blooms" were recorded in all sampled years, due to the massive development of *Microcystis*, *Anabaena*, *Anabaenopsis* or *Oscillatoria.*

Cosmopolitan, eutrophic and alkaline species dominated the planktonic algal communities from a qualitative point of view. The eutrophic character of the fishponds was confirmed by the phytoplankton indices. Fish farming techniques might represent the main cause of the increasing eutrophication in the Cefa fishponds. At the same time, a large quantity of decomposing organic matter is acumulating, as confirmed by the organic pollution indices at species and genus level. Thus, an increasing eutrophic tendency was observed from 1962 up to 2010.

REZUMAT: Comunităţi algale planctonice din zonele umede a Parcului Natural Cefa (Crişana, România).

Lucrarea prezintă rezultatele unor cercetări care au avut drept scop studierea compoziţiei calitative a comunităţilor algale planctonice, din unele heleştee din Complexul Piscicol Cefa şi a stabilirii stării lor ecologice. Heleşteele sunt localizate în Câmpia Salonta, subunitate a Câmpiei joase a Crişurilor, fiind situate în Parcul Natural Cefa, parte a unei zone protejate transfrontaliere care include şi Parcul Naţional Körös-Maros, din Ungaria.

În principal, s-au urmărit aspectele privind dinamica comuntăţilor algale planctonice din heleşteul 12, în special cele de vară (1978, 1979, 2007 şi 2010), precum şi din alte patru heleştee (3, 4, 17 şi 18), pe baza cercetărilor efectuate în 1962. Numărul taxonilor identificaţi a fost de 31, aparţinând la 8 încrengături: Cyanoprokaryota, Euglenophyta, Cryptophyta, Dinophyta, Chrysophyta, Xanthophyta, Bacillariophyta şi Chlorophyta. Grupul care a înregistrat cele mai mari valori ale abundenţei numerice procentuale, pe toată perioada investigată, a fost cel al algelor verzi, care au prezentat o tendinţă clar descrescătoare, de la 82,19% în 1962 la 35,19% în 2010. În paralel, flagelatele euglenoide au avut o tendinţă crescătoare, de la 2,74% în 1962 la 26,85% în 2010. Aceste tendinţe pot fi explicate prin accentuarea procesului de eutrofizare datorită modului de utilizare a zonelor umede de la Cefa.

Parametrii fizico-chimici măsuraţi indică ape alcaline (pH între 7,91 şi 10) cu caracter eutrof. “Înfloriri” ale apei în sezonul estival s-au înregistrat pe întreaga perioadă investigată, acestea fiind determinate de dezvoltarea masivă a *Microcystis*, *Anabaena*, *Anabaenopsis* sau *Oscillatoria*.

Comunităţile algale planctonice sunt dominate sub aspect calitativ de elemente euribionte şi cosmopolite, dar şi de multe alge eutrofe şi forme alcalifile. Caracterul eutrof al apei din heleşteele de la Cefa este confirmat şi de valorile indicilor fitoplanctonici calculaţi. Tehnologiile, aplicate pentru creşterea peştilor, constituie principala cauză a accentuării procesului de eutrofizare în heleşteele de la Cefa. În paralel are loc şi acumularea unei cantităţi mari de materie organică nedescompusă, acest lucru fiind confirmat şi de valorile indicilor de poluare organică la nivel de specie şi la nivel de gen, care arată tendinţa crescătoare a acestui proces din 1962 până în 2010.

RÉSUMÉ: Communautés algales planctoniques identifiées dans terrains humides du Parc Naturel Cefa (Crişana, Romania).

Cet article présente les résultats d'une étude sur la structure qualitative des communautés d'algues planctoniques et de l'évaluation de l'état écologique de plusieurs étangs situés dans le complexe de pêche de Cefa. Les étangs sont localisés dans la plaine Salonta qui constitue une partie de la plaine de Crişuri, située dans le Parc Naturel Cefa. Ce Parc est inclus dans un grand espace protégé qui s'étend sur la frontière hongroise, dans le parc national Körös-Maros/Criş-Mureş.

Le sujet principal de la présente étude est la dynamique des communautés planctoniques algales d’un étang numéroté 12. L’accent est mis sur les échantillons d'été des années 1978, 1979, 2007 et 2010. Quatre autres étangs numérotés 3, 4, 17 et 18 ont aussi fait l’objet d’une étude en 1962. 31 taxons appartenant à huit phylums ont été identifiés: Cyanoprokaryota, Euglenophyta, Cryptophyta, Dinophyta, Chrysophyta, Xanthophyta, Bacillariophyta et Chlorophyta. Pour toutes les années considérées, les algues vertes ont enregistrées la plus grande abondance en pourcentage. Une tendance décroissante à tout de même été enregistrée de 82,19% en 1962 à 35,19% en 2010. Les euglenophytes flagellées ont défini une tendance croissante de 2,74% en 1962 à 26,85% en 2010. Ces tendances pourraient s'expliquer par une eutrophisation culturelle croissante causée par le mode de gestion des zones humides du complexe de pêche de Cefa.

Les paramètres physiques et chimiques ont indiqué des eaux alcalines (pH compris entre 7,91 et 10) avec un caractère eutrophe mis en évidence par la salinité et la conductivité mesurées dans les étangs. En été, des efflorescences algales ont été enregistrées pour toutes les années échantillonnées. Ceci est dû au développement massif de *Microcystis, Anabaena, Oscillatoria* ou *Anabaenopsis*.

Des espèces cosmopolites, eutrophes et alcalines ont dominé les communautés planctoniques algales d'un point de vue qualitatif. Le caractère eutrophe des étangs piscicoles a été confirmé par les indices phytoplanctoniques. Les techniques de pisciculture pourraient représenter la principale cause de l'eutrophisation croissante dans les étangs de Cefa. Dans le même temps, une grande quantité de matière organique en décomposition est accumulée, comme l’ont confirmé les indices de pollution organique. Ainsi, une tendance croissante a été observée de 1962 à 2010.

INTRODUCTION

In lentic ecosystems the plankton is the most edifying (Momeu et al., 1999; Carvallio et al., 2006).

The fishponds of the Cefa Fishery Complex are located in the Salonta Plain, a subunit of the Crişurilor Lowland (Pop, 1968). The Salonta Plain, according to its genesis belongs to the subsidence plains (Pop, 2005).

Wetland drainage works at Cefa, including extended areas with ponds, swamps, banks, wet grasslands and forests, had been started since 1905 when the Criş Channel was built. This channel served as water supply of all fishponds established in the same time (Macalik and Sárkány-Kiss, 1999). Later, the fishponds system has subsequently been extended by building supplementary channels and dams. Now, the whole Cefa Fishery Complex with all fishponds, dams and channels is part of the Romania western border protected area including both the Cefa Nature Park in Romania and the Körös-Maros/Criş-Mureş National Park from Hungary, separated by the national border (Petrovici, 2010). The Cefa Nature Park has an area of 5,002 ha, with a network of channels and dams and provide on a relatively restricted area a high diversity of mosaic habitats such as bogs, fishponds, channels, puddles, salt meadows, forests but also agricultural lands, pastures, wet meadows, etc. Six habitats from these are listed in the Annexes of Habitats Directive 92/409/EEC.

The outstanding biodiversity of the area has been approached for the investigation and knowledge of several groups of organisms. From the primary producers the macrophytes were studied by Pop (1968) and Burescu (2003). The first investigations on algae were carried out by Péterfi (1964, 1965 and 1969) and subsequently by Momeu et al. (1981). The later authors dealt with the quantitative evaluation of the phytoplankton populations, without publishing the floristic checklists of algae. Their field studies were carried out in the summer of 1978 and 1979, the algal checklists being prepared to be included in the present paper. In recent years have been resumed the investigation of aquatic organisms of the Cefa Nature Park within the framework of voluntary actions. There have been investigated the planktonic algae inhabiting the Cefa fishpond no. 12, the findings being included in some dissertation theses (Scrob, 2008; Blaga, 2011) at the Taxonomy and Ecology Department, Faculty of Biology and Geology, Cluj-Napoca University, Romania.

The aim of the present work was to reinvestigate the planktonic algal communities from Cefa Fishpond no. 12 (Fig. 1), based on samples collected in the spring and summer 2010 and to compare the new findings with those published in earlier papers in 1978, 1979 and 2007, as well as with those concerning the other plots studied in 1962.

Figure 1: The location of the fishpond number 12, in the Cefa Fishery Complex.

The objectives of the present study are: to establish the qualitative structure of planktonic algal communities; to emphasize some features of seasonal dynamics of the communities sampled in 2010; to compare the taxonomic composition of the summer communities inhabiting Cefa Fishpond number 12 (data from 1978, 1979, 2007 and 2011) and those published in 1962 in other fishponds from the Cefa Fishery Complex; to comparatively estimate the ecological state of the investigated fishponds, based on trophicity and organic pollution indices, comparing the situations of 1978, 1979, 2007, 2010 and 1962.

MATERIAL AND METHODS

The algae samples were collected in spring (April) and summer (June) 2010 in Cefa Fishpond number 12, located in the Cefa Nature Park, with a 40 µm Ø mesh size plankton net, and by filtering 20-30 liters of pond water. The samples were preserved on site with 4% formalin. Physicochemical parameters of the water were measured: conductivity ($\mu S.cm^{-1}$), salinity ($mg.L^{-1}$), dissolved oxygen ($mg.L^{-1}$, %), pH and temperature (^{0}C). The algal taxa were identified at species level, using a Nikon Eclipse E 400 optical microscope. To estimate the level of eutrophication there have been employed the indices recommended by Sigel (2006) and Willen (2000). Other indices used in this paper are: cyanophycean index (Nygaard, 1949), chlorophycean index (Rawson, 1956), diatom index (Stockner, 1972), composite microalgae index (Nygaard, 1949), trophicity index (Heinonen, 1980), and zeta-eutrophic index (Oltean, 1977). To estimate the degree of organic loading, the organic pollution index (Palmer, 1969) was computed at both genera and species level.

Among indices widely used for this type of studies purpose, namely for the evaluation of stagnant waters, several phytoplankton indices are recommended, based on qualitative studies by which can be evaluated the trophic level (Sigel, 2006; Willen, 2000; Oltean, 1977), and/or that of the organic pollution (Willen, 2000). One of the indices recommended by Oltean (1977) for the estimation of water trophicity level is the zeta-eutrophic index for cyanobacterial blooms.

To estimate the level of trophicity the authors calculated the phytoplankton indices recommended by Willen (2000) and Sigel (2006), the Chlorophycean Index (Rawson, 1956), A/C Diatom Index (Stockner, 1972), Cyanophycean Index (Nygaard, 1949) and Composed Microalgae Index (Nygaard, 1949).

RESULTS AND DISCUSSION

The mean values of the physicochemical parameters of the Cefa Fishponds, based on the 2007 and 2010 measurements are presented in the table number 1. The water temperature is influenced by the air and by the season. The amount of dissolved oxygen depends on water temperature, being inversely proportional to the increase in temperature. Oxygen values might be affected during daytime by the intensity of photosynthesis. (Gomoiu et al., 2009)

Table 1: Mean values of the physico-chemical parameters in the Cefa Fishponds (M. Petrovici, personal communication; Scrob, 2008; Blaga, 2011).

Parameters		Year and season of sampling		
		2007	2010	
		Summer	Spring	Summer
Hydrogen ion concentration (pH)		8.06	7.91	8.05
Air temperature (^{0}C)		24.6	15.5	26.0
Water temperature (^{0}C)		25.3	12.6	28.6
Conductivity ($\mu S.\ cm^{-1}$)		853	854	870
Salinity ($mg.\ L^{-1}$)		130	113	150
Dissolved oxygen	($mg.\ L^{-1}$)	7.32	10.4	6.72
	%	86.05	96.8	89.4

Salinity and conductivity values depend in general on the nature of the geological substrate of the reservoirs, but they are also influenced by the water drainage basin, and the technology employed for fish growth (fodder, hygiene measures etc.), as well as by the usage of the surrounding areas. Salinity and conductance also depend on the presence of other pollution sources like household waste water, agricultural and industrial wastes, tourism, etc. The hydrogen ion concentration (pH) might be influenced as well by the intensity of photosynthesis; the intense CO_2 consumption during daytime increases pH, while, in contrast enrichment of water in CO_2 during the night decreases the pH values (Gomoiu et al., 2009). The pH values in 2007 and 2010 were alkaline (Tab. 1); similar values ranging between 8.0 and 8.9 have been recorded in 1978 and 1979 (Momeu et al., 1981), but also in 1962 (Péterfi, 1964), ranging between 8.5 and 10.

The algal flora of the Cefa Fishpond number 12, based on both spring and summer sampling campaigns in 2010, comprises a total of 108 taxa belonging to six phyla (Fig. 2). In the month of April, 61 taxa were identified, whereas in June 66 taxa were found (Figs. 3 and 4).

According to the present findings (Fig. 2), 38 green algal taxa were identified, especially *Chlorococcales*, representing 35.19% of the flora, followed by the euglenoid flagellates, with 26.85%, and diatoms, with 23.15%, the blue greens being less important from the biodiversity point of view. The spring and the summer phytoplankton community (Figs. 3 and 4) comprise more taxa (61 in April and 68 in June) but the leading phyla are the same; their order is quite different according to seasons. In spring the diatoms are dominant (Fig. 3) with 22 taxa (36.07%); followed by greens with 19 taxa (31.15%), euglenoid flagellates 10 taxa (16.39%) and blue greens with 9 taxa (14.75%). During summer time, the green algae dominate the phytoplankton algae (Fig. 4) - 26 taxa (38.23%) and the euglenoid flagellates - 23 taxa (33.82%), the diatoms and blue greens are on the third position with equal shares - 9 taxa (13.23%). The diversity of diatom species in April might be caused by the spring circulation of pond water, when diatoms have their usual maximum abundance. That is why most diatom taxa (benthic elements) are possibly washed into the plankton community by convection currents. Quantitatively, in vernal season the distribution of algae is relatively balanced, some chlorococcaleans develop high population densities, like *Coelastrum astroideum, Botryosphaeria pulchellum,* and *Monoraphidium contortum*, some of the *Oocystis, Pediastrum* and *Senedesmus* species. In contrast, although green algae have maximum diversity, some blue greens, like *Anabaena cylindrica, Anabaena planctonica, Anabaena spiroides, Microcystis aeruginosa, Microcystis viridis* and *Apahnizomenon flos-aquae*, exhibit great abundance or even heavy blooms. One can notice the high diversity of euglenoid flagellates (*Euglena, Phacus* and *Trachelomonas* species) in the warm season, some of them being mixotrophs. The above described community features are characteristic for this habitat type - ponds and fishponds, as shown by previous investigation (Reynolds, 1977; Sigel, 2006). Moreover, the taxonomic composition of phytoplankton communities of the Cefa Fishponds remained virtually the same during the last fifty years (Péterfi, 1964; Momeu et al., 1981). Similar cases have been recorded also in other fishponds located in the same area (Péterfi, 1969; Bota and Momeu, 2011), as well as in the Fizeş Rivulet catchment area (Momeu et al., 1979, 1980; Momeu et al., 2006), or in the surrounding of Sibiu locality (Momeu et al., 1991-1992).

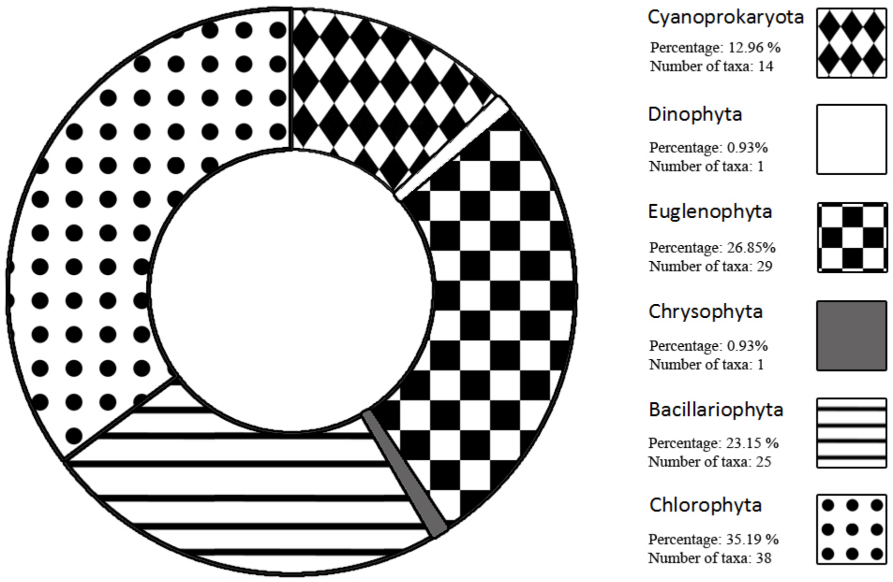

Figure 2: Relative abundances of the main phyla
from the planktonic algal community
from fishpond number 12 in 2010.

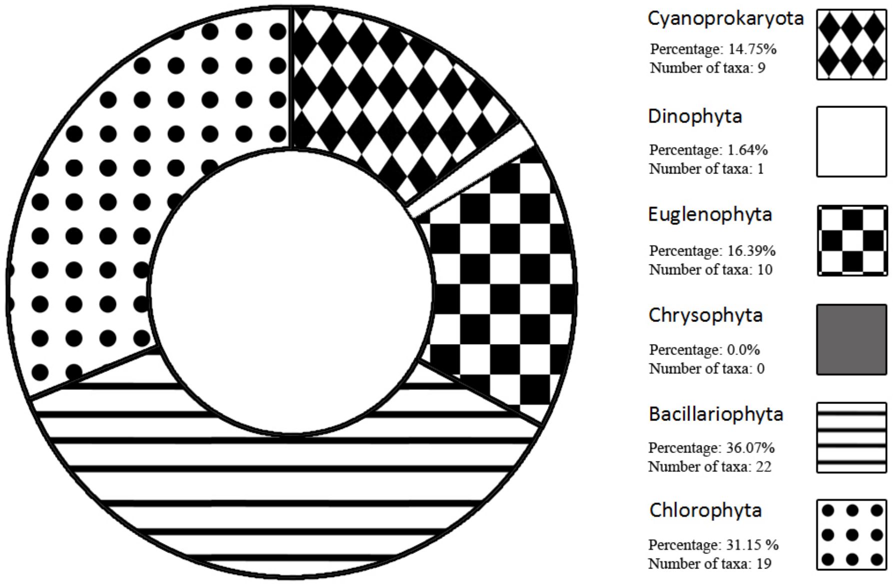

Figure 3: Relative abundances of the main phyla
from the planktonic algal community
from fishpond number 12 in April 2010.

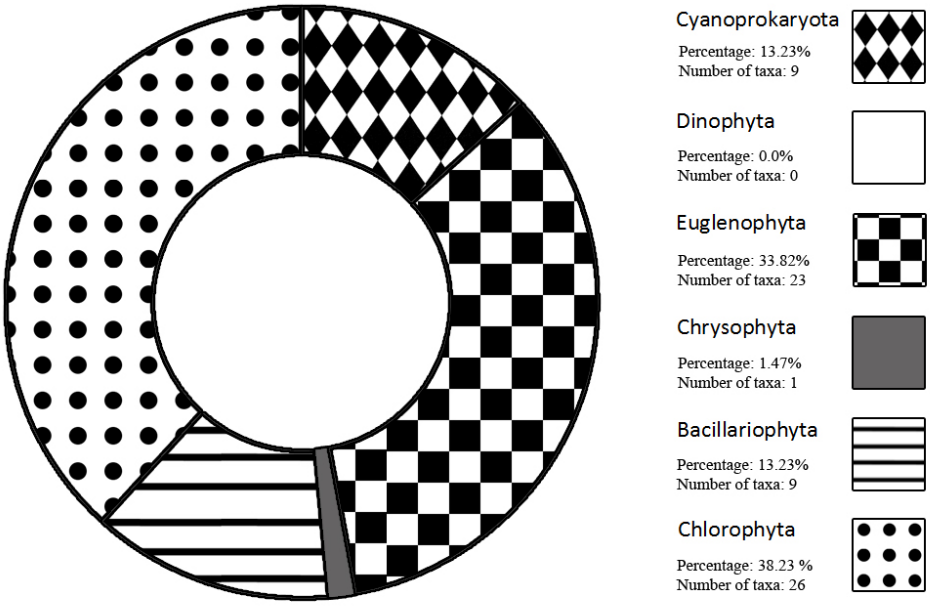

Figure 4: Relative abundances of the main phyla from the planktonic algal community from fishpond number 12 in June 2010.

Considering the ecological aspects, the highly represented are the genuine planktonic forms of algal flora (*Anabaena planctonica, A. spiroides, Aphanizomenon flos-aque, Microcystis aeruginosa, M. viridis, Oscillatoria planctonica, Euglena texta, Lepocinclis ovum, Phacus tortus, Melosira granulata, Fragilaria crotonensis, Coelastrum microporum, Monoraphidium contortum, Oocystis lacustris, Scenedesmus costatus, S. spinosus, Tetraëdron incus, Chlamydomonas monadina*, etc.). Several plankto-benthonic forms are also present like *Oscillatoria tenuis, Phacus agilis, Melosira varians, Cyclotella meneghiniana* and *Nitzschia acicularis* and benthonic elements, mostly diatoms, washed into the plankton during the spring circulation (*Amphora veneta, Cocconeis pediculus, Cymatopleura solea, Navicula* and *Nitzschia* species). Referring to the required environmental conditions for algae, there are many cosmopolite eurybionts (*Euglena agile, Phacus orbicularis, P. pleuronectes, Trachelomonas armata, T. oblonga, Fragilaria ulna, Gomphonema truncatum, Nitzschia amphibia, N. palea, Kirchneriella irregularis, Monoraphidium arcuatum, Scenedesmus quadricauda, Tetrastrum elegans, Closterium aciculare*, etc.). Many eutrophic elements have also been found with the above mentioned algae, widely distributed in pools, ponds, fishponds and shallow lakes (*Anabaena spiroides, Aphanizomenon flos-aquae, Microcystis aeruginosa, Oscillatoria limnetica, O. limosa, Euglena, Phacus* and *Trachelomonas* species, *Dinobryon sociale, Amphora lybica, Navicula cuspidata, Actinastrum hantzschii, Coelastrum sphaericum, Lagerheimia ciliata, Monoraphidium griffithii, Eudorina elegans*, etc.). The presence of several halophilic elements can be mentioned: *Cyclotella meneghiniana, Hantschia elongate* and *Navicula halophila*, together with the alkaliphilic *Closterium acerosum, C. littorale, Nitzschia linearis, Fragilaria crotonensis, Caloneis silicula* and *Melosira varians*. The occurrence of many eutrophic and halophilic forms is in accordance with the salinity and conductivity values measured. The pH values of the fishponds explain the presence of alkaliphilic elements.

Comparative review of the planktonic algal communities of the Cefa fishpond number 12, based on 1978, 1979, 2007 and 2010 samplings

To perform this retrospective, the authors used the findings of earlier published investigation (Momeu et al., 1981), as well as the unpublished checklists produced based on two earlier samplings - 1978 (Momeu et al., 1979) and 1979 (Momeu et al., 1980) are presented for the first time in this paper. The floristic information for the year 2007 was extracted from a bachelor thesis (Scrob, 2008), while those for the year 2010 were taken from a master thesis (Blaga, 2011).

Finally, the published and unpublished phytoplankton data concerning the Cefa fishpond number 12 gathered a total of 210 taxa (Tabs. 2 and 3). Analyzing this synoptic table, the authors concluded that the multiannual dynamics of the phytoplankton exhibits no significant changes and differences at the level of the main algal groups involved in community structure. In all cases, the green algae dominate the communities as percentage contribution, showing a slight decrease in the year 2010. In contrast, the euglenoid flagellates increased in density in 2010. The cyanoprokaryotes constitute the most constant group as percentage contribution to community structure during the investigated years, displaying values between 12.60% (1979) and 15.20% (2007). Some cyanoprokaryotes produced heavy blue green blooms in the investigated fishponds (ex. *Anabaena* species, *Aphanizomenon flos-aquae, Microcystis aeruginosa* and *M. viridis*). The authors' findings are basically consistent with the results of previous investigations (Péterfi, 1964) carried out on different fishponds from the same Cefa Fishery Complex (Tab. 3). In samples collected from Cefa fishponds numbers 3, 4, 17 and 18, Péterfi (1964) identified 146 taxa belonging to: Cyanoprokaryota - 14 taxa (9.68%), Euglenophyta - 4 taxa (2.83%), Dinophyta - 1 taxon (0.78%), Xanthophyta - 7 taxa (4.82%) and Chlorophyta - 120 taxa (81.8%). The most numerous are the green algae, followed by blue greens, xanthophytes and euglenoid flagellates. Diatoms, chrysophytes and dinophytes were not investigated by Péterfi (1964). Blue green algal blooms have also been reported in 1962, caused by the logarithmical development of *Oscillatoria planctonica, Anabaenopsis kulundinensis, Oscillatoria tenuis, Anabaena spiroides* and *Microcystis aeruginosa* (Péterfi, 1964). The main cause of the growing tendency of euglenoids (many are mixotrophs or heterotrophs) might be the accumulation of organic matter due to fish growth technology used (feeding, farmyard manure), and to the summer shortage of nutrients and light (shading effect of floating algal masses and aquatic plants). Another evident tendency during the investigated period was the decrease of Conjugatophyceae taxa, their number dropped to half from 1962 to 2010.

The total number of identified algae inhabiting the investigated fishponds in the Cefa Fishery Complex, during the 1962 - 2010 period is 310 taxa, distributed in eight phyla, based on the data included in the present paper (Tabs. 2 and 3) and those presented by Peterfi (1964). The present findings are similar with those recorded in other aquatic habitats of this type located in the Romanian Western Plain, at Rădvani and Mădăraş (Péterfi, 1969), like the Valea Viţeilor Lake (Bota and Momeu, 2011), or in the Transylvanian Plain (Momeu et al., 1979, 1980, 2006) and in the surroundings of Sibiu locality (Momeu et al., 1991-1992).

Table 2: Qualitative structure of the phytoplankton community from the fishpond no. 12.

TAXA		YEARS				
Cyanoprokaryota		1978	1979	2007	2010, April	2010, June
1.	*Anabaena catenula* Kützing ex Bornet and Flahault 1886	-	-	+	+	-
2.	*Anabaena cylindrica* Lemmermann 1896	-	-	-	-	+
3.	*Anabaena flos-aquae* Brébisson ex Bornet and Flauhault 1886	+	+	+	-	-
4.	*Anabaena flos-aquae f. aptekariana* Elenkin 1836	+	+	+	-	-
5.	*Anabaena planctonica* Brunnthaler 1903	-	-	-	-	+
6.	*Anabaena spiroides* Klebahn 1895	-	-	-	-	+
7.	*Anabaena variabilis* Kützing ex Bornet and Flahault 1886	+	+	+	-	-
8.	*Anabaenopsis elenkinii* V. V. Miller 1923	+	+	+	-	-
9.	*Aphanizomenon flos-aquae* Ralfs ex Bornet and Flahault 1886	+	+	+	+	-
10.	*Aphanothece chlatrata* G. West and S.West 1906	+	+	+	-	-
11.	*Arthrospira platensis* (Nordstedt) Gomont 1892	+	+	+	-	-
12.	*Gomphosphaeria aponina* Kützing 1836	-	+	-	+	-
13.	*Gomphosphaeria lacustris* Chodat 1898	-	-	+	-	-
14.	*Merismopedia tenuissima* Lemmermann 1898	-	-	+	-	-
15.	*Microcystis aeruginosa* (Kützing) Kützing 1846	+	+	+	+	+
16.	*Microcystis pulverea* (Wood) Forti in De Toni 1907	+	+	+	-	-
17.	*Microcystis viridis* (A. Braun) Lemmermann 1903	-	-	+	+	+
18.	*Microcystis wesenbergi* (Komárek) Komárek in Komárek and Ettl 1958	-	-	+	-	-
19.	*Oscillatoria chlorina* Kützing ex Gomont 1892	+	+	+	-	-
20.	*Oscillatoria cortiana* Meneghini ex Gomont 1892	-	-	-	+	-
21.	*Oscillatoria geminata* Meneghini ex Gomont 1892	-	+	+	-	-
22.	*Oscillatoria guttulata* van Goor 1918	-	+	+	-	-

Table 2 (continuing): Qualitative structure of the phytoplankton community from the fishpond no. 12.

TAXA		YEARS				
Cyanoprokaryota		1978	1979	2007	2010, April	2010, June
23.	*Oscillatoria limnetica* Lemmermann 1900	-	+	-	+	+
24.	*Oscillatoria limosa* C. Agardh ex Gomont 1892	+	+	+	+	-
25.	*Oscillatoria planctonica* Woloszynska 1912	-	+	+	-	+
26.	*Oscillatoria redekei* van Goor 1918	-	-	-	-	+
27.	*Oscillatoria tenuis* C. Agardh ex Gomont 1892	-	-	-	+	+
	Euglenophyta					
28.	*Colacium vesiculosum* Ehrenberg 1834	+	-	-	-	-
29.	*Colacium vesiculosum f. cyclopicola* (Gicklhorn) T. G. Popova 1939	-	-	-	-	+
30.	*Euglena acus* (O. F. Müller) Ehrenberg 1830	+	+	+	-	+
31.	*Euglena agilis* H. J. Carter 1856	+	+	-	+	+
32.	*Euglena contabrica* E. G. Pringsheim 1956	-	-	-	+	-
33.	*Euglena cuneata* E. G. Pringsheim 1956	-	-	-	+	-
34.	*Euglena deses* Ehrenberg 1833	+	+	+	-	-
35.	*Euglena ehrenbergii* Klebs 1883	+	+	+	-	-
36.	*Euglena geniculata* F. Schmitz 1884	-	+	+	-	-
37.	*Euglena gracilis* Klebs 1883	-	-	-	+	-
38.	*Euglena laciniata* Pringsheim 1956	-	+	+	-	+
39.	*Euglena oblonga* F. Schmitz 1884	-	-	+	-	-
40.	*Euglena oxyuris* Schmarda 1846	+	+	-	+	+
41.	*Euglena spirogyra* Ehrenberg 1832	-	-	-	+	-
42.	*Euglena texta* (Dujardin) Hübner 1886	-	+	+	+	+
43.	*Euglena tripteris* (Dujardin) Klebs 1883	-	-	-	-	+

Table 2 (continuing): Qualitative structure of the phytoplankton community from the fishpond no. 12.

TAXA		YEARS				
Euglenophyta		1978	1979	2007	2010, April	2010, June
44.	*Euglena variabilis* G. A. Klebs 1883	-	+	+	-	-
45.	*Lepocinclis ovum* (Ehrenberg) Lemmermann 1901	+	+	+	-	+
46.	*Phacus aenigmaticus* Drezepolski 1922	-	+	-	-	+
47.	*Phacus agilis* Skuja 1926	-	-	-	-	+
48.	*Phacus alatus* G. A. Klebs 1886	-	-	-	+	-
49.	*Phacus caudatus* Hübner 1886	+	+	-	-	-
50.	*Phacus curvicauda* Svirenko 1915	-	-	-	-	+
51.	*Phacus helikoides* Pochmann 1942	+	+	+	-	+
52.	*Phacus longicauda* (Ehrenberg) Dujardin 1841	+	+	+	+	+
53.	*Phacus nordstedtii* Lemmermann 1904	-	+	-	-	-
54.	*Phacus orbicularis* K. Hübner 1886	-	-	-	-	+
55.	*Phacus pleuronectes* (O. F. Müller) Nitzsch ex Dujardin 1841	-	-	-	-	+
56.	*Phacus pyrum* (Ehrenberg) W. Archer 1871	-	+	-	-	-
57.	*Phacus rudicula* (Playfair) Pochmann 1942	-	+	+	-	-
58.	*Phacus tortus* (Lemmermann) Skvortzov 1928	-	-	-	-	+
59.	*Strombomonas gibberosa* (Playfair) Deflandre 1930	-	+	-	-	-
60.	*Strombomonas verrucosa* (E. Daday) Deflandre 1930	+	+	-	-	-
61.	*Trachelomonas armata* (Ehrenberg) F. Stein 1878	-	-	-	-	+
62.	*Trachelomonas crebea* Kellicott 1887	-	+	-	-	-
63.	*Trachelomonas cylindrica* Ehrenberg 1838	-	-	-	-	+
64.	*Trachelomonas hispida* (Perty) F. Stein 1878	+	+	+	-	+
65.	*Trachelomonas oblonga* Lemmermann 1899	-	+	+	+	-

Table 2 (continuing): Qualitative structure of the phytoplankton community from the fishpond no. 12.

TAXA		YEARS				
Euglenophyta		1978	1979	2007	2010, April	2010, June
66.	*Trachelomonas planctonica* Svirenko 1914	-	+	+	-	+
67.	*Trachelomonas subverrucosa* Deflandre 1926	-	-	-	-	+
68.	*Trachelomonas verrucosa* A. Stokes 1887	-	-	-	-	+
69.	*Trachelomonas volvocina* (Ehrenberg) Ehrenberg 1834	-	-	+	-	-
70.	*Trachelomonas volvocinopsis* Svirenko 1914	-	-	-	-	+
	Dynophyta					
71.	*Ceratium furcoides* (Levander) Langhans 1925	-	-	-	+	-
	Chryptophyta					
72.	*Chroomonas acuta* Utermöhl 1925	-	-	+	-	-
73.	*Chroomonas nordstedtii* Hansgirg 1885	-	-	+	-	-
	Chrysophyta					
74.	*Chrysococcus rufescens* Klebs 1893	+	+	+	-	-
75.	*Dinobryon divergens* O. E. Imhof 1887	+	+	-	-	-
76.	*Dinobryon sociale* (Ehrenberg) Ehrenberg 1834	-	-	-	-	+
	Xanthophyta					
77.	*Goniochloris mutica* (A. Braun) Fott 1960	+	-	+	-	-
78.	*Ophiocytium cochleare* (Eichwald) A. Braun 1855	-	+	-	-	-
	Bacillariophyta					
79.	*Achnanthes lanceolata* (Brébisson ex Kützing) Grunow in Van Heurck 1880	-	-	-	+	-
80.	*Amphora libyca* Ehrenberg 1840	-	+	+	+	-
81.	*Amphora veneta* Kützing 1844	-	+	-	+	-
82.	*Asterionella Formosa* Hassall 1850	+	+	+	+	-
83.	*Aulacoseira granulate* (Ehrenberg) Simonsen 1979	+	+	+	+	-
84.	*Aulacoseira granulata f. Spiralis* (Hustedt) D. B. Czarnecki and D. C. Reinke 1982	+	+	+	-	-

Table 2 (continuing): Qualitative structure of the phytoplankton community from the fishpond no. 12.

TAXA		YEARS				
Bacillariophyta		1978	1979	2007	2010, April	2010, June
85.	*Caloneis silicula* (Ehrenberg) Cleve 1894	-	-	-	+	-
86.	*Cocconeis pediculus* Ehrenberg 1838	-	-	-	+	-
87.	*Cyclotella meneghineana* Kützing 1844	-	+	+	+	+
88.	*Cymatopleura solea* (Brébisson) W. Smith 1851	-	-	-	+	-
89.	*Fragilaria capucina* Desmazières 1830	+	+	-	+	+
90.	*Fragilaria crotonensis* Kitton 1869	+	+	-	+	-
91.	*Fragilaria ulna* (Nitzsch) Lange-Bertalot 1980	+	+	-	+	+
92.	*Fragilaria ulna var. Acus* (Kützing) Lange-Bertalot 1980	+	+	+	+	-
93.	*Gomphonema truncatum* Ehrenberg 1832	-	-	-	-	+
94.	*Gyrosigma spencerii* (W. Smith) Griffith and Henfrey 1856	-	-	-	+	-
95.	*Hantzschia elongata* (Hantzsch) Grunow 1877	-	-	-	+	-
96.	*Melosira varians* C. Agardh 1827	-	-	-	-	+
97.	*Navicula cuspidata* (Kutzing) Kutzing 1844	-	-	-	+	+
98.	*Navicula halophila* (Grunow) Cleve 1894	-	-	-	+	-
99.	*Navicula peregrina* (Ehrenberg) Kützing 1844	-	-	-	+	-
100.	*Nitzschia acicularis* (Kützing) W. Smith 1853	+	+	+	-	+
101.	*Nitzschia amphibia* Grunow 1862	-	-	-	-	+
102.	*Nitzschia closterium* (Ehrenberg) W. Smith 1853	-	+	+	-	-
103.	*Nitzschia linearis* (C. Agardh) W. Smith 1853	-	+	-	+	-
104.	*Nitzschia palea* (Kützing) W. Smith 1856	-	-	-	+	-
105.	*Nitzschia reversa* W. Smith 1853	-	+	-	-	-
106.	*Rhoicosphaenia abbreviata* (C. Agardh) Lange-Bertalot 1980	-	+	-	+	-

Table 2 (continuing): Qualitative structure of the phytoplankton community from the fishpond no. 12.

TAXA		YEARS				
Bacillariophyta		1978	1979	2007	2010, April	2010, June
107.	*Stephanodiscus hantzschii* Grunow in Cleve and Grunow 1880	-	+	+	-	+
	Chlorophyta					
108.	*Acanthosphaera zachariasii* Lemmermann 1899	+	+	+	-	-
109.	*Actinastrum gracillimum* G. M. Smith 1916	-	-	+	-	-
110.	*Actinastrum hantzschii* Lagerheim 1882	+	+	+	-	+
111.	*Ankistrodesmus bibraianus* (Reinsch) Korshikov 1953	-	-	+	-	-
112.	*Ankistrodesmus densus* Korshikov 1953	+	+	+	-	-
113.	*Ankistrodesmus falcatus* (Corda) Ralfs 1848	+	+	-	-	-
114.	*Ankistrodesmus gracilis* (Reinsch) Korshikov 1953	+	+	-	-	-
115.	*Botryococcus braunii* Kützing 1849	+	+	+	-	+
116.	*Carteria globosa* Schiller 1925	-	-	+	-	-
117.	*Carteria multifiliis* (Fresenius) O. Dill 1895	+	+	+	-	-
118.	*Chlamydomonas debaryana* Goroschankin 1891	-	-	+	-.	-
119.	*Chlamydomonas ehrenbergii* Gorozhankin 1891	-	-	+	-	-
120.	*Chlamydomonas monadina* (Ehrenberg) F. Stein 1878	+	+	-	+	+
121.	*Chlamydomonas reinhardtii* P. A. Dangeard 1888	-	+	+	+	-
122.	*Chlorogonium elongatum* (P. A. Dangeard) Francé 1897	-	+	+	-	-
123.	*Chlorogonium tetragamum* Bohlin 1897	-	-	+	-	-
124.	*Closterium acerosum* Ehrenberg ex Ralfs 1848	+	+	-	+	-
125.	*Closterium aciculare* T. West 1860	-	-	-	+	+
126.	*Closterium acutum* Brébisson in Ralfs 1848	-	-	+	-	-

Table 2 (continuing): Qualitative structure of the phytoplankton community from the fishpond no. 12.

TAXA		YEARS				
Chlorophyta		1978	1979	2007	2010, April	2010, June
127.	*Closterium glacile* Brébisson ex Ralfs 1848	-	-	+	-	-
128.	*Closterium limneticum* Lemmermann 1899	-	-	+	-	-
129.	*Closterium littorale* F. Gay 1884	-	-	+	-	-
130.	*Closterium moniliferum* Ehrenberg ex Ralfs 1848	-	-	+	-	-
131.	*Closteriopsis longissima* (Lemmermann) Lemmermann 1899	+	+	-	-	-
132.	*Coelastrum astroideum* De Notaris 1867	+	+	+	+	-
133.	*Coelastrum microporum* Nägeli 1855	+	+	-	-	+
134.	*Coelastrum reticulatum* (P. A. Dangeard) Senn 1899	+	+	+	-	-
135.	*Coelastrum sphaericum* Nägeli 1849	+	+	+	-	+
136.	*Cosmarium biretum* Brébisson ex Ralfs 1848	-	-	-	+	-
137.	*Cosmarium botrytis* Meneghini ex Ralfs 1848	-	-	+	-	-
138.	*Crucigenia irregularis* Wille 1898	+	+	+	-	-
139.	*Crucigenia quadrata* Morren 1830	+	+	-	-	-
140.	*Crucigenia rectangularis* (Nägeli) Gay 1891	-	+	-	-	-
141.	*Crucigenia tetrapedia* (Kirchner) Kuntze 1898	+	+	+	-	-
142.	*Crucigeniella apiculata* (Lemmermann) Komárek 1974	-	-	+	-	-
143.	*Dictyosphaerium ehrenbergianum* Nägeli 1849	-	-	+	-	-
144.	*Dictyosphaerium pulchellum* H. C. Wood 1873	+	+	+	+	+
145.	*Dictyosphaerium tetrachotomum* Printz 1914	-	-	+	-	-
146.	*Elakatothrix gelatinosa* Wille 1898	-	+	+	-	-
147.	*Eudorina elegans* Ehrenberg 1832	-	-	-	+	-
148.	*Golenkinia radiata* Chodat 1894	+	+	+	-	-

Table 2 (continuing): Qualitative structure of the phytoplankton community from the fishpond no. 12.

TAXA		YEARS				
Chlorophyta		1978	1979	2007	2010, April	2010, June
149.	*Kirchneriella cornuta* Korshikov 1953	+	+	-	-	-
150.	*Kirchneriella irregularis* (G. M. Smith) Korshikov 1953	+	+	+	-	+
151.	*Kirchneriella lunaris* (Kirchner) K. Möbius 1894	+	+	+	-	-
152.	*Kirchneriella obesa* (West) G. West and S. West 1894	+	+	+	-	+
153.	*Lagerheimia ciliata* (Lagerheim) Chodat 1895	-	-	+	-	+
154.	*Lagerheimia genevensis* (Chodat) Chodat 1895	+	+	+	+	-
155.	*Lagerheimia wratislaviensis* Schröder 1897	+	+	+	-	+
156.	*Micractinium pusillum* Fresenius 1858	-	-	+	-	-
157.	*Monoraphidium arcuatum* (Korshikov) Hindák 1970	-	-	+	-	+
158.	*Monoraphidium contortum* (Thuret) Komàrková-Legnerová 1969	+	+	-	+	+
159.	*Monoraphidium convolutum* (Corda) Komárková-Legnerová 1969	-	-	+	-	-
160.	*Monoraphidium griffithii* (Berkeley) Komárková-Legnerová 1969	+	+	+	+	-
161.	*Monoraphidium irregulare* (G. M. Smith) Komárková-Legnerová 1969	+	+	+	-	-
162.	*Oocystidium ovale* Korshikov 1953	-	+	+	-	-
163.	*Oocystis borgei* J. Snow 1903	-	-	+	-	+
164.	*Oocystis lacustris* Chodat 1897	+	+	+	-	+
165.	*Oocystis marssonii* Lemmermann 1898	-	-	-	+	-
166.	*Oocystis parva* G. West and S. West 1898	+	+	+	-	-
167.	*Oocystis solitaria* Wittrock 1879	-	+	-	-	-
168.	*Oocystis submarina* Lagerheim 1886	-	-	+	-	-
169.	*Oocystis verrucosa* Roll 1927	-	-	+	-	-

Table 2 (continuing): Qualitative structure of the phytoplankton community from the fishpond no. 12.

TAXA		YEARS				
Chlorophyta		1978	1979	2007	2010, April	2010, June
170.	*Pandorina morum* (O. F. Müller), Bory de Saint-Vincent and Deslongschamps 1824	+	+	-	+	-
171.	*Pediastrum boryanum* (Turpin) Meneghini 1840	+	+	-	+	+
172.	*Pediastrum duplex* Meyen 1829	+	+	+	+	+
173.	*Pediastrum simplex* Meyen 1829	-	-	+	-	-
174.	*Pediastrum tetras* (Ehrenberg) Ralfs 1845	+	+	+	-	-
175.	*Pteromonas angulosa* Lemmermann 1900	-	+	+	-	-
176.	*Polyedriopsis spinulosa* (Schmidle) Schmidle 1899	+	+	+	-	-
177.	*Scenedesmus acuminatus* (Lagerheim) Chodat 1902	+	+	+	-	-
178.	*Scenedesmus acutus* Meyen 1829	+	+	+	+	-
179.	*Scenedesmus alternans* Reinsch 1865	-	+	+	-	-
180.	*Scenedesmus arcuatus* Lemmermann 1899	+	+	-	+	-
181.	*Scenedesmus costatus* Schmidle 1895	-	-	-	-	+
182.	*Scenedesmus denticulatus* Lagerheim 1882	+	+	-	-	-
183.	*Scenedesmus dimorphus* (Turpin) Kützing 1833	-	-	+	-	-
184.	*Scenedesmus disciformis* (Chodat) Fott and Komárek 1960	-	-	+	-	-
185.	*Scenedesmus dispar* Brébisson 1868	-	+	-	-	-
186.	*Scenedesmus ecornis* (Ehrenberg) Chodat 1926	-	+	+	-	-
187.	*Scenedesmus intermedius* Chodat 1926	-	+	+	-	-
188.	*Scenedesmus ornatus* (Lemmerm.) G. M. Smith 1916	-	+	-	-	-
189.	*Scenedesmus quadricauda* Chodat 1926	-	+	-	-	+
190.	*Scenedesmus spinosus* Chodat 1926	-	+	+	-	+

Table 2 (continuing): Qualitative structure of the phytoplankton community from the fishpond no. 12.

TAXA		YEARS				
Chlorophyta		1978	1979	2007	2010, April	2010, June
191.	*Schroederia setigera* (Schröder) Lemmermann 1898	-	+	+	+	-
192.	*Schroederia spiralis* (Printz) Korshikov 1953	-	+	+	-	-
193.	*Siderocelis ornate* (Fott) Fott 1934	-	-	+	-	-
194.	*Staurastrum paradoxum* Meyen ex Ralfs 1848	-	+	+	-	-
195.	*Staurastrum tetracerum* Ralfs ex Ralfs 1848	+	+	+	-	-
196.	*Stichococcus contortus* (Lemmermann) Hindák 1996	-	+	+	-	-
197.	*Tetraedron caudatum* (Corda) Hansgirg 1888	-	+	+	-	+
198.	*Tetraedron hastatum* (Reinsch) Hansgirg 1888	-	+	+	-	-
199.	*Tetraedron incus* (Teiling) G. M. Smith 1926	-	+	+	-	+
200.	*Tetraedron minimum* (A. Braun) Hansgirg 1888	-	+	+	-	-
201.	*Tetraedron pusillum* (Wallich) G. West and S. West 1897	-	-	-	-	+
202.	*Tetrastrum elegans* Playfair 1917	-	-	-	-	+
203.	*Tetrastrum glabrum* (Y. V. Roll) Ahlstrom and Tiffany 1934	-	+	+	-	-
204.	*Tetrastrum heteracanthum* (Nordstedt) Chodat 1895	-	+	+	-	-
205.	*Tetrastrum peterfii* Hortobágy 1967	-	+	+	-	-
206.	*Tetrastrum punctulatum* (Schmidle) Ahlstrom and Tiffany 1934	-	+	+	-	-
207.	*Tetrastrum staurogeniiforme* (Schröder) Lemmermann 1900	-	+	+	-	-
208.	*Tetrastrum triangulare* (Chodat) Komárek 1974	-	+	+	+	+
209.	*Treubaria planctonica* (G. M. Smith) Korshikov 1953	-	+	-	-	+
210.	*Treubaria triappendiculata* C. Bernard 1908	-	-	+	-	-

Some aspects concerning the ecological state of the investigated water basins based on planktonic algae

One of the indices recommended by Oltean (1977) for the estimation of the water trophicity level is the zeta-eutrophic index for cyanobacterial blooms. The values of this specific index, computed by the authors for the summer communities (Tab. 4) are high and very high, signifying after Oltean (1977) the strongest eutrophication of water or the upper limit of eutrophy (index values are directly proportional to eutrophy level).

Table 3: Comparative numerical abundance and percentage contribution of algal groups to the planktonic flora of the Cefa Fishery Complex, according to the investigations carried out during the period 1962-2010.

Algal Phylum	Fishpond no. 3, 4, 17, 18		Fishpond no. 12							
	1962		1978		1979		2007		2010	
	No. taxa	%	No. taxa	%	No. taxa	%	No. taxa	%	No. taxa	%
Cyanoprokaryota	14	9.59	11	14.86	16	12.60	19	15.20	14	12.96
Euglenophyta	4	2.74	12	16.22	22	17.32	16	12.80	29	26.85
Dinophyta	1	0.68	-	-	-	-	-	-	1	0.93
Chrysophyta	-	-	2	2.70	2	1.57	1	0.80	1	0.93
Bacillariophyta	-	-	8	10.81	16	12.60	9	7.20	25	23.15
Chryptophyta	-	-	-	-	-	-	2	1.60	-	-
Xanthophyta	7	4.79	1	1.35	1	0.79	1	0.80	-	-
Chlorophyta	120	82.19	40	54.05	70	55.12	77	61.60	38	35.19
Total taxa	146	100	74	100	127	100	125	100	108	100

Table 4: Zeta-eutrophy index values computed for the Cefa Fishery Complex.

Year	Sampling sites	Index values
1962	Fishpond no. 3	122.166
	Fishpond no. 4	134.568
	Fishpond no. 17	40.516
	Fishpond no. 18	72.292
1978	Fishpond no. 12	123.354
1979	Fishpond no. 12	212.403
2007	Fishpond no. 12	243.948
2010	Fishpond no. 12	114.597

Table 5: Trophicity indices computed for the Cefa Fishery Complex.

Index / Year	1962				1978	1979	2007	2010 Spring	2010 Summer
Fishpond no.	3	4	17	18	12				
Chlorophycean	10.4	3.2	6.3	4.5	17.5	27.0	7.03	4.0	24.0
Cyanophycean	-	-	3.0	-	11.0	8.0	2.9	3.0	9.0
Diatom	-	-	-	-	2.5	2.5	2.5	2.5	2.5
Microalgae	11.6	3.5	5.3	5.1	26.0	24.5	8.6	14.0	56.0

The authors have calculated (Tab. 5) the phytoplankton indices recommended by Willen (2000) and Sigel (2006), the Chlorophycean Index (Rawson, 1956), A/C Diatom Index (Stockner, 1972), Cyanophycean Index (Nygaard, 1949) and Composed Microalgae Index (Nygaard, 1949).

The Chlorophycean Index, the ratio between chlorococcales and desmids in all investigated fishponds is higher or much higher than 1, indicating eutrophy. The A/C Diatom Index, the ratio of araphid pennate to centric diatoms (Stockner, 1972) exhibits higher values than 2, also indicating eutrophic conditions. The index can not be computed for 1962, when diatoms were not studied. The Cyanophycean Index – the ratio of blue greens to desmids (Nygaard, 1949) could be computed in 1962 only for fishpond 17, but luckily for fishpond 12, the index could be computed for this pond in all subsequent years. In case of all investigated fishponds the index values being higher than unit (>1) indicated eutrophic waters.

Heinonen (1980) proposed a trophic index based on the ratio of eutrophic elements to oligotrophic ones. The index could not be used in these fishponds because of scarcity of genuinely oligotrophic species (the few ones are possibly *Merismopedia glauca, Crucigenia rectangularis* and *Dinobryon divergens*). Otherwise, most species are eutrophic elements, widely distributed or cosmopolitan. The self-evident conclusion is therefore that, all investigate water bodies are definitely eutrophic.

Organic pollution indices calculated on genera and species level summarize the indicator values of genera and species living in a given habitat and are considered bioindicators (Palmer, 1969). The Organic Pollution Index values computed for the Cefa Fishery Complex fishponds are included in the table number 6.

Table 6: Organic Pollution Index values of the fishpond from the Cefa Fishery Complex.

Years	1962				1978	1979	2007	2010 Spring	2010 Summer
Fishponds no.	3	4	17	18	12				
Organic Pollution Index on genus level	8	9	8	10	31	30	33	35	35
Organic Pollution Index on species level	11	7	9	11	25	21	21	23	22

The Organic Pollution Index values calculated for 1962 are below the critical level, and reveal low organic pollution in all four fishponds, a partial reason for it can be the lack of suitable data on diatoms. In these fishponds are present several oligo-β- and β-mesosaprobic elements (*Microcystis aeruginosa, Trachelomonas volvocina, Ankistrodesmus hantzschii, Coelastrum microporum, Crucigenia tetrapedia, Pediastrum boryanum, Scenedesmus quadricauda, Closterium parvulum* etc.), are present, indicating slightly or moderately polluted waters.

On the contrary, in the fishpond number 12, in all studied years the index values are above the critical level, indicating massive organic loading. In this case, considerable numbers of β-α- and α- or polisaprobic indicator elements (*Oscillatoria chlorina, Euglena* species, *Phacus longicauda, Cyclotella meneghiniana, Carteria multifilis, Chlamydomonas ehrenbergii, C. reinhardtii, Closterium acerosum, Cosmarium botrytis, Navicula cuspidata* and *Nitzschia palea*) are present, indicating sensible, critical level or even excess of organic loading.

A new approach to estimate water quality in standing water bodies was proposed using the functional aspects not only the qualitative and quantitative structural patterns of the phytoplankton communities. These concern the molecular nitrogen fixing capacity of algae, nutrition type, optimal temperature and light, silica, phosphorous, reactive nitrogen requirements, motility, etc. Reynolds established the so called functional phytoplankton groups and their succession in freshwater standing waters (Reynolds, 1997). In this respect, the phytoplankton communities of the Cefa Fishponds can be categorized under the H and M functional groups, usually the characteristic for stagnant water bodies of the temperate zone.

CONCLUSIONS

Investigations carried out in some of the fishponds of the Cefa Fishery Complex in 1962, 1978, 1979, 2007 and 2010, especially in the summer, revealed in the phytoplankton the occurrence of 310 algal taxa belonging to eight phyla: Cyanoprokaryota, Euglenophyta, Cryptophyta, Dinophyta, Chrysophyta, Xanthophyta, Bacillariophyta and Chlorophyta.

The dominant phyla in all investigated period was that of green algae, showing decreasing tendency from 82.19% in 1962 to 35.19% in 2010, while increasing trend was observed for euglenoid flagellates from 2.74% to 26.85%. These tendencies can be attributed to the enhancement of eutrophication process.

During the whole period of almost three decades, heavy cyanobacterial blooms have been observed in the summer, due to logarithmic development of various *Microcystis, Anabaena, Anabaenopsis* or *Oscillatoria* species.

The physicochemical parameters indicate alkaline waters (pH range 7.91-10.0) with eutrophic character (conductance 853-870 $\mu S.cm^{-1}$).

Among the phytoplankton the eurybiont and cosmopolitan elements dominate, but there are also present many genuine eutrophic, as well as alkaliphilic elements.

The eutrophic character of the fishponds is supported by the values gained from phytoplankton indices.

The eutrophication process of the Cefa Fishponds is markedly increased by the fish growth technologies applied (great amounts of nutrients and organic loading has been introduced), development of heavy blue green blooms, leading to the accumulation of decomposed organic matter. The computed pollution indices shown an increasing trend of heavy organic loading in the fishponds starting from 1978.

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FLORA AND HABITATS OF CEFA NATURE PARK (CRIŞANA, ROMANIA)

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KEYWORDS: vascular plant species, protected and Red List plant species, plant communities, Natura 2000 habitats, Pannonic salt-steppes and salt-marshes.

ABSTRACT

This paper is a synthesis of existing data on chormoflora from Cefa Nature Park and a characterization of Natura 2000 habitats, with the description of the appropriate plant associations identified within the protected area. It presents a systematic list of 504 species (and 3 hybrids) of vascular plants known so far from the park, and an analysis of biogeographical and ecological aspects of the flora. Cefa Nature Park is an important area of conservation also from botanical point of view, hosting a number of protected species, including *Marsilea quadrifolia* and *Cirsium brachycephalum*, listed in Annex II of the EU Habitats Directive 92/43/EEC.

RÉSUMÉ: La flore et les habitats du Parc Naturel Cefa.

Ce travail est une synthèse des données existantes sur la cormophyte flore du Parc Naturel Cefa et une caractérisation des habitats Natura 2000, ainsi qu'une description des associations végétales identifiées dans la zone protégée. On présente une liste systématique des 504 espèces de plantes vasculaires et 3 hydrides connus à ce jour dans le parc et une analyse de l'aspect biogéographique et écologique de la flore. Le Parc Naturel Cefa est un domaine important pour la conservation et notamment par l'aspect botanique. Il accueille un certain nombre d'espèces protégées dont *Marsilea quadrifolia* et *Cirsium brachycephalum*, inscrites dans l'Annexe II de la Directive Habitats 92/43/CEE

REZUMAT: Flora şi habitatele din Parcul Natural Cefa.

Lucrarea reprezintă o sinteză a datelor existente, privind cormoflora din Parcul Natural Cefa, precum şi o caracterizare a habitatelor Natura 2000 cu menţionarea asociaţiilor vegetale corespunzătoare, identificate pe teritoriul ariei protejate. Este prezentată lista sistematică a celor 504 specii (şi 3 hibrizi) de cormofite, cunoscute până în prezent de pe teritoriul parcului, precum şi o analiză sub aspect biogeografic şi ecologic a florei. Parcul Natural Cefa reprezintă o importantă arie de conservare şi din punct de vedere botanic, adăpostind o serie de specii protejate, dintre care *Marsilea quadrifolia* şi *Cirsium brachycephalum*, care sunt incluse în Anexa II a Directivei Habitate 92/43/EEC.

INTRODUCTION

Data regarding the flora of the Crişurilor Plain (Eastern part of Pannonian Plain) can be found in papers published beginning at the end of the 18th century, when Kitaibel Pál mentioned from Salonta two species: *Kochia prostrata* and *Ranunculus polyphyllus* (Pop, 1968). In the 19th century Simkovics (1881) noted from the same locality 6 species. In the same period, Borbás (1890) studied the flora of the same territory. During the 20th century, the botanical researches in the area become more numerous. Data on the halophylous plants from the northern part of Romania were published by Ţopa (1939). Prodan (1956) mentions more than 150 species of vascular plants from Salonta and its surroundings, while Velea (1954) and Zahariadi (1955) dealt with the adventive species from the rice fields in the area.

However, most botanical researches in the area were carried out by Pop, beginning since 1947. Several papers were published concerning different aspects of flora and vegetation research from the western part of Salonta district (Pop, 1956, 1959, 1962a, 1962b, 1963). The data from these works were synthesized in the monograph "*Flora şi vegetaţia Cîmpiei Crişurilor*" (Flora and vegetation of Crişurilor Plain, 1968). These are the first publications which contain information on the flora and vegetation from the territory of the Cefa Nature Park. These researches were focused mainly on the vicinity of Salonta, Rădvani fish farm (which does not exist in the present), Rădvani Forest and its surroundings. Among these areas only the last one is partly included in the park. Data from these publications were later included in a series of synthetic works, like "*Flora R.P.R./R.S.R., vol. I-XIII*" (Săvulescu, 1952-1976), or "*Atlas Florae Romaniae VI Fabaceae* (*Medicago, Melilotus, Ononis, Trigonella*)" (Ştefănuţ et al., 2009).

A synthesis of the flora and vegetation from Criş rivers basins was published by Drăgulescu and Macalik (1997). The paper includes plants from Cefa Nature Park area, but the species' location is given only by the river sector. Also, some data concerning hydro- and hygrophylous flora and vegetation from Cefa area were published (Sîrbu and Benedek, 2006). More recently, a study on *Trapetum natantis* plant community from the Crişul Negru River basin was published, which includes some researches on the lakes and ponds from Cefa fish farm (Gavra, 2011).

Between 2005 and 2011 the authors carried out field surveys on the vascular plant species and habitats in the area of the present park. These investigations were part of the flora and fauna inventory program coordinated by the Apuseni Nature Park's Administration.

The aims of this paper are: i) to present a systematical overview (checklist) of the vascular plant species of the Cefa Nature Park; ii) to analyze the flora regarding the phytogeographic (floristic) elements, life forms and ecological relative indicator values; iii) to give a short characterization of Natura 2000 habitats identified in the area of Cefa Nature Park.

MATERIAL AND METHODS

Study area

Cefa Nature Park, founded in 2010 (HG 1217/2010), is located in the western part of Romania, at the border with Hungary, in Bihor County. It covers a total surface of 5002 ha, comprising a great variety of habitats: lakes and ponds, channels, marshes, cultivated fields, grasslands (pastures and hayfields), salty marshes, shrubs and forest. From administrative point of view, the protected area belongs to Cefa and Sânnicolau Român communes (Fig. 1).

The park lies between Crişul Negru and Crişul Repede rivers, in Crişurilor Plain, the the Tisa River plain. This plain was formed by the silting of Pannonian Lake in Pliocene-Quaternary with 40-600 m thick river and wind deposits (sand, loess, alluvial deposits). Due to the uneven distribution of the superficial deposits, many marshy microdepressions were found by the middle of the 19th century, especially in the low plain. Since 1851 the marshes from the plain of the three Criş rivers (Câmpia Crişurilor), as well as the numerous dead river branches started being drained, by digging a dense network of channels (Manciulea, 1938 ap. Pop, 1968), in order to increase the surface of agricultural fields.

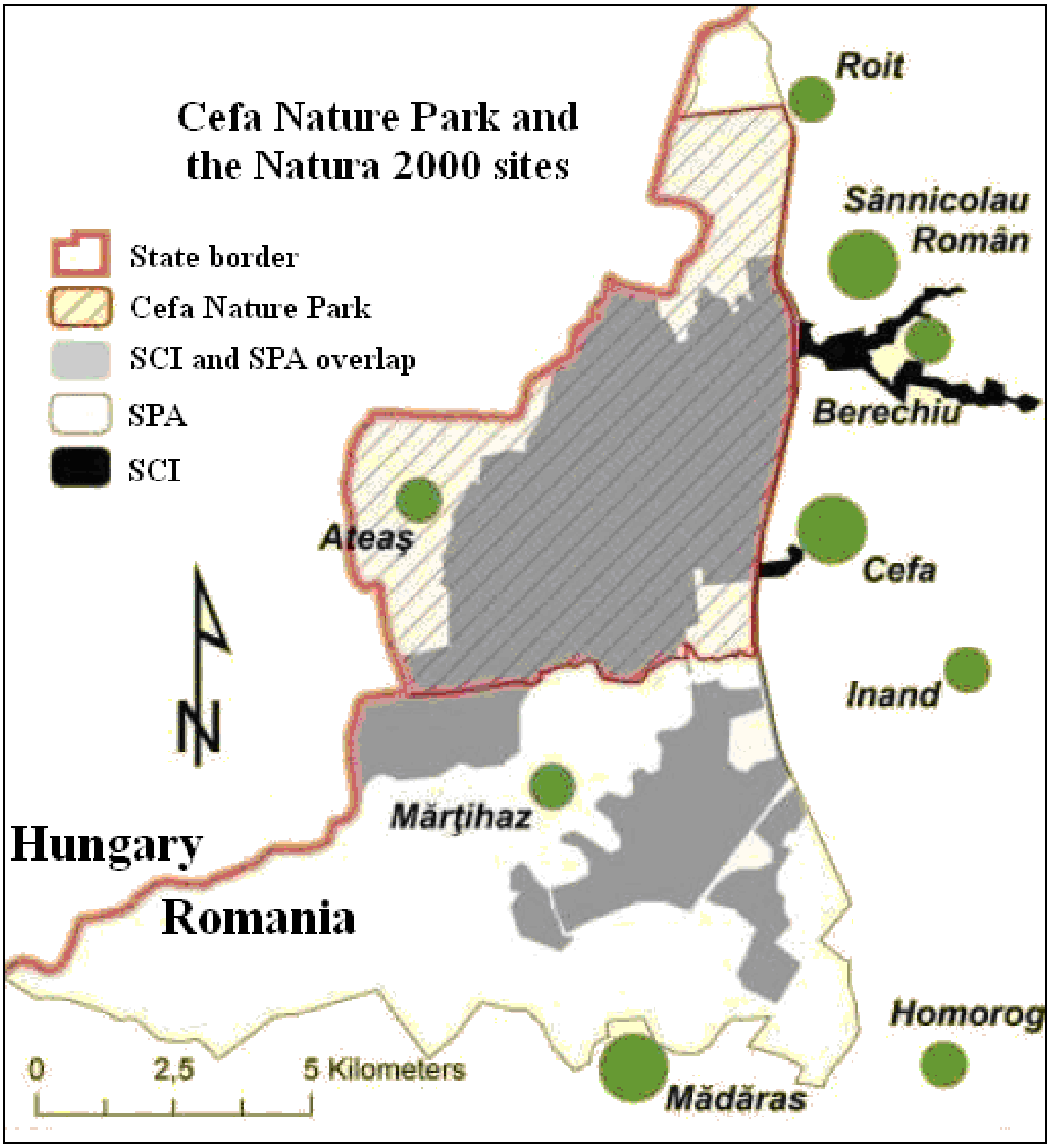

Figure 1: Map of Cefa Nature Park and the Natura 2000 sites
(SCI and SPA) (***, adapted by the authors).

Cefa Nature Park lies at a mean altitude of 95 m a.s.l., Rădvani Forest being situated in the highest part (mean altitude about 100 m). The park is located on the Crişul Negru River basin, but most of the water courses that cross its territory are artificial channels. The largest of them is the Collector (or Criş) Channel, flowing from north to south, connecting Crişul Repede and Crişul Negru rivers, bordering the eastern part of the park. An important area of the park is represented by the Cefa fish farm, established in 1905. It covers 735 ha, consisting of 16 artificial lakes and ponds of 3 to 80 ha, and other smaller water bodies used to host the breeding fish or rearing the hatchlings. The water surface covers in total 693 ha (***).

The ground water level is only 3-5 m deep, and it is characterized by a high concentration of salts (especially sulphates and chlorides) (Pop, 1968). Thus, during the heavy rain periods the ground water reaches the soil surface, favoring the processes of salinization, and influencing the evolution of soils and vegetation. Most of the soils from the area have a moderate level of salinization, which was also favoured by the drainage works carried out in the past (Pop, 1959). The diversity in salty soils is reflected in the mosaic structure of vegetation.

The climate in the Cefa Nature Park is continental. The mean annual temperature is 10-11° C and the mean annual precipitation varies between 550 and 600 mm, with a maximum at the end of spring or beginning of summer and a minimum during summer or winter. Due to the large surface covered with artificial lakes and the numerous channels, the air humidity is relatively high (76% - Pop, 1968).

Most of the Cefa Nature Park's territory is also included in the Natura 2000 sites (Fig. 1).

Working methods

Between 2005 and 2011 we carried out field surveys on the flora of vascular plants and habitats of the Cefa Nature Park. Surveys were done between June and September.

For the floristic checklist, basically the monograph of Pop (1968) and other bibliographic sources (Drăgulescu and Macalik, 1997; Sîrbu and Benedek, 2006; Gavra, 2011) have been considered. The occurrence of the cited vascular plant taxa was verified on the filed and the list was completed with personal data. The identification of vascular plant taxa was done in the field (Ciocârlan, 2009), as well as in the laboratory (Săvulescu, 1952-1976; Jávorka et Csapody, 1991; Ciocârlan, 2009), particularly for taxonomically difficult and doubtful taxa. The nomenclature of plant taxa follows Flora Europaea (Tutin et al., 1964-1980), being actualized with the electronic online version (***).

The cormophytes are presented by families, in systematic order. The systematics is according to Ciocârlan (2009). In order to facilitate finding the information, within the families the species are presented in alphabetical order. Subspecies, varieties and forms are also given. For each species bibliographic data is also presented. The authors are coded as: Pop1: I. Pop (1962a); Pop: I. Pop (1968); Gav.: C. Gavra (2011); !: original data. Among the taxa cited by Pop, we included in the list only those which are mentioned specifically from the park's territory. For example, the plants cited from Rădvani Forest or from its edge are included in the list, while those cited from habitats around the forest, outside the park’s area were not included, except when mentioned: westwards from the forest. For the taxa mentioned by Pop, both in 1962 and 1968, we used only the code Pop. The plant taxa from our checklist published previously in the monograph but not specifically cited from the park's territory, were noted with (Pop).

For the ecological and phytogeographical analysis of the flora, the life forms, ecological (HTR - humidity, temperature, soil reaction) relative indicator values, and the floristic elements are given according to Sanda et al. (1983).

In this study, for the habitats characterization only the Natura 2000 habitats were considered. These specific habitats have been identified on the park's area, taking into account their floristic structure and the presence of characteristic and recognition species. Assignment to different habitat types is given according to the Natura 2000 habitats classification (Gafta and Mountford, 2008). Within the each habitat type the characteristic plant communities are mentioned. These plant communities (associations) are given according to the bibliographic sources (Pop, 1968; Frink and Petrovici, 2010; Gavra, 2011), the list being completed by personal identifications (! - original data) based on the floristic structure of phytosociological relevés performed in the field according to the Braun-Blanquet methodology (Braun-Blanquet, 1964). For the correct name of the communities, the Romanian nomenclature and syntaxonomical classification systems were followed (Coldea, 1991; Sanda et al., 1997, 1999; Pop et al., 2002; Sanda, 2002) and the International Code of Phytosociological Nomeclature (ICPN - Weber et al., 2000) was also consulted.

RESULTS AND DISCUSSION

A. Floristic checklist

Phyllum PTERIDOPHYTA

Fam. Aspleniaceae:

Athyrium filix-femina (L.) Roth: Pop, !; in the oak forest, near the channels, rare

Fam. Marsiliaceae:

Marsilea quadrifolia L.: Pop; on the fishponds as well as in the rice plantations, !; on the fishponds, rare

Fam. Salviniaceae:

Salvinia natans (L.) All.: Pop, Gav., !; on the channels, sporadic

Phyllum SPERMATOPHYTA

Fam. Aristolochiaceae:

Aristolochia clematitis L.: Pop, !; along the forest edge and the channels, frequent

Fam. Nymphaeaceae:

Nuphar lutea (L.) Sm.: Pop, !; on the lakes and channels, frequent

Nymphaea alba L.: (Pop), !; on the lakes and channels, sporadic

Fam. Ceratophyllaceae:

Ceratophyllum demersum L.: Pop, Gav., !; in the water of the fishponds and channels, common

Ceratophyllum submersum L.: Pop, !; in the water of the fishponds and channels, frequent

Fam. Ranunculaceae:

Clematis integrifolia L.: Pop; in the hayfields in the vicinity of the forest, frequent

Clematis vitalba L.: Pop, !; in the forest, sporadic

Consolida regalis S.F. Gray: (Pop), !; along the roads and ditches, in the fields, common

Myosurus minimus L.: Pop

Ranunculus acris L.: Pop, !; in the pastures and hayfields, common

Ranunculus aquatilis L.: Pop

Ranunculus auricomus L.: Pop

Ranunculus bulbosus L.: !; dry meadows, sporadic

Ranunculus ficaria L.: Pop, !; in the forest, frequent

Ranunculus lateriflorus D.C.: Pop

Ranunculus pedatus Waldst. et Kit.: Pop

Ranunculus polyanthemos L.: Pop, also in the *Quercus cerris* plantation

Ranunculus repens L.: (Pop), !; in wet meadows, along channels and ditches, common

Ranunculus sardous Crantz: Pop

Ranunculus sceleratus L.: (Pop), !; in wet meadows, frequent

Thalictrum lucidum L.: (Pop), !; along the forest edge, sporadic

Fam. Papaveraceae

Papaver rhoeas L.: (Pop), !; in cultivated lands, abandoned fields and along roads, frequent

Fam. Fumariaceae:

Chelidonium majus L.: (Pop), !; in the vicinity of the forest, in shaded places, rare

Corydalis solida (L.) Clairv.: Pop, !; in the forest, sporadic

Fam. Ulmaceae:

Ulmus glabra Hudson: Pop

Ulmus minor Miller: Pop, !; in the forest and along the channels surrounding it, frequent

Ulmus procera Salisb.: Pop, !; Rădvani forest, frequent

Fam. Moraceae:

Morus alba L.: !; in the pastures as isolated specimens, sporadic

Fam. Cannabaceae:

Humulus lupulus L.: Pop, !; at the forest edge, rare

Fam. Urticaceae:

Urtica dioica L.: Pop, !; along the ditches and channels, as well as in the forest, frequent

Fam. Juglandaceae

Juglans regia L.: !; subspontaneous, isolated specimens

Fam. Fagaceae:

Quercus cerris L.: Pop, !; Rădvani forest, frequent

Quercus frainetto Ten.: !; Rădvani forest, rare

Quercus petraea (Mattuschka) Liebl.: Pop, !; Rădvani forest, rare

Quercus robur L.: !; in most parts of the forest, frequent, f. *vulgaris* (A. DC.) Schwz.: Pop

Fam. Betulaceae:

Corylus avellana L.: Pop1, !; Rădvani forest, along the channel, rare

Carpinus betulus L.: Pop, !; in the forest, frequent

Fam. Caryophyllaceae:

Cerastium brachypetalum Desportes ex Pers.: Pop

Cerastium dubium (Bast.) Guépin: Pop

Cerastium glomeratum Thuill.: Pop

Cerastium holosteoides Fries ampl. Hyl.: !; mesic pastures, sporadic

Cerastium pumilum Curtis: Pop, !; in pastures and along roads, frequent

Cerastium semidecandrum L.: Pop

Gypsophila muralis L.: Pop, !; in pastures and along roads, frequent

Holosteum umbellatum L.: Pop

Lychnis flos-cuculi L.: Pop, !; in the hayfields next to the forest, frequent

Lychnis viscaria L.: Pop

Moehringia trinervia (L.) Clairv.: Pop, !; at the forest edge, sporadic

Moenchia mantica (L.) Bartl.: Pop; in the hayfields west from Rădvani forest, sporadic

Scleranthus annuus L.: Pop

Silene alba (Miller) E.H.L. Krause: (Pop), !; along the ditches and fields, frequent

Silene noctiflora L.: !; at the forest edge, rare

Silene viscosa (L.) Pers.: Pop

Spergularia marina (L.) Besser: Pop

Stellaria graminea L.: Pop, !; in meadows and along channels, sporadic

Stellaria media (L.) Vill.: (Pop), !; along the channels, forest edge and in the fields, frequent

Fam. Amaranthaceae

Amaranthus blitum L.: !; along the roads and in the fields, sporadic

Amaranthus retroflexus L.: (Pop), !; along the ditches, roads, and also in the fields, frequent

Fam. Chenopodiaceae:

Atriplex littoralis L.: Pop, !; along ditches and in salty areas, frequent

Atriplex prostrata Boucher ex DC.: (Pop), !; along channels, sporadic

Atriplex tatarica L.: (Pop), !; in salty meadows, frequent

Bassia prostrata (L.) G. Beck: Pop

Chenopodium album L.: (Pop), !; along roads, on abandoned fields and cultivated lands, common

Chenopodium hybridum L.: (Pop), !; along roads and ditches, frequent

Chenopodium urbicum L.: (Pop), !; on abandoned the fields and also along the roads, sporadic

Polycnemum arvense L.: Pop

Fam. Polygonaceae:

Polygonum amphibium L.: Pop

Polygonum aviculare L.: Pop, !; along roads and in pastures, common

Polygonum dumetorum L.: !; in the reedbeds from the fish farm, sporadic

Polygonum hydropiper L.: Pop, !; along the channels, lake shores, and ditches, also in the forest, frequent

Polygonum lapathifolium L.: (Pop), !; along the channels and ditches with water, common

Polygonum mite Schrank: (Pop), !; on the shores and in wet areas from the forest (ditches with water), frequent

Rumex acetosa L.: Pop, !; in hayfields and pastures, frequent

Rumex acetosella L: (Pop), !; in hayfields, sporadic

Rumex conglomeratus Murray: (Pop), !; ruderal meadows used as pastures, frequent

Rumex crispus L.: Pop, !; in the margins of cultivated fields next to channels, frequent

Rumex hydrolapathum Hudson: !; in the channel limiting the southern part of the fish farm, rare

Rumex obtusifolius L.: Pop, !; along the channels and in the forest, sporadic

Rumex palustris Sm.: Pop

Rumex sanguineus L.: Pop; in Rădvani forest, !; at the forest edge, rare

Rumex stenophyllus Ledeb.: (Pop), !; between cultivated fields on salty soil, frequent

Fam. Plumbaginaceae:

Limonium gmelinii (Willd.) O. Kuntze: Pop, !; in halophilous meadows, frequent

Fam. Rosaceae:

Agrimonia eupatoria L.: Pop, !; at the forest edge, frequent

Cerasus avium (L.) Moench: (Pop), !; in the forest, isolated specimens

Crataegus monogyna Jacq.: Pop, !; in the shrubs near the forest, but also within it, common

Filipendula vulgaris Moench.: Pop

Fragaria vesca L.: Pop, !; in the forest, frequent

Fragaria viridis Weston: Pop, !; in meadows next to the forest, frequent

Geum urbanum L.: Pop, !; in the forest, frequent

Malus sylvestris (L.) Miller: Pop, !; in the forest, sporadic

Potentilla anserina L.: (Pop), !; in pastures, frequent

Potentilla argentea L.: Pop, !; along roads and in dry pastures, sporadic

Potentilla erecta (L.) Räusch.: !; in meadows, sporadic

Potentilla reptans L.: Pop, !; along ditches, roads and in shrubs, frequent

Prunus cerasifera Ehrh.: !; along ditches and in shrubs next to the forest, isolated specimens

Prunus spinosa L.: Pop, !; in the forest, but also in its vicinity, frequent

Pyrus pyraster (L.) Burgsd.: Pop, !; isolated specimens in the meadows next to the forest

Rosa canina L.: Pop, !; in the shrubs along the forest edge and the channels, frequent

Rosa gallica L., also var. *subglandulosa* (Borb.) H.Br. and var. *elata* Christ.: Pop; Rădvani forest, sporadic

Sanguisorba officinalis L.: Pop; Rădvani forest edge, rare

Rubus caesius L.: Pop, !; in the shrubs along the forest edge and channels, but also in the forest, common

Fam. Fabaceae:

Amorpha fruticosa L.: (Pop), !; in Rădvani forest, rare

Astragalus glycyphyllos L.: (Pop), !; in the forest, frequent

Coronilla varia L.: (Pop), !; along the lake shores, channels and ditches, and on the fields' margins, frequent

Galega officinalis L.: Pop; along the channels and around the forest, !; along the channels, frequent

Genista ovata Waldst. et Kit.: Pop

Genista tinctoria L.: Pop

Lathyrus aphaca L.: !; on the margins of cultivated fields and in ditches, sporadic

Lathyrus hirsutus L.: (Pop), !; in the vicinity of the forest, in the fields, frequent

Lathyrus pratensis L.: Pop; at the forest edge, !; at the forest edge and on the channel banks, frequent

Lathyrus sylvestris L.: Pop, !; in the meadows in the vicinity of the forest, along ditches and on the margins of cultivated fields, also var. *platyphyllos* (Retz.) A. u. G. and var. *oblongus* Ser.: Pop; at the edge of Rădvani forest, in cultivated lands, frequent

Lathyrus tuberosus L.: Pop, !; in cultivated fields and hayfields, frequent

Lotus angustissimus L.: Pop, !; in hayfields and pastures, frequent. The species is included in the Red Book (Dihoru and Negrean, 2009)

Lotus corniculatus L.: Pop, !; in meadows, common

Lotus glaber Miller: Pop, !; in meadows, sporadic

Medicago falcata L.: (Pop), !; meadows, frequent

Medicago lupulina L.: Pop, !; in dry meadows and on the margins of cultivated fields, common

Medicago sativa L.: (Pop), !; subspontaneous, frequent

Melilotus albus Medik.: (Pop), !; in pastures, abandoned fields and along channels, frequent

Melilotus officinalis Lam.: (Pop), !; in meadows, along roads and cultivated fields, frequent

Ononis arvensis L.: !; in pastures and hayfields, along roads, sporadic, ssp. *spinosiformis* (Simonkai) Ciocârlan*:* Pop.

Ononis spinosa L.: !; in meadows, rare

Robinia pseudacacia L.: !; at the forest edge, isolated specimens

Trifolium angulatum Waldst. et Kit.: Pop

Trifolium campestre Schreber: (Pop), !; pastures, frequent

Trifolium dubium Sm.: (Pop), !; pastures, sporadic

Trifolium filiforme L.: Pop

Trifolium fragiferum L.: Pop, !; halophylous pastures and hayfields, frequent, and ssp. *bohannii* (C.Presl.) Soják: Pop

Trifolium hybridum L.: (Pop), !; pastures, hayfields and ditches, sporadic

Trifolium ornithopodioides Sm.: (Pop), !; halophylous pastures and hayfields, sporadic. The species is included in the Red Book (Dihoru and Negrean, 2009).

Trifolium pratense L.: (Pop), !; meadows, frequent

Trifolium repens L.: Pop, !; pastures and hayfields, common

Trifolium retusum L.: Pop

Trifolium striatum L.: Pop

Trifolium strictum L.: Pop

Vicia angustifolia L.: (Pop), !; cultivated lands, frequent

Vicia cracca L.: (Pop), !; along ditches and meadows in the forest vicinity, frequent

Vicia grandiflora Scop.: Pop, !; meadows, frequent

Vicia hirsuta (L.) S.F.Gray: (Pop), !; fields and road margins, frequent

Vicia lathyroides L.: Pop
Vicia pannonica Crantz: Pop; along roads and in fields next to Rădvani forest, frequent
Vicia sativa L.: (Pop), !; in fields and road edges, frequent
Vicia sepium L.: (Pop), !; in cultivated fields, frequent
Vicia striata M.B.: Pop1; Rădvani forest edge, frequent
Vicia tetrasperma (L.) Schreber: (Pop), !; margins of cultivated lands, frequent

Fam. Haloragaceae:
Myriophyllum spicatum L.: (Pop), Gav.
Myriophyllum verticillatum L.: Pop

Fam. Lythraceae:
Lythrum hyssopifolia L.: Pop, !; along channels and ditches, frequent
Lythrum salicaria L.: (Pop), !; lake shores, along channels and ditches, frequent
Lythrum virgatum L.: Pop, !; lake shores and along channels, sporadic

Fam. Onagraceae:
Circaea lutetiana L.: Pop, !; in the forest, frequent
Epilobium hirsutum L.: (Pop), !; lake shores, along channels and ditches with water, frequent
Epilobium lamyi F.W. Schultz: Pop1, !; channel banks, sporadic
Epilobium palustre L.: !; on channel banks and along ditches with water, sporadic
Epilobium parviflorum Schreber: Pop1, !; on lake shores and along channels, frequent

Fam. Trapaceae:
Trapa natans L.: Pop, Gav., !; abundant in the lakes from the fishfarm, being regularly mown, common

Fam. Cornaceae:
Cornus mas L.: Pop, !; in the forest and along its edge, frequent
Cornus sanguinea L.: Pop, !; in the forest and especially in the shrubs along its edge, frequent

Fam. Santalaceae:
Thesium arvense Horvatowszky: Pop

Fam. Loranthaceae:
Loranthus europaeus Jacq.: Pop; semiparasitic on the oak branches in Rădvani forest, !; in the forest, rare
Viscum album L.: (Pop), !; in the forest, sporadic

Fam. Celastraceae:
Evonymus europaeus L.: Pop, !; in the shrubs at the forest edge and along the channels, frequent

Fam. Euphorbiaceae:
Euphorbia cyparissias L.: Pop, !; in meadows, along roads and the cultivated fields, common
Euphorbia lucida Waldst. et Kit.: Pop1, !; in meadows in the vicinity of the forest, frequent, also f. *latifolia* Koch: Pop; at the forest edge
Euphorbia palustris L.: Pop, !; along channels and the forest edge, frequent
Euphorbia villosa Waldst. et Kit.: Pop; at the forest edge, sporadic
Euphorbia virgata Waldst. et Kit.: Pop, !; at the margins of cultivated lands, frequent

Fam. Rhamnaceae:

Rhamnus cathartica L.: Pop

Rhamnus frangula L.: Pop, !; in the forest, sporadic

Rhamnus saxatilis Jacq. *ssp. tinctorius* (Waldst. et Kit.) Nyman: Pop; at the forest edge, rare

Fam. Vitaceae:

Vitis sylvestris C. C. Gmelin: Pop, !; in the forest, sporadic

Fam. Aceraceae:

Acer campestre L.: Pop, !; in the forest, frequent

Acer tataricum L.: Pop, !; in the forest and along its edge, frequent

Fam. Geraniaceae:

Erodium cicutarium (L.) L'Hérit: Pop, !; in the dry pastures

Geranium dissectum L.: (Pop), !; along roads and ditches, sporadic

Geranium pusillum L.: (Pop), !; along roads and ditches, and in the pastures, frequent

Geranium robertianum L.: Pop, !; in the forest, sporadic

Geranium sanguineum L.: !; in Rădvani forest

Fam. Araliaceae:

Hedera helix L.: Pop, !; in the forest, rare

Fam. Apiaceae:

Aegopodium podagraria L.: Pop, !; in the forest, sporadic

Angelica sylvestris L.: Pop, !; along the channels, also in the forest, sporadic

Anthriscus sylvestris (L.) Hoffm.: !; in the forest, sporadic

Bupleurum tenuissimum L.: Pop

Chaerophyllum bulbosum L.: Pop

Conium maculatum L.: (Pop), !; along the channels, frequent

Daucus carota L.ssp. *carota*: Pop, !; in meadows, common

Eryngium campestre L.: (Pop), !; in pastures, frequent

Oenanthe aquatica (L.) Poiret: Pop

Oenanthe banatica Heuff.: Pop1; along channels on the forest edge, frequent

Oenanthe silaifolia Bieb.: (Pop), !; along channels, sporadic

Pastinaca sativa L.: Pop, !; in meadows and along ditches, frequent

Peucedanum alsaticum L.: Pop, !; in the meadows in the vicinity of Rădvani forest, also f. *angustifolium* Erdn: Pop, frequent

Peucedanum carvifolium Vill.: Pop; at the forest edge, !; in the hayfields near the forest, frequent, also var. *aestivale* (Hol.) Rouy et Cam.: Pop; at the forest edge

Peucedanum officinale L.: Pop, !; in meadows near the forest, also var. *italicum* (Mill.) Ehrh: Pop; at the forest edge, frequent

Pimpinella saxifraga L.: (Pop), !; in meadows, frequent

Torilis arvensis (Hudson) Link: (Pop), !; along channels, sporadic

Torilis japonica (Houtt.) DC.: Pop

Fam. Hypericaceae:

Hypericum hirsutum L.: Pop, !; in the forest and along ditches, frequent

Hypericum perforatum L.: (Pop), !; in meadows, also var. *microphyllum* DC.: (Pop), !; along channels, frequent

Fam. Malvaceae:

Abutilon theophrasti Medik: (Pop), !; on the lake shores and on the abandoned fields, sporadic

Althaea officinalis L.: (Pop), !; along the channels, frequent

Hibiscus trionum L.: (Pop), !; at the margins of cultivated fields, sporadic

Lavathera thuringiaca L.: (Pop), !; along the channels, sporadic

Malva neglecta Wallr.: (Pop), !; along roads and fields, frequent

Malva sylvestris L.: (Pop), !; along ditches and roads, sporadic

Fam. Violaceae:

Viola arvensis Murray: (Pop), !; in the cultivated fields, frequent

Viola elatior Fries: Pop; along ditches, at the margins of orchards and at the forest edge, also f. *glabrescens* Morariu, in slightly halophylous hayfields at the forest edge, frequent

Viola hirta L.: Pop, !; in the forest, frequent

Viola jordanii Hanry: Pop; in the forest, sporadic

Viola odorata L.: Pop; in Rădvani forest, !; in the forest, frequent

Viola x *permixta* Jord. (*V. hirta* x *V. odorata*): Pop; in the forest

Viola reichenbachiana Jordan ex Boreau: Pop

Viola suavis Bieb. var. *cyanea* Cel.: Pop, !; in the forest, sporadic

Fam. Brassicaceae:

Alliaria petiolata (Bieb.) Cavara et Grande: Pop, !; in the forest, frequent

Capsella bursa-pastoris (L.) Medik.: (Pop), !; along roads and ditches, common

Erophila verna (L.) Chevall.: Pop

Lepidium campestre (L.) R.Br.: (Pop), !; in pastures and along roads, frequent

Lepidium ruderale L.: (Pop), !; in pastures, along ditches and roads, frequent

Rorippa amphibia (L.) Besser: Pop

Rorippa sylvestris (L.) Besser: (Pop), !; along channels, frequent, ssp. *kerneri* (Menyh.) Soó: Pop

Sinapis arvensis L.: (Pop), !; in cultivated fields and hayfields, frequent

Thlaspi arvense L.: (Pop), !; at the margins of cultivated fields, frequent

Thlaspi perfoliatum L.: Pop

Fam. Salicaceae:

Populus alba L.: Pop, !; at the forest edge and along channels, sporadic

Populus canescens Sm.: !; along channels, rare

Populus nigra L.: Pop, !; along channels and roads, sporadic

Populus tremula L.: !; along the channels limiting the fishfarm, rare

Salix alba L.: (Pop), !; along channels, frequent

Salix cinerea L.: (Pop), !; along ditches in the vicinity of the forest, frequent

Salix fragilis L.: (Pop), !; along ditches and channels, frequent

Salix purpurea L.: Pop, !; at the forest edge, rare

Salix triandra L.: (Pop), !; along channels, frequent

Fam. Primulaceae:

Anagallis arvensis L.: (Pop), !; in cultivated fields, frequent

Lysimachia nummularia L.: Pop, !; in wet places, both in meadows and forest, common

Lysimachia vulgaris L.: Pop, !; in wet meadows, along channels and ditches, frequent

Fam. Gentianaceae:

Centaurium erythraea Rafin.: Pop, !; in humid meadows, sporadic

Centaurium pulchellum (Swartz) Druce: Pop

Fam. Apocynaceae:

Vinca minor L.: (Pop), !; at the forest edge, rare

Fam. Asclepiadaceae:

Vincetoxicum hirundinaria Medikus (L.) Pers.: Pop, !; Rădvani forest, frequent

Fam. Oleaceae:

Fraxinus excelsior L.: Pop, !; sporadic along channels and abundant in the forest, especially as seedlings, frequent

Ligustrum vulgare L.: Pop, !; in the shrubs from the forest and its edge, frequent

Fam. Solanaceae:

Datura stramonium L.: (Pop), !; on the lakes' shore and on abandoned fields

Lycium barbarum L.: Pop; at the margins of Rădvani forest, frequent

Physalis alkekengi L.: (Pop), !; in the forest, rare

Solanum dulcamara L.: Pop, !; along channels, on the lakes' shore, and in wet places from the forest, frequent

Solanum nigrum L.: (Pop), !; at the margins of cultivated fields

Fam. Convulvulaceae:

Calystegia sepium (L.) R.Br.: Pop, !; in the reedbed on the lake shores in the fish farm, and in the shrubs along the channels, frequent

Convolvulus arvensis L.: Pop, !; along roads, ditches, and in meadows, common

Fam. Menyanthaceae:

Nymphoides peltata (S.G.Gmelin) O.Kuntze: Pop, !; in fishponds and channels, sporadic

Fam. Boraginaceae:

Anchusa officinalis L.: (Pop), !; in pastures, sporadic

Myosotis arvensis Hill.: Pop, !; in dry hayfields in the vicinity of the forest, frequent

Myosotis cespitosa C.F. Schultz: Pop1; along the channel from the forest edge, sporadic

Myosotis discolor Pers.: Pop

Myosotis scorpioides L.: Pop1, !; in ditches with water and along channels, frequent

Myosotis stricta Link ex Roem. et Schult.: Pop

Pulmonaria mollis Wulfen ex Homem. ssp. *mollissima* (A.Kern.) Nyman: Pop, !; in the forest, sporadic

Symphytum officinale L.: Pop, !; on lake shores, along channels, at the forest edge, frequent

Fam. Verbenaceae:

Verbena officinalis L.: (Pop), !; in pastures and ruderal fields, frequent

Fam. Lamiaceae:

Ajuga genevensis L.: Pop, !; in meadows and at the margins of cultivated fields, sporadic

Ballota nigra L.: (Pop), !; along roads, at the margins of cultivated fields, and in shrubs, frequent

Clinopodium vulgare L.: Pop, !; at the forest edge, frequent

Glecoma hederacea L.: Pop, !; in the forest, frequent
Glecoma hirsuta Waldst. et Kit.: Pop
Lamium album L.: Pop, !; in the forest, frequent
Lamium purpureum L.: Pop
Leonurus cardiaca L.: (Pop), !; along channels, sporadic
Lycopus europaeus L.: (Pop), !; in wet places, especially on lake shores and along channels, frequent
Lycopus exaltatus L. fil.: Pop, !; along channels, on lake shores, but also in the puddles from the forest, frequent
Mentha aquatica L.: (Pop), !; along channels and on lake shores, frequent
Mentha arvensis L.: Pop, !; in wet meadows and at the forest edge, frequent, also var. *cuneifolia* Lej. et Court.: Pop, along channels and in the forest
Mentha longifolia (L.) Hudson: (Pop), !; along channels and ditches, frequent
Mentha pulegium L.: Pop, !; along channels, frequent
Prunella vulgaris L.: Pop1; at the forest edge, !; meadows, margins of fields and along roads, frequent
Salvia nemorosa L.: (Pop), !; meadows, frequent
Salvia pratensis L.: (Pop), !; meadows, frequent
Scutellaria galericulata L.: Pop
Stachys germanica L.: (Pop), !; dry meadows, sporadic
Stachys officinalis (L.) Trev.: Pop
Stachys palustris L.: (Pop), !; along channels and on the lake shores, frequent
Stachys sylvatica L.: Pop, !; in the forest, frequent
Teucrium scordium L.: Pop; in abandoned fields in the westwards from the forest
Thymus glabrescens Willd.: Pop
Thymus pannonicus All.: !; in dry pastures and along roads, sporadic
Thymus pulegioides L. ssp *chamaedrys* (Fries) Gusuleac: Pop

Fam. Plantaginaceae:
Plantago lanceolata L.: Pop, !; in pastures and hayfields, frequent
Plantago major L.: (Pop), !; in pastures and along roads, common
Plantago maritima L.: Pop
Plantago media L.: Pop, !; in meadows and along roads, frequent
Plantago schwarzenbergiana Schur: Pop, !; halophylous pastures westwards from the fishfarm, sporadic, also f. *pilosula* (Schur) Borza: Pop; in Artemisio-Festucetum pseudovinae meadows next to Rădvani forest

Fam. Scophulariaceae:
Gratiola officinalis L.: Pop, !; in marshy areas, sporadic
Kickxia elatine (L.) Dumort.: (Pop), !; in cultivated fields and at their margins, sporadic
Linaria vulgaris Miller: (Pop), !; in meadows and the margins of cultivated fields, frequent
Lindernia procumbens (Krocker) Philcox: Pop1; on the channel banks from the forest edge, frequent
Odontites verna (Bellardi) Dumort. ssp. *serotina* (Dumort.) Corb.: Pop
Scrophularia nodosa L.: Pop, !; in the forest and at the edge, frequent
Verbascum blattaria L.: (Pop), !; at the forest edge, sporadic
Verbascum lychnitis L.: Pop

Verbascum nigrum L. f. *tomentosum* G.F.Mey: Pop; in Rădvani forest, frequent
Verbascum phlomoides L.: (Pop), !; in pastures and along roads, frequent
Verbascum phoeniceum L.: (Pop), !; in hayfields and pastures, sporadic
Veronica acinifolia L.: Pop
Veronica anagallis-aquatica L.: (Pop), !; along channels and in marshy areas, sporadic
Veronica anagalloides Guss.: (Pop), !; along channels and on lake shores
Veronica arvensis L.: Pop
Veronica teucrium L.: !; in dry meadows, sporadic
Veronica chamaedrys L.: Pop, !; in meadows, along roads but also in the forest, common
Veronica longifolia L.: Pop; at the forest edge, frequent
Veronica persica Poiret: (Pop), !; on the fringes of cultivated fields and in meadows, frecvent
Veronica prostrata L.: Pop
Veronica serpyllifolia L.: Pop, !; at the forest edge and along the channels, frequent
Veronica spicata L.: Pop, !; in meadows, sporadic
Veronica verna L.: Pop

Fam. Orobanchaceae:
Orobanche major L.: Pop; parasite on *Centaurea pannonica* and *Medicago sativa*

Fam. Lentibulariaceae:
Utricularia vulgaris L.: Pop, !; in channels and fishponds, frequent

Fam. Campanulaceae:
Campanula glomerata L. şi f. *ramosa* Nyár.: Pop, !; in the forest, sporadic

Fam. Rubiaceae:
Asperula cynanchica L.: !; in meadows, rare
Cruciata laevipes Opiz: Pop, !; in meadows but also in the forest, frequent
Galium aparine L.: Pop, !; along roads, ditches, but also in the forest, frequent
Galium mollugo L.: Pop, !; in the forest and at its edge, frequent
Galium palustre L.: Pop, !; along channels, frequent
Galium rubioides L.: Pop, in the *Q. cerris* plantation, sporadic
Galium schultesii Vest: (Pop), !; at the margins of cultivated fields, sporadic
Galium verum L.: Pop, in the *Q. cerris* plantation, !; along channels and in meadows, frequent

Fam. Caprifoliaceae:
Sambucus ebulus L.: (Pop), !; on abandoned fields and along roads, frequent
Sambucus nigra L.: Pop1; at the forest edge, !; at the forest edge and along channels, frequent
Viburnum opulus L.: Pop, !; at the forest edge and along channels, sporadic

Fam. Dipsacaceae:
Dipsacus fullonum L.: (Pop), !; along channels and roads, frequent
Dipsacus laciniatus L.: Pop, !; on the fringes of cultivated fields, in meadows, and abandoned fields, common
Dipsacus x *fallax* (*Dipsacus fullonum* x *D. laciniatus*): (Pop), !; in meadows, sporadic
Knautia arvensis (L.) Coulter: (Pop), !; in hayfields and pastures, frequent
Scabiosa ochroleuca: (Pop), !; in dry hayfields, sporadic

Fam. Asteraceae:

Achillea collina J.Becker: Pop, !; in dry halophilous meadows, sporadic

Achillea millefolium L.: Pop, !; in meadows and along roads, frequent

Achillea setacea Waldst. et Kit.: Pop, !; hayfields and pastures next to the forest, frequent

Anthemis arvensis L.: (Pop), !; in meadows, sporadic

Anthemis austriaca Jacq.: (Pop), !; in meadows and on abandoned fields, sporadic

Arctium lappa L.: (Pop), !; pastures, along roads, frequent, and sporadic in the forest

Arctium tomentosum Miller: (Pop), !; along ditches, frequent

Artemisia campestris L.: !; dry pastures, sporadic

Artemisia pontica L.: Pop, !; in pastures, sporadic

Artemisia santonica L. ssp. *monogyna* (Waldst. et Kit.) Leonova: Pop, !; in halophilous pastures, frequent

Artemisia vulgaris L.: (Pop), !; at the margins of cultivated fields and along roads, frequent

Aster linosyris (L.) Bernh.: Pop; in hayfields in the vicinity of the forest, on salty soils, sporadic

Aster sedifolius L.: Pop, !; in meadows, frequent

Aster tripolium L.: Pop, !; in pastures and hayfields on wet and salty soils, frequent, also ssp. *pannonicus* (Jacq.) Soó: Pop

Bellis perennis L.: !; in meadows along roads, sporadic

Bidens cernua L.: (Pop), !; in puddles from the forest and its vicinity, sporadic

Bidens frondosa L.: !; wet meadows in the vicinity of the forest, sporadic

Bidens tripartita L.: (Pop), !;on lake shores, along channels and ditches, frequent

Carduus acanthoides L.: (Pop), !; in meadows and on the fringes of cultivated fields, frequent

Carduus crispus L.: Pop; along channels in the vicinity of Rădvani forest, frequent

Carduus nutans L.: Pop; in dry pastures, frequent

Centaurea biebersteinii DC ssp. *biebersteinii*: !; in meadows, sporadic

Centaurea cyanus L.: (Pop), !; in cereal fields, sporadic

Centaurea jacea L.: (Pop), !; in pastures and hayfields and at the forest edge

Centaurea pannonica (Heuffel) Simonkai: Pop, !; in meadows, frequent

Cichorium inthybus L.: Pop, !; in the fields and along roads

Cirsium arvense (L.) Scop: (Pop), !; in cultivated fields, frequent

Cirsium brachycephalum Juratzka: (Pop), !; in meadows, frequent

Cirsium canum (L.) All.: Pop; in pastures and along channels, !; in wet areas at the forest edge, frequent

Cirsium pannonicum (L. fil.) Link: Pop; at the forest edge, rare

Cirsium vulgare (Savi.) Ten.: Pop; in wet meadows and at the forest edge, !; in meadows, frequent

Conyza canadensis (L.) Cronq.: (Pop), !; on the fringes of cultivated fields and along roads, frequent

Crepis foetida L.: !; along roads, sporadic

Erigeron acris L.: Pop

Erigeron annuus (L.) Pers.: Pop, !; in fields and along them, frequent

Galinsoga parviflora Cav.: (Pop), !; along roads and cultivated fields

Gnaphalium uliginosum L.: Pop; along the cultivated fields and the forest edge, also f. *strictum* Nyar.

Helianthus tuberosus L.: !; on the banks of Criş Channel and on lake shores, frequent

Hieracium bauhinii Besser: Pop

Hieracium cymosum L.: (Pop), !; in hayfields and pastures, rare

Hieracium pilosella L.: Pop

Hieracium racemosum Waldst. et Kit. ex Willd.: Pop; in Rădvani forest, frequent

Hieracium x *tauschii* Zahn. (*H. bauhini* x *H. cymosum*): Pop

Inula britannica L.: Pop, !; along channels and in meadows, frequent

Inula helenium L.: Pop; along the forest edge, sporadic

Inula salicina L. also var. *subhirta* C.A.Mey: Pop; in pastures and hayfields, next to Rădvani forest, sporadic

Lactuca quercina L.: Pop1, !; along roads and the forest edge, frequent

Lactuca saligna L.: (Pop), !; in halophylous pastures and meadows, sporadic

Lapsana communis L.: Pop, !; in the forest, frequent

Leontodon crispus Vill.: Pop

Leontodon hispidus L.: Pop

Leucanthemum vulgare Lam.: Pop, !; in meadows, sporadic

Matricaria perforata L.: Pop1, !; along channels and the forest edge, frequent

Matricaria recutita L.: Pop, !; in dry pastures and along roads and fields, frequent

Mycelis muralis (L.) Dumort.: Pop

Picris hieracioides L.: Pop (10), !; in pastures and hayfields, frequent

Pulicaria vulgaris Gärtner: Pop

Rudbeckia hirta L.: !; along channels and on lake shores, sporadic

Scorzonera cana (C.A.Meyer) Griseb.: Pop, !; in halophylous pastures, frequent

Senecio erraticus Bertol.: Pop

Senecio jacobaea L.: Pop; at the forest edge, !; in meadows in the vicinity of the forest, sporadic

Serratula tinctoria L.: Pop, !; in pastures and hayfields at the forest edge, also var. *lancifolia* S.F. Gray: Pop, frequent

Sonchus arvensis L.: (Pop), !; along roads and fields, frequent

Sonchus asper (L.) Hill.: Pop1, !; along roads, ditches and on lake shores, frequent

Sonchus palustris L.: !; along channels, rare

Tanacetum vulgare L.: (Pop), !; along channels and the forest edge, common

Taraxacum bessarabicum (Hornem.) Hand.-Mazz.: Pop, !; in halophylous meadows, sporadic

Taraxacum officinale Weber ex Wiggers: Pop, !; in pastures and hayfields, along roads, common

Tussilago farfara L.: (Pop), !; on sandy soils along roads, sporadic

Xanthium italicum Moretti: (Pop), !; in pastures, sporadic

Xanthium spinosum L.: (Pop), !; in pastures and abandoned fields, frequent

Xanthium strumarium L.: Pop, !; in cultivated and abandoned fields, frequent

Fam. Alismataceae

Alisma plantago-aquatica L.: (Pop), !; in channels, sporadic

Sagittaria sagittifolia L.: (Pop), Gav., !; in channels and fishponds, frequent

Fam. Butomaceae:

Butomus umbellatus L.: (Pop), Gav., !; in channels and ponds, sporadic

Fam. Hydrocharitaceae:

Hydrocharis morsus-ranae L.: Pop, Gav., !; on lakes and channels, frequent

Stratiotes aloides L.: (Pop); extinct from the area due to desiltation of channels and intentional removal, !; during the last 5 years the species reappeared in some spots along the channels bordering the fish farm, rare but in expansion

Fam. Potamogetonaceae:

Potamogeton crispus L.: (Pop), !; in channels and lakes, frequent

Potamogeton natans L.: (Pop), !; in channels and lakes, sporadic

Potamogeton nodosus Poiret: Pop, Gav., !; in channels and lakes, frequent

Potamogeton pussilus L.: Pop

Fam. Najadaceae:

Najas marina L.: Pop

Fam. Dioscoreaceae

Tamus communis L.: (Pop), !; in the forest, sporadic

Fam. Liliaceae:

Asparagus tenuifolius Lam.: Pop

Colchicum autumnale L.: Pop, !; in meadows from the vicinity of the forest, sporadic

Convallaria majalis L.: Pop, !; in the forest, frequent

Ornithogalum orthophyllum Ten. ssp. *kochii* (Parl.) Zahar.: Pop

Polygonatum latifolium (Jacq.) Desf..: Pop, !; in the forest, common

Polygonatum odoratum (Miller) Druce: Pop; in the forest, rare

Fam. Alliaceae:

Allium oleraceum L.: Pop; in the forest, sporadic

Allium scorodoprasum L.: Pop; at the forest edge, !; in hayfields, frequent

Allium vineale L.: (Pop), !; in dry halophylous hayfields, frequent

Fam. Iridaceae:

Iris pseudacorus L.: Pop, !; in channels, sporadic

Iris spuria L.: Pop; in slightly halophylous pastures and hayfields next to the forest, sporadic, !; in one marshy area, next to the western limit of the fishfarm, rare

Fam. Orchidaceae:

Epipactis helleborine (L.) Crantz: Pop

Orchis laxiflora Lam.: !; in the hayfield near the Park's Visiting Centre, rare

Platanthera bifolia (L.) L. C. Richard: Pop, !; in the forest, frequent

Fam. Commelinaceae

Commelina communis L.: !; on the lake shores, subspontaneous, sporadic

Fam. Juncaceae:

Juncus articulatus L.: (Pop), !; in marshy areas and along channels, frequent

Juncus atratus Krocker: !; in marshy areas, sporadic

Juncus compressus Jacq.: Pop, !; along roads, ditches and marshes, frequent

Juncus conglomeratus L.: !; in marshy areas, sporadic

Juncus effusus L.: (Pop), !; along channels and ditches, on lakeshores and in marshy areas, common

Juncus gerardi Loisel: Pop, !; in salty-marshy areas, sporadic

Juncus inflexus L.: (Pop), !; on lake shores and along channels, frequent
Juncus tenuis Willd.: !; along ditches, frequent
Luzula campestris (L.) DC.: Pop

Fam. Cyperaceae:

Bolboschoenus maritimus (L.) Palla: Pop, !; along channels and in marshy areas, frequent
Carex acuta L.: Pop, along channels, sporadic
Carex acutiformis Ehrh.: Pop, !; along channels and in marshy areas, sporadic
Carex caryophyllea Latourr.: Pop
Carex distans L.: (Pop), !; in wet meadows, frequent
Carex divulsa Stokes: Pop, !; in the forest, frequent
Carex hirta L.: Pop, !; along channels, frequent
Carex melanostachya Bieb. ex Willd.: (Pop), !; in humid slightly halophilous meadows in the vicinity of the forest, sporadic
Carex praecox Schreber: Pop
Carex remota L.: Pop, !; in the forest, sporadic
Carex riparia Curtis: Pop1, !; along the channels around Rădvani forest, frequent
Carex stenophylla Wahlenb.: Pop
Carex tomentosa L.: Pop
Carex vulpina L.: Pop, !; along channels and in marshy areas, frequent
Cyperus difformis L.: Pop; in the marshes as well as in the channels and ditches in the vicinity of Rădvani forest
Cyperus fuscus L.: Pop
Eleocharis palustris (L.) Römer et Schultes: Pop, !; in marshes, frequent
Schoenoplectus lacustris (L.) Palla: Pop, !; in ditches with water, marshes and along channels, frecvent
Schoenoplectus mucronatus (L.) Palla: Pop, !; along the channels on the forest edge
Schoenoplectus tabernaemontani (C. C. Gmelin) Palla: (Pop), !; in marshy areas, sporadic
Scirpus sylvaticus L.: Pop, !; in wet meadows, sporadic

Fam. Poaceae:

Agropyron cristatum (L.) Gaertner ssp. *pectinatum* (Bieb.) Tzvelev: !; sporadic
Agrostis stolonifera L.: Pop, !; in wet meadows, common
Alopecurus aequalis Sobol: (Pop), !; along channels, sporadic
Alopecurus pratensis L.: Pop, !; in wet meadows, frequent
Anthoxanthum odoratum L.: Pop, !; in pastures and hayfields, frequent
Apera spica-venti (L.) Beauv.: Pop; on the sandy bank of the channel towards Rădvani forest, !; at the edges of cereal fields, sporadic
Arrhenatherum elatius (L.) Beauv. ex J. et C. Presl.: (Pop), !; in meadows and along fields, sporadic
Beckmannia eruciformis (L.) Host.: (Pop), f. *colorata* Roshev.: !; in wet salty areas, frequent
Brachypodium sylvaticum (Hudson) Beauv.: Pop, !; in the forest, frequent
Bromus arvensis L.: (Pop), !; along roads, in the fields, frequent
Bromus commutatus Schrader: (Pop), !; along cultivated fields, frequent

Bromus hordeaceus L. ssp. *hordeaceus*, also f. *nanus* (Weigel) A. et G.: Pop

Calamagrostis epigeios (L.) Roth: Pop, also in the *Quercus cerris* plantation, !; in hayfields in the vicinity of the forest, frequent

Crypsis alopecuroides (Piller et Mitterp.) Schrader: Pop, !; in wet and salty microdepressions, frequent

Cynodon dactylon (L.) Pers.: (Pop), !; in pastures, along roads and on abandoned fields, common

Dactylis glomerata L.: Pop, !; common in meadows

Echinochloa crus-gali (L.) Beauv.: (Pop), !; in cultivated fields and along them

Elymus repens (L.) Gould: Pop, !; in meadows, along roads and fields, frequent

Eragrostis pilosa (L.) Beauv.: Pop

Festuca gigantea (L.) Vill.: Pop, also in the *Q. cerris* plantation

Festuca pratensis Hudson: Pop, !; in wet meadows and along ditches, sporadic

Festuca pseudovina Hackel: Pop, !; in halophylous meadows, common

Festuca valesiaca Schleicher ex Gaudin: Pop

Glyceria fluitans (L.) R.Br.: (Pop), !; along channels, on lake shores and in marshes, frequent

Glyceria maxima (Hartman) Holmberg: Pop, !; along channels and in marshes

Hordeum geniculatum All: Pop

Koeleria macrantha (Ledeb.) Schultes: Pop

Lolium perenne L.: (Pop), !; in meadows, frequent

Phalaris arundinacea L.: Pop

Phleum pratense L.: (Pop), !; in hayfields and pastures, frequent

Phragmites australis (Cav.) Steudel: Pop, !; on the lakes from the fish farm, forming a compact belt, along channels and ditches, as well as in marshy areas, common

Poa bulbosa L.: Pop, also var. *vivipara* L.: Pop

Poa nemoralis L.: Pop

Poa pratensis L.: Pop, !; in wet meadows, frequent

Puccinellia distans (L.) Parl.: !; in halophylous meadows, also ssp. *limosa* (Schur) Jáv.: Pop, frequent

Setaria pumila (Poiret) Schultes: (Pop), !; in cultivated and abandoned fields and along roads, common

Fam. Sparganiaceae:

Sparganium erectum L.: Pop, !; in channels and at the margins of lakes, sporadic

Fam. Typhaceae:

Typha angustifolia L.: Pop, !; in ditches and small channels, frequent

Typha latifolia L.: Pop, !; along channels and ditches, common

Fam. Araceae:

Arum maculatum L.: Pop, !; in the forest, frequent

Fam. Lemnaceae:

Lemna gibba L.: (Pop), !; in channels and lakes, frequent

Lemna minor L.: Pop, !; in channels and at the margins of the lake, also in ditches with water, common

Lemna trisulca L.: Pop, !; in channels, lakes and marshes, common

Spirodela polyrhiza (L.) Schleiden: Pop, !; in channels and at the margins of the lake, also in ditches with water, frequent.

B. Flora analysis

Up to the present, 504 species and 3 hybrids of cormophytes are known from the area of the Cefa Nature Park. 386 species were identified by the authors; beginning with 2005, 36 of them being first records from this area (*Ranunculus bulbosus, Juncus conglomeratus, Quercus frainetto, Rumex hydrolapathum, Potentilla erecta, Epilobium palustre, Crepis foetida, Juncus atratus, Orchis laxiflora*, etc.). Among these species some are subspontaneous, being probably ignored by Pop (1968): *Morus alba, Juglans regia, Prunus cerasifera*. Several new species for the region are adventive and probably spread to the park's area during the last decades: *Rudbeckia hirta, Helianthus tuberosus, Juncus tenuis, Commelina communis, Bidens frondosa*, etc. Although some of these species tend to become in other areas invasive, due to the high variety of habitats and the patchy and mosaic distribution of habitat types, in Cefa Nature Park they do not become prevailing in the park's vegetation. Only *Helianthus tuberosus* is locally abundant and dominant, mainly along Criş Channel and on some lake shores.

The flora of Cefa Nature Park presents some characteristic biogeographical features. Due to its geographical position, geomorphologic and geological features and climatic conditions, the park presents favorable conditions for establishing and maintaining plant species of very different origin. Eurasian plants are prevailing in the park, representing 51.3% of the total number of species (Fig. 2), being the most numerous floristic elements, both in meadows (*Xanthium strumarium, Alopecurus pratensis, Anthoxantum odoratum, Consolida regalis, Lychnis flos-cuculi*) and in the forest (*Allium oleraceum, Ulmus minor, Fragaria vesca*), followed by the European species (*Trifolium campestre, Epilobium lamyi, Euphorbia palustris*), with 12.9%. Cosmopolitan plants (*Erodium cicutarium, Geranium robertianum, Capsella bursa-pastoris, Datura stramonium, Solanum nigrum*) are also well represented in Cefa Nature Park, representing 10.5% of the flora. Most of the species belonging to this floristic element are aquatic plants (*Alisma plantago-aquatica, Potamogeton crispus, Glyceria fluitans, Phragmites australis*), with seeds that are carried for long distances by birds, which are numerous in the lakes of the fish farm, especially during spring and autumn migration. In some cases (*Lemna spp., Spirodela polyrhiza*) the entire plant is transported by birds.

All the other floristic elements are poorly represented in the park, with less than 10% of the species. The presence of numerous water bodies (lakes, ponds, channels) on the park's territory enabled the installation and survival of a relatively high number of the circumpolar species (6.1%), especially including the wetland plants (*Galium palustre, Utricularia vulgaris, Potamogeton nodosus, Veronica anagallis-aquatica, Juncus articulatus, J. gerardi*). An important category is represented by the thermophylous plants of southern origin. The southern mild climate influence in the area is revealed not only by the presence of the Mediterranean (*Quercus cerris, Lathyrus aphaca, Medicago sativa, Oenanthe silaifolia*) (4.3%) and Ponto-Mediterranean plants (*Galega officinalis, Lotus angustissimus, Vitis sylvestris*) (2.7%), but also within the Eurasian (*Brachypodium sylvaticum, Ranunculus acris, Polygonum dumetorum*) and European (*Ononis spinosa, Trifolium dubium*) elements, where a third of the species belong to the Mediterranean subelements. The steppic character of the vegetation is given by the Pannonic (*Cirsium brachycephalum, Iris spuria, Carex stenophylla*) (0.6%) and Ponto-Pannonic (*Thymus glabrescens, Cirsium pannonicum, Polygonatum latifolium*) (0.6%) plants, but also by the continental Eurasian species (*Fragaria viridis, Euphorbia lucida, Acer tataricum, Anthemis austriaca*). The 19 adventive species (*Bidens frondosa, Conyza canadensis, Erigeron annuus, Galinsoga parviflora, Xanthium italicum, X. spinosum, Amaranthus retroflexus*) from the Cefa Nature Park represent 3.7% of its flora.

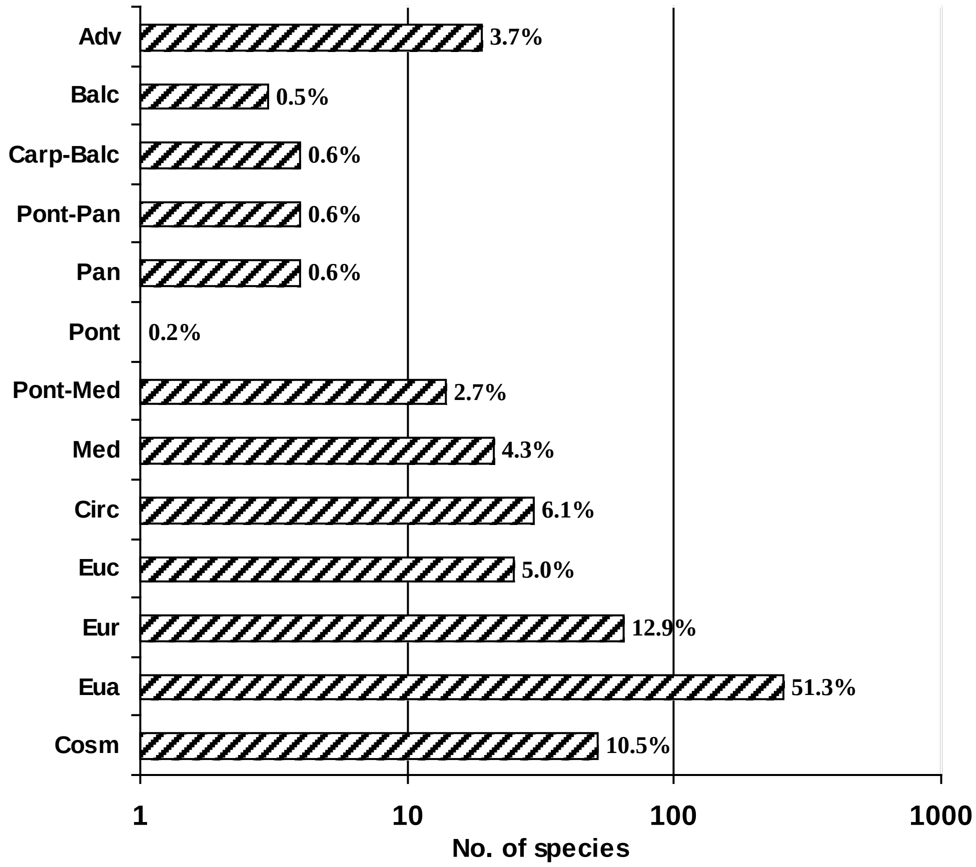

Figure 2: Floristic elements of the Cefa Nature Park (logarithmic scale).

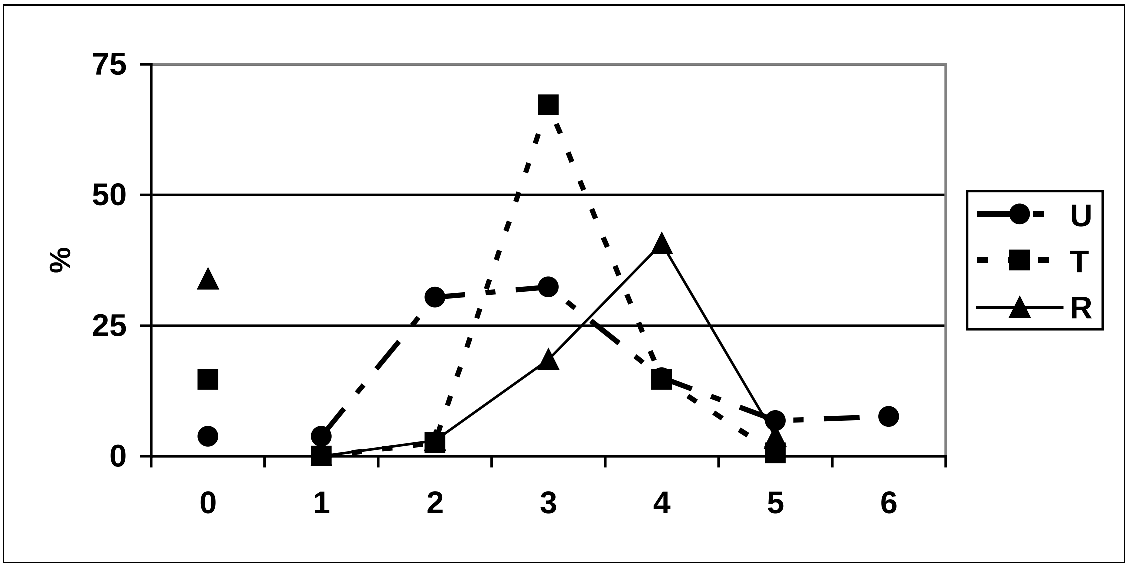

Figure 3: The ecological spectrum for the flora of the Cefa Nature Park.

The characteristics of the environmental conditions of the Cefa Nature Park are reflected by the vegetation's ecological preferences (Fig. 3). The climate is characterized by relatively mild winters and hot summers. Micro-mesothermic (T3) species are best represented, with two thirds (67.2%) of the species (*Juncus effusus, Schoenoplectus lacustris, Dipsacus laciniatus, Sambucus ebulus, Lycopus europaeus*), followed at the same distance by eury-thermic (T0) (*Agrostis stolonifera, Phragmites australis, Lemna minor, Ranunculus acris*) and mesothermic (T4) (*Trapa natans*, *Typha angustifolia*, *Juncus inflexus*, *Xanthium spinosum*) species (14.7%). The influence of the water bodies and forest on the microclimate of the park area is revealed by the presence of the microthermic (T2; 2.6%) species (*Athyrium filix-femina, Lychnis flos-cuculi, Fragaria vesca, Populus tremula, Potamogeton natans*).

The numerous salty areas are populated by halophytes. A few species are mandatory halophytes (*Limonium gmelinii, Plantago maritima, P. schwarzenbergiana, Aster tripolium, Scorzonera cana*), while most of them are halotolerant (*Schoenoplectus tabernaemontani, Juncus compressus, Achillea collina*). These species form patches of characteristic vegetation, both on dry and wet soils.

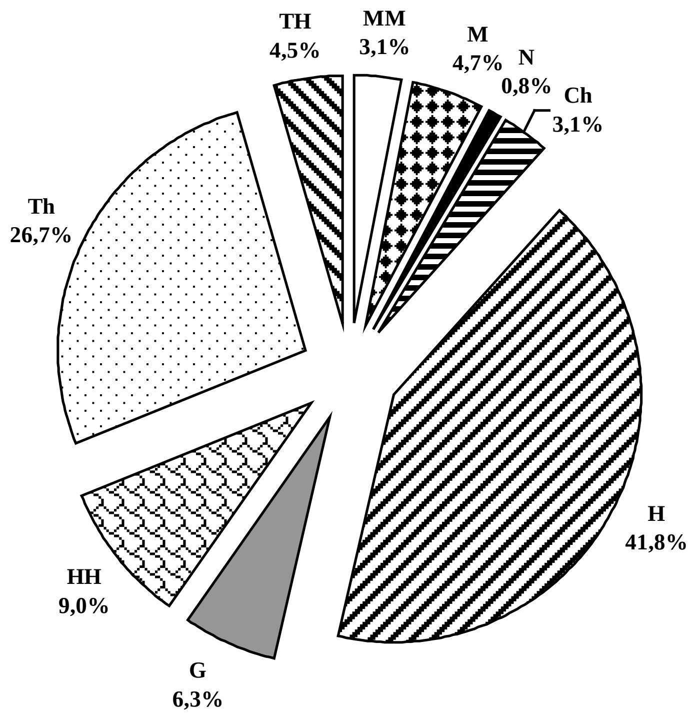

Figure 4: The life forms' spectrum for the flora of the Cefa Nature Park.

Considering the curve for the soil reaction, it has a strong right sided asymmetry. The strong acidophilous (R1) plants are missing, while neutro-basiphilous (R5) species (*Juncus gerardi, Puccinellia distans, Thalictrum lucidum, Aristolochia clematitis*) are present, with a higher percentage (3.8%) than the acidophilous (R2) species (*Gypsophila muralis, Potentilla argentea, Trifolium ornithopodioides*) (3%). The vegetation has a mild acid-neutrophilous character; most of the identified species belonging to this ecological category (R4 - 40.7%). Some of them are halophylous (*Scorzonera cana, Crypsis* *alopecuroides*, *Aster linosyris*, *Juncus compressus*), some grow on soil rich in organic matter, along the forest edge, the roads or on the lake shores (*Vicia hirsuta, Epilobium parviflorum, Euphorbia palustris*), and some inhabit the eutrophic marshes and ponds (*Trapa natans, Potamogeton natans, P. crispus, Lemna gibba, L. trisulca*). Most of the forest plants also belong to this category (*Acer tataricum, Alliaria petiolata, Convallaria majalis, Polygonatum latifolium, Arum maculatum*). The euryionic plants (R0) (*Agrostis stolonifera, Alopecurus pratensis, Iris pseudacorus, Tanacetum vulgare, Arctium lappa*) are also well represented (33.9%).

The variety of habitat types and ecological conditions in the area of the Cefa Nature Park is best illustrated by the preference for humidity (soil moisture), all the categories being represented in the park's area, with a more similar distribution. The great range of soil humidity in the park favours the exacting species, while the eury-hygrophilous (U0) species (*Anthoxanthum odoratum, Elymus repens, Matricaria perforata*) are poorly represented (3.8%) in comparison to other areas. The curve has a slight left sided asymmetry, the vegetation being dominated by mesophilous species (U3; 32.4% - *Arrhenatherum elatius, Brachypodium sylvaticum, Dactylis glomerata, Poa pratensis, Puccinellia distans*) and xero-mesophylous species (U2; 30.4% - *Peucedanum alsaticum, P. officinale, Calamagrostis epigeios, Vincetoxicum hirundinaria, Stachys germanica*). However, the large marshy areas and numerous lakes, ponds and channels from the park also offer suitable conditions also for meso-hygrophilous plants (U4; 15%) inhabiting the wet meadows (*Agrostis stolonifera, Alopecurus pratensis, Lythrum virgatum, L. salicaria, Galega officinalis*), to hygrophilous species (U5; 6.8%) from the marshes and the channel banks (*Glyceria fluitans, Sparganium erectum, Rumex palustris, Eleocharis palustris*), and to hydrophilous plants (U6; 7.6%) populating the flowing waters from channels or the standing waters from the ponds and lakes (*Rumex hydrolapathum, Lemna minor, Typha latifolia, Potamogeton natans*). The hot and dry summers favour the steppic xerophilous plants (U1; 3.8%), present in the dry pastures and meadows (*Thymus pannonicus, Carduus nutans, Veronica spicata, Festuca valesiaca*).

The flora of the Cefa Nature Park is dominated by hemicryptophytes (41.8%), inhabiting especially grasslands (*Linaria vulgaris, Plantago lanceolata, Galium verum, Centaurea pannonica, Agrostis stolonifera, Festuca pseuovina*), but also the forest herbaceous layer (*Brachypodium sylvaticum, Galium mollugo, Lamium album, Geum urbanum*), followed by therophytes (31,2%), living for one (*Ranunculus sceleratus, Polygonum hydropiper, Galium aparine, Alliaria petiolata, Capsella bursa-pastoris*) or two (*Verbascum phlomoides, V. nigrum, Cirsium brachycephalum, Daucus carota*) vegetation seasons (Fig. 4). The high ratio of the therophytes is due to both the dry steppic climate and the human impact on the habitats. Thus, the rophytes are present in the dry pastures and meadows (*Lotus angustissimus, Matricaria recutita, Xanthium italicum, Polygonum aviculare*), but also in and along the cultivated fields, as weeds (*Kickxia elatine, Veronica persica, Galinsoga parviflora, Erigeron annuus, Papaver rhoeas*). The numerous wet habitats shelter a high number of helohydrophytes (9% - *Marsilea quadrifolia, Nuphar lutea, Butomus umbellatus, Hydrocharis morsus-ranae*), while the forest is inhabited by a relatively high diversity of phanerophytes (8.6%), trees (*Quercus robur, Q. cerris, Fraxinus excelsior, Acer campestre, Ulmus procera*) and shrubs (*Ligustrum vulgare, Prunus spinosa, Crataegus monogyna, Rhamnus frangula*). The geophytes (6.3%) with bulbs inhabit mainly the meadows (*Colchicum autumnale, Allium vineale*), while those with rhizomes are found especially in the forest (*Convallaria majalis, Polygonatum latifolium*). Chamaephytes are poorly represented (3.1%) in the area (*Lysimachia nummularia, Solanum dulcamara, Thymus glabrescens*).

Figure 5: *Marsilea quadrifolia*
(photo A. Nagy).

Due to its mosaic structure, the large variety of the habitat types and this area environmental conditions are on a relatively small surface, the Cefa Nature Park presents a high diversity of living organisms, representing an important conservation area for plants. Several protected species (at national and European level) are found here: 4 species (*Marsilea quadrifolia, Salvinia natans, Lindernia procumbens,* and *Trapa natans*) are included in the Annex I of the Bern Convention (L 13/1993). Three species are part of the 92/43/EEC EU Habitats Directive: *Marsilea quadrifolia* (Fig. 5) and *Cirsium brachycephalum* (Fig. 6) in Annex II and *Lindernia procumbens* in Annex IV. *Lotus angustissimus* and *Trifolium ornithopodioides* are included in the Red Book of Romanian plants (Dihoru and Negrean, 2009).

Cardamine parviflora, Limosella aquatica and *Elatine triandra,* which are also belonging of the Red List (Dihoru et Negrean, 2009), were mentioned by Pop (1962 a, 1968) near Rădvani Forest area, but the lack of exact location or recent data from the park determines the absence of these species from our checklist. However, it is possible that new research in the southern part of the park will lead to the identification of the above mentioned plants.

Figure 6: *Cirsium brachycephalum*
(photo J. P. Frink).

C. Habitats characterization

Vegetation history

According to bibliografic sources, in the prehistorical period, the Plain of the three Criş rivers (Câmpia Crişurilor) was covered by oak forests in alternance with steppic grasslands (Pop, 1968). The valleys and the moist places were covered by riparian mixed forests and lowland oak forests. These forests were more extensive and more compact in the past. About 140-160 years ago (in the 19th century), the forest between Marţihaz and Cefa localities was larger and also extended nearby to the Mădăraş locality. Today, on this entire territory only a small patch of forest remains (Rădvani Forest) due to the deforestations of the past in order to gain and increase the agricultural fields (especially for rice cultivation). Thus, the remains of the primary woody vegetation on the Cefa Nature Park are represented today by the Rădvani Forest (Fig. 7), covering 276 ha.

The areas covered by steppic grasslands were also transformed in agricultural land. Due to the drainage actvities carried out on large areas, the upper parts and the surface of the soil became salty, giving rise to secondary salty plant communities, which today are widespread and characteristic in the Plain of Criş rivers. The primary and secondary halophilous vegetation cannot be distinguished.

Borbás (1890) mentioned that in 1877 the territory between Crişul Repede and Crişul Negru rivers was still covered by reed beds and rich aquatic vegetation. In the following decades, as a consequence of the drainage works, the aquatic and paludal vegetation retreated mainly to the lakes and channels, being replaced by mesic and later mesic-xeric and xeric vegetation, with numerous halophytes. Among the species that were once abundant, but had become extinct due to the desiccation of marshes, Borbás notes several species and varieties of *Mentha*. By 1890 numerous other species were already rare: *Aldrovanda vesiculosa*, species of *Elatine, Schoenoplectus supinus, Lythrum tribracteatum, Ranunculus polyphyllus,* most of them becoming later extinct. These species were replaced by more resistant plants, some of them adventive: *Echinochloa oryzoides, Schoenoplectus mucronatus,* and *Cyperus difformis,* introduced toghether with the rice in the cultivated fields on the western part of the present park's territory. Today, the rice fields do not exist anymore, but some of the accompanying plants still populate the resembling habitats.

Figure 7: Rădvani Forest
(photo I. Sîrbu).

The establishment of the Cefa fish farm in 1905, with its artificial lakes, ponds and channels changed the landscape and the vegetation of the area. Thus, the aquatic and paludal vegetation of the park's area is represented in/around the lakes and in/along the channels; however the characteristic zonation of this vegetation is very rare or is missing, due to the steep banks. Large areas around the lakes and channels are covered by compact phytocoenosis of *Phragmites australis* (Fig. 8) with reduced species diversity, due to the lack of microhabitats needed by the majority of paludal species.

Identified Natura 2000 habitats

1530* Pannonic salt-steppes and salt-marshes, with the following associations:

Puccinellietum limosae Rapaics ex Soó 1933
Artemisietum santonici Soó 1947
Artemisio santonici-Festucetum pseudovinae Soó in Máthé 1933
Achilleo-Festucetum pseudovinae Soó (1933) corr. Borhidi 1996
Peucedano-Festucetum pseudovinae (Rapaics 1927) Pop 1968

3150 Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation, with the following associations:

Lemnetum minoris Soó 1927
Lemno-Utricularietum vulgaris Soó (1928) 1947
Spirodelo-Salvinietum natantis Slavnič 1965

3160 Natural dystrophic lakes and ponds, including the following associations:

Nymphoidetum peltatae (Allorge 1922) Bellot 1951
Trapetum natantis Kárpáti 1963
Potametum natantis Soó 1927

6440 Alluvial meadows of river valleys of the Cnidion dubii alliance, with the following associations:

Poëtum pratensis Răvăruţ et al., 1956
Agrostetum albae Ujvárosi 1941 (subas. caricetosum vulpinae Soó 1957)
Agrostio-Festucetum pratensis Soó 1949
Agrostio stoloniferae-Alopecuretum pratensis Soó 1933 corr. Borhidi 2003

91F0 Riparian mixed forests of *Quercus robur, Ulmus laevis* and *Ulmus minor, Fraxinus excelsior* or *Fraxinus angustifolia* along the great rivers (Ulmenion minoris)

Fraxino danubialis – Ulmetum Soó 1936 corr. 1963

Figure 8: Lakes in the fish farm (photo I. Sîrbu).

1530* Pannonic salt-steppes and salt-marshes

Most areas in the park are characterised by salty soils and they are covered by characteristic halophilous grasslands, included in this habitat type. This habitat type is the most frequent, the most important and considered a priority habitat on European level. The following plant communities are included: Puccinelietum limosae (Pop, 1968), Artemisietum santonici (Pop, 1968; !), Artemisio santonici-Festucetum pseudovinae (Pop, 1968; !), Achilleo-Festucetum pseudovinae (Pop, 1968; !), and Peucedano-Festucetum pseudovinae (Pop, 1968; !).

The Puccinelietum limosae is a typical halophylous community which covers salty soils whith a neutral or basic chemical reaction and areas where the concentration in mineral salts of the superficial soil layer is higher during the summer, as a result of water evaporation. It covers small surfaces and it is less frequent in the western part of the Rădvani Forest. The grasslands are up to 10-15 cm high. Frequent halophyte species are *Juncus gerardi, Polygonum aviculare, Trifolium fragiferum, Aster tripolium* ssp. *pannonicus* etc. Some phytocoenosis are dominated by *Spergularia marina*, others by *Aster tripolium*.

Phytocoenosis of Artemisietum santonici have been identified in 2005 on small patches between the Rădvani Forest and the fish farm. They occur on salty, tramped, and dry soils. These communities are characterised by a low number of species. Beside the dominant species *Artemisia santonica* ssp. *monogyna*, there are *Scorzonera cana, Matricaria recutita, Limonium gmelinii, Gypsophila muralis, Plantago maritima*, etc.

On semi-salty soils, *Festuca pseudovina* together with *Achillea setacea* and *A. collina* are forming compact grasslands, up to 25-30 cm high, included in the Achilleo-Festucetum pseudovinae community. These phytocoenosis have a mesic-xeric character and are more frequent in the western part of the Rădvani Forest. The species number in the structure of this community is relatively high. More frequent are *Alopecurus pratensis, Trifolium strictum, T. striatum*. Due to intensive grazing, in the structure of this community are present ruderal species like: *Polygonum aviculare, Euphorbia cyparissias, Erodium cicutarium, Eryngium campestre, Convolvulus arvensis, Plantago media*, etc.

Most of the grasslands in the area are dominated by phytocoenosis of Artemisio-Festucetum pseudovinae community. They occur on salty soils; the high salinity of the soil facilitates the development of a large number of halophytes, which represent approximately half of the species encountered in the phytocoenosis of this association. The number of halophytes and their abundance varies in accordance with the concentration of mineral salts in the soil, which in turn depends on the fluctuation in groundwater level. The dominant species of the association are *Festuca pseudovina* and *Artemisia santonica* ssp. *monogyna*. Other constant species are *Poa bulbosa, Scleranthus annuus, Scorzonera cana, Plantago maritima, Gypsophila muralis, Trifolium fragiferum, T. ornithopodioides, Limonium gmelinii*, etc. Due to intensive grazing some of the species in this association may reach a high abundance: *Poa bulbosa, Lotus angustissimus, Limonium gmelinii*, and *Artemisia santonica*. The grassland dominated by *Festuca pseudovina* and *Artemisia santonica* is 20-25 cm high.

On the western part of Rădvani Forest, on salty soils were identified the phytocoenosis of Peucedano-Festucetum pseudovinae community. These phytocoenosis are relatively rich in species and are composed of 2 layers: the highest layer is 150 cm high and is dominated by *Peucedanum officinale*, along with *Alopecurus pratensis*, which is relatively sporadic. The second, 20-25 cm high layer, is formed mainly by *Festuca pseudovina*, followed by *Aster lynosiris, A. sedifolius, Scorzonera cana, Achillea collina, Poa pratensis, Carex praecox*, etc.

3150 Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation

The aquatic vegetation of the park's area is present in the lakes and channels. The following plant communities have been identified and included in this habitat type: Lemnetum minoris (Pop, 1968; !), Lemno-Utricularietum vulgaris (Pop, 1968), Spirodelo-Salvinietum natantis (Pop, 1968).

The Lemnetum minoris community is frequent in puddles and lakes, as well as on the edge of channels with gently flowing, 0.5 -1 m deep water. The Lemno-Utricularietum vulgaris community appears at the surface of standing water with depths between 0.5-2 m, rich in decaying organic substances. From the succesional point of view, this community results from the phytocoenosis Lemnetum minoris, by the enrichment of sludge in organic substances resulting from decomposition of previous aquatic vegetation. The phytocoenosis of Salvinio-Spirodeletum community occupies the surfaces of 0.5-1.5 m deep water, and are composed of the following species: *Salvinia natans, Spirodela polyrhiza, Lemna minor, L. trisulca, Potamogeton fluitans, P. pussilus, Hydrocharis morsus-ranae, Ceratophyllum demersum*.

3160 Natural dystrophic lakes and ponds

This aquatic habitat type is composed of the following plant communities: Nymphoidetum peltatae (Pop, 1968), Trapetum natantis (Pop, 1968; Gavra, 2011; !), Potametum natantis (Pop, 1968; !).

Phytocoenosis of Nymphoidetum peltatae have been identified sporadically in the lakes and some of the channels with gentle flowing, maximum 1 m deep water. Comparing with *Trapa natans,* which finds optimal living conditions in deeper water, *Nymphoides peltata* develops in shallow waters, preferably 0.5 m deep.

Periodical cleaning of the lakes, which means the systematic harvesting of aquatic plants, as well as their draining for the exploitation of fish, determines a reduced diversity of aquatic plant species. These are present only at the edges of the lakes. *Trapa natans* is the most frequent species, reaching high abundance in some of the lakes, developing in 0.60 - 2 m deep water, and forming compact aquatic phytocoenosis on relatively large surfaces. Thus, Trapetum natantis community is abundant in lakes, as well as in the channels. In the floristic structure of this community the following species appear: *Ceratophyllum demersum, Nuphar luteum, Nymphoides peltata, Ranunculus aquatilis, Myriophyllum verticillatum*.

6440 Alluvial meadows of river valleys of the Cnidion dubii

This habitat type, consisting of meso-hygric and mesic grasslands (with changing wetness in relation to the changing groundwater table), covers the flooded areas along the channels in the form of long and narrow stripes, as well as other moist soils, with high groundwater level in the spring, which became mesic and semi-salty during the summer. These grasslands are used as pastures or hayfields.

In this habitat type the following plant communities are included: Poëtum pratensis (Pop, 1968), Agrostetum albae (subas. caricetosum vulpinae) (Pop, 1968; Frink et Petrovici, 2010), Agrostio-Festucetum pratensis (Pop, 1968), Agrostio stoloniferae-Alopecuretum pratensis (Pop, 1968).

One characteristic community is Poëtum pratensis, which covers the areas with high ground water level in the spring. Their phytocoenosis becomes mesic during summertime, when the groundwater level decreases. The phytocoenosis are composed of *Poa pratensis, Ranunculus polyanthemos, Trifolium pratense, T. repens, Arrhenatherum elatius, Potentilla reptans, Cirsium canum, Serratula tinctoria,* etc.

The Agrostetum albae community covers the soils with variable moisture, as well. In this case, the soils covered by the phytocoenosis of this community have a higher mineral salt concentration during summer and autumn. This salinity variation in the soil is outlined by the identification of caricetosum vulpinae subassociation, and by the presence in the community structure of Agrostion and Magnocaricion species, as well as the presence of semi-halophytes and halophytes (*Festuca pseudovina, Juncus gerardi, Limonium gmelinii, Puccinellia distans*).

Phytocoenosis of Agrostio-Alopecuretum pratensis community have been identified in small depressions, on semi-salty soils, in the western part of the Rădvani Forest. In the community composition there are *Agrostis stolonifera, Alopecurus pratensis, Juncus gerardi, Trifolium fragiferum, Scorzonera cana.* Due to the decrease in the groundwater level these phtyocoenosis have an evolution towards the phytocoenosis of Achilleo-Festucetum pseudovinae community.

91F0 Riparian mixed forests of *Quercus robur, Ulmus laevis* and *Ulmus minor, Fraxinus excelsior* or *Fraxinus angustifolia* along the great rivers (Ulmenion minoris)

The woody vegetation is concentrated in the southern part of the park, being represented by the Rădvani Forest and the neighbouring shrubs. The Rădvani Forest is a riparian mixt forest dominated by *Quercus robur, Fraxinus excelsior, Ulmus minor,* influenced by the oscillating groundwater table.The Fraxino danubialis-Ulmetum community has been identified here (Pop, 1968; !).

In spring, the soil of this forest is very moist up to swampy, and in summer is dried. Groundwater is close to the soil surface. Tree layer is composed of 9 species, *Quercus robur* being the dominant species. Other important species are *Ulmus minor, Fraxinus excelsior* and sporadically are present *Carpinus betulus, Quercus cerris* and *Populus* sp., the last two being planted. The shrub layer is well developed, consisting of 24 species, more frequent being: *Acer campestre, A. tataricum, Crataegus monogyna, Cornus sanguinea, Ligustrum vulgare, Evonymus europaeus, Rubus caesius,* etc. Among the lianas there have been identified *Clematis vitalba, Hedera helix, Humulus lupulus, Vitis sylvestris,* and *Tamus communis*. The herbaceous layer is relatively rich, covering 5-30% of the ground surface. Frequent species of the herbaceous layer are: *Brachypodium sylvaticum, Carex divulsa, Hypericum hirsutum, Geum urbanum, Circaea lutetiana, Scrophularia nodosa, Festuca gigantea,* etc. However, the Rădvani Forest is under strong human influence: in some parts *Quercus cerris* and *Populus* sp. are planted, and grazing sheep have been also observed, at the forest edges.

CONCLUSIONS

As results of the Cefa Nature Park flora and habitats survey, the following conclusions can be outlined:

- up to the present date 504 vascular plant species and 3 hybrids were identified (including from previous bibliographic sources);
- 386 taxa were identified in the field by the authors, 36 of them being first records from this area; among these, some are subspontaneous, being probably ignored by Pop (1968), and some are new in the region, as they are adventive and probably spread in the park during the last decades;
- the salty soils are populated by halophytes: a few species are obligatory halophytes, which form patches of characteristic vegetation;

- five protected species are present; *Marsilea quadrifolia, Salvinia natans, Lindernia procumbens,* and *Trapa natans* are included in Annex I of Bern Convention; three species are part of the 92/43/EEC Habitats Directive's annexes: *Marsilea quadrifolia* and *Cirsium brachycephalum* in Annex II, and *Lindernia procumbens* in Annex IV;
- *Lotus angustissimus* and *Trifolium ornithopodioides* are included in the Red Book of Romanian plants;
- five Natura 2000 habitats have been identified;
- the Pannonic salt-steppes and salt-marshes is a priority habitat which includes characteristic halophilous or semi-halophilous plant communities and species;
- the aquatic vegetation is well represented in the park, found in the lakes and channels;
- the alluvial meadows of river valleys of the Cnidion dubii habitat type consists of meso-hygrophilous and mesic grasslands which cover the flooded areas with various soil moisture and salinity;
- the woody vegetation is concentrated in the southern part of the park, being represented by the Rădvani Forest, a riparian mixt forest covering 276 ha.

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THE STRUCTURE OF OLIGOCHAETA AND CHIRONOMIDAE COMMUNITIES FROM THE AQUATIC ECOSYSTEMS OF THE CEFA NATURE PARK (CRIŞANA, ROMANIA)

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KEYWORDS: oligochaetes, chironomids, species composition, density, similarity.

ABSTRACT

This paper represents the first study on oligochaetes and chironomids from the aquatic habitats of the Cefa Nature Park. The principal aim of the paper is to describe the structure of the benthic community dealing with these two groups. Oligochaetes were identified to species level, while chironomids to genus level in most of the cases. 27 Oligochaeta species and 18 Chironomidae genera were found in the sampling period. The quantitative samples were collected seasonally in 2010.

RÉSUMÉ: La structure des communautés d’oligochètes dans les écosystèmes aquatiques du Parc Naturels Cefa (Crişana, Roumanie).

Ce papier est la première étude des communautés d’oligochètes et de chironomidés des habitats aquatiques du Parc Naturel Cefa. L'objectif principal de cet article est de faire connaître la structure taxonomique des communautés étudiées. Les oligochètes ont été identifiés jusqu’à l’espèce, tandis que les chironomidés seulement jusqu’au genre. Lors de la période d’étude, 27 espèces d’oligochètes et 18 genres de chironomidés ont été identifiés en totalité. Les échantillons quantitatifs ont été recueillis en 2010 durant la période saisonnière.

REZUMAT: Structura comunităţilor de oligochete şi chironomide din ecosistemele acvatice ale Parcului Natural Cefa (Crişana, România).

Lucrarea de faţă reprezintă primul studiu referitor la comunităţile de oligochete şi chironomide din habitatele acvatice de pe teritoriul Parcului Natural Cefa. Scopul principal al lucrării este acela de a face cunoscută structura taxonomică a comunităţilor de oligochete şi chironomide studiate. Oligochetele au fost identificate până la nivel de specie, în timp ce chironomidele doar până la nivel de gen. În total, în perioada studiată, au fost identificate 27 specii de oligochete şi 18 genuri de chironomide. Probele cantitative au fost colectate sezonier în 2010.

INTRODUCTION

Freshwater oligochaetes have long been recognized as common and permanent inhabitants of diverse aquatic habitats including lotic and lentic systems, surface waters, groundwaters, and coarse as well as fine sediments (Botea, 1968; Brinkhurst and Jamieson, 1971; Cupşa, 2005).

During their life span, the chironomids are, for a long period of time, the main inhabitants of the aquatic ecosystems. Thus, the larvae can be easily found in the benthic samples, and can be used when they are identified to species level, like the oligochaetes, in monitoring the of water quality.

The aim of this paper is a general characterization of the aquatic systems from the Cefa Nature Park considering the communities of Oligochaeta and Chironomidae communities. Regarding these two groups, no research was made before in the Cefa Nature Park.

Cefa Nature Park is located at a distance of 25 km south from the city of Oradea and it was institutionalized in 2006. At the beginning of 2011 it was officially declared as a protected area. The total surface of the park is 5002 ha, including Rădvani forest, and 700 ha represent different types of aquatic ecosystems. The sampling sites were located inside the park and it were investigated both lentic and lotic ecosystems. Two types of lentic ecosystems were chosen: two fishponds (lake 12- L12 and lake 14 – L14) and natural permanent pools (permanent pool Ateaş – Bp Ateaş). From lothic ecosystems were investigated three types: collector canal – the most similar with natural river (Cc), canal for water supply (Ca L14) and canal for water runoff (Ce Ateaş). Detailed information on the location, geomorphology and hydrology characteristics were reported in Petrovici et al. (2010).

MATERIAL AND METHODS

The quantitative samples were collected seasonally (March, June and October 2010) from six stations, three on lakes (L12, L14 and BP Ateaş) and three on canals (Ca L14, Ce Ateaş and Cpa/Cc). More details about these sampling sites can be found in Petrovici et al. (2010). Three benthic samples were collected at each site and sampling period by means of Ekman grab sampler with 250 µm mesh size. The samples were preserved in the field in 4% formaldehyde. In the laboratory, they were sorted on major invertebrate groups. Oligochaetes were identified to the species level (Sperber, 1950; Brinkhurst, 1986 and Timm, 1999) and chironomids to the genus level (Botnariuc and Cure, 1999). Individuals were transparentized with lacto phenol for oligochaetes and potassium hydroxide 10% for chironomids and then analyzed under a compound microscope.

RESULTS AND DISCUSSIONS

Oligochaeta

27 species of Oligochaeta, belonging to five families were identified during samplings. Family Naididae is the most numerous, including 13 species. Family Tubificidae is also well represented with 8 species. Family Enchytraeidae comprises two species. The other 2 families (Lumbriculidae and Lumbricidae) are represented by only one species. Regarding the density family Tubificidae represented the main component of Oligochaeta community (Tab. 1).

The highest number of species was identified at Cc, followed by L14 and Ce Ateaş. The lowest number was found at L12 (Tab. 1). The number of species identified from lakes are almost those from the canals (20 species for former and respectivelly 22 for the latter). Most Naididae species occurred at L14. Only three species – *Dero obtusa, Limnodrilus hoffmeisteri* and *Tubifex tubifex* – were found in the all sampling sites.

Aulodrilus pluriseta, Branchiura sowerbyi, Nais elinguis, Potamothrix hammoniensis, P. vejdovsky and *Rhynchelmis limosella* were presented only on canals, while *Fridericia* sp., *Nais christinae, Paranais frici, Pristina aequiseta* and *P. longiseta* were confined in lakes.

It is well known that species belonging to the Family Tubificidae are usually associated with low amounts of oxygen and high organic enrichment, particularly in lakes (Goonight and Whitley, 1961; Brinkhurst, 1993). According to Brinkhurst (1974) and Milbrink (1973), *Limnodrilus hoffmeisteri* and *Tubifex tubifex*, two species present in our samples, are characteristic of highly eutrophic waters. Some of the species belonging to Family Naididae which are presented in our samples can be successfully used as indicators of a poor water quality (e.g. *Dero obtusa*, *Nais barbata*, *Paranais frici*) (Pavelescu and Tudorancea, 2005).

The densities of oligochaetes strongly varied seasonally and among one sampling site to another. The highest density was recorded in October at L14 (16441 ind./m^2). Similar values of density were noticed at Bp Ateaş (June - 12612 ind./m^2), Ce Ateaş (October - 10489 ind./m^2) and Cc (October - 9032 ind./m^2). Regarding the density of oligochaetes in L12, they had the lowest values during the sampling period (annual mean 1929 ind./m^2).

Table 1: List of Oligochaeta identified at the sampling sites.

Taxon/sampling site	L12	L14	BP Ateaş	Ca L14	Ce Ateaş	Cc
Fam. Tubificidae						
Aulodrilus pluriseta (Piguet, 1906)				+	+	+
Branchiura sowerbyi Beddard, 1892				+		+
Limnodrilus claparedeianus Ratzel, 1868	+	+	+		+	+
Limnodrilus hoffmeisteri Claparede, 1862	+	+	+	+	+	+
Limnodrilus udekemianus Claparede, 1862	+	+	+		+	
Potamothrix hammoniensis (Michaelsen, 1901)				+	+	+
Potamothrix vejdovskyi (Hrabe, 1941)						+
Psammoryctides albicola (Michaelsen, 1901)		+				+
Tubifex tubifex (Múller, 1774)	+	+	+	+	+	+
Fam. Naididae						
Dero obtuse Udekem, 1855	+	+	+	+	+	+
Nais barbata Múller, 1773		+				+

Table 1 (continuing): List of Oligochaeta identified at the sampling sites.

Taxon/sampling site	L12	L14	BP Ateaş	Ca L14	Ce Ateaş	Cc
Nais bretscheri Michaelsen, 1899		+				+
Nais christinae Kasprzak, 1973		+				
Nais communis Piguet, 1906		+			+	
Nais elinguis Múller, 1773						+
Nais pardalis Piguet, 1906		+				+
Nais sp.					+	+
Ophidonais serpentine (Muller, 1773)	+	+		+		+
Paranais frici Hrabe, 1941		+				
Pristina aequiseta Bourne, 1891		+				
Pristina jenkinae (Stephenson 1931)		+			+	+
Pristina longiseta Ehrenberg, 1828		+				
Stylaria lacustris (Linnaeus, 1767)		+			+	+
Fam. Enchytraeidae						
Cognettia glandulosa (Michaelsen, 1888)			+			+
Fridericia sp. Folli, 1658			+			
Fam. Lumbriculidae						
Rhynchelmis limosella Hoffmeister, 1843						+
Fam. Lumbricidae						
Eiseniella tetraedra (Savigny, 1826)	+		+	+		+

The species *Limnodrilus hoffmeisteri*, *Tubifex tubifex* and *Dero obtusa* were the most ubiquistic species, each of them occurring at six sampling stations, but in varying densities. The former taxa had densities ranging between 83 ind./m^2 (L12 and Bp Ateaş) and up to 6785 ind./m^2 at Bp Ateaş. The second species had also high densities, varying between 42 ind./m^2 (L12) and 4662 ind./m^2 (Bp Ateaş). *D. obtusa* like the other two species presented the lowest density at L12 (83 ind./m^2). *Potamothrix hammoniensis*, widely distributed in canals, occurred as well in high densities (from 500 ind./m^2 to 4995 ind./m^2). Out of the 4 species belonging to familyes Tubificidae and Naididae, three of them – *Aulodrilus pluriseta*, *Psammoryctides albicola*, and *Stylaria lacustris* – were registered in high densities. The others species of oligochaetes identified were present in low densities.

The percentage of the oligochaetes from the whole benthic community varied between 1 and 91%. This variation range was higher for inside lake community without any noticeable pattern with respect to their distribution (Fig. 1). The highest percentange of oligochaetes was found at Bp Ateaş during summer time, followed by L12 during spring. Regarding the oligochetes' canal community can be observed that the structure of the community is more stable. The variation of oligochaetes' percentage was smaller and not exceed 55%. At all the sampling sites the highest abundance was recorded in June and October periods (Fig. 1). Other invertebrate groups occurring with oligochaetes in samples included Ephemeroptera, Trichoptera, Odonata, Diptera larvae, Amphipoda, Coleoptera, Hydrachnidia, Nematoda, Ostracoda, Hirudinea, Isopoda, Heteroptera, Copepoda and Cladocera.

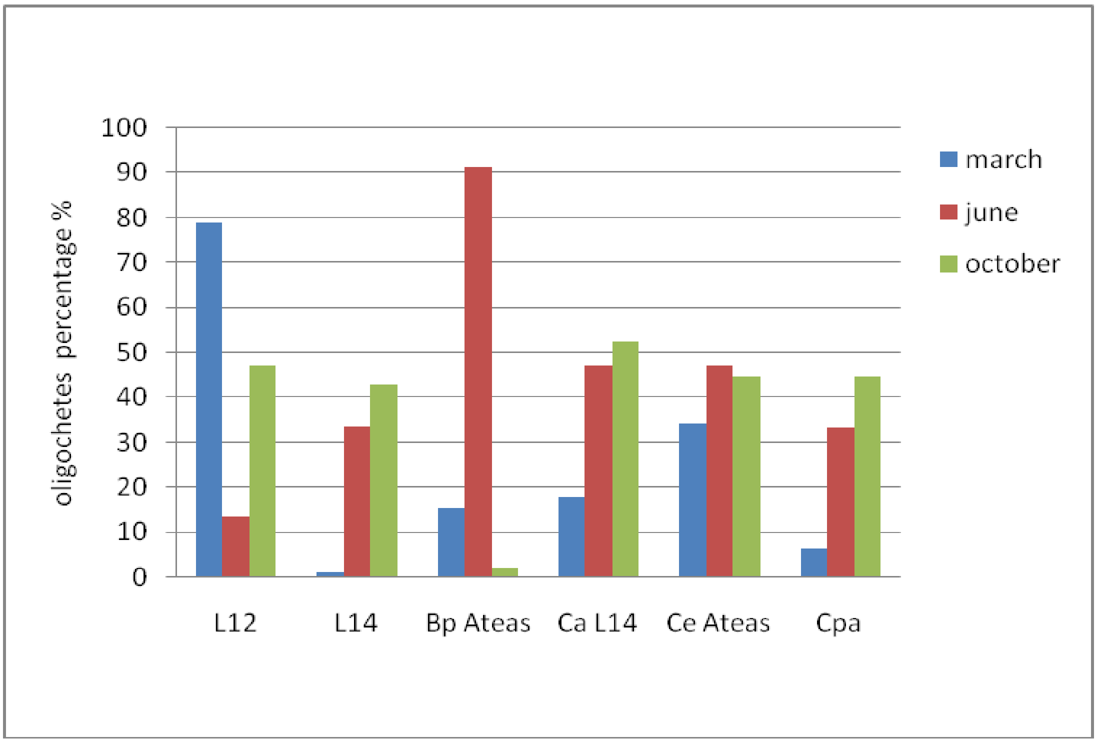

Figure 1: The oligochaetes as a percentage by density
from the total benthic macroinvertebrate communities collected during 2010.

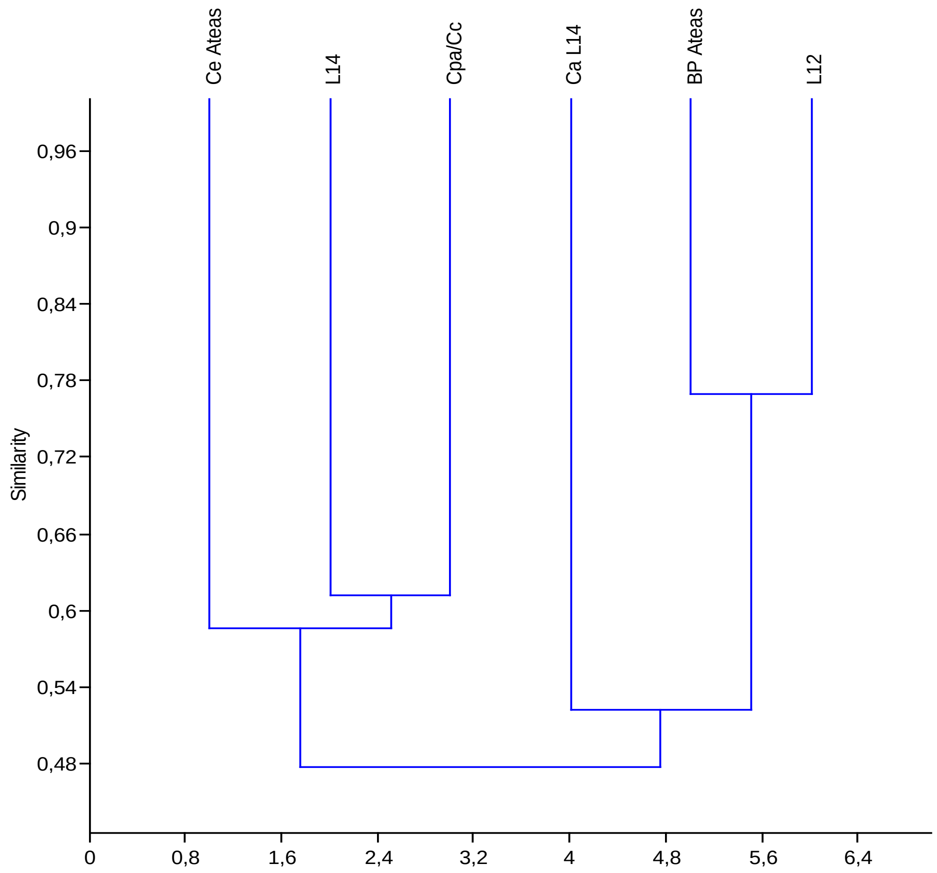

Figure 2: Dendrogram of the similarity of the Oligochaeta species composition, based on Morisita index, during 2010.

Because of the relatively low number of samples, no advanced statistical analyses were needed. However, a similarity analysis of Oligochaeta assemblages at the six sampling locations during 2010, based on Morisita index (Wolda 1981, Krebs 1999) is displayed in a dendrogram (Fig. 2). There seem to be two different assemblages: one group is characteristic to two canals and one lake where the number of species and number of common species was higher; a second group is comprises the other assemblages.

Chironomidae

18 genera of chironomids were identified at the six sampling stations. In some cases the samples could be identified to species level (Tab. 2). The genera were appurtenant to three subfamilies: Tanypodinae, Orthocladiinae and Chironominae. The first subfamily comprised by five genera, the second one three genera and the last one was the dominant, numbering eleven genera. Most of the genera (16 out from 18) were found in canals. *Chironomus* sp. and *Cryptochironomus* sp. were present only in lakes (Tab. 2). The highest number of genera was found at Ce Ateaş (16), followed by Cpa with 13. Like in case of oligochaetes, in L12 were found the lowest number of genera (5).

Dicrotendipes nervosus, *Einfeldia pagana*, *Micropsectra praecox*, *Microtendipes pedellus*, *Pentapedillum* sp. and *Procladius* sp. were identified in both types of habitats, lakes and canals. The other genera which are not mentioned above were found only on canals (Tab. 2).

Table 2: List of Chironomidae identified at the sampling sites.

Taxon/sampling site	L12	L14	BP Ateaş	Ca L14	Ce Ateaş	Cc
Subfam. Tanypodinae						
Clinotanypus sp. Kieff, 1913				+	+	+
Coelotanypus sp. Coquillett, 1895				+		
Conchapelopia sp. Fittkau, 1957					+	+
Procladius sp. Skuze, 1889	+	+		+	+	+
Tanypus sp. Meigen, 1803		+			+	+
Subfam. Orthocladiinae						
Cricotopus bicinctus Meigen, 1818					+	+
Cricotopus sp. Wulp, 1874						+
Orthocladius sp. Wulp, 1874				+	+	
Subfam. Chironominae						
Chironomus sp. Meigen, 1803	+	+	+			
Cladotanytarsus sp. Kieff, 1921			+			+
Cryptochironomus sp. Kieff, 1918		+				
Demicryptochironomus sp. Lenz, 1941					+	
Dicrotendipes nervosus Staeg, 1839	+	+	+		+	+
Dicrotendipes trinomus Kieff, 1916				+	+	
Einfeldia pagana Meigen, 1838	+	+	+	+	+	

Table 2 (continuing): List of Chironomidae identified at the sampling sites.

Taxon/sampling site	L12	L14	BP Ateaş	Ca L14	Ce Ateaş	Cc
Glyptotendipes sp. Kieff, 1913					+	
Micropsectra praecox Meigen, 1818		+	+	+	+	+
Microtendipes pedellus De Geer, 1776	+	+		+	+	+
Pentapedilum sp. Kieff, 1913			+	+	+	+
Polypedilum bicrenatum Kieff, 1921				+	+	+
Polypedilum nubeculosum Meigen, 1804				+	+	+

The density of chironomids varied strongly between seasons, as amid genera. In general, the density of chironomids was smaller than the density of oligochetes. At the sampling sites Ca L14 and Cc, the annual average of chironomids density was higher than the one of oligochaetes. The highest value of density was reached in March at Cc (46909 ind./m^2)**.** Like in case of oligochetes, the lowest density was noticed at L12 (annual average - 208 ind./m^2). The species *Micropsectra praecox, Microtendipes pedellus, Dicrotendipes nervosus* and *Einfeldia pagana* were the most widespread taxa, but in varying densities. The first and the last species had the highest density in March at Cc (9116 ind./m^2 and respectively 1165 ind./m^2). The second species reached the highest value of density in March at Ca L14 (4287 ind./m^2) but it had also high density at station Cc during all sampling period (around 3000 ind./m^2 every month). The species *Chironomus bicinctus, Polypedilum nubeculosum* and *Polypedilum bicrenatum* were present in high densities in the studied habitats (for ex. 23809 ind./m^2, 1873 ind./m^2 and respectively 1207 ind./m^2).

Unlike the oligochaetes inhabiting lakes, the percentage of chironomids from the entire benthic community was very small; it never exceeded 12%. The lowest value was noticed at each lake in spring. Their percentage increased during summer, whilst in autumn it reached the highest value (Fig. 3). Anyway, at Bp Ateaş during the study period, this percentage was very low, around 5%. With respect to canals habitat, the percentage of chironomids increased for all seasons. The values were more or less similar with these of oligochaetes and varied between 9 and 63%. The highest values were found in March and June at Cpa. No noticeable pattern was observed with respect to their distribution and dynamic.

The figure number 4 depicts the dendrogram of similarity based on the Morisita similarity index for the chironomids communities. Like in the case of oligochaetes two distinct groups are pointed out. The first one includes the sampling sites situated on canals. The similarity between these stations could be due to narrow riverbed width, to vegetation and to flow regime. Also the number of species was higher in these ecosystems. The second group is formed by the stations located on lakes. These sampling sites are similar in taxonomic composition the following aspects: low specific diversity and lenthic systems characteristics.

Taking into consideration both communities, oligochetes and chironomids, the number of samples was higher and some DCA analysis were made.

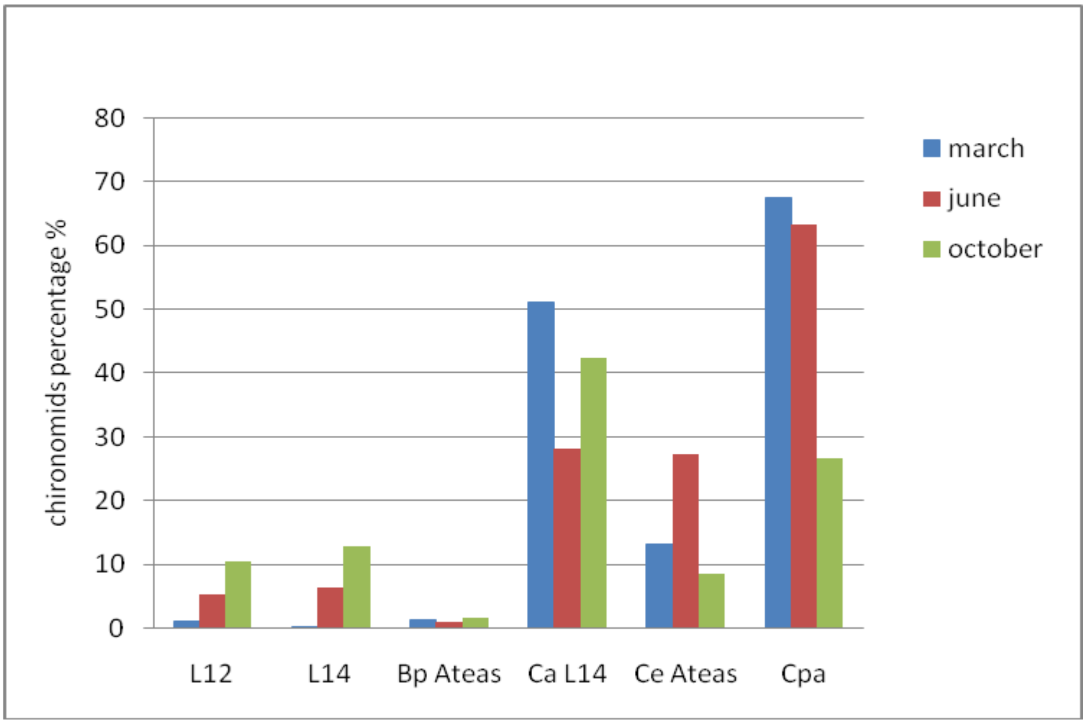

Figure 3: The chironomids as a percentage by densities
of the total benthic macroinvertebrates
collected from six sampling stations.

In the figure number 5 is presented the ordination of sampling sites due to some specific gradients like the flow regime, the substratum, the vegetation and the taxonomical diversity.

In the left side of the presented graph can be noticed the group of stations located on canals. Here the taxonomical diversity was high, not only for oligochetes but also for chironomids.

The second group appear in the upper right side of the graph. It is formed by the two sampling sites situated on L12 and Bp Ateaş where the species composition was very poor.

The positon of L14 on the graph is diverse from the other two groups, in the down right side of the graph. In this case the community of oligochaetes presents high diversity (17 species) whilst the chironomides' community is species poor (eight species).

The most important gradients on axis 1 seem to be the water velocity (the flow regime) and the type of substratum. On axis 2, the ordination is driven by species composition and diversity.

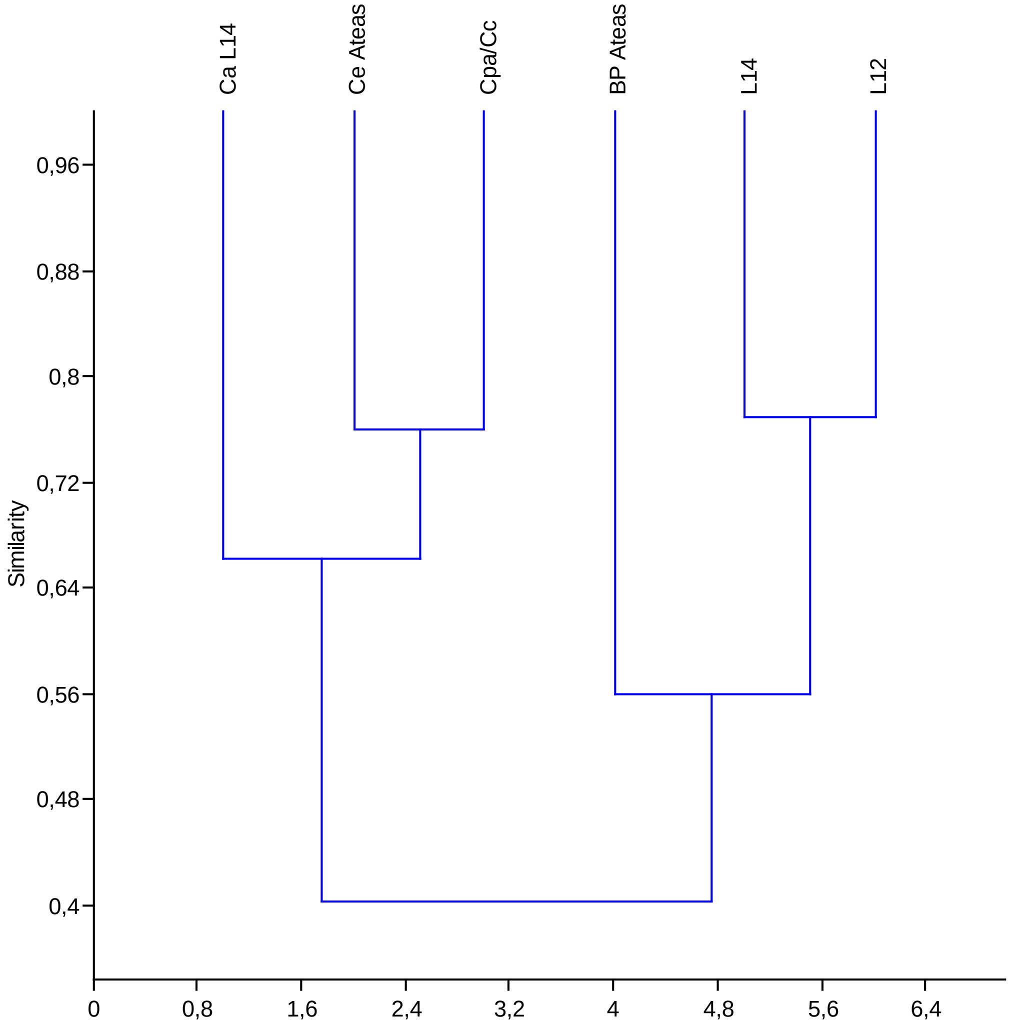

Figure 4: Dendrogram of the similarity of the Chironomidae species composition, based on Morisita index, between six sampling sites.

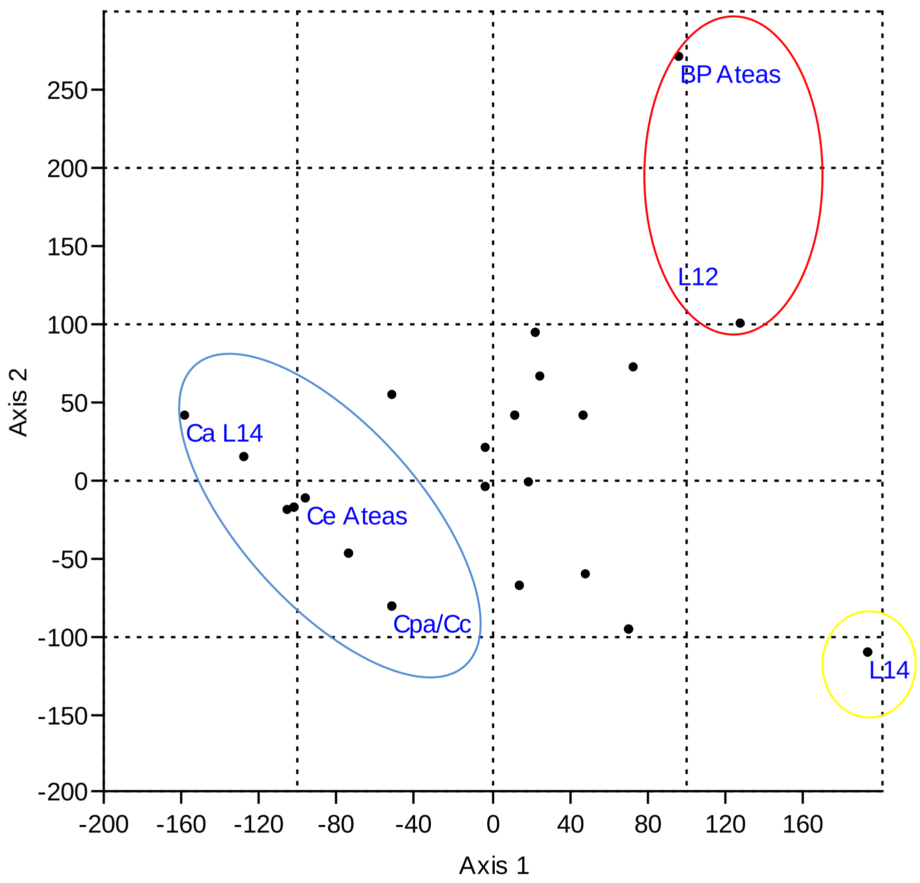

Figure 5: Detrended canonical analysis
of the six sampling sites.

CONCLUSIONS

This study represents a contribution to a better knowledge of Oligochaeta and Chironomdae communities from the aquatic ecosystems of Cefa Nature Park.

27 species of Oligochaeta belonging to five families and 15 genera have been recorded. The highest species richness was displayed by family Naididae (13 species) with genus *Nais* represented by six species. Family Tubificidae was also well represented (8 species).

The chironomids were represented by 18 genera belonging to three subfamilies. The highest number of genera was found on the samples collected from channels.

Generally, the density of oligochaetes was higher than that of chironomids. Only in two cases the situation was different. The species *Limnodrilus hoffmeisteri, Tubifex tubifex* and *Dero obtusa* (Oligochaeta) were the most widespread species, each occurring at six sampling sites, but in varying densities. The species *Micropsectra praecox, Microtendipes pellus, Dicrotendipes nervosus* and *Einfeldia pagana* (Chironomidae) are the chironomids species that recorded the highest values of density during the sampling period.

The oligochaeta percentage in benthic community strongly varied among lakes and was more stable for channels.

The chironomids percentage in benthic community was very small in lakes and similar to that of oligochaetes for channels.

Morisita similarity index reached high values for both communities and dendrograms pointed out two major groups formed by three branches each.

Detrended canonical analysis on the six sampling sites showed that the ordination of sampling sites could be possible due to some gradients like flow regime, substratum and taxonomical diversity.

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PLANKTONIC MICROCRUSTACEAN COMMUNITIES FROM CEFA NATURE PARK (CRIŞANA, ROMANIA)

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KEYWORDS: cladocerans, copepods, dominance, indicator value, species richness.

ABSTRACT

The present paper represents an inventory of microcrustacean species from nine sampling sites situated in Cefa Nature Park, in two different sampling periods: 2008 and 2010. Six sites were located in canals, three in fishponds. A total of 31 crustacean species were identified in the park, 18 cladocerans and 13 copepods, together with immature stages (copepodites and nauplii). The influence of the main physical and chemical parameters on the species distribution in the nine sites, the similarity of microcrustacean communities from the sampling locations and their diversity were also considered. Concerning the indicator value of microcrustacean species, they revealed high organic pollution in all three fishponds.

RÉSUMÉ: Les communautés de microscrustacés planctoniques du Parc Naturel de Cefa (Crisana, Roumanie).

Cette article présente un inventaire des espèces de microcrustacés du Parc Naturel de Cefa. Neuf sites ont été échantillonnés dont six sont situés dans des canaux et trois dans des étangs piscicoles. L’échantillonnage a été réalisé au cours de l'année 2008 et 2010. En totalité, 31 espèces de crustacés ont été identifiés dans le Parc Naturel, à savoir 18 cladocères, 13 copépodes et des stades immatures (copépodites et nauplii). L'influence des principaux paramètres physiques et chimiques sur la répartition des espèces dans les neuf sites, ainsi que la similitude des communautés microcrustacés et leur diversité ont été aussi considérés. La valeur indicatrice des espèces de microcrustacés échantillonnés a permis de mettre en évidence une importante pollution organique dans les trois étangs piscicole.

REZUMAT: Comunităţile de microcrustacee planctonice din Parcul Natural Cefa (Crişana, România).

Lucrarea de faţă reprezintă o inventariere a bogăţiei specifice a microcrustaceelor planctonice din nouă staţii situate în Parcul Natural Cefa, şase situate pe canale de evacuare şi trei pe heleştee, probele fiind prelevate din doi ani diferiţi, 2008 şi 2010. În total, s-au identificat 31 de specii, 18 de cladocere şi 13 de copepode, la care s-au adăugat în toate staţiile stadiile imature de copepode, respectiv copepodiţii şi nauplii. Influenţa principalilor parametri fizico-chimici asupra distribuţiei speciilor pe staţii, similaritatea comunităţilor de microcrustacee planctonice, cât şi diversitatea acestora sunt de asemenea considerate în prezentul studiu. În ceea ce priveşte valoarea indicatoare a speciilor de microcrustacee planctonice, acestea au arătat condiţii de poluare organică în toate heleşteele analizate.

INTRODUCTION

The aim of the present paper was to investigate the biodiversity of planktonic microcrustaceans, cladocerans and copepods, living in Cefa Nature Park, a lowland region having a remarkable richness of aquatic ecosystems, with both running and still waters (Crişan, 2007). Zooplankton of inland waters is dominated by four major groups of organisms (Wetzel, 2001): protists, rotifers and two groups of microcrustaceans that represent the topic of the present paper: cladocerans and copepods. Most cladocerans are small (0.2 - 3.0 mm) and feed on particles filtered from the water. Planktonic copepods consist of three major groups: the calanoids, the harpacticoids and the cyclopoids, with both carnivorous and herbivorous species. (Kobayashi et al., 2009)

The Cefa fish farming area, with a surface of about 700 ha, is located in the Salonta Plain, part of the Western Plain, in the Crişul Repede catchment area (Crişan, 2007). Two rivers provide the water needed for the fishponds: the Crişul Repede and the Crişul Negru Rivers. One river is connected to the other by a 61 km waterway, The Criş Canal, which collects the surface waters of the region. In fact, the majority of water courses and water pools from the Cefa fish farming area are man-made, including numerous canals built for water supply, water evacuation or for irrigation. The fishponds undergo severe fluctuations of water levels caused by fish harvesting performed by complete water evacuation.

The region was declared a Nature Park at the beginning of 2011 due to the presence of numerous protected species, living in a variety of habitats: fishponds, temporary water pools, marshes or canals with running water. The area is part of the same complex of ecosystems as the near-by region across the Hungarian border, Körös-Maros/Criş-Mureş, which is already a National Park.

There are very few previous studies concerning cladocerans and copepods from the Cefa fish farming area. Negrea (1962) in his general conspectus of cladoceran species from Romania included "Cefa" as a valid geographical location. However, only one species was found in this particular geographical area in June period, *Bosmina longirostris* O. F. Müller 1776, according to the scientific literature cited (Enăceanu, 1956). For copepods on the other hand, no previous citations were found in the literature, even if Pleşa (1957, 1958) and also Damian-Georgescu (1963, 1966, 1970) included "Oradea" or „Valea Crişului" geographical areas on their distribution maps. However, no indication about "Cefa" was recorded.

MATERIAL AND METHODS

Nine sites were sampled in Cefa Nature Park, in both running and standing water ecosystems, in two different sampling periods: CA1 - Criş Canal, CA2 - Cefa 2 Canal, CA4 - Cefa 1 Canal, CA5 - Western Canal, CA6 - Northern Canal and FP2 - fishpond number 3 in April 2008, while CA3 - Csukasz Canal, FP1 - fishpond number 4 and FP3 - fishpond number 12 in April 2010 (Fig. 1). Only one location, the sampling site FP3 - fishpond number 12, was sampled twice in the year 2010, in April and in June.

The table number 1 depicts the nine sampling sites with their GPS coordinates and main characteristics. Six were located on canals, having different values of water width and water velocity, while the rest of them were placed on three shallow, accessible fishponds. The altitude indicated lowland conditions for all stations and the presence or absence of emerged, submerged and/or floating vegetation was considered.

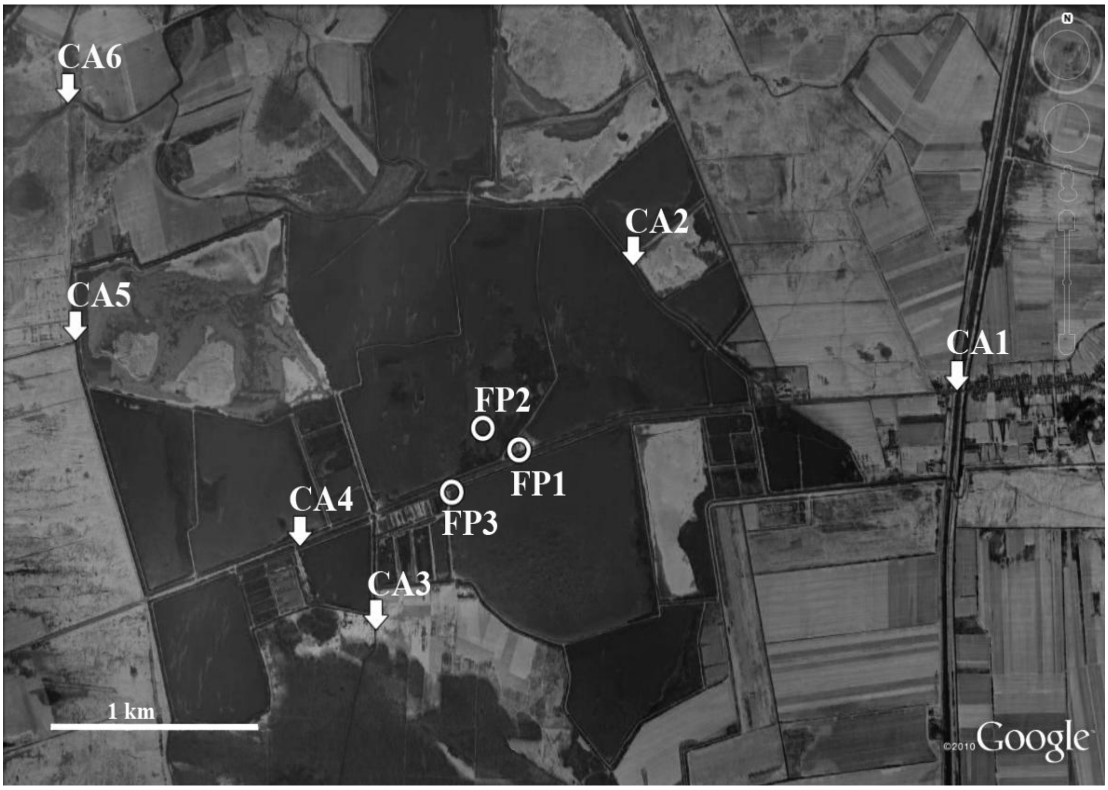

Figure 1: The location of the nine sampling sites from Cefa Nature Park
(CA1 – Criş Canal; CA2 – Cefa 2 Canal; CA3 – Csukasz Canal; CA4 – Cefa 1 Canal;
CA5 – Western Canal; CA6 – Northern Canal; FP1 – fishpond no. 4;
FP2 – fishpond no. 3; FP3 – fishpond no. 12).

Several physical and chemical parameters (pH, salinity, dissolved oxygen, water and air temperature) were measured in the field in all the sampling occasions, using portable meters (Consort P902 for pH, Consort K911 for salinity and YSI 52 for dissolved oxygen).

Qualitative samples of microcrustaceans were taken, using a 55 µm mesh zooplankton net. All samples were collected from the banks of the water bodies, except the case of the FP2 sampling site, where a boat was used.

The samples were preserved with sucrose solution according to the Haney and Hall method (1973) and in 4% formaldehyde.

The biological material identifications were made to the species level in the case of cladocerans (Negrea, 1983; Negrea, 2002; Dumont and Negrea, 2002) and copepods (Damian-Georgescu, 1963, 1966, 1970; Einsle, 1993; Dussard and Defaye, 2001; Pleşa and Müller, 2002).

The present day validity of the identified taxa was checked in the Freshwater Animal Diversity Assessment checklist (FADA, 2011) and also in the Fauna Europaea database (2010). Planktonic rotifers, as well as different benthic groups were also found in the samples.

Table 1: The name in local toponymy, the code and main characteristics of the nine sampling sites located in Cefa Nature Park.

Sampling site		GPS coordinates	Altitude (m)	Other characteristics
code	name			
CA 1	Criş Canal	46°54'49.0"N 21°41'48.1"E	101.1	main canal for water supply; high water velocity; width of about 6 m; emerged vegetation near the banks
CA 2	Cefa 2 Canal	46°55'06.2"N 21°40'34.1"E	101.5	secondary canal for water supply; width of about 3 - 4 m; floating vegetation and emerged macrophytes near the banks
CA 3	Csukasz Canal	46°54'13.6"N 21°39'37.0"E	88.0	small, narrow canal for water evacuation; width of about 1 - 2 m; emerged vegetation near the banks
CA 4	Cefa 1 Canal	46°54'25.2"N 21°39'19.4"E	97.4	secondary canal for water supply; width of about 5 - 6 m
CA 5	Western Canal	46°54'54.0"N 21°38'27.0"E	91.3	low water velocity; emerged, submerged and floating vegetation
CA 6	Northern Canal	46°55'28.5"N 21°38'23.5"E	89.9	width of about 4 - 5 m; rich emerged and submerged vegetation
FP1	Fishpond no. 4	46°54'39.5"N 21°40'08.7"E	101.2	shallow water body; emerged vegetation around the pond
FP2	Fishpond no. 3	46°54'42.5"N 21°40'0.40"E	100.4	shallow water body; emerged vegetation around the pond; rich submerged vegetation
FP3	Fishpond no. 12	46°54'33.3"N 21°39'53.6"E	99.1	shallow water body; emerged vegetation around the pond; rich submerged vegetation

The canonical correspondence analysis (CCA) was performed to display the distribution of the species along environmental variables and to visualise the variation of species composition from one site to another. The ordination diagram of the CCA includes sites, species and environmental variables, which are represented by vectors (Ter Braak, 1986). Presence/absence data for all microcrustacean species and immature copepode stages from the nine sites were considered for the construction of the CCA diagram, together with the following environmental parameters: the salinity, the dissolved oxygen values and the presence or absence of submerged vegetation. Water temperature and the pH were excluded because their values had very low variations from one site to another. The CCA ordination diagram was constructed using XLSTAT software, evaluation version 2006.3.

Even if only qualitative samples were collected, several quantitative estimations were carried out for seven out of the nine sampling sites, by calculating the relative percentage abundance. A number of individuals was counted in each of the seven samples (in CA2, 53 individuals; in CA3, 34; in CA4, 50; in CA6, 166; in FP1, 274; in FP2, 100 and in FP3, 93) and the percentage of the species present was calculated. In two sites (CA1 and CA5) the relative percentage abundance was not estimated, the very low number of individuals made this calculation impossible.

The similarity between the microcrustacean communities from the nine sampling sites was calculated using the Dice index, also known as “Sørensen” index (Dice, 1945; Sørensen, 1948), which only uses qualitative data (presence/absence). It is calculated as follows: $S = 2c/(a+b)$, where *S* = the similarity based on the Dice index; *a* = the number of species in sample 1; *b* = the number of species in sample 2 and *c* = the number of species common to samples 1 and 2. The Dice index ranges between 0 (low similarity) and 1 (high similarity). The cluster was drawn using PAST software, version 1.94b, 2009.

Finally, the semi-quantitative estimations were used to express the biological divesity in the seven sites where counts were possible (CA2, CA3, CA4, CA6, FP1, FP2, FP3). The Simpson’s index of diversity was used, 1 – D, where $D = \sum (n_i / n)^2$, with *D* = dominance, n_i = the total number of organisms of a particular species and *n* = the total number of organisms of all species. The index measures the “evenness” of the community from 0 to 1. The greater its value, the greater the sample diversity (Simpson, 1949). In this case, *n* represents the total number of individuals counted from the sample, and n_i is the total number of individuals counted belonging to taxon *i*.

RESULTS AND DISCUSSION

The values of the main physical and chemical parameters recorded in the sampling sites are presented (Tab. 2). Only April samples were considered, thus air and water temperatures recorded normal values for spring samples. The pH values ranged from neuter to alkaline, while salinity exceeded in all cases 75 mg/L, reaching as high values as 300 mg/L (CA6). Because all the sampling sites were located on man-made water pools, an interpretation of these values might be difficult, especially when most of the canals were used for water evacuation. The oxygen saturation on the other hand exceeded 100% in many cases (CA1, CA2, CA4, CA6, FP1, FP2), showing an intense algal activity.

Table 2: The physical and chemical parameters recorded in the nine sampling sites (Sal. - salinity; Wat. - water; temp. - temperature).

Site	Sampling year	pH	Sal. (mg/L)	Dissolved oxygen (mg/L)	Dissolved oxygen (%)	Wat. temp. (^{0}C)	Air temp. (^{0}C)
CA1	2008	8.83	76.90	12.41	124.40	15.50	18.50
CA2	2008	8.29	78.90	12.08	121.50	15.70	19.00
CA3	2010	6.85	144.00	8.66	79.70	11.60	14.50
CA4	2008	8.01	116.00	11.88	119.80	15.70	17.50
CA5	2008	7.46	202.00	9.39	94.10	15.60	18.00
CA6	2008	8.40	313.00	10.37	101.50	14.40	18.00
FP1	2010	6.97	139.00	11.14	110.40	14.90	20.00
FP2	2008	9.62	90.20	9.97	104.50	17.40	19.50
FP3	2010	6.91	134.00	10.40	96.80	12.60	15.50

The variation of species distribution among sites and along environmental variable gradients is depicted in the CCA ordination diagram (Fig. 2).

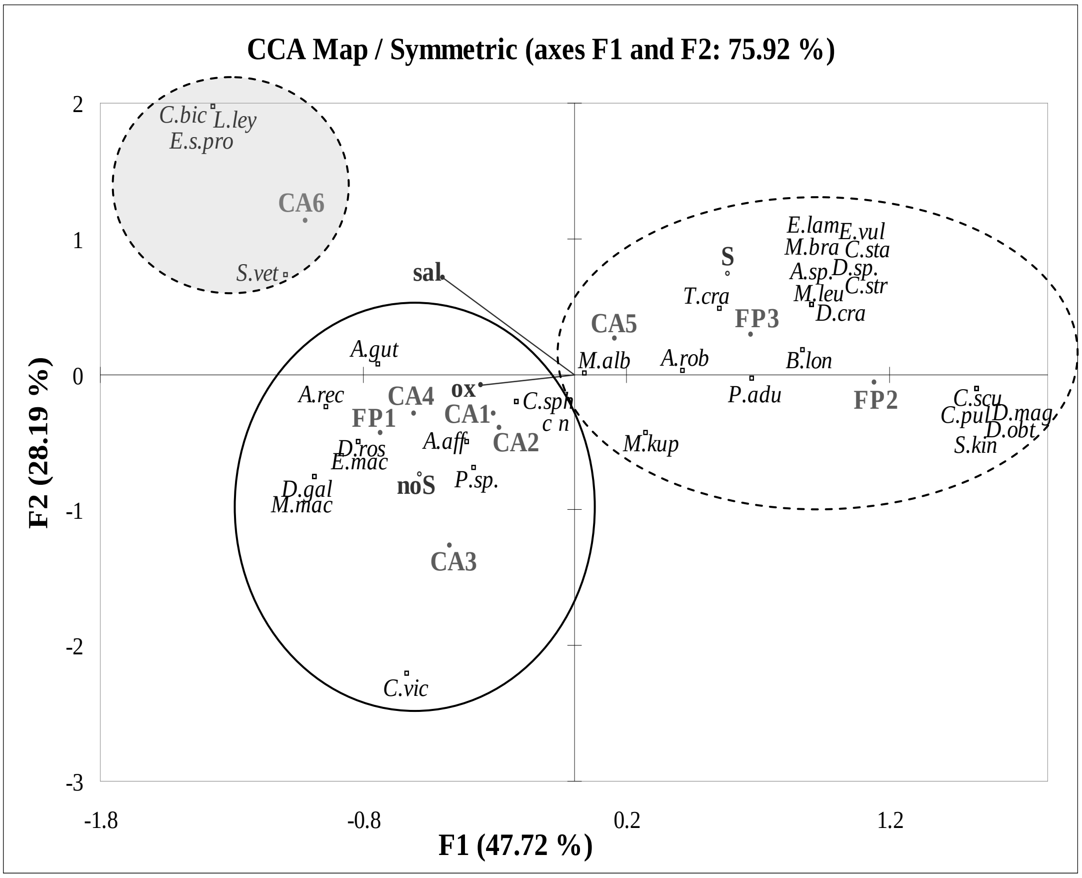

Figure 2: CCA ordination diagram with the sites (CA1-CA6, FP1-FP3), microcrustacean species and immature copepod stages (for abbreviation lists, see Tabs. 3 and 4) and environmental variables (sal - salinity; ox - dissolved oxygen; S - submerged vegetation present; noS - no submerged vegetation present); first axis F1 horizontally, second axis F2 vertically.

Eighteen species of cladocerans were identified in the nine sampling sites (Tab. 3). In three cases, cladocerans were impossible to identify to the species level because of the small number of representatives, so they were recorded at the genus level: *Alona* sp. and *Daphnia* sp. in FP3 and *Pleuroxus* sp. in CA2. Thirteen species of copepods were found, together with immature stages (copepodites and nauplii) (Tab. 4). A problematic aspect concerned the genus *Acanthocyclops* that has been the subject of numerous redescriptions over the years (Einsle, 1993; Mirabdulaev and Defaye, 2002). The identification of *Acanthocyclops* individuals to the species level is difficult, especially those from two common species, *A. robustus* and *A. vernalis*, due to their high morphologic variability, caused in turn by the diversity of the environments they inhabit. Thus, the individuals collected from Cefa Nature Park for this paper were considered part of the *Acanthocyclops robustus-vernalis* species group.

The presence or absence of submerged vegetation represented a very important difference between sampling locations, determining the species composition in the nine sites. From this point of view, sites CA5, FP2 and FP3 were grouped together in the right part of the chart, because they were characterized by rich submerged macrophytes at the time of sampling (Fig. 2, the right circle). On the other hand, sites CA1, CA2, CA3, CA4 and FP1 had no submerged vegetation, so they were grouped together in the lower left (Fig. 2, the left circle, straight line). Finally, a third cluster was shown by the CCA biplot (Fig. 2, the left circle, gray fill), comprising site CA6 and species present there, the reason for its isolation being high salinity values (Tab. 2). *Canthocamptus staphylinus, Cyclops strenuus* (Fig. 3), *Dunhevedia crassa, Eudiaptomus vulgaris, Eurycercus lamellatus, Mesocyclops leuckarti, Moina brachiata* (Fig. 4) were only present in FP3, so they were grouped together in the right part of the CCA diagram, similar to *Ceriodaphnia pulchella*, *Cyclops scutifer* (Fig. 5), *Scapholeberis kingi Daphnia magna* and *D. obtusa*, present only in FP2. Some of these species prefer the areas near submerged vegetation, but most of them are found in different kinds of waters (Tabs. 5 and 6). The other species from the right half of the CCA diagram appeared in more than one sampling site: *Acanthocyclops* sp. (Fig. 6), *Bosmina longirostris* (Fig. 7, left), *Macrocyclops albidus* etc. No clear groups were formed in the left part of the biplot, where most cosmopolitan species were present: *Alona affinis, A. guttata, Chydorus sphaericus* (Fig. 7, right), *Simocephalus vetulus* (Tab. 5). Some preferences could be observed, however, in the case of *Daphnia galeata* species, that only appeared in the site FP1, due to its requirements for large water bodies without macrophytes.

In case of the site FP3, species found both in April and in June 2010 periods were included in the table number 3. The cladoceran *Moina brachiata* and the cyclopoid copepod *Cyclops strenuus* were frequent and common in April 2010, while small rotiferans clearly dominated the plankton community. On the other hand, the calanoid copepod *Eudiaptomus vulgaris* and the cyclopoid copepod *Acanthocyclops* sp. became frequent and common in June 2010, when and all the cladocerans were ranked “rare”. This represented a drastic change of the microcrustacean community in only two months, due seasonal variations (*Cyclops strenuus*, a cold water species, was replaced by *Acanthocyclops* species group, dominant usually in the warmer months of the year). Dietary preferences might also cause this shift.

As concerns the indicator value of the species identified in the nine sampling sites (Tabs. 5 and 6), 16 cladoceran and copepod species indicated relatively clean waters, with low organic pollution (oligosaprobic and oligosaprobic - β mesosaprobic conditions), 7 species indicated an intermediate status (β mesosaprobic conditions), 4 species showed very polluted waters (β, α mesosaprobic and polysaprobic conditions), while 3 species had no indicator value whatsoever.

Cross-checked with the observed frequency of occurrence (Tabs. 3 and 4), the indicator values of cladoceran and copepod species showed high quantity of decomposing organic matter, meaning high organic pollution, in all three fishponds considered. In FP1 and in FP2, the common species were the cladocerans *Moina macrocopa* and *Daphnia magna*, respectively, both indicating α mesosaprobic conditions. In the site FP3, the cladoceran *Moina brachiata* and the cyclopoid copepod *Cyclops strenuus*, both found in April 2010, one frequent and the other common, indicated β, α mesosaprobic to polysaprobic conditions.

Table 3: Observed frequency of occurrence for cladoceran species in the sampling sites (*Abb*. - species abbreviation; R - rare; S - sporadic; C - common; F - frequent; ♀ - females; ♂ - males).

Taxa/Sites	*Abb.*	CA1	CA2	CA3	CA4	CA5	CA6	FP1	FP2	FP3
Alona affinis (Leydig, 1860)	*A.aff*	R ♀								
Alona guttata Sars, 1862	*A.gut*	R ♀	R ♀		R ♀		R ♀			
Alona rectangula Sars 1862	*A.rec*			R ♀	R ♀		R ♀			
Alona Baird, 1843	*A.sp*									R ♀
Bosmina longirostris (O.F. Müller 1776)	*B.lon*					R ♀			S/C ♀	
Ceriodaphnia pulchella Sars 1862	*C.pul*								S ♀	
Chydorus sphaericus (O.F. Müller 1776)	*C.sph*	C ♀	C ♀	S ♀	C ♀	R ♀	F ♀	R ♀	S ♀	R ♀
Daphnia galeata Sars 1863	*D.gal*							R ♀		
Daphnia magna Straus, 1820	*D.mag*								C ♀♂	
Daphnia obtusa Kurz, 1875	*D.obt*								F ♀	
Daphnia O.F. Müller, 1785	*D.sp*									S ♀
Disparalona rostrata (Koch, 1841)	*D.ros*				R ♀					
Dunhevedia crassa King 1853	*D.cra*									R ♀
Eurycercus lamellatus (O.F. Müller 1776)	*E.lam*									R ♀
Leydigia leydigi (Schödler, 1862)	*L.ley*						R ♀			
Moina brachiata (Jurine, 1820)	*M.bra*									F ♀
Moina macrocopa (Straus, 1819)	*M.mac*							C ♀♂		
Pleuroxus aduncus (Jurine, 1820	*P.adu*	R ♀							R ♀	R ♀
Pleuroxus Baird, 1843	*P.sp*		R ♀							
Scapholeberis kingi Sars, 1888	*S.kin*								R ♀	
Simocephalus vetulus (O.F. Müller, 1776)	*S.vet*				S ♀		R/S ♀			

Table 4: Observed frequency of occurrence for copepod species, together with immature stages (copepodites and nauplii) in the nine sampling sites: CA1-CA6; FP1-FP3 (*Abb.* - species abbreviation; R - rare; S - sporadic; C - common; F - frequent; ♀ - females; ♂ - males).

Taxa / Sites	*Abb.*	CA1	CA2	CA3	CA4	CA5	CA6	FP1	FP2	FP3
Acanthocyclops robustus – vernalis species group	*A.rob*					R ♂		C ♀♂	S/C ♀♂	C ♀♂
Canthocamptus staphylinus (Jurine 1820)	*C.sta*									R ♀
Cryptocyclops bicolor (Sars, 1863)	*C.bic*						R ♀			
Cyclops scutifer Sars, 1863	*C.scu*								R ♀	
Cyclops strenuus Fischer, 1851	*C.str*									C ♀♂
Cyclops vicinus Ulianine, 1875	*C.vic*			S ♀♂						
Eucyclops macruroides (Lilljeborg, 1901)	*E.mac*				S ♀♂					
Eucyclops serrulatus proximus (Lilljeborg, 1901)	*E.s.pro*						R ♀♂			
Eudiaptomus vulgaris (Schmeil, 1898)	*E.vul*									F ♀♂
Macrocyclops albidus (Jurine, 1820)	*M.alb*				R ♂					R/S ♀♂
Mesocyclops leuckarti (Claus, 1857)	*M.leu*									S ♀♂
Mixodiaptomus kupelwieseri (Brehm, 1907)	*M.kup*							R/S ♀♂	S/C ♀♂	
Thermocyclops crassus (Fischer, 1853)	*T.cra*					R ♀				S ♀♂
Copepodites	*c*	R	R	S/C	S	R	C	C/F	C	C
Nauplii	*n*	R	R	R	S	R	R	R	C	S

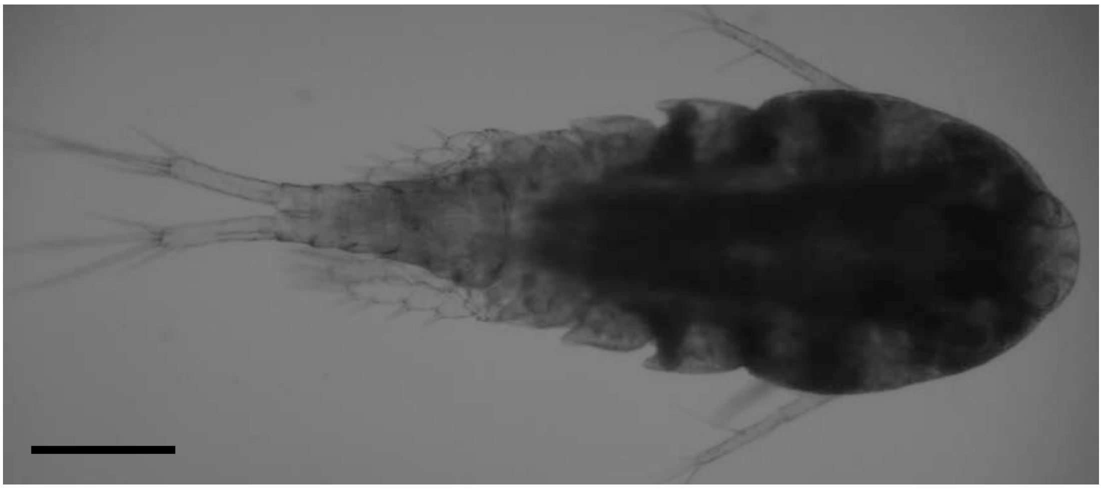

Figure 3: *Cyclops strenuus*, female, from site FP3 (scale bar: 300μm).

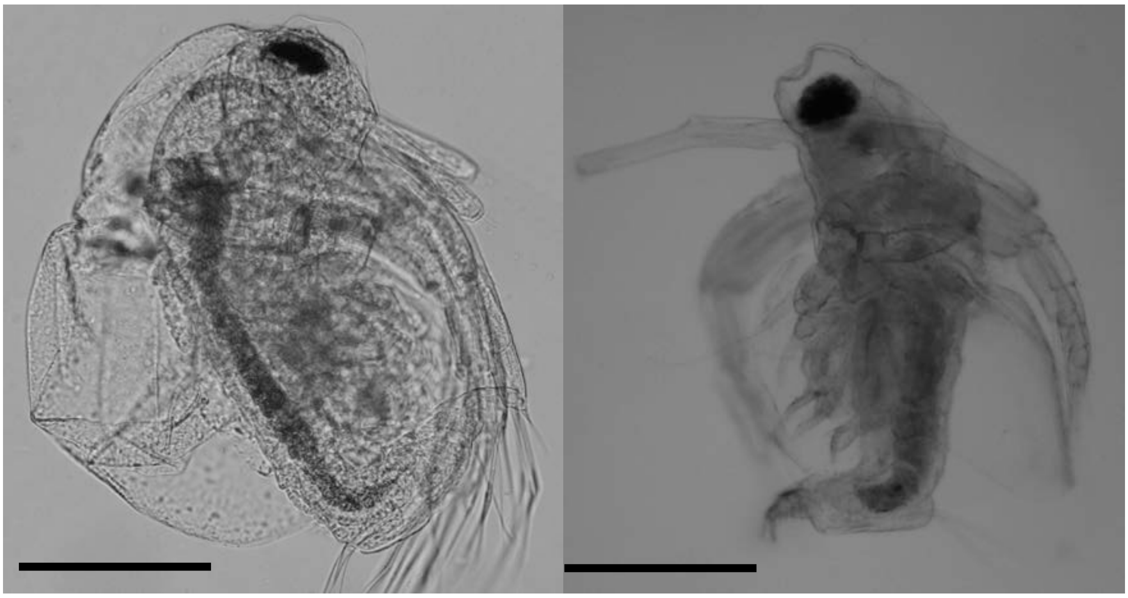

Figure 4: *Moina brachiata*, parthenogenetic female, from site FP3 (left);
Moina macrocopa, male, from site FP1 (right) (scale bar: 300µm)

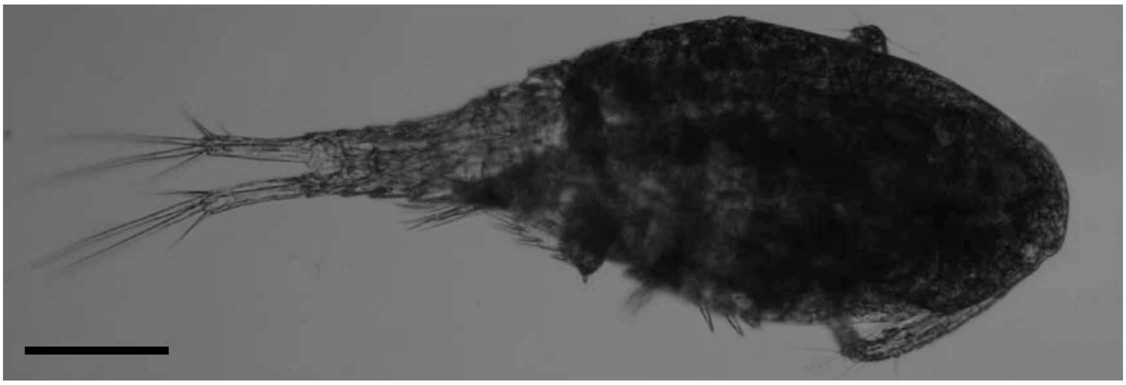

Figure 5: *Cyclops scutifer*, female, from site FP2 (scale bar: 250 µm).

Figure 6: *Acanthocyclops* sp., female, from site FP3 (scale bar: 250 µm).

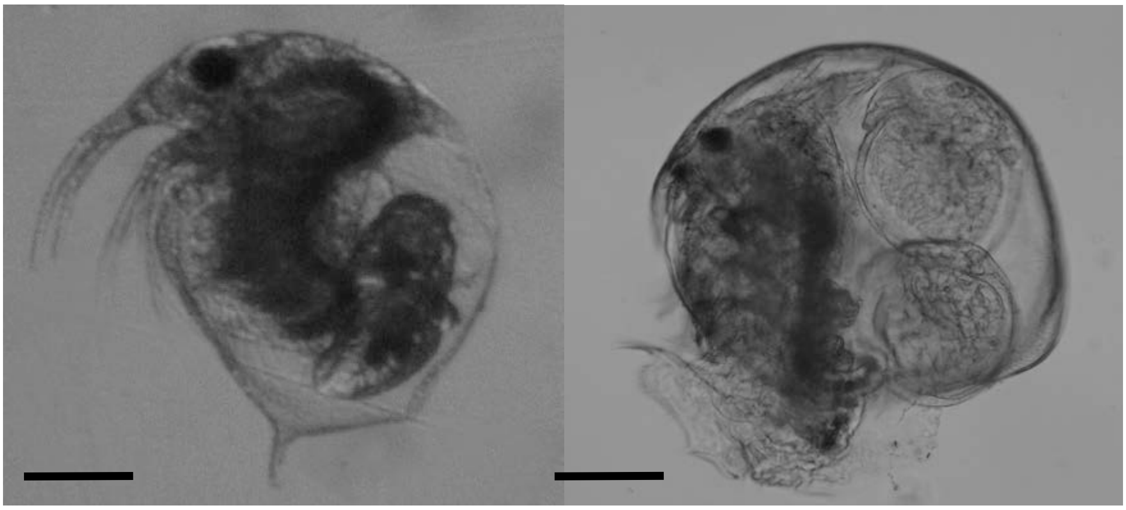

Figure 7: *Bosmina longirostris*, parthenogenetic female, from site FP2 (left);
Chydorus sphaericus, parthenogenetic female, from site CA6 (right);
(scale bar: 100 µm).

Cleaner waters were indicated by the species identified in the six canal sites, but most of the species present were ranked “rare” or “sporadic”. The only “common” or “frequent” species in four out of the six sites (CA1, CA2, CA4 and CA6) was *Chydorus sphaericus*, a cosmopolitan species, able to withstand very different conditions (Tabs. 3 and 5). Thus, even if microcrustacean communities indicated lower levels of organic pollution in the six canals, this might be explained by the continuous circulation of water in these ecosystems.

Other taxonomic groups were found in the nine planktonic samples (Tab. 7), most of them coming from the benthic area of the water bodies.

As for the planktonic rotifers, they were also captured with the sampling net, but only individuals larger than 55 µm remained in the samples.

The following genera were present in the analised samples: *Lecane* in CA2; *Keratella* in CA3, *Brachionus* in CA4; *Asplanchna*, *Brachionus*, *Keratella* and *Polyarthra* in CA5; *Brachionus* and *Keratella* in FP1; *Asplanchna*, *Filinia*, *Keratella* and *Polyarthra* in FP2; *Asplanchna*, *Brachionus*, *Filinia*, *Keratella* and *Polyarthra* in FP3. On the other hand, in CA4, CA6 and FP2, the samples were dominated by filamentous algae (e.g. *Oscillatoria*, Cyanoprokaryota), while *Ceratium* (Dinophyta) and *Volvox* (Chlorophyta) were frequent in FP3.

Table 5: The saprobic level (S) indicated by cladoceran species identified in Cefa Nature Park (o - oligosaprobic; β - β mesosaprobic; α - α mesosaprobic; p - polysaprobic) and the habitat(s) they prefer (Ref - References: 1 - Sládeček, 1973; 2 - Negrea, 1983; 3 - Negrea, 2002).

Cladoceran species	S	Habitat(s)	Ref
Alona affinis (Leydig, 1860)	-	cosmopolitan; periphyton; in the open water near aquatic vegetation; near the muddy bottom with detritus	2
Alona guttata Sars, 1862	o➡β	cosmopolitan; periphyton; in open water near aquatic vegetation; near the muddy bottom with detritus	1; 2
Alona rectangular Sars 1862	o	clear eutrophic waters; in the open water near aquatic vegetation; near the muddy/sandy bottom with detritus; periphyton	1; 2; 3
Bosmina longirostris (O.F. Müller 1776)	o➡β	small eutrohic unpolluted water bodies; open water; near aquatic vegetation; littoral zone	1; 2; 3
Ceriodaphnia pulchella Sars 1862	o➡β	clear eutrophic waters with submerged macrophytes; open water near aquatic vegetation	1; 2; 3
Chydorus sphaericus (O.F. Müller 1776)	β	cosmopolitan; the most frequent cladoceran in Romania (from the Black Sea coast to 2240 m a.s.l); eutrophic waters	1; 2; 3
Daphnia galeata Sars 1863	o➡β	eutrophic waters; large and calm water bodies	2; 3
Daphnia magna Straus, 1820	β➡p	small eutrophic lowland waters, rich in animal organic matter; open and shallow water; near submerged or emerged vegetation	2; 3
Daphnia obtuse Kurz, 1874	o➡β	temporary and permanent water pools; different types of waters, from natural oligotrophic to human-made concrete basins	1; 2; 3
Disparalona rostrata (Koch, 1841)	-	near the bottom; open water near macrophytes; never in waters covered entirely with macrophytes	2
Dunhevedia crassa King 1853	β	not frequent; near submerged and emerged macrophytes; near the muddy bottom with detritus and *Spirogira*	1; 2
Eurycercus lamellatus (O.F. Müller 1776)	o	near submerged, emerged or floating macrophytes; near the muddy bottom with detritus; open water	1; 2
Leydigia leydigi (Schödler, 1863)	β	benthic species; muddy/sandy bottom with detritus; open water near aquatic vegetation or near the bottom	1; 2; 3
Moina brachiata (Jurine, 1820)	β➡p	small eutrophic warm waters with muddy or clay bottom; open water	1; 2; 3
Moina macrocopa (Straus, 1820)	α	small temporary, polluted and warm water bodies; low to medium altitudes	1; 2
Pleuroxus aduncus (Jurine, 1820)	o	near submerged, emerged or floating macrophytes; muddy or sandy bottom, open water near the bottom	1; 2; 3
Scapholeberis kingi Sars, 1888	o	hyponeustonic species; shallow eutrophic warm waters, clear or with macrophytes	1; 2
Simocephalus vetulus (O.F. Müller, 1776)	o➡β	cosmopolitan (except for high altitudes); open water near aquatic vegetation; near the bare bottom close to macrophytes	1; 2; 3

Table 6: The saprobic level (S) indicated by copepod species identified in Cefa Nature Park (o – oligosaprobic; β – β mesosaprobic; α - α mesosaprobic; p – polysaprobic) and the habitat(s) they prefer (Ref - References: 1 - Sládeček, 1973; 2 - Damian-Georgescu, 1963; 3 - Pleşa and Müller, 2002; 4 - Hansen and Santer, 2003; 5 - Damian-Georgescu, 1966).

Copepod species	S	Habitat(s)	Ref
Canthocamptus staphylinus (Jurine 1820)	o	cosmopolitan and ubiquitous; different types of waters	1; 3
Cryptocyclops bicolour (Sars 1863)	o	cosmopolitan; small, calm waters with rich vegetation; littoral, macrophyte rich areas in large lakes	1; 2; 3
Cyclops scutifer Sars 1863	-	open water; frequent in oligotrophic lakes; usually in the cold seasons	2; 3
Cyclops strenuous Fischer 1851	β➡α	usually small temporary waters; maximum reached during winter and early spring	1; 2; 3
Cyclops vicinus Ulianine 1875	β	mesotrophic and eutrophic lakes; open water	1; 2; 3; 4
Eucyclops macruroides (Lilljeborg 1901)	o	different types of waters; frequent in lowland large lakes, in littoral, macrophyte rich areas	1; 2; 3
Eucyclops serrulatus proximus (Lilljeborg 1901)	β	cosmopolitan	1; 2; 3
Eudiaptomus vulgaris (Schmeil, 1898)	β	shallow waters or littoral areas of large lakes; its size changes with the size of the water body	1; 3; 5
Macrocyclops albidus (Jurine 1820)	β	cosmopolitan; different types of waters; frequent in clear waters, rich in macrophytes	1; 2; 3
Mesocyclops leuckarti (Claus 1857)	o	cosmopolitan; different types of waters	1; 2; 3
Mixodiaptomus kupelwieseri (Brehm, 1907)	o➡β	abundant in spring temporary pools	1; 3; 5
Thermocyclops crassus (Fischer 1853)	o➡β	cosmopolitan; mesotrophic and eutrophic lakes; open water	1; 2; 3

Table 7: Other taxa found in zooplankton samples at the nine sites from Cefa Nature Park.

Taxa / Sites	CA1	CA2	CA3	CA4	CA5	CA6	FP1	FP2	FP3
Cnidaria, Hydrozoa	✓		✓			✓			
Platyhelminthes						✓			
Nematoda	✓	✓	✓	✓	✓				✓
Rotifera		✓	✓	✓	✓		✓	✓	✓
Annelida, Oligocheta			✓	✓		✓		✓	
Mollusca, Class Gastropoda			✓			✓			✓
Insecta, Ephemeroptera (larvae)		✓				✓			✓
Insecta, Odonata (larvae)						✓			
Insecta, Diptera (larvae)	✓	✓		✓		✓	✓	✓	✓
Insecta, Coleoptera (larvae)									✓
Insecta, Coleoptera (adults)						✓			
Insecta, Collembola (adults)						✓			
Insecta, Heteroptera (adults)						✓			✓
Crustacea, Ostracoda	✓					✓		✓	✓
Crustacea, Amphipoda						✓			
Crustacea, Isopoda						✓			
Acari (terrestrial and water mites)		✓						✓	✓

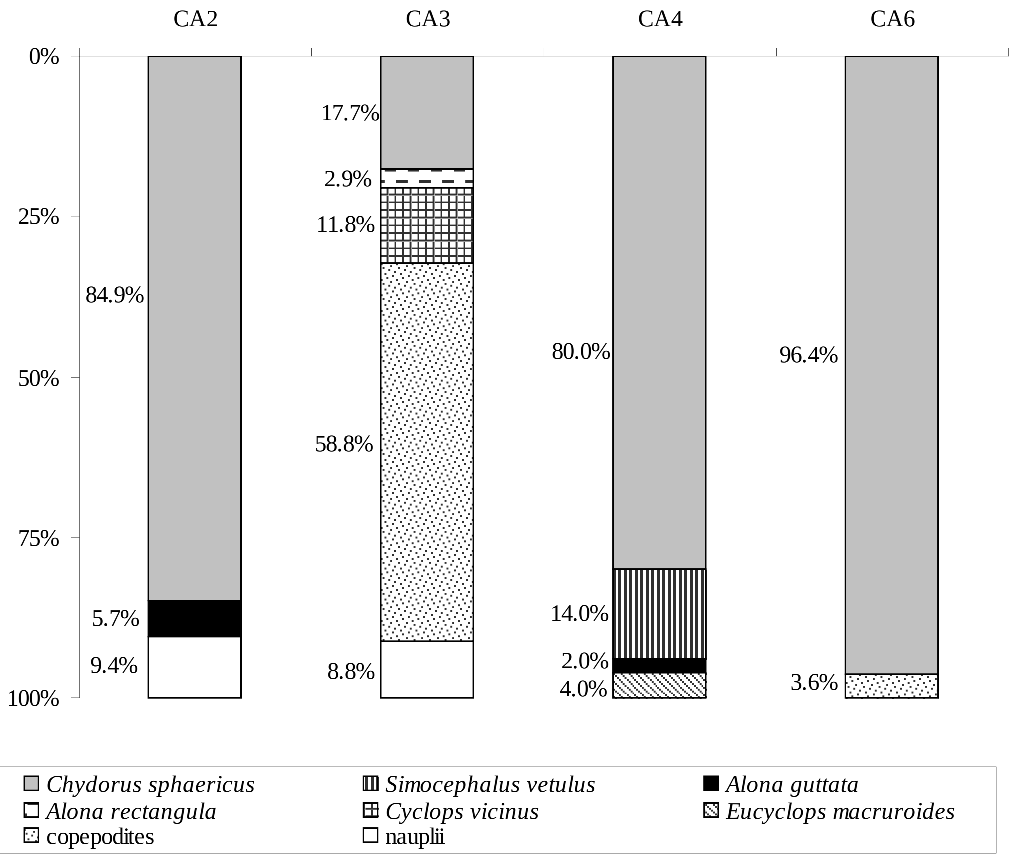

Figure 8: The relative percentage abundance of microcrustacean species identified in four canal sampling sites (CA2, CA3, CA4, CA6).

The relative percentage abundance calculated for the canal samples (Fig. 8) showed that the cosmopolitan cladoceran *Chydorus sphaericus* dominated all four microcrustacean communities where counts were possible. Only in site CA3, the copepodites exceeded the percentage of *C. sphaericus*. This difference might be explained by the fact that this location was sampled in 2010, while the rest, CA2, CA4 and CA6 in 2008. The constant flow conditions of the canals created an unstable environment for the microcrustaceans, thus only eurybiont species were found, most of them in low numbers.

Numerous microcrustacean species were identified in the three fishponds, so only those exceeding 2% were considered in the figure number 9. In case of site FP3, the semi-quantitative analysis was made for the sample collected in June. The microcrustacean communities from sites FP1 and FP3, both sampled in 2010, were similar because of the domination of copepods: in FP1 copepodites exceeded 80%, while in FP3 calanoid (*Eudiaptomus vulgaris*) and cyclopoid adults (*Acanthocyclops* sp., *Thermocyclops crassus*, *Mesocyclops leuckarti*), together with copepodites, reached 86%. On the other hand, in site FP2, sampled in 2008, the planktonic community was dominated by two large cladoceran species, *Daphnia magna* and *D. obtusa*, both reaching 84%. These differences are difficult to interpret, due to the artificial regime of the water pools, whose main purpose are fish farming.

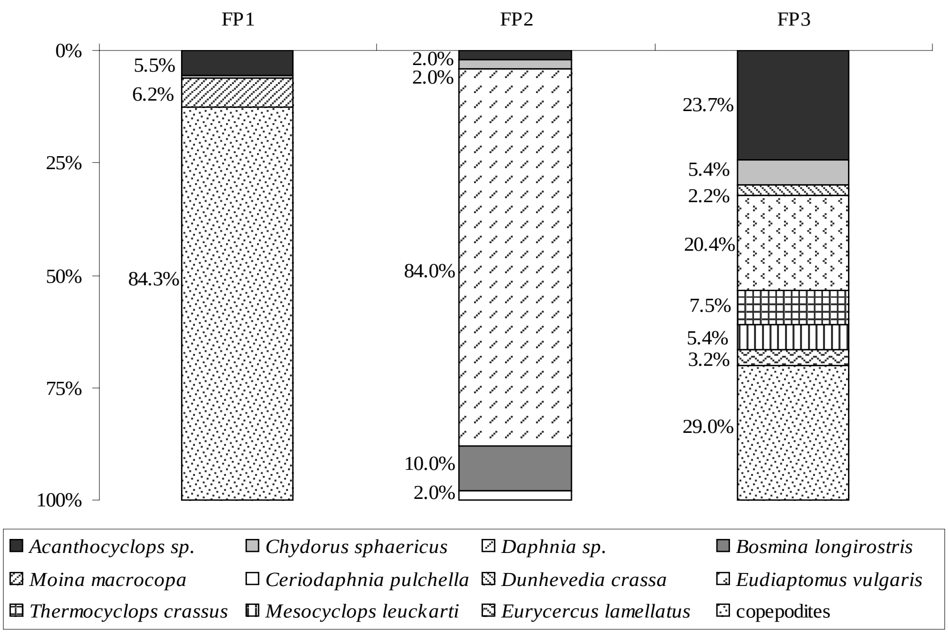

Figure 9: The relative percentage abundance of microcrustacean species identified in the three fishpond sampling sites (FP1, FP2, FP3) (only species exceeding 2% were considered).

The similarity based on the Dice index (Fig. 10) recorded low values, no more than 60%, based on the species composition (presence/absence of microcrustacean species, nauplii and copepodites excluded) in the nine sampling sites. One cluster included five from the six canal sites, CA1, CA2, CA3, CA4 and CA6 (Fig. 10), due to the presence of similar species. The site CA5 was part of the second cluster, together with the fishpond sites, due to the rich submerged vegetation characteristic to the site and to several common species, like *Bosmina longirostris*, *Acanthocyclops* sp. or *Thermocyclops crassus* (Tabs. 3 and 4).

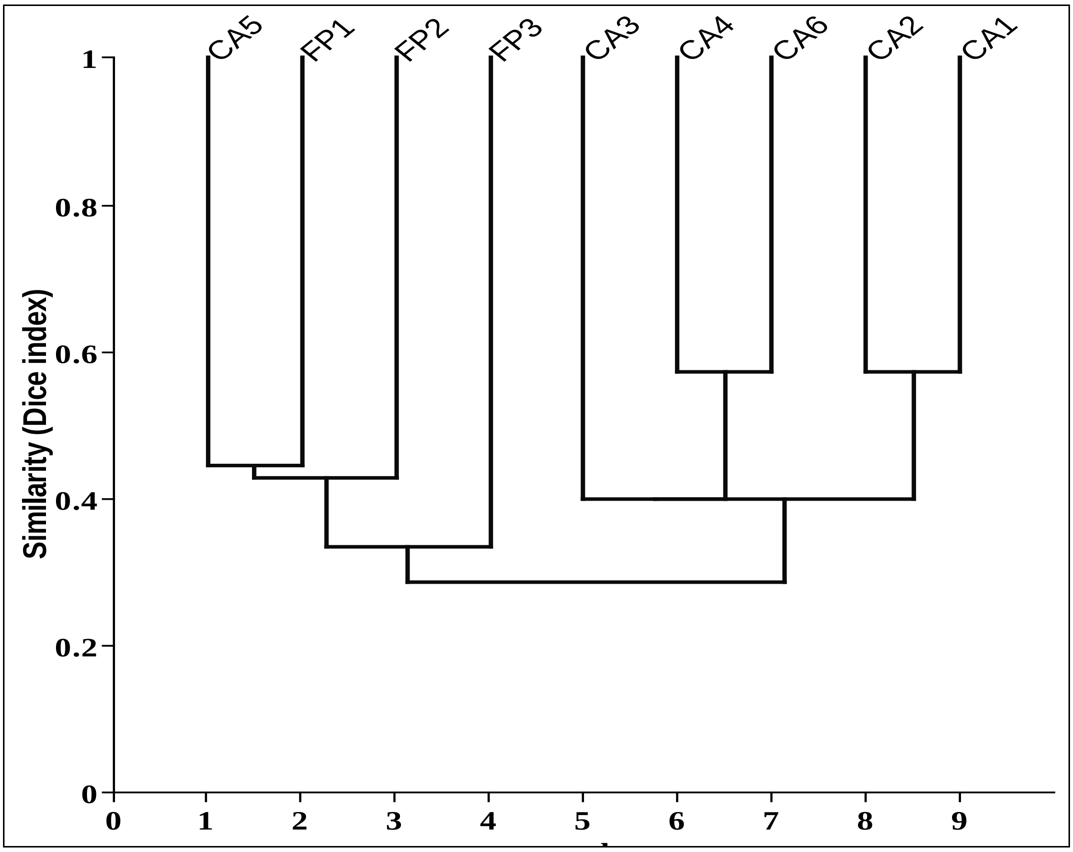

Figure 10: The similarity based on the Dice index for the microcrustacean communities from the nine samples: CA1-CA5; FP1-FP3 (single linkage).

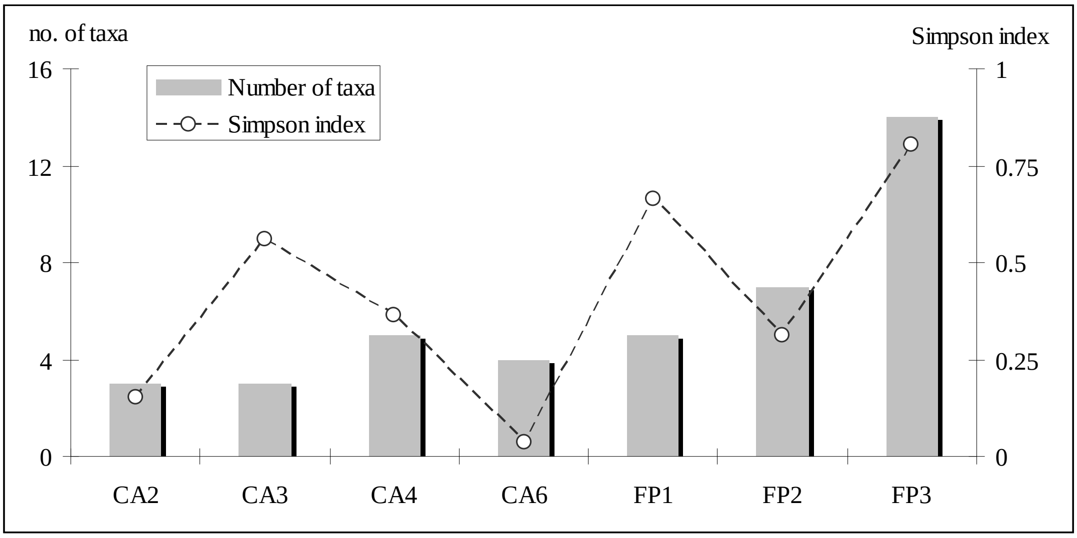

Figure 11: The total number of taxa present in each sample and the Simpson index (considering only samples where countings were performed).

Semi-quantitative analyses were also used to calculate the diversity of the seven sampling sites where counts were possible (Fig. 11). The Simpson index was estimated considering the total number of individuals counted in each sample. The highest value of biodiversity was recorded in FP3, in June, due not only to the large number of taxa present but also to the equitability of the percentages of all taxa. High diversity values were also recorded in CA3 and FP1, even if the number of taxa was lower. On the other hand, in site CA6 the diversity reached its minimum, due to the dominance of *Chydorus sphaericus*.

CONCLUSIONS

A total number of 31 microcrustacean species was identified in the nine sampling sites from Cefa Nature Park. Only the cladoceran *Chydorus sphaericus* and the immature stages of copepods were common to all nine sampling sites. From the physical and chemical parameters measured in the field, salinity and dissolved oxygen recorded large variations from one site to another. The rest had more or less similar values. Another difference between sites was the presence or absence of submerged vegetation. An important role of microcrustacean species was to provide information regarding the ecological status of the environment they lived in. Thus, the cladoceran and copepod species indicated high organic pollution in all three fishponds considered, and cleaner conditions in the canal sampling locations, due probably to the permanent of waterflow. The relative percentage abundance showed differences between the crustacean communities from the canals and those from the fishponds. High diversity values were recorded not only in fishponds, as expected, being relatively stable environments for microcrustaceans, but also in some canal samples, with low number of taxa, equally represented.

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FAUNISTIC OVERVIEW UPON THE AQUATIC MALACOSTRACANS (CRUSTACEA, MALACOSTRACA) OF CEFA NATURE PARK (CRIŞANA, ROMANIA)

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KEYWORDS: malacostracan, amphipoda, decapoda, isopoda, Cefa Nature Park, faunistics.

ABSTRACT

This is a preliminary study on the aquatic epigean malacostracan fauna of the Cefa Nature Park. Four malacostracan species belonging to the orders Amphipoda, Isopoda and Decapoda have been identified. Some discussions about the ecology of the identified species are given. The amphipod species are discussed from a biogeographic point of view. Because they are considered tertiary relicts it is possible that the ecological and geological conditions in the study area were relatively stable in recent geological time and not very affected by anthropic impact, thus making the Cefa Nature Park suitable for the conservation of *Niphargus valachicus*, species declared as “vulnerable” on the IUCN Red List.

RÉSUMÉ: Aperçu des malacostracés aquatique (Crustacea: Malacostraces) du Parc Naturel de Cefa (Crişana, Roumanie).

Ce travail est une étude préliminaire sur la faune aquatique des Malacostracés épigés du Parc Naturel de Cefa. Dans les échantillons ont été identifiés quatre espèces appartenant aux Amphipodes, Isopodes et Décapodes. Aussi, des éléments sur l'écologie des espèces identifiées sont donnés. La biogéographie des espèces d’amphipodes est discutée parce qu'ils sont considérés comme des reliques tertiaires. En effet, il est possible que les conditions écologiques et géologiques de la zone d'étude aient été relativement stables dans un temps géologique récent. Par conséquent ces espèces ne sont pas très affectées par l'impact anthropique, ce qui rend le Parc Naturel de Cefa approprié pour la conservation de l’espèce *Niphargus valachicus*, déclarée «vulnérable» sur la Liste rouge de l'UICN.

REZUMAT: Studiu faunistic asupra malacostraceelor acvatice din Parcul Natural Cefa (Crişana, România).

Acesta este un studiu preliminar asupra faunei de malacostracee acvatice epigee ale Parcului Natural Cefa. Patru specii de malacostracee au fost identificate, aparţinând ordinelor Amphipoda, Isopoda şi Decapoda. De asemenea, sunt prezentate câteva discuţii asupra ecologiei speciilor identificate. Speciile de amfipode sunt discutate din punct de vedere biogeografic. Deoarece sunt considerate relicte terţiare, probabil condiţiile ecologice şi geologice din zona de studiu au fost relativ stabile în timpul geologic recent şi nu au fost afectate foarte mult de impactul antropic, astfel Parcul Natural Cefa este adecvat pentru conservarea speciei *Niphargus valachicus*, specie declarată vulnerabilă pe Lista Roşie a IUCN.

INTRODUCTION

The Class Malacostraca comprises a wide variety of crustaceans such as crabs, crayfish, shrimp, scud and woodlice that live in marine, freshwater and even terrestrial habitats (Radu and Radu, 1967). They play a major role in the ecosystem functionality, due processes like converting organic matter and detritus into biomass and are also a food source for numerous species (Welton, 1979). Amphipods and decapods are used as biological indicators for water quality because they are sensitive to increased levels of nitrites (Camargo and Alonso, 2006), soluble phosphorus (Pârvulescu and Hamchevici, 2010) and other chemical pollutants (Grabowski and Pešić, 2007). Isopods like *Asellus aquaticus* are tolerant to some pollutants and are therefore used in monitoring water quality (Maltby, 1991).

The distribution and ecology of malacostracans, with few exceptions, was poorly studied in the Romanian territory. High resolution maps regarding species distribution are not available despite their wide occurrence.

This is the first faunistic study conducted on the malacostracan crustaceans from the Cefa Nature Park.

MATERIAL AND METHODS

Cefa Nature Park covers an area of 5002 ha. The park reaches the Romanian-Hungarian border in the north-west, the Tărian Canal (a canal that connects the rivers Crişul Repede and Crişul Negru) in the east and the Rădvani Forrest in the south (Fig. 1). The aquatic habitats are represented by fishponds that cover around 700 ha and a mosaic of drainage canals that are common throughout the pannonic steppes and marshes.

Qualitative samples were collected with a 250 µm mesh size benthic net. Specimens were preserved in Eppendorf plastic tubes in 90% ethanol. Decapods were captured using a baited crayfish mesh trap. Collection of the samples took place in March 2010. Species identification was carried out using the identification keys of the following authors: for Amphipoda - Cărăuşu et al. (1955), for Isopoda - Radu (1985) and for Decapoda - Băcescu (1967), and Pârvulescu (2009).

Seven sampling stations were investigated (Fig. 1). The sampling stations with a short description and GPS coordinates are listed below:

1. Ateaş pond, muddy substrate, GPS: 46°55’26’’N, 21°36’56”E;
2. Ateaş drainage canal - average depth 2 m, width aproximatively 10 m, scarce aquatic vegetation, muddy and sandy substrate, GPS: 46°55’16’’N, 21°36’30’’E;
3. Canal 3 - average depth 1 m, width around 3 m, muddy substrate, GPS: 46°54’40’’N, 21°38’34’’E;
4. Canal 4 - average depth 1 m, width around 6 m, muddy substrate, GPS: 46°55’20’’N, 21°37’29’’E;
5. Canal that supplies lake 14 with water - average depth 1.5 m, width around 3 m, muddy substrate, GPS: 46°54’33’’N, 21°39’26’’E;
6. Lake 14, muddy substrate, GPS: 46°54’15’’N, 21°38’50’’E;
7. Canal near the Rădvani Forrest - average depth 0.5 m, width around 2.5 m, muddy substrate covered with leaves, GPS: 46°54’08’’N, 21°39’15’’E.

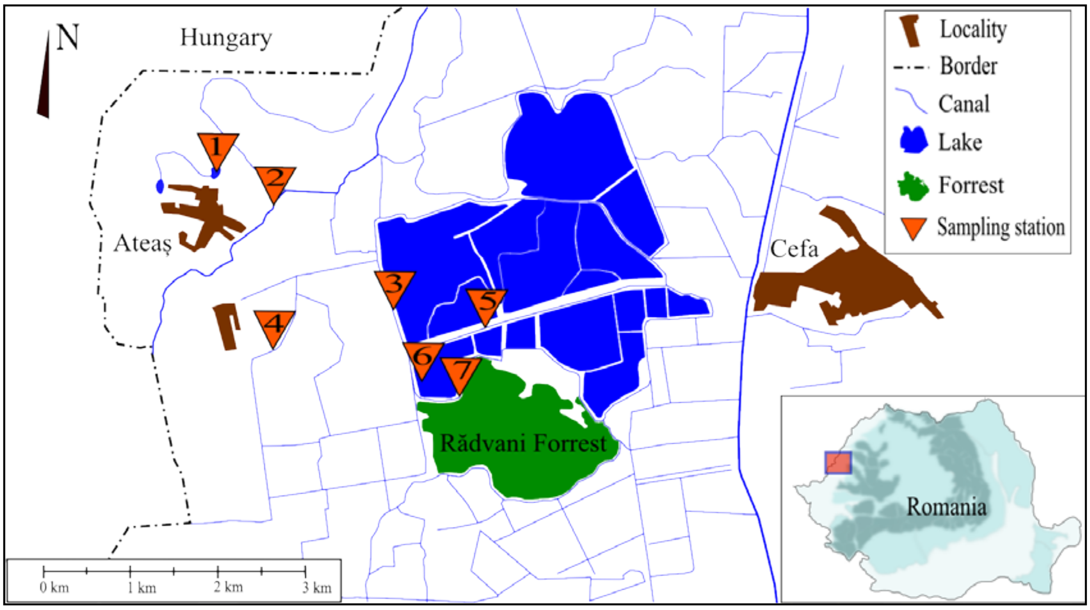

Figure 1: Distribution of the sampling stations in Cefa Nature Park study area.

RESULTS AND DISCUSSION

A total of four malacostracan species were identified: two species of amphipods belonging to the families Niphargidae - *Niphargus valachicus* Dobreanu and Manolache 1933 and Crangonictydae - *Synurella ambulans* Müller 1846, one isopod species belonging to the family Asellidae - *Asellus aquaticus* Linnaeus 1758, and one decapod species belonging to the family Astacidae - the narrow-clawed crayfish *Astacus leptodactylus* Eschscholtz 1823. Similar assemblages of species were reported by Hungarian authors in nearby Hungarian regions, representing the same lowland habitat (Lantos, 1986, Puky et al., 2005, Borza et al., 2010). The association between *N. valachicus*, *S. ambulans* and *A. aquaticus* is common throughout the lowland regions of Romanian territory, in ponds, lakes and slow running waters (Cărăuşu et al., 1955, Copilaş, unpublished data). This type of association was previously reported in Turkey (Akbulut et al., 2001).

Table 1: Species presence/absence in the Cefa Nature Park.

Species	Sampling stations						
	1	2	3	4	5	6	7
Niphargus valachicus Dobreanu and Manolache 1933	-	+	+	+	+	-	+
Synurella ambulans Müller 1846	+	+	+	+	+	+	-
Asellus aquaticus Linnaeus 1758	+	+	+	+	+	+	+
Astacus leptodactylus Eschscholtz 1823	-	+	-	+	-	-	+

Due to its morphological particularities *N. valachicus* (Fig. 2) is probably a basal, primitive niphargid. Because of the characteristics of its habitat, it is possible that *N. valachicus* is an euryoecious species, but competitively weak and linked to a degree of conservatism (Sket, 1981). Its geographical range is large and fragmented, being distributed from Slovenia, across Croatia, Hungary and Romania, up to Turkey and Iran (Fišer et al., 2009). This area also corresponds to the extension of former Paratethys Sea during Miocene/Pliocene. From here, the species, probably spread into continental waters through costal lagoons (Sket, 1981). *N. valachicus* is one of the few epigean species that comprise this genus, the majority of niphargids being hypogean (Sket, 1999).

During this study, the species was present only in the canals of Cefa Nature Park, missing from the ponds and lakes (Tab. 1). It was more frequently collected near the banks of the canals in the dense submerse vegetation and between the roots of riparian plants where it finds shelter.

Synurella ambulans

It is the most euryoecious amphipod species of central Europe (Meijering et al., 1995), being common through the lowlands in lakes, ponds, ditches and slow running waters from Central and Eastern Europe to the Middle East (Cărăuşu et al., 1955, Konopacka and Blazewicz-Paszkowycz, 2000, Akbulut et al., 2001). It can also be found at higher altitudes if the environmental conditions are adequate, being reported at an altitude of 1600 m (Cărăuşu et al., 1955). *Synurella ambulans* (Fig. 2b) can also be found in hypogean waters, it was reported from wells in Hungary and Romania in association with *Asellus aquaticus* and planarians (Cărăuşu et al., 1955). This species prefers large densities of macrophytes because its main diet consists of detritus and algae that it consumes from vegetation or from the water bottom (Lantos, 1986).

In the present study, this species was found in every sampling station except the canal near the Rădvani Forest (sampling station number 7). The species was frequently collected from macrophytes alongside the banks of the canals and the benthic zones of lakes and ponds.

Asellus aquaticus

Asellus aquaticus (Fig. 2c) is wide spread throughout the West Palearctic. It is present in a large variety of freshwater habitats like rivers, lakes, springs and even subterranean and brackish waters (Gruner, 1965). It generally avoids marine saline and oligotrophic freshwater habitats like fast-flowing mountain streams (Verovnik et al., 2005). The species is highly tolerant to organic pollution and therefore it is used as an indicator for water quality (Whitehurst, 1991). It is a polyphagous species, spending most of its life on aquatic vegetation but can also be found on the bottom of water bodies (Lantos, 1986).

Due to its ecological plasticity it was encountered at every sampling station during the present study.

Astacus leptodactylus

Indigenous to the Ponto-Caspian areal, its distribution area occupies almost all the Europe, due to its introduction in Western Europe (Souty-Grosset et al., 2006). In Romania, this species is present throughout the lowland regions from large rivers to canals, lakes and fish ponds (Băcescu, 1967). It lives in slow running waters, burrowing in muddy banks or hiding in dense aquatic vegetation or under submerged objects. In lagoons and deltas, it can withstand brackish and even saltwater. *Astacus leptodactylus* (Fig. 2d) is active both day and night, feeding upon a wide array of animal and vegetal food (Souty-Grosset et al., 2006).

In comparison with the other three species mentioned above, *A. leptodactylus* was not so frequently encountered at the sampling stations. The species was captured at only three locations: sampling stations no. 2, 4 and 7 (Tab. 1).

A B

C D

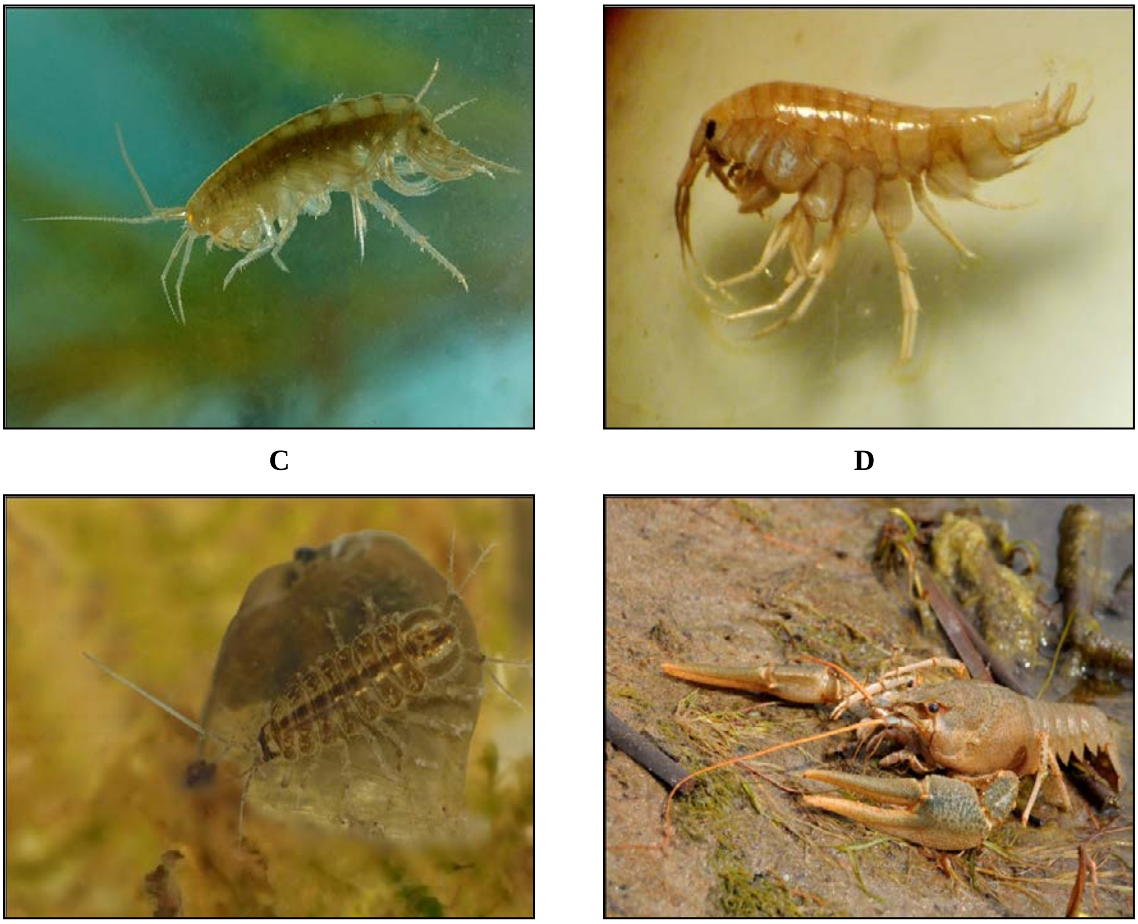

Figure 2: The malacostracan species of Cefa Nature Park photographed by the authors:
A. *Niphargus valachicus*, B. *Synurella ambulans*,
C. *Asellus aquaticus*, D. *Astacus leptodactylus*.

This survey revealed four malacostracan species present in the studied area, a small number compared to the around 120 aquatic malacostracan species that occur in Romanian waters, almost 70 being epigean (de Jong, 2011). Nevertheless, these species are important from a phylogeographic point of view. The association between the amfipods *Niphargus sp.* and *Synurella sp.* is described as being very old, dating back approximately 50 million years ago, since Eocene, as suggested by the discovery of Baltic amber with fossilized remains (Coleman, 2004, 2006; Jaźdźewski and Kupryjanowicz, 2010). The encasing of these species in amber suggests that they were living near the water surface like nowadays *N. valachicus* and *S. ambulans*. Dedyu (1980) considers that *S. ambulans* is an ancient freshwater species. The same can be plausible for *N. valachicus* because its distribution range corresponds to the extension of the Paratethys Sea during the Miocene – Pliocene transition. The wide occurrence of these amphipod species at Cefa Nature Park probably indicates a relative stability of the habitats during recent geological time and that the species were not significantly affected by anthropic impacts over time.

Asellus aquaticus is widespread throughout the Pannonian Basin (Verovnik et al., 2005). The habitats at Cefa Nature Park are suitable for its ecological demands as suggested by the wide occurrence of the species throughout the sampling stations.

The presence of *A. leptodactylus* within the study area indicates a relative good water quality. Like other crayfish species, it does not tolerate chemical pollution, although it is less sensitive to oxygen deficit and temperature variations (Schultz et al., 2002). The dense aquatic vegetation, stagnant and slow running waters and muddy substrate offer a suitable habitat for this species. The presence of the invasive spiny-cheek crayfish *Orconectes limosus* Rafinesque, 1817, a species carrying crayfish plague, on the Romanian and Hungarian territories (Pârvulescu et al., 2009, Puky and Schád, 2006) does not pose a threat for the moment.

According to the IUCN Red List of Threatened Species *N. valachicus* is listed as a Vulnerable species (Sket, 1996) and *A. leptodactylus* is listed as a species of Least Concern (Gherardi and Souty-Grosset, 2010). *Synurella ambulans* and *Asellus aquaticus* are not listed, except for a few subspecies of the latter. Sket, 1996a, b, c.

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CADDISFLIES (INSECTA, TRICHOPTERA) COMMUNITY STRUCTURE IN CEFA NATURE PARK (CRIŞANA, ROMANIA)

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KEYWORDS: caddisflies, larvae, adults, Western Romania.

ABSTRACT

The wide distribution of caddisflies and their different sensitivity shown upon modifying the qualitative parameters of aquatic ecosystems led to a frequent use of these species as bioindicators in different studies. The present study aims at presenting a list concerning the different species of caddisflies identified in the larva and adult stage in the Cefa Nature Park perimeter. The sample collecting sites were represented by 12 places used to identify the caddisfly species in the larval phase, and 3 for the adult phase. 36 species, respresenting 8 families, were identified. The most frequent species were *Limnephilus flavicornis* and *Limnephilus rhombicus* (larval phase), and *Oecetis lacustris*, *Oecetis ochracea*, *Leptocerus tineiformis*, *Psychomyia pusilla*, *Ecnomus tenellus*, *Hydropsyche angustipennis*, *Hydropsyche bulgaromanorum*, *Limnephilus flavicornis*, *Limnephilus lunatus*, *Neureclipsis bimaculata* (adult phase).

RÉSUMÉ: La structure des communautés de trichoptères (Insecta, Trichoptera) du Parc Naturel de Cefa (Crişana, Roumanie).

La large distribution des trichoptères et leur sensibilité différente, manifestée par la modification des paramètres qualitatifs des écosytèmes aquatiques, ont mené à l'utilisation fréquente de ces espèces dans des études diverses comme bioindicateurs. Cette étude se propose de présenter une liste des espèces de trichoptères identifiées aux stades larvaire et adulte sur le territoire du Parc Naturel de Cefa. Les points de collecte des échantillons ont été représentées par 12 stations pour l'identification des espèces de trichoptères au stade larvaire et 3 stations correspondantes au stade adulte. On a identifié 36 espèces incluses dans 8 familles. Les plus répandues ont été: *Limnephilus flavicornis* et *Limnephilus rhombicus* (stade larvaire), avec *Oecetis lacustris*, *Oecetis ochracea*, *Leptocerus tineiformis*, *Psychomyia pusilla*, *Ecnomus tenellus*, *Hydropsyche angustipennis*, *Hydropsyche bulgaromanorum*, *Limnephilus flavicornis*, *Limnephilus lunatus*, *Neureclipsis bimaculata* (stade adulte).

REZUMAT: Structura comunităţii de trichoptere (Insecta, Trichoptera) în Parcul Natural Cefa (Crişana, România).

Larga răspândire a trichopterelor şi sensibilitatea diferită, manifestată la modificarea parametrilor calitativi ai ecosistemelor acvatice, au condus la utilizarea frecventă a acestor specii în diverse studii ca bioindicatori. Prezentul studiu îşi propune prezentarea unei liste privind speciile de trichoptere identificate în stadiul larvar şi adult pe teritoriul Parcului Natural Cefa. Punctele de colectare a probelor au fost reprezentate de 12 staţii pentru identificarea speciilor de trichoptere în stadiul de larvă, respectiv 3 staţii corespunzătoare celui de adult. Au fost identificate 36 de specii incluse într-un număr de 8 familii. Cele mai frecvente specii au fost: *Limnephilus flavicornis* şi *Limnephilus rhombicus* (stadiul de larvă), respectiv *Oecetis lacustris*, *Oecetis ochracea*, *Leptocerus tineiformis*, *Psychomyia pusilla*, *Ecnomus tenellus*, *Hydropsyche angustipennis*, *Hydropsyche bulgaromanorum*, *Limnephilus flavicornis*, *Limnephilus lunatus*, *Neureclipsis bimaculata* (stadiul de adult).

INTRODUCTION

The assessment of freshwater quality is routinely determined by emplying the caddisflies larvae (among other groups of macroinvertebrates), in many running waters (Ciubuc, 2010; Shiels, 2010; Tran et al., 2010). Moreover, the caddisflies larvae represent an important source of food for fish, of both benthic and plankton forage type, whilst helping filtering the water from many suspended particles (Higler and Tolkamp, 1983; Gheţeu, 2008; Thorp and Rogers, 2011).

Ciubuc was one of the co-authors of this paper was the first scientist who publishes a list of caddisflies that have been identified in Romania. This list was completed by other authors later on (Ujvárosi, 1998; Ujvárosi, 2002; Ciubuc, 2004; Robert and Curtean-Bănăduc 2005; Curtean-Bănăduc, 2006; Cupşa et al., 2007; Curtean-Bănăduc, 2008, Cupşa et al., 2009; Ciubuc, 2009, 2010; Curtean-Bănăduc and Radu, 2010).

Cefa Nature Park is located in the western part of the country, bordering Hungary, in the south-western part of the Bihor County, and it includes a great variety of flora and fauna due to its diverse forms of relief and to the large distribution of the lentic ecosystems.

So far there haven't been conducted any studies concerning the caddisfly fauna in the Cefa Nature Park area, and this present work intends to add new data and complete the already existing lists regarding this topic in Romania.

MATERIAL AND METHODS

Collecting the benthos samples

During March 2010 and August 2011 there were collected benthic samples by using the Ekman dredge (equivalent to a surface of 240.25 cm^2), at 12 sampling sites, with the codes between S1 to S12) to identify the caddisfly species that were in the larva (aquatic) phase (Fig. 1). The benthos samples were preserved in ethanol (70%). In the laboratory, the taxonomic identification of the sampled individuals was conducted on a species level (Waringer and Graf, 1997; Wallace et al., 2003). The individuals in the first stages of life were not identified at a species level, due to the fact that they did not feature the fully developed morphological traits to allow a proper analysis.

Collecting the adults

The adults were captured from May to June 2006, and from August 2010 to August 2011. In order to capture the individuals in this particular stage of development, we used light traps having a mercury vapors light bulb as a source (250 W) (3 stations: code S13 - S15) (Fig. 1). The samples were preserved in ethanol (80%). In the laboratory, the identification was made up to a species level (Ciubuc, 2010).

Localizing the sampling stations and processing the data

The localization of sampling stations according to the code number and the life stage are as follows:

Larva phase: S1 (46°54'35.53" N and 21°40'11.33" E): fish pond; S2 (46°54'22.69" N and 21°39'27.55" E): fish pond; S3 (46°55'07.46" N and 21°37'52.26" E): Ateaş permanent slough; S4 (46°54'46.25" N and 21°41'54.66" E): collecting canal (Criş in the local toponymy); S5 (46°54'10.74" N and 21°37'37.88" E): Ateaş drainage canal; S6 (46°54'27.51" N and 21°39'38.06" E): pond feeder canal 14; S7 (46°54'12.56" N and 21°39'17.38" E): the canal near the visitation center; S8 (46°55'08.60" N and 21°40'39.01" E): canal 2; S9 (46°54'06.63" N and 21°37'29.04" E): canal 4; S10 (46°54'54.97" N and 21°37'20.63" E): Ateaş drainage canal; S11 (46°54'11.92" N and 21°38'55.14" E): canal 3; S12 (46°54'33.98" N and 21°39'53.87" E): canal 1 (Fig. 1).

Adult phase: S13 (46°54'41.25" N and 21°39'37.21" E): Cefa Nature Park visitation center; S14 (46°54'33.98" N and 21°39'53.87" E): the fish inn; S15 (46°54'46.08" N and 21°39'20.37" E): the forest range (Fig. 1).

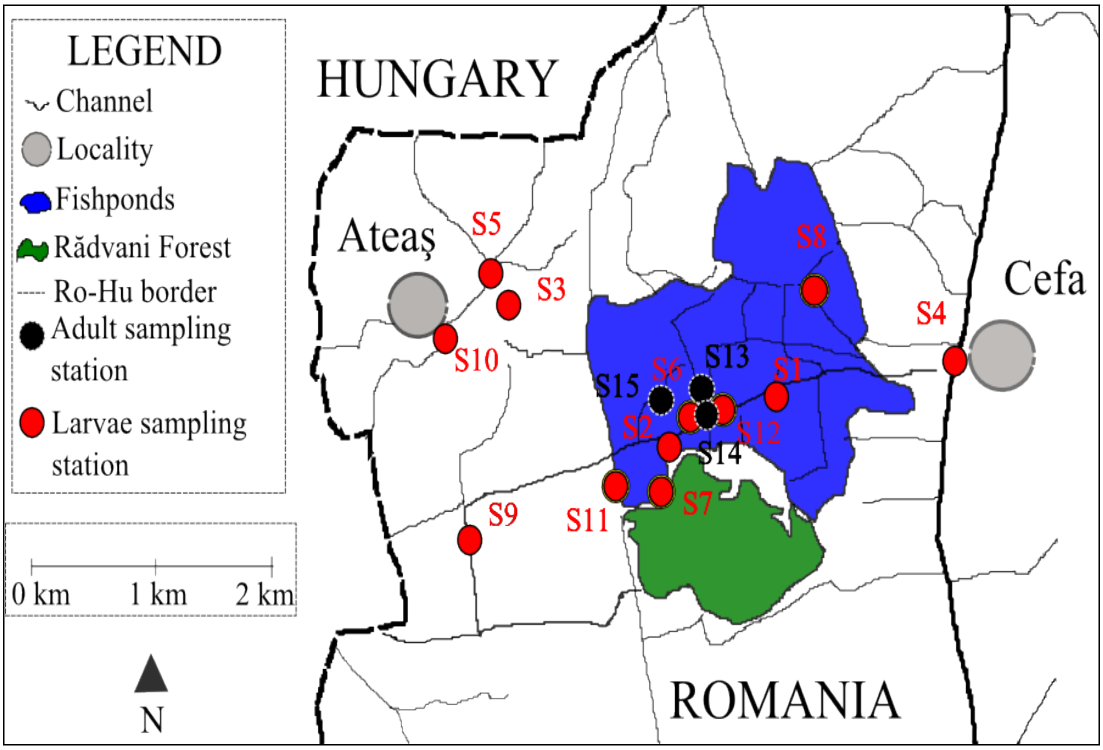


Figure 1: The location of the sampling sites
in Cefa Nature Park, 2006/2010-2011.

The density Di = ni Sp -1, abundance A= (ni N-1)*100 and frequency F = (Ni*100) Np-1 were further calculated, where ni represents the total number of individuals for the i species, Sp the total researched area, N the total number of individuals belonging to all species (from the sample or samples studied), Ni the number of stations where i species was identifies, Np total number of stations (Stan, 1995).

RESULTS

The sediment type corresponding to the benthos samples collecting points varied from the one with a slurry consistency (S1, S2), to the sandy - slurry and the fine detritus one (S3, S4, S7 - S9, S12), and to the sandy - clay one (S5, S6, S10, S11) (Tab. 1). The vegetation covering degree was found to be between 1-85%, with average canal depth and width values of 1.80±0.4 m, and 3.58±0.43 m, respectively. There were collected 543 larvae and 425 adults.

Table 1: Caddisflies species presence/absence (larva) in Cefa Nature Park, 2010-2011.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Hydropsyche angustipennis Curtis 1834	-	-	-	+	+	+	-	-	-	-	-	-
Polycentropus flavomaculatus Pictet 1834	-	-	-	+	+	+	-	-	-	-	-	-
Mystacides nigra Linnaeus 1761	-	-	-	+	-	-	-	-	-	-	-	+
Limnephilus affinis Curtis 1834	-	-	-	-	-	-	+	+	+	-	-	-
Limnephilus binotatus Curtis 1834	-	-	-	-	-	-	-	-	+	-	-	+
Limnephilus extricates McLachlan 1865	-	-	-	-	-	-	-	-	-	-	+	-
Limnephilus flavicornis Fabricius 1787	+	+	-	-	-	+	+	-	-	+	+	-
Limnephilus lunatus Curtis 1834	-	-	-	-	-	-	-	-	+	-	-	-
Limnephilus nigriceps Zetterstedt 1840	-	-	-	-	-	-	+	-	-	-	-	-
Limnephilus rhombicus Linnaeus 1758	-	-	+	-	-	-	+	-	-	-	+	+
Limnephilus stigma Curtis 1834	-	-	-	-	-	-	-	+	-	-	-	-
Hydroptila Clathrata Kolenati 1848	-	-	-	-	-	-	-	-	+	-	-	-
Orthotrichia flavicornis Pictet 1834	-	-	-	+	-	-	-	-	-	-	-	-

The larva phase: there were identified 6 genera included in a number of 6 families: Fam. Hydropsychidae: genus *Hydropsyche* (*H. angustipennis* Curtis 1834), Fam. Polycentropodidae: genus *Polycentropus* (*P. flavomaculatus* Pictet 1834), Fam. Leptoceridae: genus *Mystacides* (*M. nigra* Linnaeus 1761), Fam. Limnephilidae: genus *Limnephilus* (*L. affinis* Curtis 1834, *L. binotatus* Curtis 1834, *L. extricatus* McLachlan 1865, *L. flavicornis* Fabricius 1787, *L. lunatus* Curtis 1834, *L. nigriceps* Zetterstedt 1840, *L. rhombicus* Linnaeus 1758, *L. stigma* Curtis 1834), Fam. Phryganeidae: genus *Hagenella* (*H. clathrata* Kolenati 1848), Fam. Hydroptilidae: genus *Oxyethria* (*O. flavicornis* Pictet 1834).

The *Limnephilus* genus was dominant (8 species). The rest of genera comprised one species each (Tab. 1).

The main species of caddisflies identified in the aquatic phase together with the average density values, the numeric abundance percentages (%), and the frequency values were shown in the figure number 2.

The adult phase

There were identified 11 genera included in 9 families: Fam. Glossosomatidae: genus *Agapetus* (*A. laniger* Pictet 1834), Fam. Leptoceridae: genus *Athripsodes (A. cinereus* Curtis 1834), genus *Oecetis (O. furva* Rambur 1842, *O. lacustris* Pictet 1834, *O. notata* Rambur 1842, *O. ochracea* Curtis 1825), genus *Setodes* (*S. punctatus* Fabricius 1793), genus *Leptocerus* (*L. tineiformis Curtis 1834*), Fam. Psychomyiidae: genus *Ceraclea* (*C. dissimilis* Stephens 1836, *C. senilis* Burmeister 1839), genus *Psychomyia* (*P. pusilla* Fabricius 1781), Fam. Ecnomidae: genus *Ecnomus* (*E. tenellus* Rambur 1842), Fam. Hydropsychidae: genus *Hydropsyche* (*H. angustipennis* Curtis 1834, *H. bulgaromanorum* Malicky 1977, *H. contubernalis* McLachlan 1865, *H. incognita* Pitsch 1993, *H. modesta* Navas 1925), Fam. Limnephilidae: genus *Limnephilus* (*L. affinis* Curtis 1834, *L. auricula* Curtis 1834, *L. flavicornis* Fabricius 1787, *L. lunatus* Curtis 1834, *L. vittatus* Fabricius 1798), Fam. Polycentropodidae: genus *Polycentropus* (*P. flavomaculatus* Pictet 1834), genus *Neureclipsis* (*N. bimaculata* Linnaeus 1758), Fam. Hydroptilidae: genus *Hydroptila* (*H. angustata* Mosely 1939), genus *Orthotrichia* (*O. tragetti* Mosely 1930), and Fam. Phryganeidae: genus *Agrypnia* (*A. pagetana* Curtis 1835). The dominant genera were *Limnephilus* and *Hydropsyche*, with 5 species each (Tab. 2).

Table 2: Caddisflies species presence/absence (adults) in Cefa Nature Park, 2010-2011.

	2006	2010-2011		
	S15	S13	S14	S15
Agapetus laniger Pictet 1834	-	-	-	+
Athripsodes cinereus Curtis 1834	-	+	-	-
Oecetis furva Rambur 1842	-	+	+	+
Oecetis lacustris Pictet 1834	+	+	+	+

Table 2: Caddisflies species presence/absence (adults) in Cefa Nature Park, 2010-2011.

	2006	2010-2011		
	S15	S13	S14	S15
Oecetis notata Rambur 1842	-	-	-	+
Oecetis ochracea Curtis 1825	+	+	+	+
Setodes punctatus Fabricius 1793	-	-	-	+
Leptocerus tineiformis Curtis 1834	+	-	-	+
Ceraclea dissimilis Stephens 1836	-	+	-	+
Ceraclea senilis Burmeister 1839	-	-	-	+
Psychomyia pusilla Fabricius 1781	+	-	-	+
Ecnomus tenellus Rambur 1842	+	+	-	+
Hydropsyche angustipennis Curtis 1834	+	-	-	-
Hydropsych bulgaromanorum Malicky 1977	+	+	+	+
Hydropsyche contubernalis McLachlan 1865	-	+	+	+
Hydropsyche incognita Pitsch 1993	-	-	-	+
Hydropsyche modesta Navas 1925	-	+	-	+
Limnephilus affinis Curtis 1834	-	+	+	-
Limnephilus auricula Curtis 1834	-	+	-	-

Table 2: Caddisflies species presence/absence (adults) in Cefa Nature Park, 2010-2011.

	2006	2010-2011		
	S15	S13	S14	S15
Limnephilus flavicornis Fabricius 1787	+	+	-	+
Limnephilus lunatus Curtis 1834	+	-	+	-
Limnephilus vittatus Fabricius 1798	+	-	-	-
Polycentropus flavomaculatus Pictet 1834	+	-	-	-
Neureclipsis bimaculata Linnaeus 1758	+	+	+	+
Hydroptila angustata Mosely 1939	+	-	-	-
Orthotrichia tragetti Mosely 1930	+	-	-	-
Agrypnia pagetana Curtis 1835	+	-	-	-

DISCUSSIONS

The larva phase

The numerical abundance percentages have shown high values for 2 species belonging to genus *Limnephilus* (*L. flavicornis* - 24.29%, *L. affinis* - 21.25%) and a species belonging to genus *Hydropsyche* (*H. angustipennis* - 13.85%). The rest of the taxa had frequency values ranging from 6.45% (*L. rhombicus*) to 0.57% (*Hagenella clathrata*) (Fig. 2A).

The larvae of the *L. flavicornis* species feed on detritus and algae, being generally tolerat taxa when the qualitative parameters of the aquatic ecosystems change. This species is characteristic for sloughs, canals and ponds (Lepneva, 1971; Wood et al., 2001; Lorenz et al., 2004; Pascale et al., 2004). Inside the CPN, it was identified in 3 locations (S7, S10, S11).

The co-dominant taxa (*L. affinis*) was described by experts as being specific for the lake shores, both open and with an abundant vegetation, as well as for ponds, canals and lotic ecosystems with an average speed (Lepneva, 1971). In the present study, it was identified in the samples collected from 3 stations (S7, S8, S9).

The species of genus *Hydropsyche*, such as the one identified in the current study, are generally characteristic for the lotic ecosystems whose speed can vary from moderate to high, although their high tolerance to the water quality may suggest a large distribution (Admiraal et al., 2000; Bonada et al., 2004; Brunke, 2004). It was identified in the pond 14’s feeding canal (S6), the Ateaş evacuation canal (S5) and the collecting canal (S4).

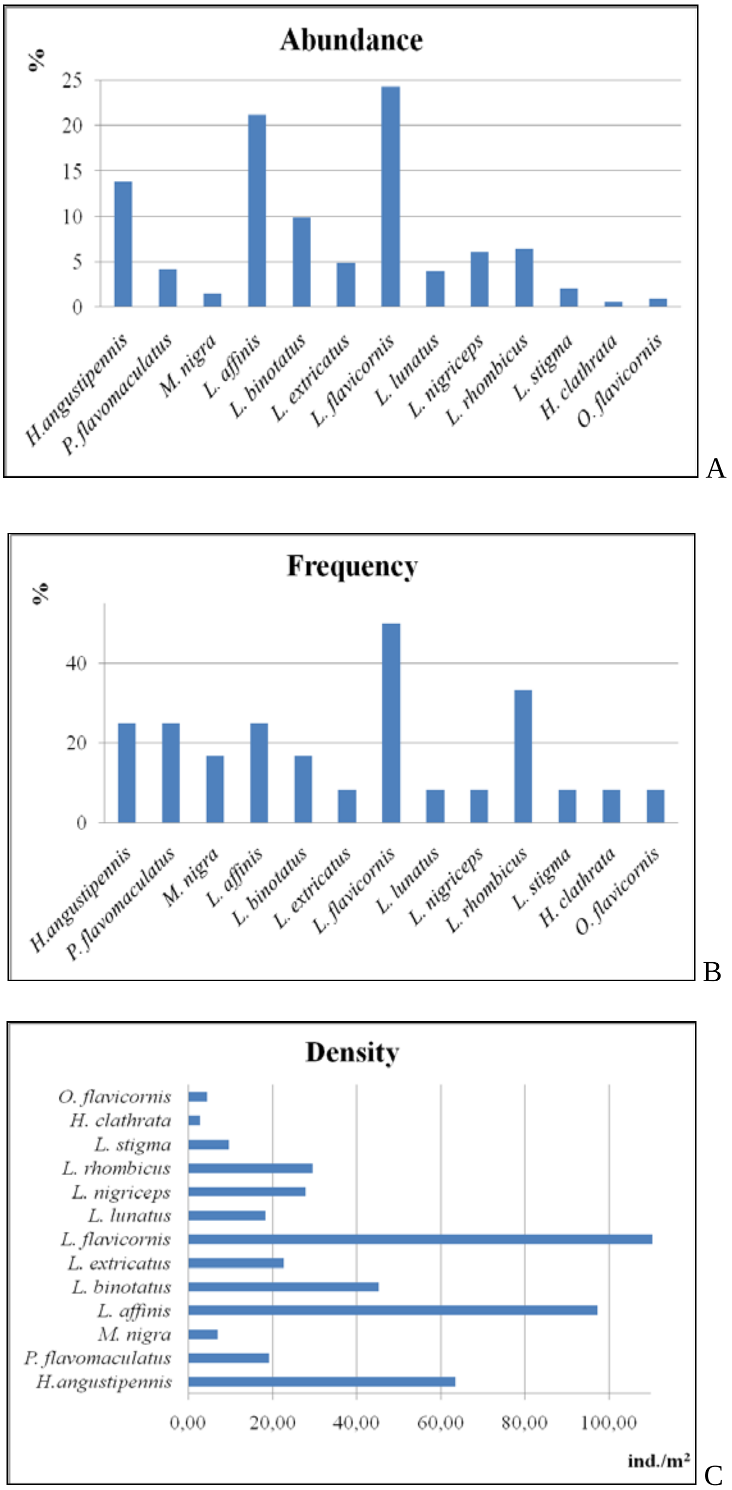


Figure 2: Percentage numerical abundance- % - (A), frequency - % - (B) and average density - ind./m^2 - (LC at 0.05 p) (C) of caddisflies species larvae in Cefa Nature Park, 2006/2010-2011.

As far as frequency is concerned, the *L. flavicornis* species values remained highest (50%), followed by *L. rhombicus* (33%), as opposed to the remaining species whose frequency did not go exceed 25%. As in the case of the majority of the species identified as belonging to the *Limnephilus*, *L. rhombicus* can be found in sloughs, lakes and well lightened canals, in the mires and the slowly flowing rivers (Lepneva, 1970). The lowest values were identified as belonging to 6 species, with a frequency value of 8% each (Fig. 2B).

Calculating the average density (LC = the confidence limit at 0.05p) there were noticed high values for the 3 species mentioned earlier, with a maximum of 111.11 ind./m^2 for *L. flavicornis*, followed by *L. affinis* (97,22 ind./m^2) and *H. angustipennis* (63.37 ind./m^2). The smallest value was established as belonging to *Hagenella clathrata* (2.60 ind./m^2) (Fig. 2C).

The adult phase

The collected samples which were processed to identify the adult phase showed a high numerical abundance percentage (%) for 4 of the 11 species identified in the current study (*E. tenellus* - 23.40%, *O. ochracea* and *N. bimaculata* with values of 15.20% each, and *C. dissimilis* - 11.20% respectively). The smallest numerical abundance percentages (0.20%) were established for the same number of species (*A. laniger*, *Ath. cinerea*, *S. punctatus*, *L. auricula*) (Fig. 3A).

Ecnomus tenellus is a highly frequent species, easily found in the lentic ecosystems (lakes, ponds, etc.), and very rarely in the lotic ones (epi/metapotomal), since it avoids the strong current and manifests a preference for those habitats that are characterized by a macrophites coverage which can exceed 20% (Waringer et al., 2005). As far as altitude goes, the species can be found with values under 150 m, and sometimes exceeding the maximum of 450 m altitude. This is a univoltine, stenotherm species which can be found at temperatures which exceed 18°C in the aquatic environment. Adults' flight duration is longer than 2 months (Graf et al., 2008).

Graf et al. (2008) describes the *O. ochracea* species as specific for the lentic and lotic ecosystems which have a reduced flowing speed and an altitude distribution similar to the species described beforehand. Being an eurytherm species, it manifests tolerance when the pH is being modified and has a salt level ranging from 0,5‰ - 34,7‰. The adults lifespan is one year and the flight duration is longer than 2 months (Hickin, 1967; Nedeaua et al., 2003; Bochert and Bochert, 2005). It was identified in all stations monitored in the current study, together with *N. bimaculata* (Tab. 2).

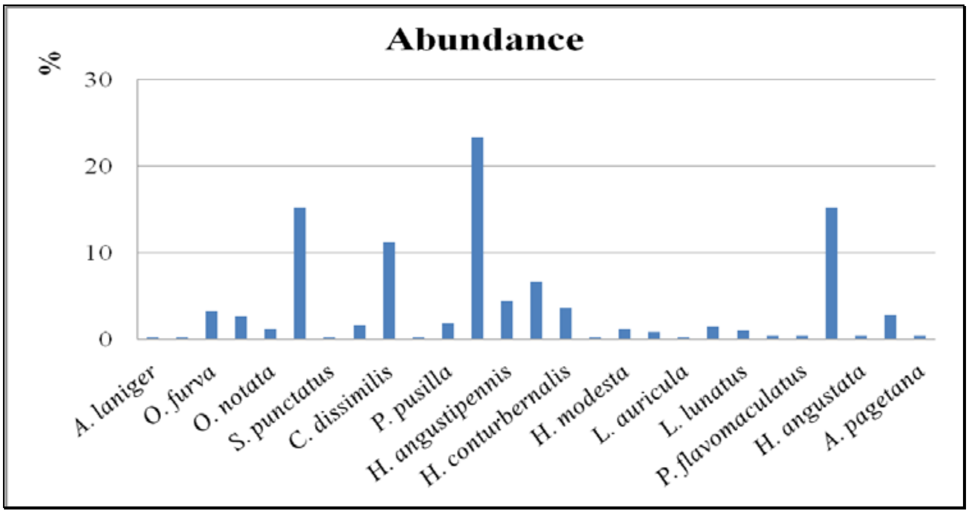
With a distribution and a preference similar for genus habitat, *N. bimaculata* can frequently be found at altitudes lower than 150 m (Graf et al., 2008). During the larva phase, it manifests tolerance to the acid pH and a salt level of 0,5‰ - 34,7‰ (Raddum and Fjellheim, 1984; Brunke, 2004). During reproduction, the adults' flight lasts less than 2 months (Graf et al., 2008).

Numerical abundance percentages were also established for *C. dissimilis*, identified (2010 - 2011) in 2 out of the 3 monitored stations (S13, S15). This is a species which during the larva phase is characterized by high tolerance to the modification of the water qualitative parameters and variation of pH. (Hickin, 1967; Elexová and Némethová, 2003).

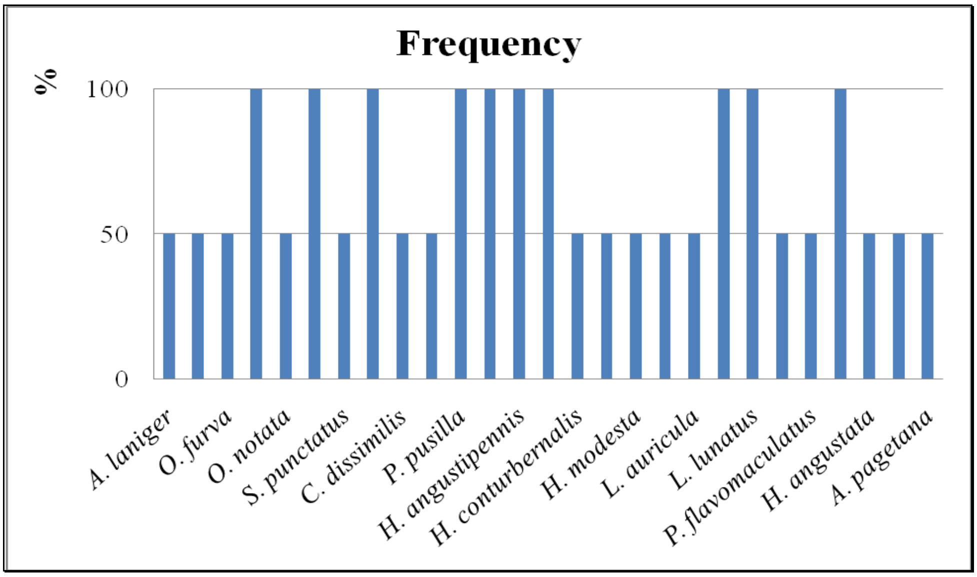
The frequency (%) shows maximum values for a great number of species (10), while the rest of the species identified in the Cefa Nature Park in the current study accumulated values of 50% each (Fig. 3B).

The hard bentic sublayer generally made up of fragments of average sized stones and sand (in the canals), specific habitats for the *H. bulgaromanorum* and *H. incognita*, alternate with areas of fine clay structures and organic fragments (in the lake areas belonging to the sme ecosystem). The organic content microhabitats are preferred by the *O. trageti*, identified both in the Danube Delta and in the flooded meadow, as well as in the slowly streaming waters in the Romanian Field. The submersed vegetation roots are the preferred microhabitats for species like *Mystacides*, *Oecetis*, *Neureclipsis*, *Ecnomus.*

The large part of the caddisfly species are potamobiont, although the diversity of the mirohabitats allows even the presence of those species such as *A. laniger* which is a species with a wider ecological spectrum.



A



B

Figure 3: Percentage numerical abundance- % - (A) and frequency - % - (B) of caddisflies species (adult stage) in Cefa Nature Park, 2006/2010 – 2011.

CONCLUSIONS

A number of 36 caddisflies species (13 - in the larva phase, 23 - in the adult phase) were identified in this survey in the Cefa Nature Park (2006/2010 - 2011). During the larva phase, the highest numerical abundance percentages and high density were established for 3 of the 13 species which had been identified (*Limnephilus flavicornis, Limnephilus affinis,* respectively *Hydropsyche angustipennis*). The lowest values were identified for *Hagenella clathrata*. The frequency showed maximum values for 2 of the species belonging to genus *Limnephilus* (*L. flavicornis, L. rhombicus*). During the adult phase, values of 100% frequency were noticed in 10 of the 26 species, while the remaining registered values of 50% each. The highest values of the numerical abundance percentages were established for 4 species identified at this stage (*Ecnomus tenellus*, *Oecetis ochracea*, *Neureclipsis bimaculata* and *Ceraclea dissimilis*).

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CONTRIBUTION TO THE KNOWLEDGE OF THE ORTHOPTERA FAUNA (CAELIFERA, ENSIFERA, DERMAPTERA, MANTODEA AND BLATTARIA) OF THE CEFA NATURE PARK (CRIŞANA, ROMANIA)

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ABSTRACT

The objective of this study is to create the first faunistic list of Orthoptera species (Insecta: Orthoptera) in the Cefa Nature Park of north-western Romania. The study site is located close to the border between Romania and Hungary, near the Körös-Maros/Criş-Mureş National Park. Four habitat types, listed on Annex I of the EU Habitats Directive, were identified. Five plots of approximately 1 hectare were established at the study site. Soil traps, vegetation sweeps, nets, visual observation and song identification were the methods used to survey Orthoptera species. During the duration of the study from April 2009 to March 2011, 40 species of Orthoptera were identified, which included 18 Ensifera, 17 Caelifera, 3 Blattaria, 1 Dermaptera and 1 Mantodea. One of these species, *Isophya stysi* Cejhan, 1957, is listed as a species subject to habitat conservation and management measures in Annex II and IV of the EU Habitats Directive.

ZUSAMMENFASSUNG: Beitrag zur Kenntnis der Orthopterenfauna (Caelifera, Ensifera, Dermaptera, Mantodea und Blattaria) des Naturparks Cefa (Crişana/Kreischgebiet, Rumänien).

Hauptziel dieser Arbeit war, das Vorkommen und die Verbreitung der Orthopteren (Blattaria, Dermaptera, Mantodea, Ensifera, Caelifera) in der Region um Cefa (Rumänien) zu dokumentieren. Das untersuchte Gebiet (UG) befindet sich im Nord-Westen Rumäniens an der Grenze zu Ungarn, nahe des Körös-Maros//Criş-Mureş Nationalparks. Im UG konnten vier Lebensraumtypen nach Anhang I der FFH Richtlinie ermittelt werden. Zur Erfassung der Orthopteren wurden 5 Untersuchungsflächen mit einer Größe von jeweils etwa 1 ha ausgewählt. Die Geradflügler wurden sowohl mittels qualitativer Methoden wie Sichtbeobachtung, Wenden von Steinen, Klopfen, Verhören und gezielter Hand- bzw. Kescherfänge, als auch quantitativer Methoden wie standardisierte Kescherfänge erfasst. Bodenfallen wurden auch eingesetzt. Im UG konnten 40 Arten von Geradflüglern, darunter 18 Ensiferen-, 17 Caeliferen-, 3 Blattarien-, 1 Dermapteren- und 1 Mantodeenart nachgewiesen werden. Ferner gelang der Nachweis einer FFH-Art, *Isophya stysi* Cejhan, 1957, die sowohl im Anhang II als auch im Anhang IV der FFH-Richtlinie gelistet ist. Um den Schutz dieser Art zu gewährleisten, müssen Gebiete von Gemeinschaftlicher Bedeutung gemeldet und ausgewiesen warden.

REZUMAT: Contribuţii la cunoaşterea faunei de ortoptere (Caelifera, Ensifera, Dermaptera, Mantodea şi Blattaria) din Parcul Natural Cefa (Crişana, România).

Scopul acestui studiu este de a crea prima listă a faunei de ortoptere (Insecta: Orthoptera) din cadrul Parcului Natural Cefa, localizat în Nord-Vest-ul României, la graniţa cu Ungaria, în vecinătatea Parcului Naţional Criş-Mureş/Körös-Maros. Patru habitate, listate în Directiva Habitate a Uniunii Europene, au fost identificate. Pentru studiul ortopterelor au fost desemnate 5 suprafeţe de aproximativ 1 hectar. Metodele folosite pentru capturarea ortopterelor au fost: metoda fileului standardizat, metoda de capturare cu fileul entomologic prin cosiri selective şi capturarea cu mâna, metoda ascultării stridulaţiilor (masculi), metoda numărării indivizilor (vizual) şi capcane Barber. Pe durata studiului, din aprilie 2009, până în Martie 2011, au fost identificate 40 de specii de Ortoptere, care includ 18 Ensifera, 17 Caelifera, 3 Blattaria, 1 Dermaptera şi 1 Mantodea. Una din speciile amintite, *Isophya stysi* Cejhan, 1957, este listată în Anexa II şi IV a Directivei Habitate a cărei conservare necesită desemnarea unor arii speciale de conservare.

INTRODUCTION

The purpose of this study is to contribute to the knowledge of the Orthopteran fauna (Grasshoppers, Crickets, Katydids, Locusts, Mantids, Earwigs and Cockroaches) of the Cefa Nature Park. This study also aims to examine the Orthoptera species in terms of their ecology. Some of the species are bioindicators and therefore, reflect the influence of human activity on the environment. An analysis of the Orthoptera species in terms of zoogeographical characteristics was also studied for the protected area.

The Cefa Nature Park is located in the northwestern part of Romania near Cefa on the Hungarian border in close proximity to Körös-Maros/Criş Mureş National Park (Hungary; Fig. 1). The site is located in Bihor County at elevations ranging from 84 to 107 meters.

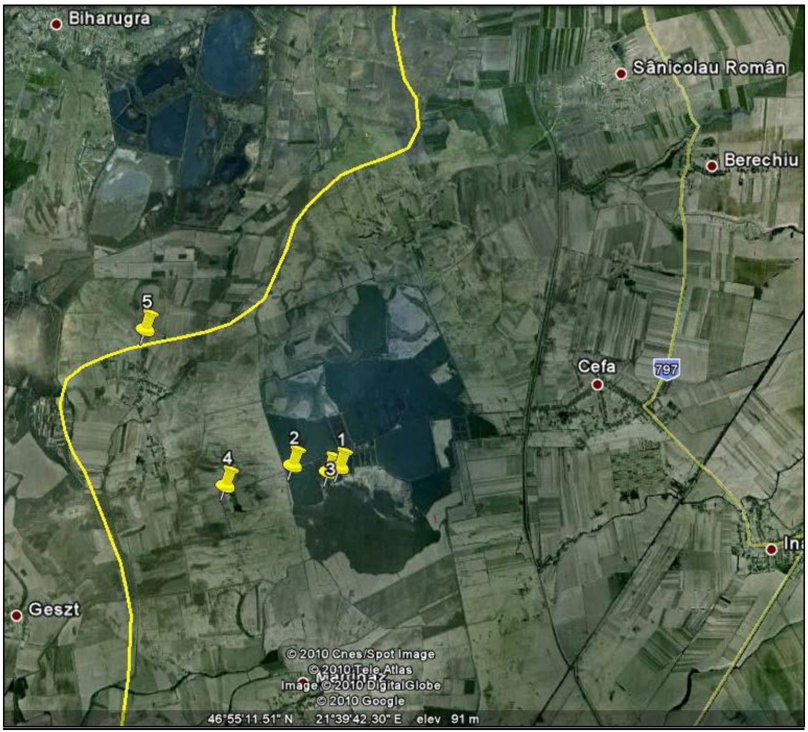

Figure 1: Map with locations of study plots (Google Earth, 2011).

MATERIAL AND METHODS

Five plots were setup and located in five different habitat types within the park. The plots were named as follows: plot 1 – meadow, plot 2 – pasture, plot 3 – wet meadow, plot 4 – fallow ground and plot 5 – salt marsh (Fig. 1). Each of the plots measured 1ha (100 x 100 m) and were marked. Five GPS points were taken in each plot (point 1-4 above the plot and the point 5 for a survey). Names of the plots were chosen based on habitat and soil type (Tab. 1). Plot abbreviations will be used in all future tables and charts.

For the purposes of the study, five plots were located in areas of varied habitats: the first was in a meadow, the second was in a pasture, the third was in a wet meadow, the fourth in a fallow ground and the fifth was located on salt marsh. Vegetation sampling was conducted during the growing season in each of these plots. The percent cover was estimated using a modified scale from Blanquet (1964).

Table 1: Name of the plots and the used abbreviations.

1. Meadow	M.
2. Pasture	P.
3. Wet meadow	W.m.
4. Fallow ground	F.g.
5. Salt marsh	S.m.

Field supplies used in the study were: entomological net (30 cm diameter), a GPS/PDA (ASUS A636), a camera CANON (Power Shot S31S), containers (400 ml) for Barber traps, collection containers with ethanol (50 ml), a container for Malaise trap and identification manuals. In the laboratory were used: a microscope, calipers, entomological pins, scissors and identification manuals. The collection of samples took place in the protected area during the years 2009 to early 2011. Inventory methods of Orthoptera fauna were: standardized net method, selectively capturing of samples by hand and placing them in an entomological net, by listening to the males' stridulations, by counting observed individuals, Barber traps, Malaise trap, tree canopy shaking method and raising stones and logs. All these methods were applied - each for a certain amount of time and in combination (Tab. 2).

Table 2: The program of collection samples.

Methods	Frequency of collections
Standardized net	2010: 28.05, 07.06, 24.06, 05-06.07, 12.07, 16.08, 20.09 2011: 25.03
Selective capture by hand and net	2009: August - September 2010: 28.05, 07.06, 24.06, 05-06.07, 12.07, 16.08, 20.09 2011: 25.03
Counting individuals	2010: 28.05, 07.06, 24.06, 05-06.07, 12.07, 16.08, 20.09 2011: 25.03
Barber traps	2009: April - September 2010: 08.02, 26-28.03, 30.04, 28.05
Listening to stridulations (males)	2010: 28.05, 07.06, 24.06, 05-06.07, 12.07, 16.08, 20.09 2011: 25.03
Malaise trap	2010: 12.07, 16.08, 20.09
Tree canopy shaking	2010: 05-06.07, 12.07, 16.08, 20.09
Turning stones and logs	2010: 28.05, 07.06, 24.06, 05-06.07, 12.07, 16.08, 20.09

The standardized net method is a means by which samples can be collected semiquantitative and consists of using an entomological net within an area of the 1 ha plot. This method was applied in each of the five study plots: meadow, pasture, wet meadow, fallow ground and salt marsh, from May 2010 to March 2011.

Barber traps were placed in the five habitats. In each of these habitats, ten batteries were located with 1 in the middle and 9 around it. Each trap bottle (400 ml) contained 75% antifreezing solution and 25% water and was filled up to ¾. The traps were checked for 12 months.

A Malaise trap is a trap for flying insects. The one used in this study, and it was located near the administration for three months. The container for this trap contained 25% formalin and 75% water. The trap was checked and samples were collected twice a month.

A series of Identification Manuals were used to determine the plant species in the protected area: Ciocarlan (2000), Grau et al. (1989), Jávorka and Csapody (1979), Prodan (1939) and Speta and Rákosy (2010); for plant associations: Doniţă et al. (1992); habitats determination: Doniţă et al. (2005), Gafta and Mountford (2008) and Schneider and Drăgulescu (2005), to identify Ortoptera species: Kis (1976) and Harz (1969), for Ensifera and Caelifera: Kis (1978a), Harz (1975), Bellmann (2006), Baur et al. (2006), Iorgu et al. (2008), Kocárek et al. (2005), Szij (2004) and Fontana et al. (2002). We also used Bellmann, (2004). The identification of larvae became possible by using Oschmann (1968) and Ingrisch (1977).

The abbreviations which were used in the charts and tables for the lists of Orthoptera species (Ensifera, Caelifera, Dermaptera, Mantodea and Blattaria) identified in this study are presented in the table number 1.

Table 3: Abbreviations of Orthoptera species.

Species	Species abbreviations
Phaneroptera nana Fieber, 1853	P. nan
Leptophyes albovittata (Kollar, 1833)	L. alb
Isophya stysi Cejchan, 1957	I. sty
Polysarcus denticauda (Charpentier, 1825)	P. den
Conocephalus fuscus Fabricius, 1781	C. fus
Ruspolia nitidula Scopoli, 1786	R. nit
Tettigonia viridissima Linnaeus, 1758	T. vir
Decticus verrucivorus (Linnaeus, 1758)	D. ver
Gampsocleis glabra Herbst, 1758	G. gla
Platycleis affinis Fieber, 1853	P. aff

Table 3 (continuing): Abbreviations of Orthoptera species.

Species	Species abbreviations
Platycleis veyseli Kocak, 1984	P. vey
Metrioptera roeselii (Hagenbach, 1822)	M .roe
Gryllotalpa gryllotalpa (Linnaeus, 1758)	G. gry
Oecanthus pellucens Scopoli, 1763	O. pel
Pteronemobius heydenii Fischer, 1853	P. hey
Gryllus campestris Linnaeus, 1758	G. cam
Melanogryllus desertus (Pallas, 1771)	M.des
Eumodicogryllus bordigalensis (Latreille, 1804)	E. bor
Tetrix ceperoi (Bolivar, 1887)	T. cep
Tetrix subulata (Linnaeus, 1758)	T. sub
Tetrix tenuicornis Sahlberg, 1893	T.ten
Pezotettix giornae (Rossi, 1794)	P. gio
Acrida ungarica Herbst, 1786	A. ung
Aiolopus thalassinus Fabricius, 1781	A. tha
Chrysochraon dispar (Germar, 1834)	C. dis
Stenobothrus stigmaticus (Rambur, 1838)	S. sti
Omocestus rufipes (Zetterstedt, 1821)	O. ruf
Omocestus haemorrhoidalis (Charpentier, 1825)	O. hae
Chorthippus oschei Helversen, 1986	C. osc
Chorthippus brunneus (Thunberg, 1815)	C. bru
Chorthippus biguttulus (Linnaeus, 1758)	C. big
Chorthippus dorsatus (Zetterstedt, 1821)	C. dor
Chorthippus mollis (Charpentier, 1825)	C. mol

Table 3 (continuing): Abbreviations of Orthoptera species.

Species	Species abbreviations
Chorthippus parallelus (Zetterstedt, 1821)	C. par
Chorthippus brunneus (Thunberg, 1815)	C. bru
Chorthippus biguttulus (Linnaeus, 1758)	C. big
Chorthippus dorsatus (Zetterstedt, 1821)	C. dor
Chorthippus mollis (Charpentier, 1825)	C. mol
Chorthippus parallelus (Zetterstedt, 1821)	C. par
Euchorthippus declivus (Brisout de Barneville, 1849)	E. dec
Chorthippus mollis (Charpentier, 1825)	C. mol
Chorthippus parallelus (Zetterstedt, 1821)	C. par
Euchorthippus declivus (Brisout de Barneville, 1849)	E. dec
Forficula auricularia Linnaeus, 1758	F. aur
Mantis religiosa (Linnaeus, 1758)	M. rel
Ectobius balcani Ramme, 1923	E. bal
Ectobius lapponicus (Linnaeus, 1758)	E. lap
Phyllodromica megerlei (Fieber, 1853)	P. meg

RESULTS

The total number of Orthoptera species found in Cefa Nature Park was 40.

Habitats

We identified four Natura 2000 habitats on the selected plots: in the meadow (coordinate: 46.9031716666667, 21.6561583333333, 61.6999999999999 alt.) **Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*) (6510)**, in the pasture (coordinate: 46.9034516666667, 21.6462816666667, 58.7 alt.) **Pannonic loess steppic grasslands (6250*)**, in the wet meadow (coordinate: 46.9025166666667, 21.6538566666667, 50.9 alt.) **Hydrophilous tall herb fringes communities of plains and of the montane to alpine levels** (**6430)** and in the salt marsh (coordinate: 46.9230578333333, 21.615277, 54.69 alt.) **Pannonic salt steppes and salt marshes (1530*)** (Fig. 2). Two of them are priority habitats (*) and needs of protection; it is recommended to render them as natural protected areas.

Figure 2: The Pannonic salt steppes and salt marshes habitat (foto by Hoffmann, 2009).

All of these habitats identified for protection are listed in the EU Habitats Directive, with other habitats of community and national interest. In addition, all of these habitats are listed in the area protected standard list with the exception of the **Pannonic loess steppic grasslands.** The fallow ground plot (coordinate: 46.90052, 21.6321383333333, 62.6 alt.) was selected for studying the sequence with which the ortoptera species recolonize the area.

Orthoptera (Ensifera et Cealifera, Dermaptera, Mantodea and Blattaria)

During the study, we identified 40 Orthoptera species (18 Ensifera, 17 Caelifera, 3 Blattaria, 1 Dermaptera and 1 Mantodea) in the protected area. One of them is listed in Annex II and IV of the EU Habitats Directive. It is *Isophya stysi* Cejchan, 1957, a species that was not listed in protected area until now (Fig. 4).

731 individuals were captured during the study (Tab. 4). In the plots, the samples were thus divided: in the meadow-159 individuals, in the pasture and wet meadow-158 individuals, in the fallow ground-58 individuals, in the salt marsh-100 individuals and in the other plots of the protected area - 98 individuals. In terms of species composition in the studied plots, we obtained the following data: *Chorthippus sp.* (134 individuals), E.dec (86 individuals), C.par (77), C.fus (56), O.ruf (50), A.tha (47), P.aff (43), M.des (42), M.roe (37), C.osc (20), C.dor (19), P.hey (15), M.rel (11) (Fig. 3), L.alb (8), E.bor (8), T.vir (6), C.big (6), A.ung (5), O.pel (5), C.dis (5), S.sti (5), C.bru (5), G.cam (4), T.ten (4), P.vey (3), T.sub (3), O.hae (3), F.aur (3), E.lap (3), P.meg (3), R.nit (2), D.ver (2), P.gio (2), E.bal (2), P.nan (1), I.sty (1), P.den (1), G.gla (1), G.gry (1), T.cep (1) and C.mol (1).

Figure 3: Mantis religiosa (Linnaeus, 1758) ♀ (Hoffmann, 2009).

Figure 4: *Isophya stysi* Cejchan, 1957 ♀ (Hoffmann, 2009).

Table 4: All Orthoptera species (Ensifera, Caelifera, Dermaptera, Mantodea, Blattaria) inventoried in the protected area [Heller et al. (1998)]; *****: other plots in the Cefa Nature Park.

Taxon	Study plots						Total
Ensifera	M.	P.	W. m.	F. g.	S. m.	*	
Phaneroptera nana Fieber, 1853	1	-	-	-	-	-	1
Leptophyes albovittata (Kollar, 1833)	-	-	1	7	-	-	8
Isophya stysi Cejchan, 1957	-	-	1	-	-	-	1
Polysarcus denticauda (Charpentier, 1825)	-	-	-	-	1	-	1
Conocephalus fuscus (Fabricius, 1793)	19	9	11	8	2	7	56
Ruspolia nitidula (Scopoli, 1786)	-	-	-	-	-	2	2
Tettigonia viridissima Linnaeus, 1758	3	1	-	-	2	-	6
Gampsocleis glabra (Herbst, 1786)	-	1	-	-	-		1
Decticus verrucivorus verrucivorus (Linnaeus, 1758)	-	1	-	-	-	1	2
Platycleis (Platycleis) affinis Fieber, 1853	2	12	21	-	8	-	43
Platycleis (Tessellana) veyseli Kocak, 1984	-	-	-	2	1	-	3
Metrioptera (Metrioptera) roeselii (Hagenbach, 1822)	1	9	13	5	9	-	37
Gryllotalpa gryllotalpa (Linnaeus, 1758)	-	1	-	-	-	-	1
Oecanthus pellucens (Scopoli, 1763)	3	-	2	-	-	-	5
Pteronemobius heydenii (Fischer, 1853)	4	2	3	-	6	-	15
Gryllus campestris Linnaeus, 1758	1	3	-	-	-	-	4
Melanogryllus desertus (Pallas, 1771)	4	5	-	-	3	30	42
Eumodicogryllus bordigalensis (Latreille, 1804)	-	-	-	-	-	8	8

Table 4 (continuing): All Orthoptera species (Ensifera, Caelifera, Dermaptera, Mantodea, Blattaria) inventoried in the protected area [Heller et al. (1998)]; *****: other plots in the Cefa Nature Park.

Taxon	Study plots						Total
Caelifera							
Tetrix ceperoi (Bolivar, 1887)	-	-	-	-	-	1	1
Tetrix subulata (Linnaeus, 1758)	1	-	1	-	-	1	3
Tetrix tenuicornis Sahlberg, 1893	1	-	-	2	1	-	4
Pezotettix giornae (Rossi, 1794)	1	-	-	-	-	1	2
Acrida ungarica (Herbst, 1786)	-	1	-	-	3	1	5
Aiolopus thalassinus (Fabricius, 1781)	3	11	1	-	20	12	47
Chrysocraon dispar (Germar, 1834)	-	-	5	-	-	-	5
Stenobothrus stigmaticus (Rambur, 1838)	4	-	-	-	1	-	5
Omocestus rufipes (Zetterstedt, 1821)	13	5	7	3	13	9	50
Omocestus haemorrhoidalis (Charpentier, 1825)	1	-	-	-	-	2	3
Chorthippus oschei Helversen, 1986	1	5	-	1	5	8	20
Chorthippus brunneus (Thunberg, 1815)	2	-	1	1	-	1	5
Chorthippus biguttulus (Linnaeus, 1758)	-	-	1	4	-	1	6
Chorthippus dorsatus (Zetterstedt, 1821)	4	2	1	1	3	8	19
Chorthippus mollis (Charpentier, 1825)	-	-	-	-	-	1	1
Chorthippus parallelus (Zetterstedt, 1821)	10	27	28	4	8	-	77
Euchorthippus declivus (Brisout de Barneville, 1848)	56	4	19	3	-	4	86
Chorthippus sp.	16	60	34	14	10	-	134

Table 4 (continuing): All Orthoptera species (Ensifera, Caelifera, Dermaptera, Mantodea, Blattaria) inventoried in the protected area [Heller et al. (1998)]; *****: other plots in the Cefa Nature Park.

Taxon	Study plots						Total
Dermaptera							
Forficula auricularia Linnaeus, 1758	3	-	-	-	-	-	3
Mantodea							
Mantis religiosa (Linnaeus, 1758)	-	-	8	-	3	-	11
Blattaria							
Ectobius (Ectobius) balcani (Ramme, 1923)	2	-	-	-	-	-	2
Ectobius (Ectobius) lapponicus (Linnaeus, 1758)	3	-	-	-	-	-	3
Phyllodromica megerlei (Fieber, 1853)	-	-	-	3	-	-	3
Total	159	158	158	58	100	98	731

It was found that the plots with the most favorable conditions for Orthoptera fauna were the meadow, the pasture and the wet meadow, with the greatest diversity of species (Fig. 5). The bar chart below also shows that the species *Conocephalus fuscus* and *Chorthippus parallelus* were present in all of the plots, while *Isophya stysi* only existed in the wet meadow plot, *Gampsocleis glabra* and *Gryllotalpa gryllotalpa* at the pasture, *Phaneroptera nana* only in the meadow, *Polysacus denticauda* only in the salt marsh, *Phyllodromica megerlei* only in the fallow ground plot and *Platycleis affinis* was absent just from the fallow ground plot and *Euchorthippus declivus* only from the salt marsh.

In the present study, we examined some of the ecological aspects of ortoptera, like humidity of the site, the way of life of the species, the associated substrate type and hemerobiotic degree of species. By analyzing the ecological characteristics of Ensifera we determined that most of the species were xerophilous (6 species) followed by xero-mesophilous species (3) (Tab. 5).

Concerning the landscape structure, most frequent of Ensifera was that praticol (10 species) and the substrate type populated the most was graminicol (6 species). The species with an average tolerance to human disturbance were the most common (10), followed by the sensitive species (5) and some others that had a high tolerance (3).

Most Caelifera were xerophilous (8), followed by hygrophyllous (4), mesophilous (2), xero-mesophilous (2) and single representative from hygrophyllous to mesophilous (Tab. 6). The Caelifera’s most common landscape structure was praticol (9), followed by desert/praticol (7) and ripicol (1). The most common species were graminicol (10), in terms of substrate type, fewer terricol (2) and terri/graminicol (2) and just one geophil, gramini/arbisticol and from geophil to phitophil. Based on their hemerobiotic degree, most species had an average tolerance to human disturbance (8), some were less sensitive (6) and a few had a high tolerance (3).

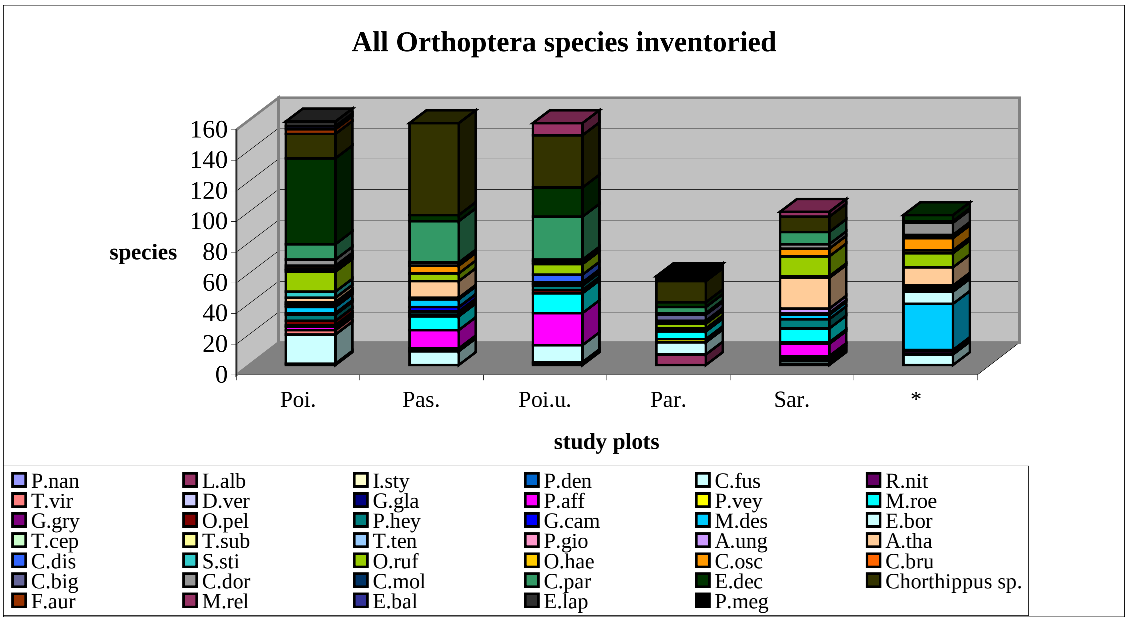

Figure 5: Diagram of the species found on each surface part.

Table 5: Ecological characteristics of Ensifera species [Pisica and Iorgu (2006); Hoffmann (2009); Ingrisch and Köhler (1998)]; Hem. – hemerobiotic degree, om – oligo-mesohemerob, ome – oligo-meso-euhemerob, omep – oligo-meso-eu-polyhemerob. (taxons abreviations in Tab. 3).

Taxon	Ecological characteristics			
Ensifera	Humidity	Landscape structure	Substrate type	Hem.
P. nan	xero-mesophilous	deserti/praticol	arbusti/arboricol	ome
L. alb	meso-xerophilous	deserti/praticol	gramini/arbusticol	ome
I. sty	meso-xerophilous	praticol	gramini/arbusticol	om
P. den	hygro-mesophilous	praticol	geocol-graminicol	ome
C. fus	hygro-mesophilous	ripi/praticol	graminicol	ome
R. nit	hygrophyllous - meso-xerophilous	praticol	gramini/arbusticol	om
T. vir	mesophilous	prati/silvicol	arbusti/arboricol	ome
D. ver	xero-mesophilous	praticol	graminicol	ome
G. gla	xerophilous	praticol	graminicol	ome
P. aff	xerophilous	deserti/praticol	graminicol	om
P. vey	xerophilous	praticol	graminicol	om
M .roe	hygrophyllous	praticol	graminicol	om
G. gry	hygrophyllous -mesophilous	ripi/praticol	geobiont	omep
O. pel	xerophilous	deserti/praticol	graminicol-arboricol	omep
P. hey	hygrophyllous	praticol	terricol	ome
G. cam	xero-mesophilous	deserti/praticol	terricol	ome
M. des	xerophilous	praticol	geobiont-terricol	omep
E. bor	xerophilous	praticol	geobiont-terricol	ome

Table 6: Ecological characteristics of Caelifera species (Pisica and Iorgu, 2006; Hoffmann, 2009; Ingrisch and Köhler, 1998); Hem. – hemerobiotic degree, om – oligo-mesohemerob, ome – oligo-meso-euhemerob, omep – oligo-meso-eu-polyhemerob.

Taxon	Ecological characteristics			
Caelifera	Humidity	Landscape structure	Substrate type	Hem.
T.cep	hygrophyllous	ripicol	geophil	om
T.sub	hygrophyllous	praticol	terricol	ome
T.ten	xerophilous	praticol	terricol	ome
P.gio	xerophilous	deserti/praticol	gramini/arbusticol	ome
A.ung	xerophilous	deserti/praticol	graminicol	om
A.tha	hygrophyllous	praticol	geophil-phitophil	ome
C.dis	hygrophyllous	praticol	graminicol	om
S.sti	xerophilous	praticol	terri/graminicol	ome
O.ruf	xero-mesophilous	deserti/praticol	graminicol	ome
O.hae	xerophilous	deserti/praticol	graminicol	om
C.osc	hygrophyllous - mesophilous	praticol	graminicol	ome
C.bru	xerophilous	deserti/praticol	terri/graminicol	omep
C.big	xero-mesophilous	deserti/praticol	graminicol	omep
C.dor	mesophilous	praticol	graminicol	om
C.mol	xerophilous	deserti/praticol	graminicol	om
C.par	mesophilous	praticol	graminicol	omep
E.dec	xerophilous	praticol	graminicol	ome

The table number 7 shows the ecological characteristics of Dermaptera, Mantodea and Blattaria species, otherwise: *Forficula auricularia* presents a high tolerance to human disturbance, it is mesophilous, campi/prati/silvi/deserticol and terri/gramini/arbusti/arboricol, *Mantis religiosa* was xerophilous, with a preference landscape structure of deserti/praticol, it lived on the substrate gramini/arbusticol and had an average tolerance to the human disturbance. The Blattaria species are meso-xerophilous, two of them are silvi/praticols and one prati/silvicol. They live on the substrate type from terricol to arbusticol and terri/graminicol, and all have a high tolerance towards human disturbance (Tab. 7).

Table 7: Ecological characteristics of Dermaptera, Mantodea and Blattaria species (Pisica and Iorgu, 2006; Hoffmann, 2009; Ingrisch and Köhler, 1998); Hem. – hemerobiotic degree, om – oligo-mesohemerob, ome – oligo-meso- euhemerob, omep – oligo-meso-eu-polyhemerob.

Taxon	Ecological characteristics			
Dermaptera	Humidity	Landscape structure	Substrate type	Hem.
F.aur	mesophilous	campi/prati/silvi/deserticol	terri/gramini-arboricol	omep
Mantodea				
M.rel	xerophilous	deserti/praticol	gramini/arbusticol	ome
Blattaria				
E.bal	meso-xerophilous	silvi/praticol	terricol-arbusticol	omep
E.lap	meso-xerophilous	silvi/praticol	terricol-arbusticol	omep
P.meg	meso-xerophilous	prati/silvicol	terri/graminicol	omep

Of all the othoptera species, the most common were xerophilous (15 species) followed by hygrophyllous (6 species), meso-xerophilous (5 species), xero-mesophilous (5 species), mesophilous (4 species), hygro-mesophilous (2 species), from hygrophyllous to mesophilous (2 species) and one species from hygrophyllous to meso-xerophilous (Fig. 6). The landscape preference of the Orthoptera species is represented in the figure number 7. 19 species were praticol, 13 deserti/praticol, 2 silvi/praticol, 2 prati/silvicol, 2 ripi/praticol and one ripicol and campi/prati/silvi/deserticol (Fig. 7).

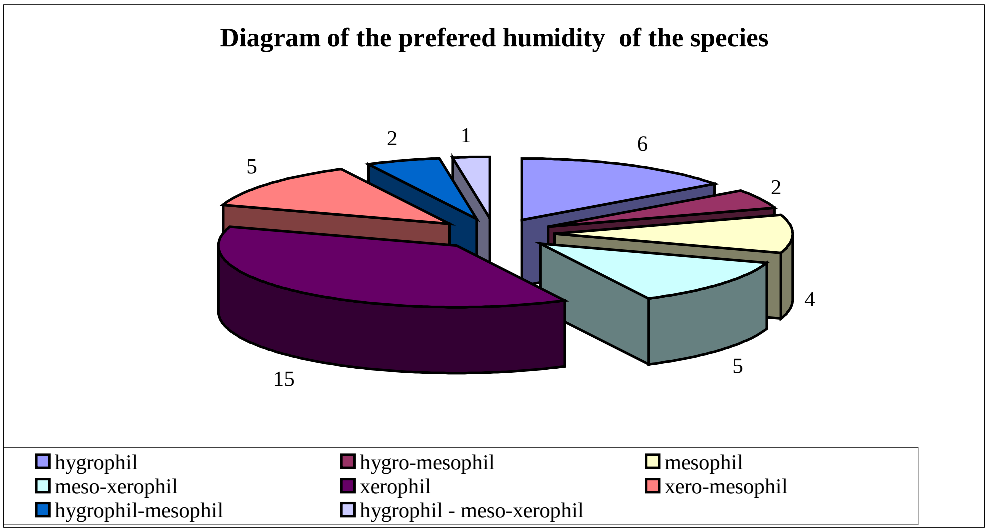

Figure 6: Diagram of the preferred humidity of the Orthoptera species in the study plots.

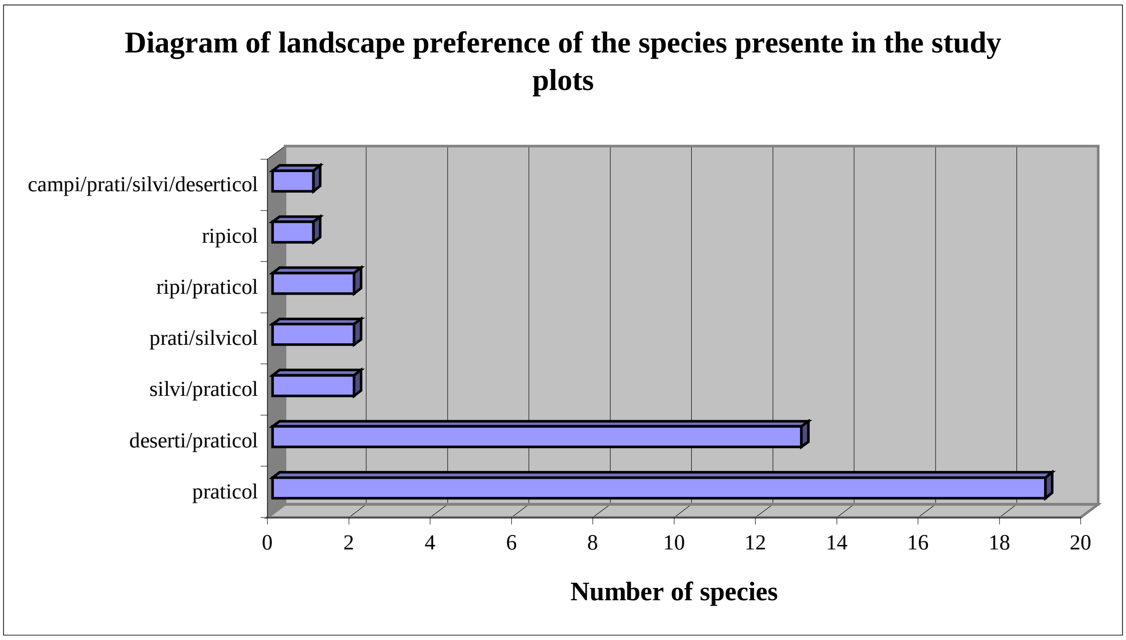

Figure 7: Diagram of landscape preference of species from the study plots.

In the diagram of substrate types associated with the Orthoptera in the protected area, we observed that the most of the species were graminicols (16 species), followed by gramini/arbusticols (5 species), terricols (4 species) and others (Fig. 8).

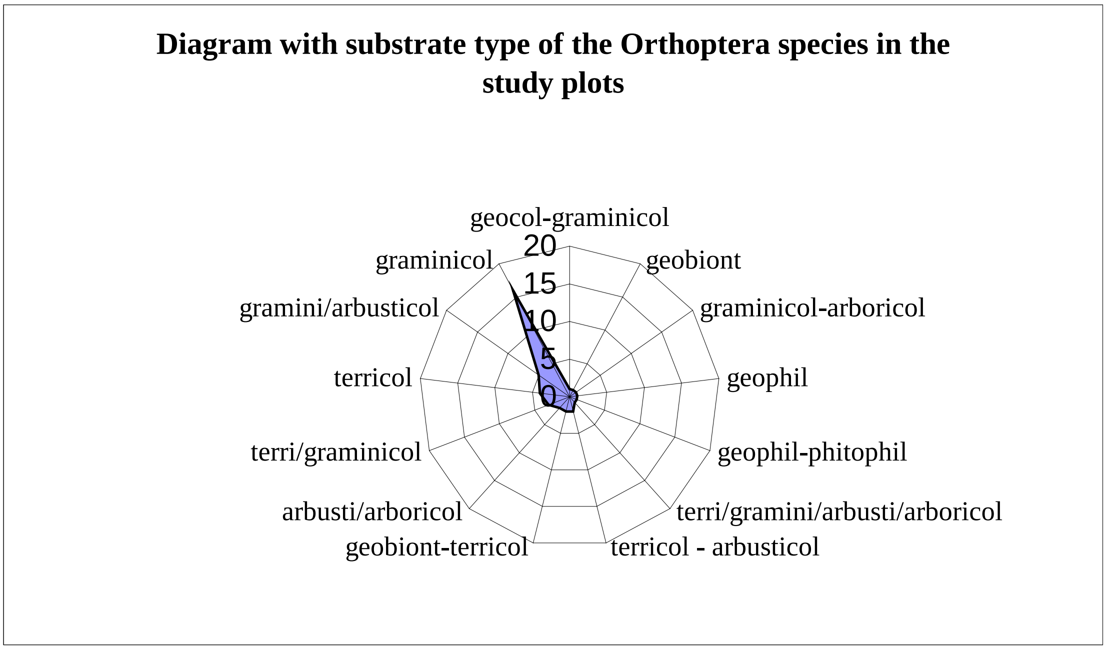

Figure 8: Diagram with substrate type of species.

In terms of the tolerance of species to the human disturbance, our analysis of this ecological characteristic gave the following results: 19 species had an average tolerance, 11 species had a low tolerance and 10 species had a high tolerance (Fig. 9).

The table number 8 depicts the origin and distribution of the inventoried species in this study which are varied. These will be presented below in the figures number 9 and 10.

In the table number 8 are presented the yzogeographical characteristics of Orthopteran fauna (Ingrisch and Köhler, 1998)] with the following abreviations: **Origin**: A – Angar; At – Atlantic; Atm – Atlantomediteran; Af – African; Af-T – Afro-Tropical; CM – Circum-Mediterranean; M – Mediterranean; NAt – Neoatlantic; NM – Neomediterranean; PEg – Paleoegeic; Po – Pontic; PT – Paleotropical; Rt – Relict tertiar; T – Tropical; **Distribution:** Af – African; CE – Central-European; CM – Circum-Mediterranean; Cos – Cosmopolitan; CSE – Central-Sud-European; CSEE – Central-Southeast-Easteuropean; EE – Est-European; EU – European; Es – Eurosiberian; H – Holarctic; M – Mediterranean; P – Palearctic; Pom – Pontomediterranean; Po – Pontic; PT – Paleotropical; SE – Sud-European; SEE – Sud-Est-European; SEAf – Sud-Est-African; SWAs – Sud-West-Asiatic; WAs - West-Asiatic; WE – west-European; WEs – West-Eurosiberian; WP – West-Palearctic.

Table 8: Zoogeographical characteristics of Orthopteran fauna, by Ingrisch and Köhler (1998).

Taxon	Zoogeographical characteristics		Taxon	Zoogeographical characteristics	
Ensifera	Origin	Distribution	Caelifera	Origin	Distribution
P.nan	T	CM	T.cep	Atm	WE
L.alb	At-Po	Po	T.sub	Rt-A-At-T	H
I.sty	Po	EE	T.ten	Rt-A-At-T	P
P.den	Po	CSE	P.gio	NM	M-SE
C.fus	T	P	A.ung	Af-T	SE-Af
R.nit	T	PT-M	A.tha	PT	P-Af-SWAs
T.vir	A-At	P	C.dis	A	Es
D.ver	A	Es	S.sti	A	P
G.gla	Po-A	WEs	O.ruf	A	Es
P.aff	PEg-At	M-WAs	O.hae	NAt ?	WP
P.vey	PEg	EE-SEE	C.osc	A	P
M.roe	A	Es	C.bru	A	Es
G.gry	At-T	P	C.big	A	Es
O.pel	T?	P	C.dor	A	Es
P.hey	T	M-CE-SWAs	C.mol	A	Es
G.cam	M-T	P	C.par	A	P
M.des	Po	P	E.dec	Po	SE
E.bor	M	P			
Dermaptera			Blattaria		
F.aur	EU	Cos	E.bal	?	SEE
Mantodea			E.lap	?	EU
M.rel	AF	Pom	P.meg	?	CSEE

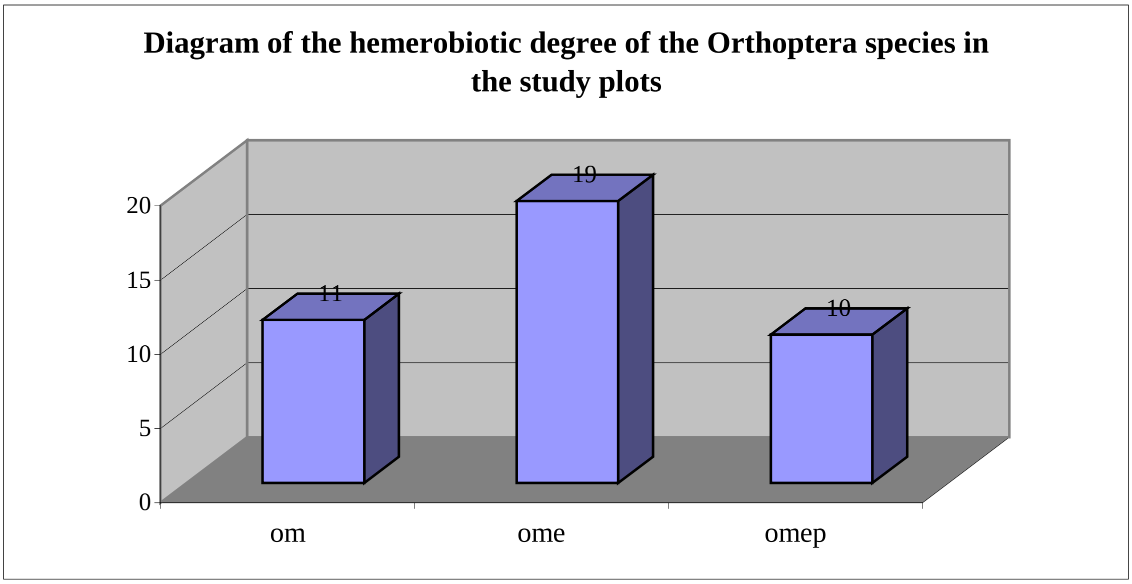

Figure 9: Diagram of the hemerobiotic degree of the Orthoptera species in the study plots.

The origin of the sampled species was varied. Most of the species had an angar origin, followed by tropical origin, pontic etc. (Fig. 10).

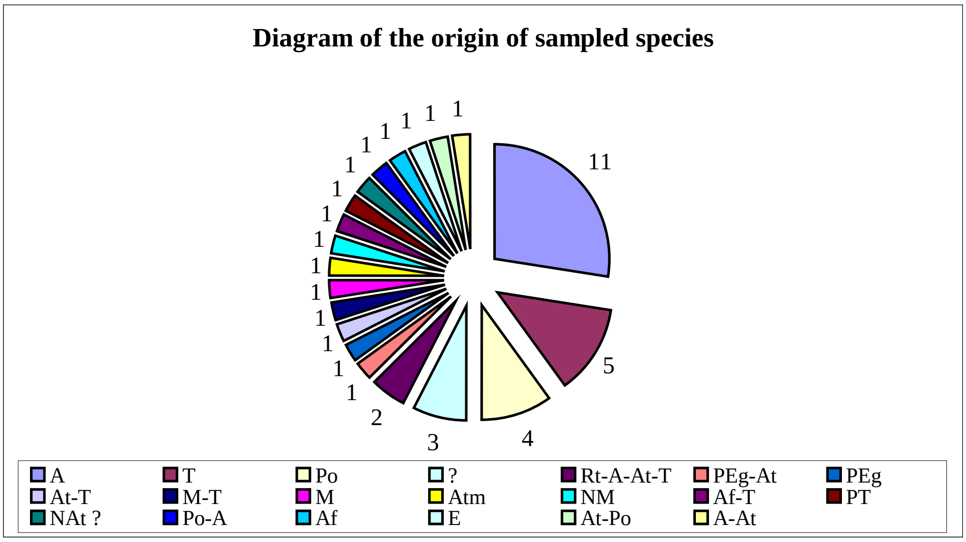

Figure 10: Diagram of the origin of sampled species.

The distribution of sampled species in the protected area is presented in the figure number 11. Most species have a palearctic distribution, followed by eurosibirian species; the other categories had fewer representative.

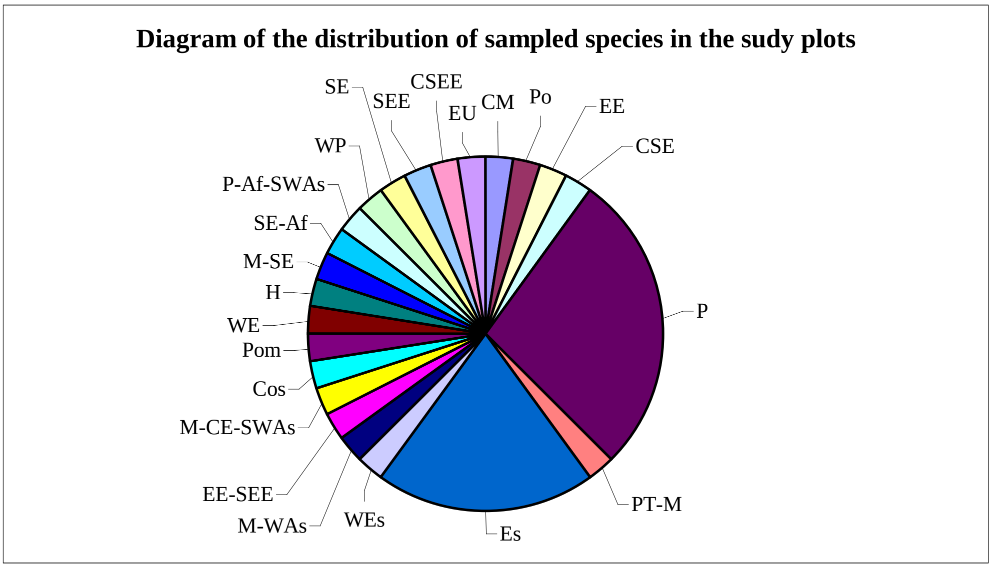

Figure 11: Diagram of the distribution of the Orthoptera species from the Cefa Nature Park.

In the figure number 12 we can see a very close relationship between the species: *Chrysochraon dispar*, *Chorthippus biguttulus*, *Chorthippus brunneus*, *Conocephalus fuscus*, *Euchorthippus declivus*, *Isophya stysi*, *Leptophyes albovittata*, *Metrioptera roeselii*, *Oecanthus pellucens*, *Omocestus haemorrhoidalis* and *Tetrix subulata*.

This can also be seen in the group of *Platycleis veyseli*, *Stenobothrus stigmaticus* and *Tetrix tenuicornis* and the group of species *Chorthippus oschei* and *Omocestus rufipes* (Fig. 12).

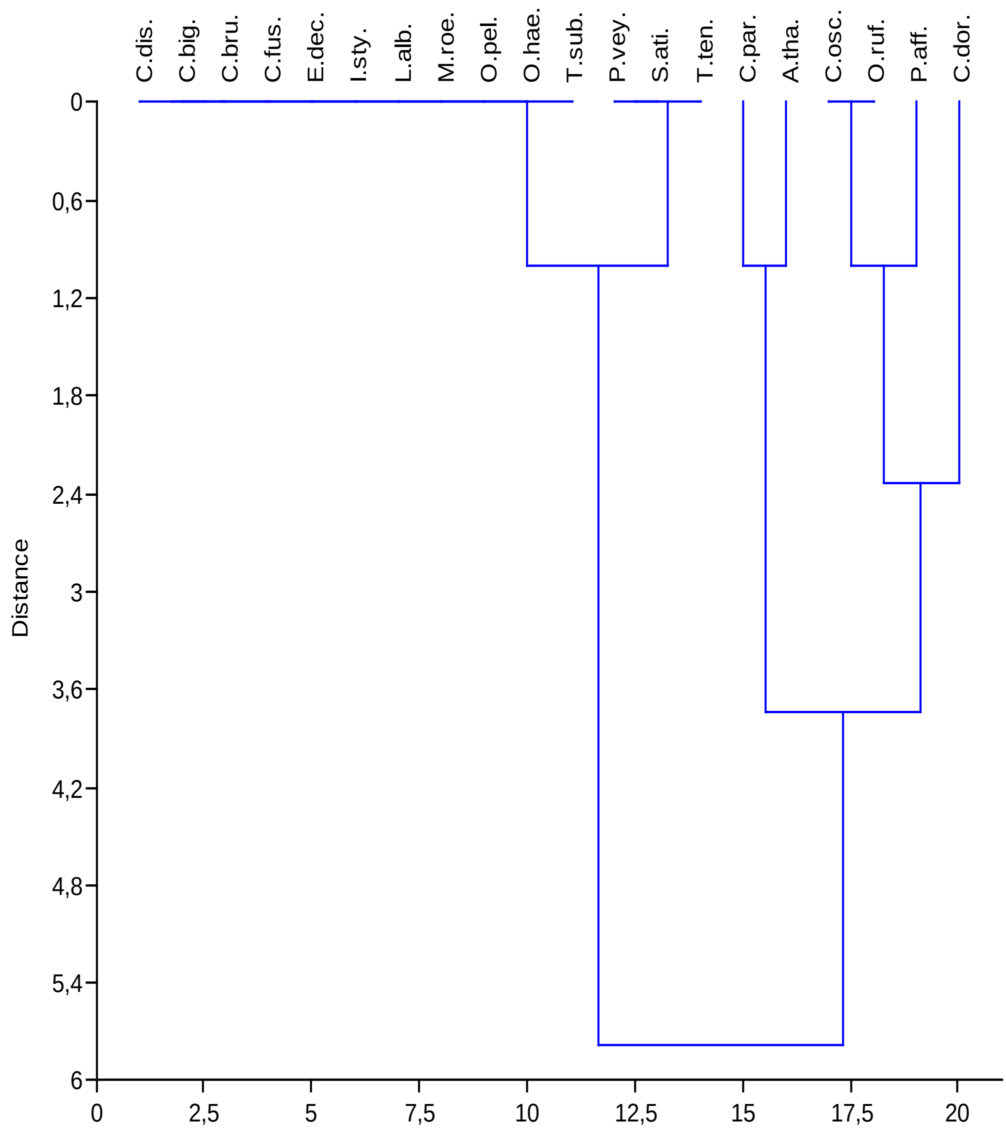

Figure 12: Dendrogram with Orthoptera species captured with standardized mesh method (data obtained using the program PAST).

The figure number 13 shows a high similarity between the wet meadow, pasture and meadow plots. At the same time, we can see less of a similarity between the salt marsh and fallow ground (Fig. 13).

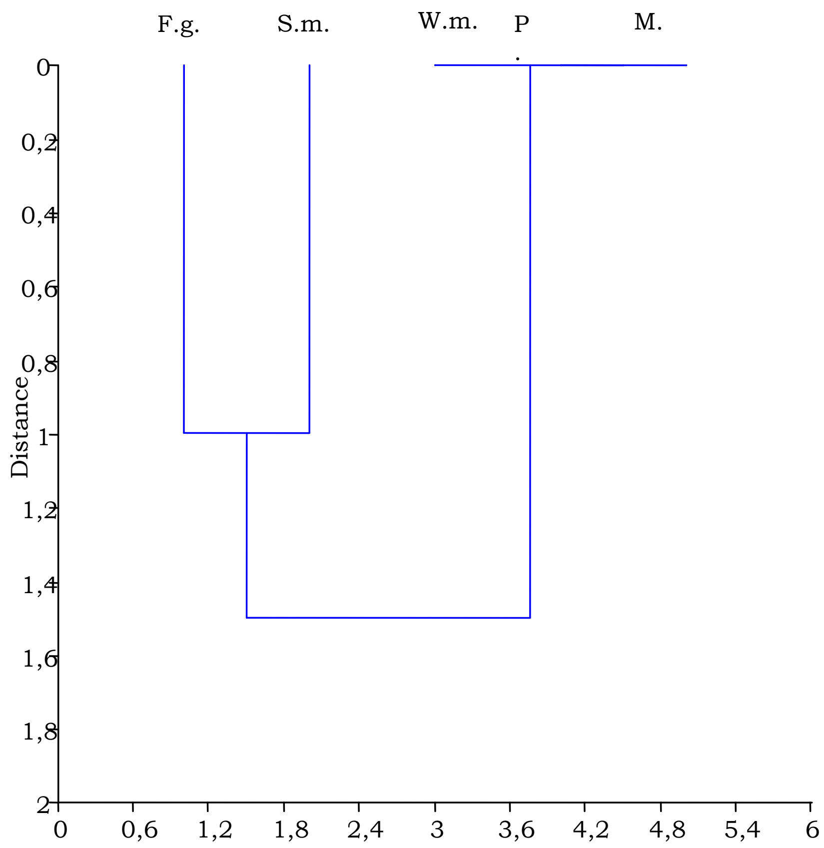

Figure 13: Dendrogram with study plots (data obtained using the program PAST).

The total number of species was 40, which included 18 Ensifera, 17 Caelifera, 3 Blattaria, 1 Dermaptera and 1 Mantodea. One of these species, *Isophya stysi* CEJHAN, 1957, is listed in Annex II and IV of the EU Habitats Directive. This species of community interest is a vulnerable species that requires protection and should warrant designated a protected area. Populations of this species are small and are vulnerable to the human disturbances such as grazing and mowing (Tatole et al., 2009). Because it is a sensitive species with declining populations, it was used to implement protective measures were implemented throughout Europe by EU Habitats Directive: Annexe II and IV and nationally by OUG 57/2007 and OMMDD 1964/2007. It was identified in other protected areas, like: Apuseni, Cheile Turzii, Defileul Mureşului Inferior, Făgetul Clujului – Valea Morii, Strei – Haţeg, Trascău, Zarand Mountains and others. In Europe, it occurs in Poland, Slovakia, Hungary and Romania (Fig. 14).

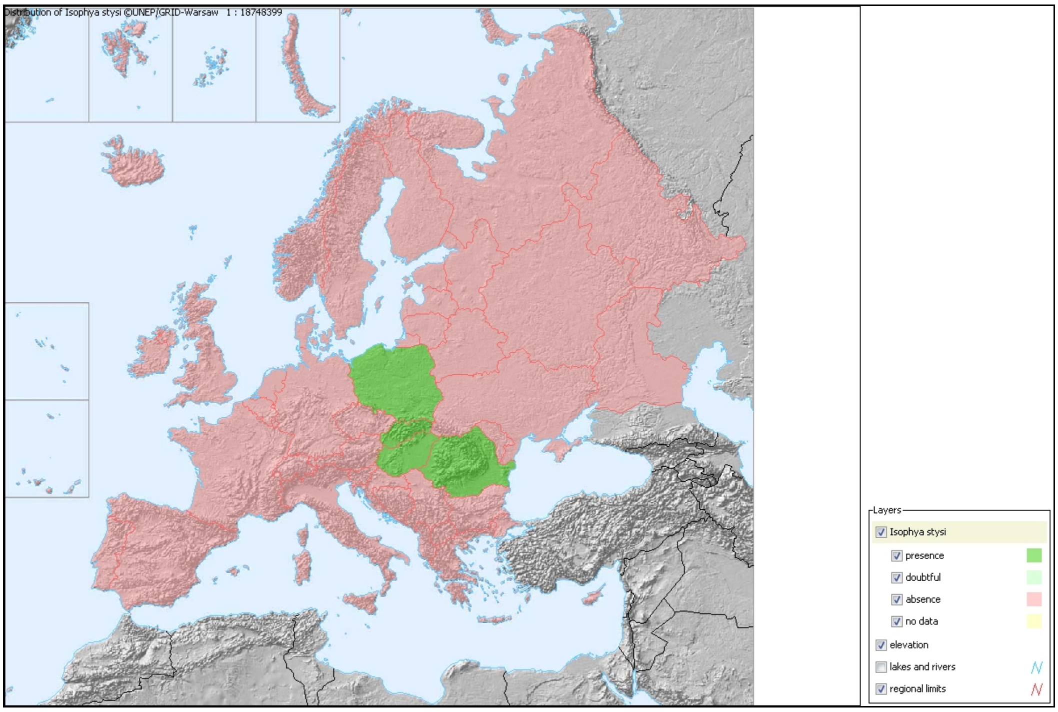

Figure 14: The distribution of *Isophya stysi* in Europa
(Fauna Europaea version 2.4, http://www.faunaeur.org).

DISCUSSION

One of the Orthoptera species, *Isophya stysi* Cejejhan, 1957, is listed in the EU Habitats Directive Annexe II and IV. Romania has a great responsibility for this species because Romania lies at the southern limit of the species distribution.

Besides the species mentioned, others may exist that were not seen or captured (Nagy et Szövényi, 1998). Of these species may be: *Phaneroptera falcata* (Poda, 1761), *Isophya costata* Brunner von Wattenwyl, 1878, *Meconema thalassinum* (De Geer, 1773), *Tettigonia caudata* (Charpentier, 1842), *Metrioptera (Metrioptera) bicolor* (Philippi, 1830), *Pholidoptera griseoptera* (De Geer, 1773), *Tetrix bolivari* Saulcy, 1901, *Calliptamus italicus* (Linnaeus, 1758), *Locusta migratoria* (Linnaeus, 1758), *Oedipoda caerulescens* (Linnaeus, 1758), *Celes variabilis* (Pallas, 1771), *Epacromius coerulipes* (Ivanov, 1887), *Dociostaurus maroccanus* (Thunberg, 1815), *Dociostaurus brevicolis* (Eversmann, 1848), *Stenobothrus crassipes* (Charpentier, 1825) and *Gomphocerippus rufus* (Linnaeus, 1758). Species cited above were found in the Körös-Maros/Criş-Mureş National Park which is in close proximity to Cefa Nature Park.

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32. Map with locations of studied surfaces: Google Earth 2011.
33. www. Faunaeur.org

SEASONAL DYNAMICS OF THE GROUND BEETLES (COLEOPTERA, CARABIDAE) IN CEFA NATURE PARK (CRIŞANA, ROMANIA)

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ABSTRACT

The Carabidae family is very well represented in terrestrial epigeal fauna. Due to their ecological roles: predator, prey, herbivore and scavenger, their study within ecosystems has a scientific and practical importance. This is the first long-period study of ground beetles in Cefa Nature Park. The individuals were collected using Barber pitfalls. The pitfalls were mounted in four different biotopes: meadow, dams between fishponds, pasture and forest. The study period was 12 months from May 2009 to April 2010. Each biotope had 10 pitfalls distributed in a two meter diameter circular pattern. Samples were collected monthly. The results show that the ground beetles are most active during April and July. In total 70 species were identified belonging to 29 genera. From the four investigated biotopes the pasture had the highest activity over 12 months study period. The most abundant species were: *Pterostichus ovoideus*, *Pterostichus macer*, *Trechus quadristriatus*, *Harpalus flavicornis*, *Anchomenus dorsalis*.

ZUSAMMENFASSUNG: Saison Dynamik der Boden (Coleoptera, Carabidae) in dem Cefa Natur Park (Rumänien).

Die Familie der Laufkäfer (Carabidae) ist in der terrestrischen, epigäischen Fauna sehr gut stark vertreten. Aufgrund ihrer ökologischen Rollen: Räuber, Beute, Pflanzenfresser und Aasfresser, hat die Untersuchung von Laufkäfern in den Ökosystemen wissenschaftliche und praktische Bedeutung. Vorliegende Arbeit beinhaltet die erste Langzeitstudie über Laufkäfer im Cefa Naturpark. Die Tiere wurden mit Hilfe von Barberfallen, gefüllt mit Glycerin und Ethylalkohol als Konservierungsmittel, gefangen. Diese wurden in vier unterschiedlichen Habitaten Heuwiese, Damm zwischen Fischteichen, Weide und Forst eingesetzt. Die Untersuchung dauerte 12 Monate von Mai 2009 bis April 2010. Jedes Habitat wurde mit 10 ringförmig angeordneten Fallen ausgestattet und monatlich besammelt. Die Ergebnisse zeigen, dass die Laufkäfer während der Monate April und Juli am aktivsten sind. Insgesamt wurden 70 Arten aus 29 Gattungen festgestellt. Unter den vier untersuchten Habitaten zeigte sich während der 12 Untersuchungsmonate in der Weide die höchste Aktivität. Die häufigsten Arten waren: *Pterostichus ovoideus*, *Pterostichus macer*, *Trechus quadristriatus*, *Harpalus flavicornis*, *Anchomenus dorsalis*.

REZUMAT: Dinamica sezonală a carabidelor (Coleoptera, Carabidae) în Parcul Natural Cefa (Crişana, România).

Familia Carabidae este foarte bine reprezentată în fauna epigee terestră. Datorită funcţiilor ecologice ale acestei familii, precum: pradă, prădător, detritivor şi necrofag, studiul ei are importanţă ştiinţifică şi practică. Lucrarea de faţă prezintă primul studiu de lungă durată a carabidelor din Parcul Natural Cefa. Indivizii au fost colectaţi cu ajutorul capcanelor Barber, acestea fiind montate în patru habitate diferite: fâneaţă, dig între heleştee, păşune şi pădure. Capcanele au fost în funcţie pe o periodă de 12 luni, între mai 2009 şi aprilie 2010. În fiecare habitat, au fost montate 10 capcane, având distribuţie circulară cu diametru de doi metri. Colectarea materialului a fost facută lunar. Rezultate au arătat că cea mai mare activitate a carabidaelor se înregistrează în luniile aprilie şi iulie. În total au fost identificate 70 de specii, aparţinând la 29 de genuri. Pe perioada studiului, cea mai mare activitate a carabidelor s-a înregistrat în habitatul de păşune. Cele mai abundente specii au fost: *Pterostichus ovoideus, Pterostichus macer, Trechus quadristriatus, Harpalus flavicornis, Anchomenus dorsalis*.

INTRODUCTION

The ground beetles are very diverse (Desender et. al., 2010) and well represented in the arthropod epigeal fauna (Desender et al., 2010; Gobbi and Fontaneto, 2008). They are important in the ecological surveys (Sakine, 2006) and often used as bioindicators (Thiele, 1977; Lövei and Sunderland, 1996; Holland, 2002; Rainio and Niemelä, 2003; Allegro and Sciaky, 2003; Pearce and Venier, 2006; Varvara et al., 1981) for assessing the health of the ecosystems (Varvara and Cîrlan, 1990). Due to their multiple ecological role as invertebrate top predator, but pray as well, of omnivorous, herbivorous and scavenger food spectrum, their study in the ecosystems have a scientific and practical importance (Varvara et al., 1981, Karen et al., 2008). It is known that their activity is seasonal dependent (Varchola and Dunn, 1999), thus it is important to know their seasonal dynamics in a protected area. In Romania, the ground beetles (Fam. Carabidae) has a long research tradition (Máthé, 2003-2004). For Cefa Nature Park there is no literature on this family of coleopterans. However, with respectFor to Cefa Nature Park we are not aware of any pevious study concerning the ground beetles; therefore, this is the first taxonomic survey ron the ground beetles in this protected area. The aim of this study was to identify the taxonomic composition of ground beetles and to define their seasonal dynamics in four habitats from Cefa Nature Park.

MATERIAL AND METHOD

Study area. Cefa Nature Park is located in North West of Romania and has a total surface of 5002 ha (Crişan, 2007). In the north-weste, it borders Hungary and another natural protected area (Körös-Maros/Criş-Mureş National Park), similar in the reachiness of habitats to Cefa Nature Park. The eastern border is defined by the main stem of Criş River system and the Rădvani Forest limits its southern parts. The altitude of the region is fairly characteristic of a lowland , ranging between 90 and 110 m above see level. The main type of habitats are represented by meadows, fishponds and forest.

Sampling procedure. The ground beetles were collected using Barber pitfalls (500 ml volume plastic cups with 17 cm height and 8 cm wide, filled with glycerin and ethyl-alcohol). The pitfalls were installed on the ground, covered with linoleum caps for rain protection, in four different type of habitats. In each type of habitat 10 pitfalls were mounted, in a circular distribution of two meters. The samples were collected monthly (Mai 2009 - April 2010) and preserved in Eppendorf tubes and other recipients with 70% ethyl-alcohol. The individuals were identified in the laboratory under the stereomicroscope using the key of the following authors: Trautner and Geigenmüller (1987), Hurka (1996).

Statistical methods. The relative abundance $A=(ni*N^{-1})*100$ and frequency $F=(Ni*Np^{-1})*100$ of the species were calculated, where *ni* represents the number of individual from specie *i*, *N* represents the total number of individual belonging to all species, *Ni* is the number of sampling sites where specie *i* was identified and *Np* the total number of sampling sites (Stan, 1995). Shannon-Weiner index $H' = \sum_{i=1}^{R} pi * \log pi$ was used to express the species diversity, where *pi* represents the proportion of individual from species *i* and *R* the total number of species (Shannon, 1948). For similarity, the Jaccard index was calculated, which is defined as the size of the intersection divided by the size of the union of the sample sets $J(A,B)= |A \cap B|*|A \cup B|^{-1}$ (Jaccard, 1901). Also the Pielou index $e= H'*H'max^{-1}$, was calculated, where $H'max=\ln S$ is the maximum of diversity and *S* the number of species (Pielou, 1966).

Sampling stations. The pitfalls were set into four different biotopes: pasture (5°28'37.62"N, 98°18'19.90"W), hayfields (5°28'36"N. 95°17'36.05"W), forest (5°28'37"N, 95°17'46.22"W) and dam between fishponds (5°29'3.27"N, 95°16'57.17"W). The pasture is on salted soils predominant halophilous vegetation: *Poa bulbosa*, *Lotus angustissimus*, *Statice gmelinii*, *Artemisia santonica*, *Juncus gerardii*, *Polygonum aviculare*, *Trifolium fragiferum*, *Aster tripolium pannonicus*, *Festuca pseudovina*, *Artemisia santonica ssp. monogyna*, *Scorzonera cana*, *Plantago maritima* and *Gypsophila muralis*. In spring and autumn the soils are covered with puddles During the growing season this habitat it is highly grazed by sheep and cows. The hayfields are characterized by pannonical salt meadows, untouched by livestock, with a different vegetation the in the pasture. Here the characteristic species are: *Peucedanum officinale*, *Statice gmelinii*, *Cirsium brachycephalum*, *Festuca pseudovina*, *Alopecurus pratensis* and *Poa pratensis*. The forest is 80 years old and represents the remnant of an ancient oak meadow that use to cover the north-western fields of the Criş River catchment. Nowadays the dominant trees are still the *Quercus robur*, *Ulmus minor* and *Fraxinus excelsior*. The water profile if heavily influenced by the underneath groundwater , being oversaturated with water during spring and very dry in summer. The dams between fishponds are long and are covered with mezohydrophile vegetation: *Juncus gerardi*, *Juncus articulatus*, *Mentha arvensis*, *Polygonum mite*, *Lycopus exaltatus*, *Rorippa sylvestris*, *Rumex stenophyllus*, *Rumex palustris*, *Polygonum hydropiper*, *Rorippa amphibia*, *Glyceria maxima*, *Oenanthe aquatica* and *Sparganium erectum*.

RESULTS AND DISCUSSION

A total of 720 individuals of ground beetles, belonging to 70 species and 29 genera, were captured in the pitfalls from all the habitats (Tab. 1). The highest number of ground eetles was found in the pitfalls from the forest (29 species), equalised by the dam between fishponds (29 species) .In the pasture there were found 21 species, and 24 in the hayfield. Amid these latter two habitats, 6 species are common and 15 were found either in pasture or in hayfield.

The genus *Harpalus* featured the highest number of species (17) followed by *Pterostichus* (7). A number of 15 genera are present in the ecosystems with only one species: *Agonum*, *Anchonemus*, *Callistus*, *Calosoma*, *Diacromus*, *Elaphrus*, *Cryptophonus*, *Philochtus*, *Patrobus*, *Poecilus*, *Polystichus*, *Pseudophonus*, *Stenolophus*, *Stomis* and *Syntomus* (Tab. 1).

Only eight species (11.42% of all the species) were present in three of four habitats (Tab. 1): *Trechus quadristriatus*, *Anisodactylus binotatus*, *Pseudophonus rufipes*, *Harpalus affinis*, *Harpalus dimidiatus*, *Poecilus cupreus*, *Pterostichus macer* and *Brachinus crepitans*. The dominant taxa in the pitfalls were represented by: *Pterostichus ovoideus*, *Pterostichus macer*, *Trechus quadristriatus*, *Harpalus flavicornis* and *Anchomenus dorsalis*.

Table 1: The ground beetles species structure in Cefa Nature Park, 2009-2010; x – Confirming the presence of the species in: 1 – pasture, 2 – hayfields, 3 – forest, 4 – dam between fishponds.

	Species	Habitat 1	Habitat 2	Habitat3	Habitat 4
1	*Calosoma inquisitor* Linné 1758			x	
2	*Carabus marginalis* Fabricius 1794			x	
3	*Carabus ullrichi* Germar 1824			x	x
4	*Notiophilus rufipes* Curtis 1829			x	
5	*Notiophilus laticollis* Chaudoir 1850			x	
6	*Elaphrus riparius* (Linné 1758)				x
7	*Trechus obtusus* Erichson 1837			x	
8	*Trechus quadristriatus* (Schrank 1781)	x	x	x	
9	*Trechus sp.* Clairville 1806	x			
10	*Philochthus guttula* (Fabricios 1792)		x		
11	*Bembidion sp.* Latreille 1802		x	x	
12	*Bembidion semipunctatum* (Donovan 1806)				x
13	*Patrobus atrorufus* (Stroem 1768)				x
14	*Anisodactylus binotatus* (Fabricius 1787)				x
15	*Anisodactylus nemorivagus* (Duftschmid 1812)				x
16	*Anisodactylus signatus* (Panzer 1797)	x	x		x
17	*Diachromus germanus* (Linné 1758)			x	
18	*Ophonus schaubergerianus* Puel 1937			x	
19	*Ophonus diffinis* (Dejean 1829)	x		x	
20	*Ophonus puncticollis* (Paykull 1798)				x
21	*Ophonus stictus* Stephens 1828	x		x	
22	*Ophonus sabulicola* Panzer 1796		x	x	
23	*Ophonus azureus* (Fabricius 1775)		x		
24	*Ophonus puncticeps*				x

	Stephens 1828				
25	*Pseudophonus rufipes* (De Geer 1774)		x	x	x
26	*Harpalus hospes* Sturm 1818	x			
27	*Harpalus affinis* (Schrank 1781)	x	x	x	
28	*Harpalus anxius* (Duftschmid 1812)	x			
29	*Harpalus cupreus* Dejean 1829		x	x	
30	*Harpalus cursorius* Dejean 1829		x		
31	*Harpalus dimidiatus* (Rossi 1790)	x	x		x
32	*Harpalus distinguendus* (Duftschmid 1812)	x	x		
33	*Harpalus flavicornis* Dejean1829	x			
34	*Harpalus honestus* (Duftschmid 1812)			x	
35	*Harpalus luteicornis* (Duftschmid 1812)		x		
36	*Harpalus marginellus* Dejean 1829	x			
37	*Harpalus modestus* Dejean1829	x			
38	*Harpalus picipennis* (Duftschmid 1812)	x			x
39	*Harpalus rubripes* (Duftschmid 1812)		x		
40	*Harpalus decipiens* (Duftschmid 1812)		x		
41	*Harpalus saxicola* Dejean 1829	x			
42	*Harpalus smaragdinus* (Duftschmid 1812)		x		
43	*Cryptophonus tenebrosus* Dejean 1829	x			x
44	*Stenolophus mixus* (Herbst 1784)				x
45	*Stomis pumicatus* (Panzer 1796)				x
46	*Poecilus cupreus* (Linné 1758)		x	x	x
47	*Pterostichus nigrita* (Paykull 1790)				x
48	*Pterostichus anthracinus* (Illiger 1798)			x	x

49	*Pterostichus macer* (Marscham 1802)	x	x	x	
50	*Pterostichus melanarius* (Illiger 1798)			x	x
51	*Pterostichus ovoideus* (Sturm 1824)		x	x	
52	*Pterostichus strenuus* (Panzer 1797)				x
53	*Pterostichus niger* (Schaller 1783)				x
54	*Calathus fuscipes* (Goeze 1777)	x		x	
55	*Calathus melanocephalus* (Linné 1758)	x	x		
56	*Agonum lugens* (Duftschmid 1812)				x
57	*Anchomenus dorsalis* (Pontoppidan 1763)				x
58	*Amara aenea* (De Geer 1774)	x			
59	*Amara anthobia* A. Villa and G. B. Villa 1833			x	
60	*Amara communis* (Panzer 1797)		x		
61	*Chlaeniellus vestitus* (Paykull 1790)				x
62	*Chlaeniellus nitidulus* (Schrank 1781)			x	
63	*Callistus lunatus* (Fabricius 1775)		x		
64	*Badister bullatus* (Fabricius 1792)				x
65	*Badister larcetosus* Sturm 1815				x
66	*Syntomus truncatellus* Linné 1761			x	
67	*Microlestes maurus* (Sturm 1827)	x			
68	*Microlestes minutulus* (Goeze 1777)			x	x
69	*Polistichus connexus* (Fourcroy 1785)		x		
70	*Brachinus psophia* Serville 1821			x	
71	*Brachinus crepitans* (Linné 1758)		x	x	x
72	*Brachinus explodens* Duftschmid 1812				x
Total number of species		21	24	29	29
Procent of the total number (%)		29.17	33.33	40.28	40.28

During spring (March - May), the dominant species were: *Harpalus flavicornis* (43.14%) in pasture, *Pterostichus ovoideus* in the hayfield (38.89%) and forest (52.94%) and *Anchomenus dorsalis* at the dam between fishponds (40%) (Figs. 1-4).

The species with significant high abundance, over 10%, (eudominant) in the spring season were: *Harpalus dimidiatus* in the pasture and hayfield, *Pterostichus macer* in the pasture, *Notiophylus laticollis* in the forest, *Brachinus crepitans* and *Ophonus puncticollis* at the dam between fishponds (Figs. 1-4). The most frequent species were: *Harpalus dimidiatus* (66.67%) and *Pterostichus ovoideus* (50%).

Among dominant taxa, more then 10%, (eudominant) during spring season were: represented by the species *Harpalus dimidiatus* in the pasture and hayfield, *Pterostichus macer* in the pasture, *Notiophylus laticollis* in the forest, *Brachinus crepitans* and *Ophonus puncticollis* at the dam between fishponds (Figs. 1-4). The most frequent species were: *Harpalus dimidiatus* (66.67%) and *Pterostichus ovoideus* (50%). During summer, the dominant axa were represented by : *Harpalus flavicornis* in the pasture (64.18%), *Pseudophonus rufipes* in the hayfield (35.29%) and forest (31.03%), *Chlaeniellus vestitus* at the dam between fishponds (46.15%). In the forest *Pterostichus melanarius* (27.59%) and *Trechus quadristriatus* (17.24%) had the highest presence in the pitfalls. In the other habitats, *Ophonus stictus* (11.94%) and *Pterostichus macer* (13.43%) in the pasture, *Poecilus cupreus* (11.76%) and *Pterostichus ovoideus* (17.65%) in the hayfield and *Pterostichus niger* (17.95%) in the dam between fishponds (Figs. 1-4) were abundant. *Pseudophonus rufipes* (33.33%) and *Pterostichus ovoideus* (25%) were the dominant species during summer.

Between September and November (the autumn season), at the dam between fishponds, all the species were represented by only one individual (14.29%). The dominant species were represented by : *Pterostichus macer* (67.11%) in the pasture and *Ophonus stictus* (53.45%) in the forest. In the hayfield *Pterostichus macer*, *Pterostichus ovoideus* (27.78%) and *Trechus quadristriatus* (22.22%) were the most abundant species (Figs. 1-4). The species with the highest presence in the pitfalls in autumn season were *Pterostichus macer* (66.67%) and *Trechus quadristriatus* (50%).

14 species (*Anisodactylus signatus*, *Calathus melanocephalus*, *Harpalus dimidiatus*, *Pterostichus macer*, *Pterostichus ovoideus*, *Pterostichus anthracinus*, *Pterostichus nigrita*, *Trechus quadristriatus*, *Poecilus cupreus*, *Microlestes minutulus*, *Chlaeniellus vestitus*, *Carabus ullrichi* and *Anchomenus dorsalis*) were present in the pitfalls during the winter. In the forest only one specimen of *Pterostichus ovoideus* was captured. The dominant species were represented by : *Pterostichus ovoideus* in the hayfield (73.33%), *Trechus quadristriatus* in the pasture (68.18%) and *Chlaeniellus vestitus* in the dam between fishponds (55.56%) (Figs. 1-4). During winter *Pterostichus ovoideus* (33.33%) was the most frequent species.

The difference in species richness is reflected in the diversity registered between habitats significantly covered by vegetation (forest, hayfield and dam) and open biotopes (pasture) but not between biotopes with high vegetation. The lowest diversity (H´= 0.86) in pasture can be easily explained by the open landscape, where the ground beetles are more expose to predators and impacted by livestock grazing (any refrence to support that?)\. In the habitats covered with trees, like in the forest (H´= 1.08), hayfield (H´= 1.01) and dam between fishponds (H´= 1.06) the Shannon index is very similar. This similarity could appear because the habitats have better ecological conditions. The species are equitably distributed in these four biotopes, fact which is showed by the high values of the Pielou index (pasture: 0.65, hayfields: 0.73, forest: 0.74, dam between fishponds: 0.72).

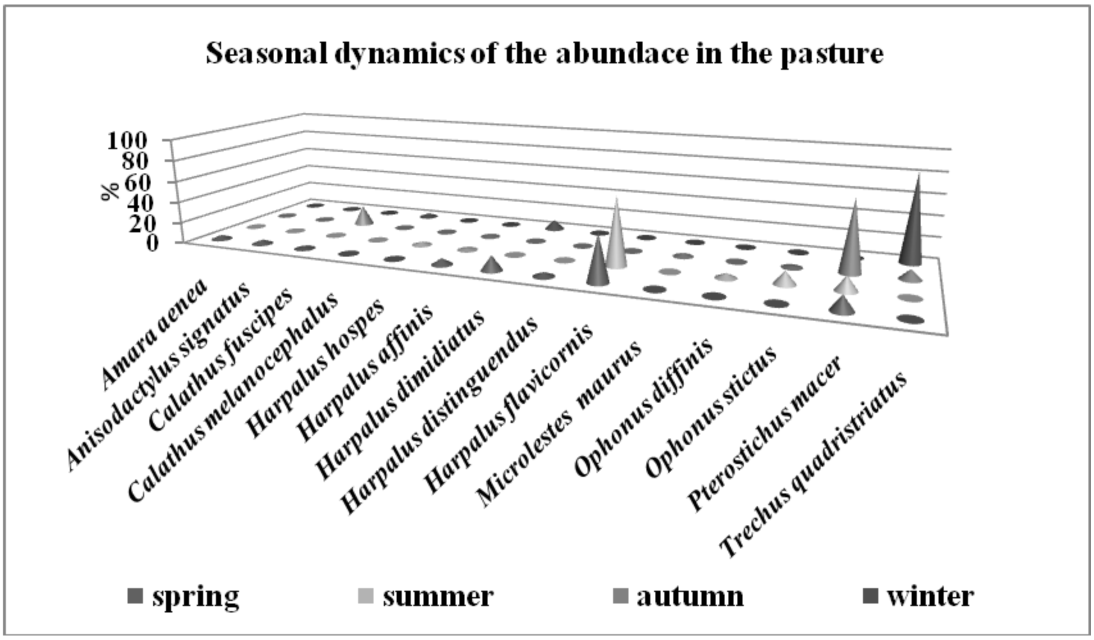

Figure 1: Seasonal dynamics of the dominance of species in the pasture (May 2009 - April 2010); only the species with a frequency higher than 2% are stated.

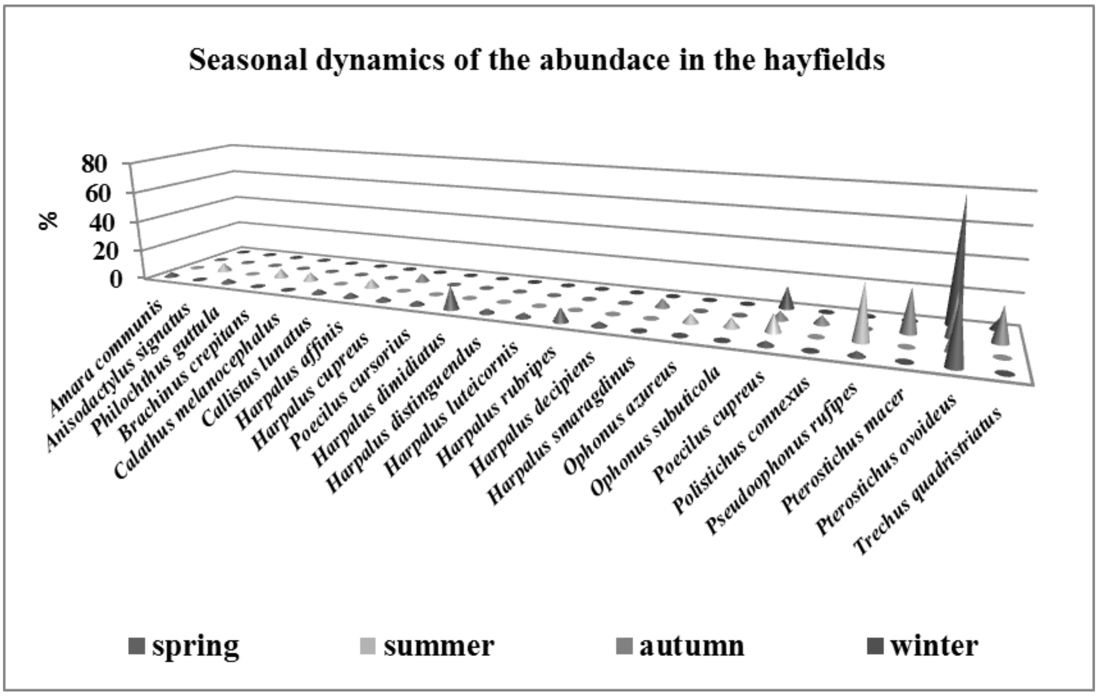

Figure 2: Seasonal dynamics of the dominance of species in the hayfield(May 2009 - April 2010). Only the species with a frequency higher than 2% are stated.

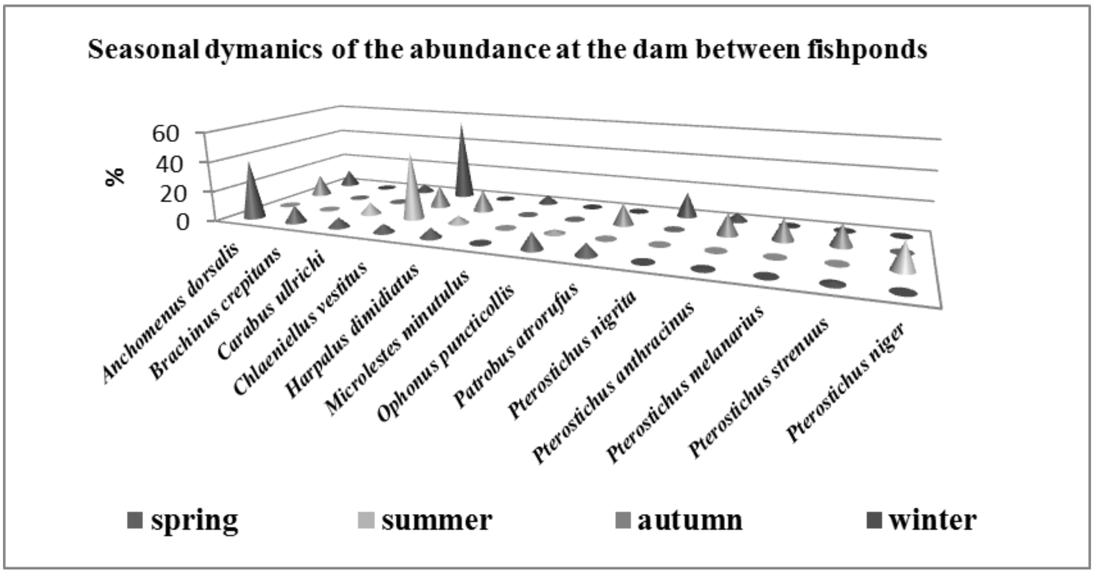

Figure 3: Seasonal dynamics of the dominance of species in the dam between fishponds, May 2009 - April 2010 (only species with dominance higher than 2% are represented in the graphic).

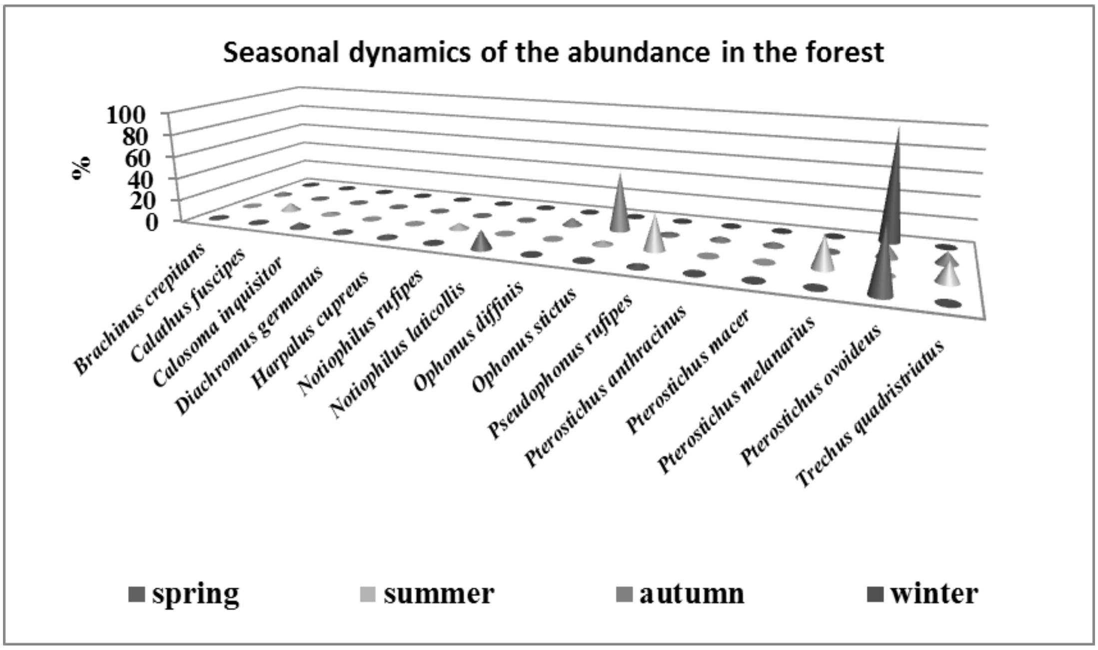

Figure 4: Seasonal dynamics of the dominance of species in the forest, May 2009 - April2010 (only species with dominance higher than 2% are represented in the graphic).

The Jaccard index suggests that the most similar communities are those found in the forest and grassland (Fig. 5). This was expectable, because the two biotopes are in neighbourhood and the species can migrate in-between. The community of the ground beetles from the dam between fishponds shows a clear departure from the terrestrial habitats (Fig. 5) due to the mezohydrophilous and hydrophilous species.

The ground beetles community is well represented in the biotope of forest (31 species), with a higher number of species in comparison with forest biotopes from other protected area from Romania: Buila-Vânturariţa National Park (17 species) (Huidu, 2011) and Dragomirna Nature Reserve (23 species) (Varvara, 1999). This difference can be due to different geographic zone of the areas or to the different sampling period.

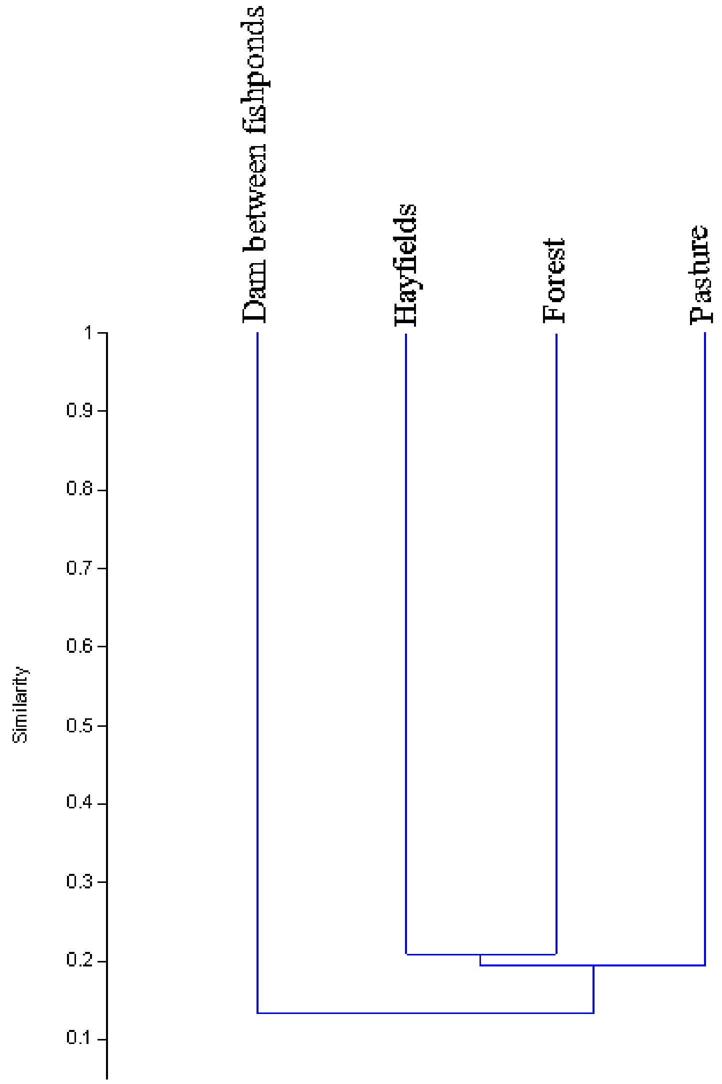

Figure 5: Jaccard index of Similarity for the ground beetles communities/ type of habitat of Cefa Nature Park main biotopes.

Despite high values for species richness (70 taxa in total) identified in this natural protected area there is a number of species (e.g. *Calosoma sycophanta* (Linné 1758), *Calosoma auropunctatum* (Herbst 1784), *Carabus granulatus* Linné 1758, *Carabus violaceus* Linné 1758, *Carabus hortensis* Linné 1758, *Carabus coriaceus* Linné 1758, *Carabus cancellatus* Illiger 1798, *Carabus convexus* Fabricius 1775, *Acinopus picipes* (Olivier 1795), *Nebria bravicollis* (Fabricius 1792), *Harpalus rufipes* (De Geer 1774), *Pterostichus vulgaris* (Linné 1578), *Pterostichus oblongopunctatus* (Fabricius 1787), *Demetrias atricapillus* (Linné 1758), *Dromius lineraris* (Olivier 1795), *Lebia cruxminor* (Linné 1758), *Drypta dentata* (Rossi 1790) and *Brachinus plagiatus* Reiche 1868) found in the fauna of Körös-Maros/Criş-Mureş National Park (Harmos et al., 2001) and not captured in this survey. Further investigations are recommended in the area of Cefa Nature Park.

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COMMUNITY STRUCTURE AND SEASONAL DINAMYCS OF THE EPIGEAL FAUNA FROM FOUR MAIN HABITATS IN CEFA NATURE PARK (CRIŞANA, ROMANIA)

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KEYWORDS: epigeal fauna, Barber pitfall traps, community structure seasonal dynamic, Cefa Nature Park.

ABSTRACT

This is the first study of the epigeal fauna of the Cefa Nature Park. Individuals were collected using Barber pitfall traps mounted in the main ecosystems: a dam placed between fishponds, pasture, hayfields and forest. The study was conducted over a one year period between, May 2009 to April 2010, and the samples were collected monthly.

In total 16969 individuals were captured, belonging to three phylum, four subphylum, six classes and nine orders. The mild climatic conditions of Cefa Nature Park mean that the soil dependent organism are active even in the winter season.

The epigeal fauna was numerically dominated by Coleoptera, Aranea and Isopoda.

ZUSAMMENFASSUNG: Saisonale Dynamik der Laufkäfer (Coleoptera, Carabidae) im Cefa Natur Park (Rumänien).

Vorliegende Untersuchung der epigäischen Fauna ist die erste dieser Art im Naturpark Cefa. Das Material wurde mit Hilfe der Barberfallenmethode gesammelt, die in den vier wichtigsten Ökosystemen, Deich zwischen den Teichen, Weide, Wiese und Wald eingesetzt wurden. Die Untersuchungen erstreckten sich über den Zeitraum eines Jahres von Mai 2009 bis Ende April 2010, wobei die Proben monatlich eingesammelt wurden.

Insgesamt wurden 16969 Individuen ausgezählt, die zu drei Stämmen, vier Unterstämmen, sechs Klassen und neun Ordnungen gehören. Unter den klimatischen Bedingungen des Cefa Naturparks wurden für die Gruppen der in der kalten Jahreszeit als inaktiv bekannten epigäischen Fauna, hohe Abundanz- und Frequenzwerte verzeichnet.

Die epigäische Fauna war zahlenmäßig dominiert von Käfern, Spinnen und Isopoden.

REZUMAT: Structura comunităţii şi dinamica sezonieră a faunei epigee din patru habitate principale ale Parcului Natural Cefa (Crişana, Romania).

Acesta este primul studiu al faunei epigee din cadrul Parcului Natural Cefa. Materialul a fost colectat cu ajutorul capcanelor Barber montate în principalele ecosisteme: dig între heleştee, păşune, fâneaţă şi pădure. Studiul s-a efectuat pe o perioadă de un an, din mai 2009 până în aprilie 2010, probele fiind colectate lunar.

În total au fost capturaţi 16969 indivizi aparţinând la trei încrengături, patru subîncrengături, şase clase şi nouă ordine. În condiţiile climatice ale Parcului Natural Cefa, grupurile din fauna epigee cunoscute ca fiind inactive în sezonul rece au înregistrat valori remarcante ale abundenţei şi frecvenţei în lunile de iarnă.

Fauna epigee a fost numeric dominată de Coleoptera, Aranea şi Izopoda.

INTRODUCTION

The soil is one of the major components in the ecosystems and the focus subject of many ecological studies (Lavelle and Fragoso, 2000, André et al., 2002, Bardgett, 2002, Goede and Brussaard, 2002, Santos et al., 2007, Kazemia et al., 2009). The epigeal fauna is considerated to be a biodiversity hot spot and a key factor in the function and structure of ecosystems (Ghilarov, 1977, Giller, 1996, Lee, 1991) due to their role in litter decomposition, nutrient mineralization, soil aeration, seed dispersal, biological control and providing food for higher taxa (Santos et al., 2007, Mejer et al., 2006). The most important components of the epigeal fauna are the beetles and spiders (Melnychuk et al., 2003, Pohla et al., 2007, Pearce and Venier, 2006).

In Romania the epigeal fauna is very well studied focusing on different target groups (Máthé, 2003, 2004). The purpose of this study is to get a first perspective on the structure of the epigeal fauna in the main ecosystems of Cefa Nature Park and to compare the seasonal dynamic of those communities.

MATERIALS AND METHODS

Cefa Nature Park is the newest Nature Park in Romania with a total surface of 5002 ha. It is located in North West of Romania and has common borders with Körös-Maros/Criş-Mureş National Park in Hungary which has the same main ecosystems: meadows, fishponds and forest. The altitude of the region is constant, ranging between 90 and 110 m.

The epigeal fauna was collected using Barber pitfall traps. This is the most frequently used method to study the epigeal fauna and has many advantages. The efficiency of different variables like size, shape and many other are tested by many researchers in the attempt to create a standardization model (Schmidt et al., 2006, Hyvärinen et al. 2006, Buchholz and Hannig, 2009, Buchholz et al., 2010). The pitfalls were made consisting of 500 ml plastic cups with 17 cm height and 8 cm width, filled with 9:1 mixture ethyl-alcohol and glycerine. They were set into the ground, covered with linoleum caps for rain protection, in four different biotopes. Each ecosystem had a battery of 10 pitfalls distributed circular with a diameter of two meters. The samples were picked up monthly from May 2009 - until April 2010, and preserved in recipients with 70% ethanol. The individuals were identified in the laboratory using the stereomicroscope until the order level using the work of the following authors: Chinery, 2007, Pârvulescu, 2011, Robinson, 2005.

For the seasonal dynamics the relative abundance $A=(ni*N^{-1})*100$ and frequency $F=(Ni*Np^{-1})*100$ of the taxons were calculated, where *ni* represents the number of the individual from specie *i*, *N* represents the total number of individual belonging to all species, *Ni* is the number of sampling sites where species *i* was identified and *Np* the total number of sampling sites (Stan, 1995).

The pitfalls were set into the main ecosystems: pasture (5°28’37.62”N, 98°18’19.90”W), hayfields (5°28’36”N. 95°17’36.05”W), forest (5°28’37”N, 95°17’46.22”W) and dam between fishponds (5°29’3.27”N, 95°16’57.17”W).

The pasture is located on salted soils with predominant halophilous vegetation: *Poa bulbosa, Lotus angustissimus, Statice gmelinii, Artemisia santonica, Juncus gerardii, Polygonum aviculare, Trifolium fragiferum, Aster tripolium pannonicus, Festuca pseudovina, Artemisia santonica ssp. monogyna, Scorzonera cana, Plantago maritime* and *Gypsophila muralis*.

The second ecosystem is represented by hayfield, which are characterized by pannonical salt meadows with the fallowing characteristic species: *Peucedanum officinale*, *Statice gmelinii*, *Cirsium brachycephalum*, *Festuca pseudovina*, *Alopecurus pratensis* and *Poa pratensis*.

The Rădvani forest is 80 years old and it is the remnant of an ancient oak meadow that used to covered the north-west fields of the Criş River catchments. The soils of this forest became very muddy in the raining seasons. The dominant tree species are: *Quercus robur*, *Ulmus minor* and *Fraxinus excelsior.*

The last ecosystem is the dam between fishponds with a big surface of occupancy in the fish farm and has a mezohygrophile vegetation: *Juncus gerardi*, *J.articulatus*, *Mentha arvensis*, *Polygonum mite*, *Lycopus exaltatus*, *Rorippa sylvestris*, *Rumex stenophyllus*, *Rumex palustris, Polygonum hydropiper*, *Rorippa amphibia*, *Glyceria maxima*, *Oenanthe aquatica* and *Sparganium erectum*.

RESULTS AND DISCUSSION

A total of 16109 individuals were captured, belonging to three phylum, four subphylum, six classes and nine orders, from all four ecosystems (Tab. 1). The highest epigeal activity was registred by the order Aranea, followed by Isopoda and Coleoptera (Tab. 1). A sporadic presence in the pitfalls was recorded by the orders: Dictyoptera (0.06 %) and Pseudoscorpiones. The family Formicidae from the order Hymenoptera was not included in this study due to the high number of individuals, over 600, in each sample because of the nests near the pitfalls.

The community structure of the epigeal fauna includes the soil arthropods, represented by the following taxa: Coleoptera, Hemiptera, Orthoptera, Dictyoptera, Collembola, Aranea, Pseudoscorpiones, Isopoda, Myriapoda, the snails (Class Gasteropoda) and worms (Class Oligocheta). The orders Aranea and Isopoda numerically dominates the soil arthropods community in the entire study period and from the Class Insecta the beetles (order Coleoptera) have the higher activity in all four habitats (Tab. 1).

The highest number of individuals were captured in the dam between fishponds. The habitat with the lowest activity of the studied taxons was the pasture. There was significantly differences between habitats for orders: Isopoda, Collembola, and Class Gasteropoda which registred the highest activity in the dam between fishpond, a habitat with typically high humutidy typical for these groups of organism (Tab. 1). The order Aranea registered the lowest number of individuals in the pastures as the order Coleoptera registred the higest activity (Tab. 1).

The community structure from the four studied habitats is very similar to other epigeal community from different habitats like: sylvo-steppe (Varvara et al., 1992/1993), olive groove plantations (Santos et al., 2007) and maize crops (Farinós et al., 2008; Rodríguez et al., 2006).

The epigeal fauna community from the Radvani forest in comparation with other forest ecosystem from Romania (Varvara, 2003) presents a higher activity of the organisms especially of the orders: Aranea, Hemiptera and the Subphylum Myriapoda.

Table 1: Structure of the epigeal fauna of Cefa Nature Park, 2009- 2010, H1-pasture, H2-hayfields, H3-forest, H4-dam between fishponds.

Phylum	Subphylum	Class	Order	H1	H2	H3	H4	Total
Arthropoda	Hexapoda	Insecta	Coleoptera	877	478	589	716	2660
			Hemiptera	37	156	44	150	387
			Orthoptera	161	19	8	11	199
			Dictyoptera	1	7	1	1	10
		Entognatha	Collembola	20	46	19	93	178
	Chelicerata	Arachnida	Aranea	843	2163	1834	1819	6659
			Pseudoscorpiones	1	0	0	12	13
	Crustacea	Malacostraca	Isopoda	1591	1112	504	2121	5328
	Myriapoda			38	160	86	33	317
Mollusca		Gasteropoda		4	36	24	158	222
Annelida		Oligocheta		18	24	87	7	136
Total number of individuals				3591	4201	3196	5121	16109

The insects have a constant activity true all the four seasons but with different patterns. The beetles (order Coleoptera) activity decreases along with the temperature of the seasons with a high peak in the spring season (Fig. 1). In the winter season the number of individuals decreases in all the insect groups but still the beetles remain the most abundant (Fig. 1).

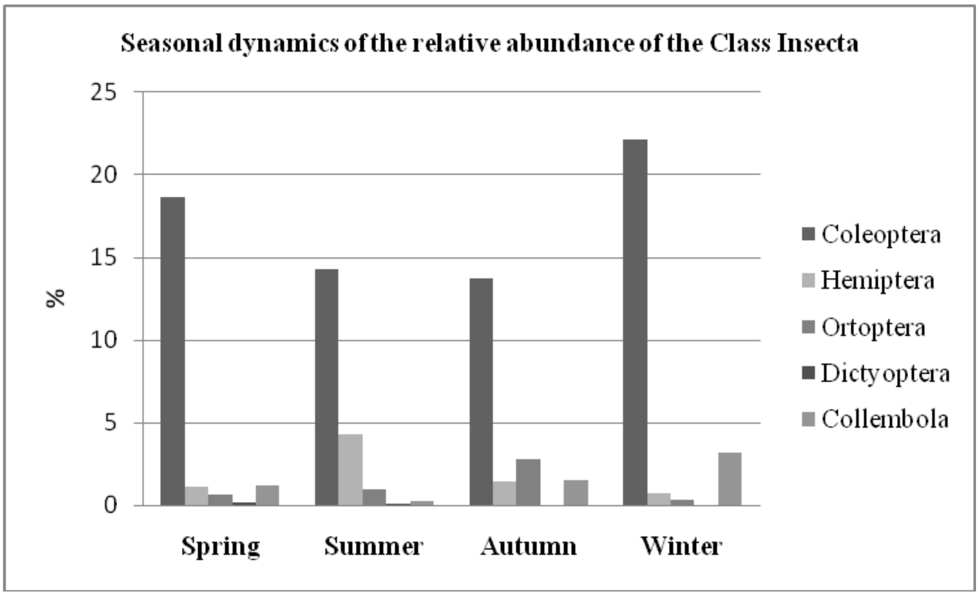

Figure 1: Sesonal dynamics of the relative abundace of the Class Insecta, May 2009 - April 2010.

The activity of the true bugs (order Hemiptera) has a high peak in the summer season. The order Orthoptera has a constant activity true the spring and summer seasons with a maximum in autumn.

From summer to autumn, the spiders activity presumbly decreased, with the higest abundance in the spring season and the Isopods activity increasing with a high nice peak in the autumn season (Fig. 2). From the activity patterns of this two groups it seems that the Isopods are more rezistent to low temperatures and positively influence by the humidity, while the spiders prefer the wormer seasons.

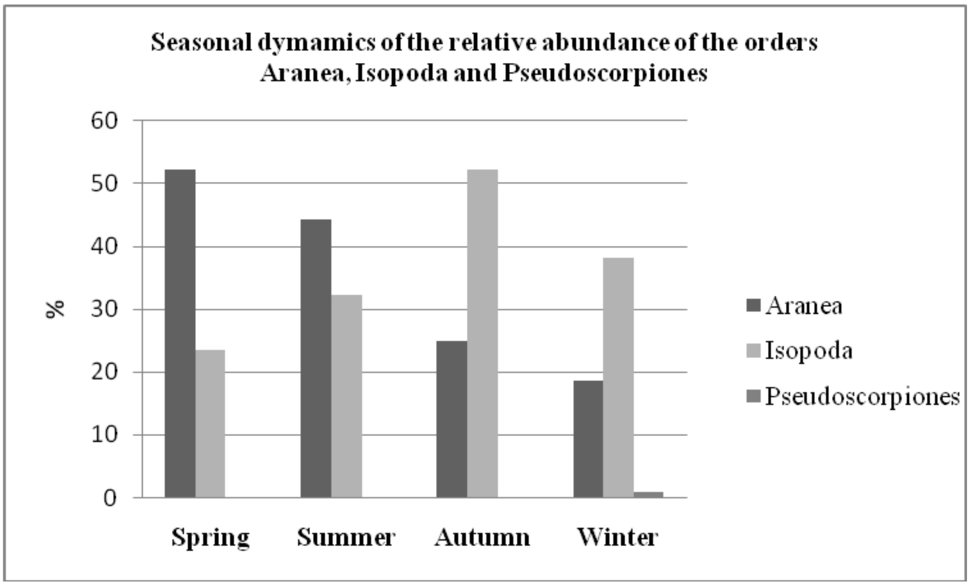

Figure 2: Sesonal dynamics of the relative abundace of the orders: Aranea, Isopoda and Pseudoscorpiones, May 2009 – April 2010.

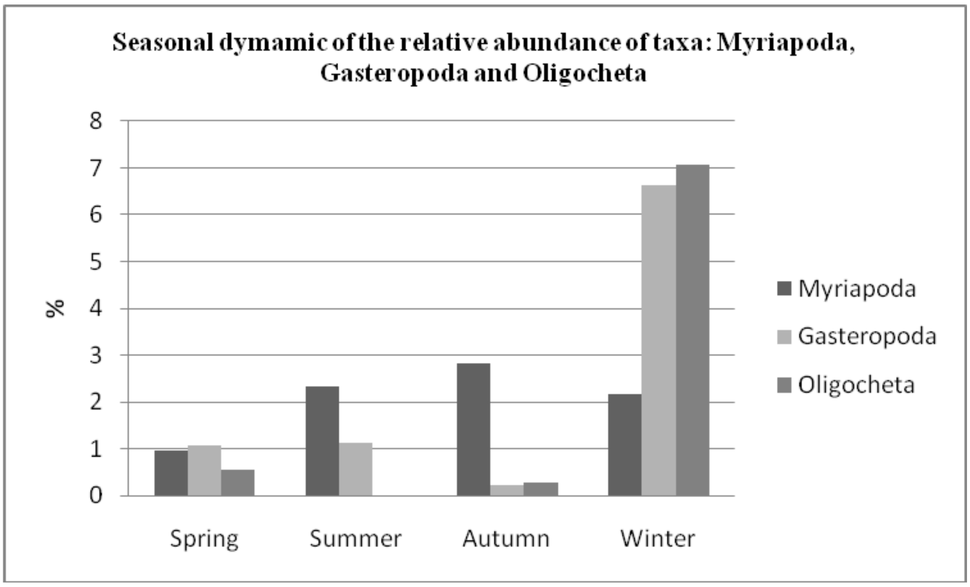

Figure 3: Sesonal dynamics of the relative abundace of the taxa:Myriapoda, Gasteropoda and Oligocheta, May 2009 – April 2010.

The order Dictyoptera was active only during in the summer season (Fig. 1), while the order Pseudoscorpiones was captured in the pitfall traps only in the winter season, with only 13 individuals, 12 at the dam between fishponds and one in the pasture (Fig. 2).

Two high peaks of activity are registred for the class Gasteropoda and Oligocheta in the winter season, whilst for in the rest of the seasons there is a very low activity, in opposite pattern with the activity of the beetles which are predators for this two class of organisms.

The increases in the activity of the gasteropods can be explain also by the increases of the humidity. Myriapods had the higher abundance in the autum season but did not decrease significantly in the winter season when it regstred an activity almost like in the summer season (Fig. 3).

The most frequent orders were Coleoptera and Aranea, followed by order Isopoda, subphylum Myriapoda. Other orders with frecuency higher then 50% were Hemiptera and Orthoptera (Tab. 2). The orders Coleoptera, Aranea and Izopoda had a 100 % frecuency in more than one ecosystem and subphylum Myriapoda had a 100% frecuency in the hayfields ecosystem (Tab. 2). The lowest frecuency was registred by the orders with the sporadic presence in the pitfalls, Pseudoscorpiones and Dictyoptera (Table 2).

Table 2: Frecuency (%) of the epigeal fauna of Cefa Nature Park, 2009- 2010, H1-pasture, H2-hayfields, H3-forest, H4-dam between fishponds.

Phylum	Subphylum	Class	Order	H1	H2	H3	H4	Total
Arthropoda	Hexapoda	Insecta	Coleoptera	100.0	100.0	87.50	100.0	96.15
			Hemiptera	66.67	58.33	31.25	91.67	59.62
			Ortoptera	83.33	58.33	31.25	50.00	53.85
			Dictyoptera	8.33	8.33	12.50	8.33	9.62
		Entognatha	Collembola	41.67	41.67	31.25	58.33	42.31
	Chelicerata	Arachnida	Aranea	100.0	91.67	93.75	100.0	96.15
			Pseudo-scorpiones	8.33	0.00	0.00	25.00	7.69
	Crustacea	Malacostraca	Isopoda	100.0	100.0	81.25	100.0	94.23
	Myriapoda			83.33	100.0	87.50	66.67	84.62
Mollusca		Gasteropoda		25.00	50.00	25.00	75.00	42.31
Annelida		Oligocheta		25.00	25.00	25.00	16.67	23.08

From the results of abundance and frequency we can conclude that in the Cefa Nature Park the organisms of the epigeal fauna that are known to be inactive in the winter season – that is normal, registered a small activity during the season with notable abundance of orders Coleoptera (Fig. 1) and Aranea (Fig. 2).

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FISHERIES MANAGEMENT INFLUENCE ON SOME ECOPHYSIOLOGICAL GROUPS OF BACTERIA IN LENTIC ECOSYSTEMS OF THE CEFA NATURE PARK (CRIŞANA, ROMANIA)

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KEYWORDS: lentic ecosystems, Cefa Nature Park, fishery management, microorganisms.

ABSTRACT

In aquatic ecosystems, sediments are the most important chemical elements of the biochemical cycle. Microorganism populations may undergo both qualitative and quantitative changes. These changes establish the ecological state of an aquatic environment. Furthermore, these changes help to identify pollution sources. Microorganisms, components of the nitrogen biochemical cycle are represented by aerobic and anaerobic nitrogen fixing bacteria, ammonifying, nitrifying and denitrifying bacteria. Based on established processes, specific dilution techniques and culture environments have been determined: the Ashby, the peptone environment, the Barjac and the Alexander. The bacterial indicator of sediment quality (BISQ), based on individual values for each ecophysiologic group, has helped us to obtain a larger view about the nitrogen circuit efficiency in the studied aquatic ecosystem. The bacterial indicator of sediment quality in lentic ecosystems from Cefa Natural Park, highlights a lack of certain biological, physical and chemical pollution sources. The fishery management was shown to negatively influence the nitrogen biochemical circuit in the studied aquatic ecosystem.

RÉSUMÉ: L'influence de la gestion piscicole sur quelques groupes écophysiologiques de bactéries des écosystèmes lentiques du Parc Naturel de Cefa (Crisana, Roumanie).

Les sédiments sont des liaisons entre les cycles biogéochimiques et les écosystèmes aquatiques. Dans les écosystèmes aquatiques, les populations de micro-organismes peuvent changer qualitativement ou quantitativement et sont capables d`établir l'état écologique d`une environnement aquatique et identifier les possibles sources de pollution. Les micro-organismes dans le cycle biogéochimique de l'azote au l`écosystèmes aquatiques du Parc Naturel Cefa sont représentés par les bactéries fixatrices d'azote aérobie et anaérobie, bactéries ammonificateurs, les bactéries nitrifiantes et les bactéries de dénitrification. Ils étaient quantitativement déterminés en utilisant la technique des dilutions en série et les cultures d`environnement spécifiques à chaque groupe ecophysiologique: l`environnement Ashby, l`environnement avec la peptone, l'environnement Barjac et l'environnement Alexandre. La qualité du l`indicateur bactérienne des sédiments, calculée à partir des valeurs individuelles pour chaque groupe ecophysiologique identifié, a fait réaliser un portrait global de l'efficacité, en ce qui concerne le circuit d`azote dans l`écosystèmes aquatiques analysés. La qualité du l`indicateur bactérienne des sédiments (QIBS) dans les écosystèmes lentiques étudiées au Parc Naturel Cefa met en évidence le manque de sources de pollution biologique, physique ou chimique. Le management piscicole a exerce une influence négative sur le cycle biogéochimique de l'azote dans les écosystèmes aquatiques analysés.

REZUMAT: Influenţa managementului piscicol asupra unor grupuri ecofiziologice de bacterii, din ecosistemele lentice din Parcul Natural Cefa (Crişana, România).

Veriga cheie a ciclurilor biogeochimice ale elementelor chimice în ecosistemele acvatice îl reprezintă sedimentele. Populaţiile de microorganisme din ecosistemele acvatice pot prezenta modificări calitative sau cantitative, capabile să permită determinarea stării ecologice a unui mediu acvatic, cât şi identificarea unei surse posibile de poluare. Microorganismele implicate în circuitul biogeochimic al azotului în ecosistemul acvatic lentic, al Parcului Natural Cefa sunt reprezentate prin bacteriile fixatoare de azot aerobe şi anaerobe, bacteriile amonificatore, bacteriile nitrificatoare şi bacteriile denitrificatoare. Acestea au fost determinate cantitativ, utilizând tehnica diluţiilor seriate şi mediile de cultură specifice fiecărui grup ecofiziologic: mediul Ashby, mediul cu peptonă, mediul Barjac şi de asemenea mediul Alexander. Indicatorul bacterian al calităţii sedimentului, calculat pe baza valorilor individuale, pentru fiecare grup ecofiziologic identificat a permis realizarea unei imagini de ansamblu în ceea ce priveşte eficienţa circuitului azotului în ecosistemul acvatic analizat. Indicatorul bacterian de calitate a sedimentului (IBCS) în ecosistemele lentice studiate, din Parcului Natural Cefa, evidenţiază lipsa unor surse de poluare biologică, fizică sau chimică foarte mari. Managementul piscicol influenţează negativ circuitul biogeochimic al azotului în ecosistemul acvatic, analizat.

INTRODUCTION

The aquatic sediments are considered highly heterogeneous systems where different phases (solid, liquid and gaseous phases), biotic environmental components (many microorganisms), abiotic components (minerals, humus, organic-mineral aggregates) are involved in physical, chemical and biological processes in the environment. All biochemical transformations based on bacteria that take place in the sediment depend on the activity of enzymes (Gianfreda and Bollag, 1996).

The final characteristics of the aquatic sediments are determined by the relative proportions of these components. The sediments are considered a key link in the biogeochemical cycle of the elements in aquatic environments. Here are the completed mineralization processes of organic substances which have not been decomposed in the water column (Muntean et al., 2001).

Microorganisms act on the environmental substrate via enzymatic processes which are achieved by redox and hydrolysis, respectively, due to the action of some final products of microbial metabolism (Muntean et al., 2004). Sediments are environments where various factors are involved in developing some complex functions. The following factors are considered important: the major mineral matrix, texture, the quantity of organic carbon, location and geographic conditions.

In microbial populations, quantitative and qualitative changes, despite of their magnitude makes possible assessing the ecological status of the aquatic environment and are therefore, good indicators of pollution. In freshwater sediments, the bacteriological parameters are more constant and more stable, being less affected by changes in the environment. Thus, in time, these parameters can reflect the evolution of water quality. These indicators can be used as standards for assessing the water quality and are successfully employed as crucial key players in the ecological rehabilitation of aquatic ecosystems (Bodoczi and Carpa, 2009; Kümmerer, 2004).

Bacteria are present in the sediment in large numbers. Their biomass is greater than the biomass of all other benthonic organisms. They have a high rate of metabolic activity. The dissolved organic and inorganic substrates can be metabolized by a substrate with high affinity and specificity. Particles of organic matter can be broken down by hydrolytic enzymes (Deming and Baross, 1993). For oxidation of organic matter, in addition to oxygen, bacteria can use nitrate, manganese, iron, sulfate and carbon dioxide as final electron acceptor (Edwards et al., 2005).

In Romania the microbiological research on sediments in lentic ecosystems has been conducted since the 90’s: Japa and Ailiesei (1999) analyzed the quantitative distribution of ecophysiological groups of bacteria involved in the biogenic cycle in lake Siriu; Ailiesei et al. (1998) conducted observations regarding the ecology of some bacterial populations in Serbanesti dam lake, and in 1999 in Bicaz lake (Ailiesei et al., 1999); Ailiesei and Japa (1995) analyzed the microbiological characteristics of Vaduri barrier lake in natural conditions and under the influence of salmonid aquaculture.

Further scientific studies were conducted by Grigore and Dragan-Bularda (2003) who aimed to study the dynamics of ecophysiologic groups of bacteria involved in nitrogen cycle in the sediments of Techirghiol lake. The distribution of ecophysiologic groups of bacteria involved in the nitrogen cycle in barrier Gilau lake (Lumperdeanu and Dragan-Bularda, 2002; Curticapean and Dragan-Bularda, 2005) and in Târniţa barrier lake (Curticapean and Dragan-Bularda, 2007) was also observed. The evaluation of the activity and dynamics of the ecological groups of bacteria (heterotrophic, lipolytic, amylolytic, proteolytic, ammonifying, nitrifying, denitrifying and iron reducing bacteria), depending on the state of eutrophication of Ochiul Mare lake ("1 Mai" Bai, Bihor country) was made by Puskás et al. (2006).

The purpose of this scientific paper is to identify the influence of fisheries management on microorganism communities in the aquatic ecosystems of Cefa Nature Park based on ecophysiologic groups of bacteria involved in the biogeochemical cycle of nitrogen.

MATERIAL AND METHODS

Description of sampling points

The lentic ecosystems from Cefa Nature Park occupy a large portion of the protected area (approximate 680 ha), and constitute uniform habitats in terms of several parameters (water depth, substrate, vegetation, etc.); they are extremely eutrophic, being used for intensive fish farming, which requires the emptying of each pond once a year; this process favors the sedimentations. We established three stations, where we collected three benthos samples and a sediment sample each season.

Station 1. Fish pond, numbered on the fisheries map with H12 (Lake 12). Water depth: 1.5 m. The collected sediment has oozing consistency.

Station 2. Fish pond, numbered on the fisheries map with H14 (Lake 14). Water depth: 1.5 m. The collected sediment has oozing consistency.

Station 3. Ateaş permanent pool. Water depth: 60 cm. The collected sediment has a mixed consistency.

Methods for bacteriological analysis

Nitrogen fixing bacteria was emphasized using the Ashby method, with the following chemical composition: K_2HPO_4 0,5 g NaCl 0,5 g $MgSO_4$ 0,2 g, K_2SO_4 0,1 g, $CaCO_3$ 5 g, 5 g of commercial sugar, 1000 ml distilled water. Samples were incubated for a week at 27° C, then for each sample and dilution, the number of positive tubes were read. For nitrogen aerobic fixing the appearance of a mantle on the surface or at least a ring on the tube walls on the surface was considered positive. Often the color of this mantle was fluorescent yellowish-green (characteristic of *A. vinellandii*). Most often the color was brown (typical for *A. chroococcum*). For anaerobic fixing (the *Clostridium sp.*) a positive feature was the appearance of gas bubbles (Dunca et al., 2004).

Numerical determination of ammonifying bacteria was done using the culture medium with peptone which had the following chemical composition: NaCl 0.5 g, Peptone 2 g, distilled water 1000 ml. The incubation was carried out at 22º C for 14 days. Highlighting ammonia produced by ammonifying bacteria activity was made by a specific color reaction with the Nessler reagent. Intense yellow coloration was obtained with or without precipitation (Cușa, 1996).

For the growth of nitrifying bacteria, the Barjac culture medium with the following chemical composition was used: KNO_3 2 g, glucose 10 g, $CaCO_3$ 5 g, Sol. Vinogradski 50 ml, distilled water 950 ml. The nitrate freed following the nitrifying bacteria's activity can be evidenced through a blue color reaction with diphenylamine-sulfuric acid reactant (Drăgan-Bularda, 2000).

To highlight the denitrifying process we used the seeded dilutions of sediment in a liquid medium where the nitrogen was present as nitrate. The culture medium had the following composition: Standard saline solution 50 ml, KNO_3 20g, $C_6H_{12}O_6$ 10 g, $CaCO_3$ 5 g, oligoelemental solution 1 ml, distilled water until 1000 ml. The incubation was carried out at 28^o C for 7-15 days after which diphenylamine-sulfuric acid was added in the tubes. In the tubes, where nitrate remained, a blue coloration occured (negative reaction). The eprubetes, where the nitrates disappeared, were colorless (positive reaction) (Dunca et al., 2007).

According to the ecophysiologic bacterial groups, the bacterial indicator of soil quality (BISQ) was assessed based on the formula proposed by Muntean (1995-1996): BISQ = 1/n x Σ log10 N, where: BISQ - bacterial indicator of soil quality, n - number of ecophysiologic groups, N - number of bacteria.

RESULTS AND DISCUSSION

Bacteriological studies were made on sediment samples collected from Cefa Natural Park in order to determine four ecophysiologic groups of bacteria: nitrogen-fixing bacteria, ammonifying bacteria, nitrifying bacteria and denitrifying bacteria. Using serial dilutions, specific culture medium for each ecophysiologic group and Alexander table, we determined the most probable number of bacteria found in the three stations. Lake 12, Lake 14 and Ateas permanent pool.

The values obtained by the analyzed ecophysiologic groups of bacteria vary greatly from one type to the other. The highest abundances were obtained for ammonifying bacteria (of the order 10^4-10^6), followed by *Azothobacter vinellandi* species (of the order 10^4-10^5), the anaerobic nitrogen-fixing bacteria represented by species of genus *Clostridium sp.* (of the order 10^4-10^5), nitrifying and denitrifying bacteria (of the order 10^3-10^4). The lowest densities were obtained for aerobic nitrogen-fixing bacteria represented by *Azothobacter chroococcum* species (of order 10^3).

Nitrogen-fixing bacteria consisted of two groups: aerobic nitrogen-fixing bacteria represented by *Azothobacter vinellandi* and *Azothobacter chroococcum*, and anaerobic nitrogen-fixing bacteria represented by species of the genus *Clostridium* sp.

Aerobic nitrogen-fixing bacteria of the species *A. vinellandi* were better represented than *A. chroococcum* which had low values in all seasons and in all sampling stations. Seasonal variations and variations depending on the sampling stations in the number of aerobic nitrogen-fixing bacteria represented by species of *A. vinellandi*, and anaerobic nitrogen-fixing bacteria from *Clostridium sp*. genus were observed (Fig. 1). The population dynamics of nitrogen-fixing bacteria is shown in the figure number 1.

The presence of large numbers of anaerobic nitrogen-fixing bacteria at station 3, Ateas permanent pool, in the spring and winter seasons indicates the creation of a closed loop of matter in the analyzed ecosystem, meaning that molecular nitrogen resulting from decomposition is fixed in sediment, avoiding losses in water or atmosphere.

In the summer and autumn seasons, an increased number of aerobic nitrogen-fixing bacteria, *A. vinellandi*, was observed, indicating a contribution of molecular nitrogen from the external environment (dissolved from atmosphere, nitrogen oxides trained by precipitation, nitrate and organic nitrogen) (Fig. 1).

The highest recorded density values (Fig. 1) for nitrogen fixing-bacteria in Ateas permanent pool, in the winter season indicates intense processes of decomposition of matter and elimination of large quantities of reduced nitrogen compounds. This is because a limited quantity of nitrogen gas was eliminated in the water and atmosphere.

At sampling station Lake 12, during all four seasons there were relatively high and similar values for aerobic nitrogen-fixing bacteria, *A. vinellandi*, indicating an external input of nitrogen from the atmosphere and water column.

Ammonifying bacteria registered an explosive growth in the spring season in all three sampling stations from Cefa Natural Park which indicates an additional contribution from vegetal or animal nitrogen organic compounds. This contribution can be considered a “constant source of pollution” in studied lentic ecosystems, which stimulates the development and growth of ammonifying bacteria communities. This leads to an increase in ammonia concentration which is very toxic to aquatic animals, especially to fish, even though the ammonium ions are not toxic or have very low toxicity.

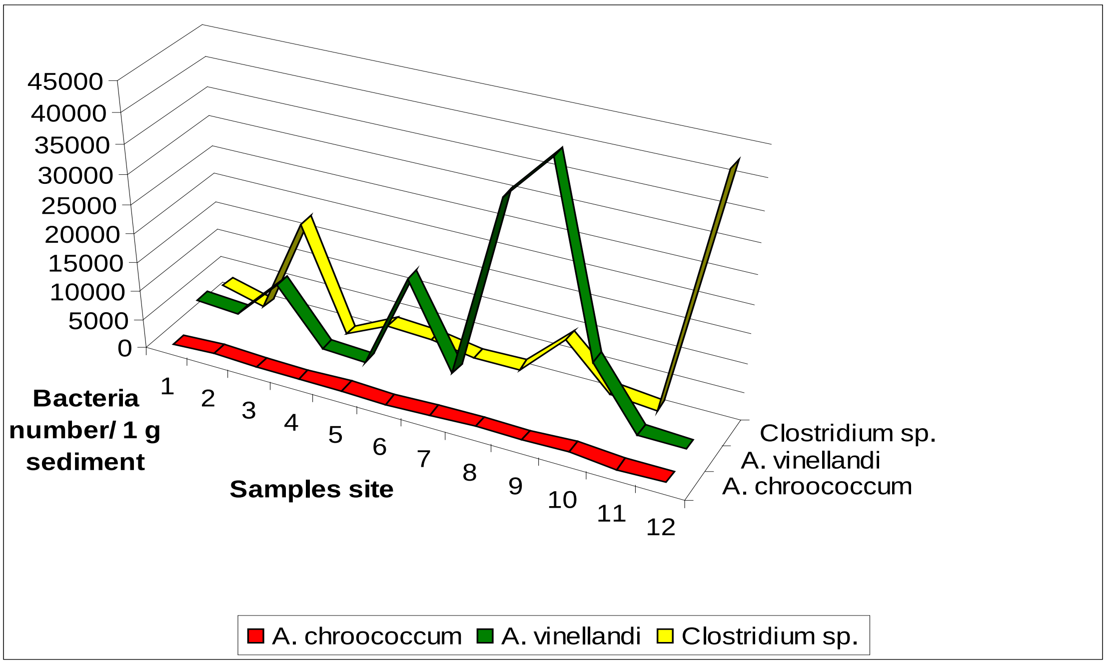

Figure 1: Dynamics of nitrogen-fixing bacteria, from analyzed sediment samples (Cefa Nature Park).

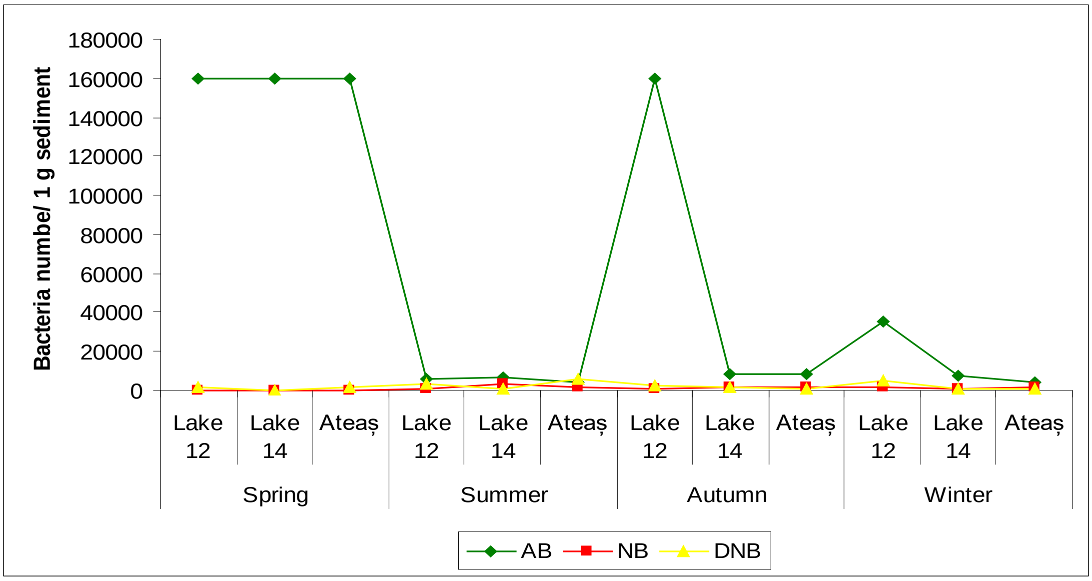

Figure 2: Dynamics of ammonifying, nitrifying and denitrifying bacteria in analyzed sediment samples (Cefa Nature Park).

Amonifying bacteria were better represented in the two lakes compared to Ateas permanent pool in all seasons (Fig. 2). This can be attributed to the fact that prior to the first frost, straw bales were placed in the lakes to maintain meshes of unfrozen waters, which are necessary to oxygenate fish communities.

Nitrifying and denitrifying bacteria were well represented numerically in summer, autumn and winter. An inverse proportional relationship existed between them (Fig. 3). Nitrates and nitrites resulting from nitrifying bacteria activity also have toxic effects on living organisms in aquatic environments. Nitrites are less toxic, and they are necessary nutrients for plants.

Based on individual values for each ecophysiologic group of bacteria, the bacterial indicator for sediment quality (BISQ) was determined using the formula proposed by Muntean (1995-1996) (Fig. 4).

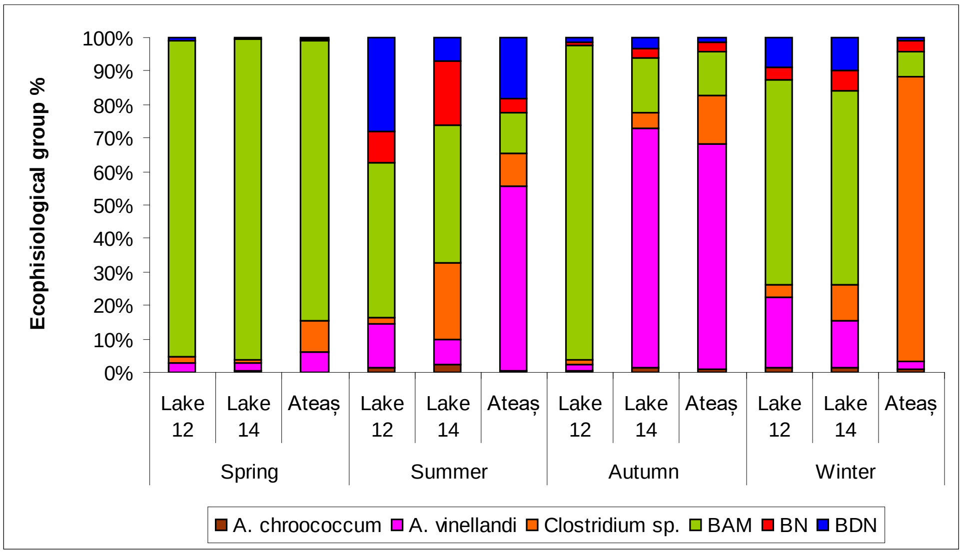

Figure 3: Weight of each ecophysiological group of bacteria involved in nitrogen cycle in aquatic ecosystems from Cefa Nature Park (amonifying bacteria (AMB) nitrifying bacteria (NB) and denitrifying bacteria (DNB).

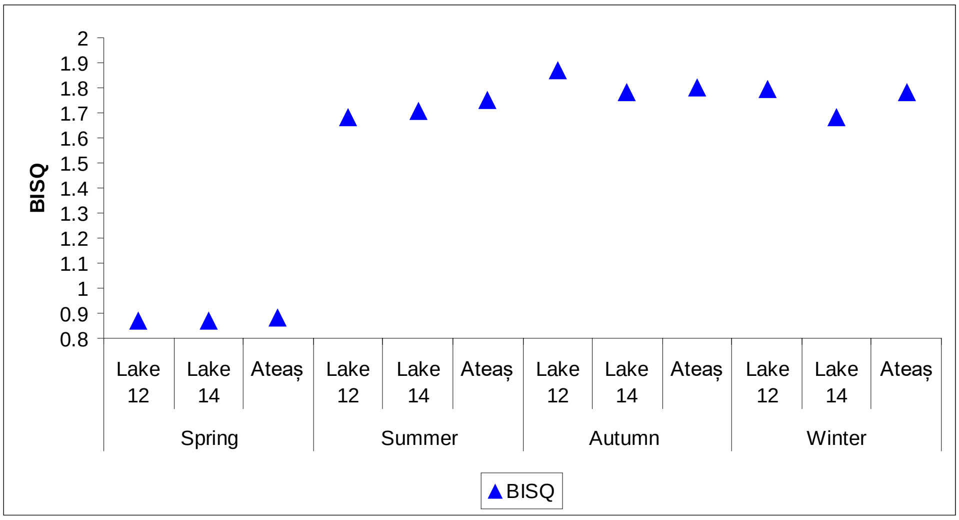

Figure 4: Variations of bacterial indicator for sediment quality (BISQ) at sampling points from Cefa Nature Park.

The bacterial indicator for sediment quality allows us to make a complete picture regarding the number and activity of microbial populations in the sediment from the studied areas. With this indicator we can also identify possible sources of organic and inorganic pollution, and the way in which this pollution sources affect the number of microorganisms.

Values recorded at the sampling points varied between 0.870 at the sampling point Lake 14 in the spring season and 1.871 at the sampling point Lake 12 in autumn season, which indicates that microbial populations were in large numbers and thus, in studied habitats the biological, chemical and physical pollutants/ impacts were not so high. The smallest value was recorded in the winter season in the sediment collected from Lake 14 (0.872), followed by 0.872 from Lake 12 in the summer season. The highest values were recorded in spring season at all sampling stations: Lake 12 (0.872), Lake 14 (0.870) and Ateas permanent pool (0.880).

The higher values registered during spring season, there were determined by an additional contribution of organic or inorganic compounds with nitrogen represented by animal dejections (farmyard manure from horses, sheep).

It is observed that the microbial population activity was the lowest in summer, except at Lake 14, which registered low values of BISQ in winter too.

At the sampling station 3 - Ateas permanent pool there are relatively similar values of BISQ in all four seasons which indicates the absence of major disturbance factors which could strongly influence the number and the activity of bacterial communities at this point. The main factor which determines the variations in the calculation of BISQ at this sampling point seems to be the temperature. So there are no additional sources of vegetal or animal organic waste or compounds and there is no loss of areas of compounds resulting from the decomposition of own organic matter. We can say that in this aquatic ecosystem, the decomposition of own vegetal or animal organic compounds ensures a closed loop of organic and inorganic matter.

At sampling stations Lake 12 and Lake 14, low values of BISQ in the summer season were observed due to the decline of the number of nitrogen-fixing and ammonifying bacteria. Decreases in the number of bacteria from these ecophysiologic groups is due to the consumption of organic and inorganic compounds with nitrogen by fish communities.

The sediments from the bottom of the aquatic ecosystems, or sludge, are broken down relatively slowly through an anaerobic denitrification process made by anaerobic bacteria. Anaerobic decomposition is due to excessive acidification of sludge which does not allow aerobic bacterial activity. Anaerobic decomposition also eliminates other putrefaction gases. Nitrates are released in gaseous form from the lake. If sludge decomposition is slower than its accumulation, the process is slow and the result is an excessive accumulation of sludge pollutant, seriously affecting water quality.

CONCLUSIONS

We can conclude that in this aquatic ecosystem, the decomposition of own vegetal and animal organic compounds ensures a closed cycle of organic and inorganic matter.

Bacterial indicator of sediment quality (BISQ) in studied lentic ecosystems highlights the lack of major physical, chemical and biological pollution sources.

Fisheries management negatively influence the biogeochemical cycle of nitrogen in studied ecosystems.

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NOTES UPON THE HERPETOFAUNA OF THE CEFA NATURE PARK, (CRIŞANA, ROMANIA)

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KEYWORDS: Cefa Nature Park, herpetofauna, forest, protected species.

ABSTRACT

The taxonomic list of herpetofauna of Cefa Nature Park comprises nine amphibian species (*Lissotriton vulgaris, Triturus dobrogicus, Bombina bombina, Bufo bufo, Epidalea viridis, Pelobates fuscus, Hyla arborea, Rana dalmatina, Pelophylax ridibundus*) and four reptile species (*Emys orbicularis, Lacerta agilis, Anguis fragilis, Natrix natrix*). Regarding its composition, it is typical for the Western Plain. From a conservation point of view, the herpetofauna of Cefa Nature Park is very important due to a high number of species of community interest, including *Triturus dobrogicus, Bombina bombina* or *Emys orbicularis*. Several species of the herpetofauna have large populations, these being species of the plain with ecological needs that are satisfied in the area under study. However, most of the species that are important from a conservation or faunistic view, are exclusively or almost exclusively present at the level of the forest, and are thus vulnerable and exposed to anthropogenic activity that affects the forest.

ZUSAMMENFASSUNG: Anmerkungen zur Herpetofauna des Naturparks Cefa (Kreis Crişana/Kreischgebiet, Rumänien).

Die Herpetofauna des Naturparks Cefa umfasst neun Amphibien- (*Lissotriton vulgaris, Triturus dobrogicus, Bombina bombina, Bufo bufo, Epidalea viridis, Pelobates fuscus, Hyla arborea, Rana dalmatina, Pelophylax ridibundus*) und vier Reptilienarten (*Emys orbicularis, Lacerta agilis, Anguis fragilis, Natrix natrix*). Die Zusammensetzung der Herpetofauna entspricht der für die Westebene, d.h. den östlichen Rand der Theißtiefebene typischen. Vom naturschutzfachlichen Standpunkt aus gesehen, ist die Herpetofauna des Naturparks Cefa sehr bedeutend, da mehrere Arten von gemeinschaftlichem Interesse festgestellt wurden, zu denen *Triturus dobrogicus, Bombina bombina* und *Emys orbicularis* zählen.Bei mehreren Arten der Herpetofauna handelt es sich um große Populationen kennzeichnender Arten der Tiefebene, deren ökologische Ansprüche den Bedingungen im Untersuchungsgebiet entsprechen. Die Mehrheit der Arten von faunistischem oder naturschutzfachlichem Interesse sind jedoch fast ausschließlich oder nahezu ausschließlich im Wald zu finden, wo sie gefährdet und jedwelchen menschlichen Tätigkeiten mit Auswirkungen auf diesen ausgesetzt sind.

REZUMAT: Note referitoare la herpetofauna Parcului Natural Cefa (Crişana, Romania).

Herpetofauna Parcului Natural Cefa este compusă din nouă specii de amfibieni (*Lissotriton vulgaris, Triturus dobrogicus, Bombina bombina, Bufo bufo, Epidalea viridis, Pelobates fuscus, Hyla arborea, Rana dalmatina, Pelophylax ridibundus*) şi 4 specii de reptile (*Emys orbicularis, Lacerta agilis, Anguis fragilis, Natrix natrix*). Sub aspectul compoziţiei, herpetofauna este tipică Câmpiei de Vest. Sub aspect conservativ, herpetofauna Parcului Natural Cefa este foarte importantă prin prisma prezenţei unui număr ridicat de specii de interes comunitar, precum *Triturus dobrogicus, Bombina bombina* sau *Emys orbicularis*. Populaţiile multor specii ale herpetofaunei sunt mari, acestea fiind specii de câmpie, a căror cerinţe ecologice sunt satisfăcute în zona studiată. Totuşi, majoritatea speciilor importante conservativ sau faunistic sunt prezente exclusiv sau aproape exclusiv la nivelul pădurii, fiind deci vulnerabile şi expuse oricărei acţiuni antropice cu efect asupra pădurii.

INTRODUCTION

The herpetofauna of the protected areas from western Romania has been the subject of many scientific investigations in the past years (Covaciu-Marcov et al., 2008a, 2009a, Cicort-Lucaciu et al., 2011). These have resulted both in scientific information and in applied data useful in the management of the respective protected natural areas. The previous scientific investigations lead to an accumulation of valuable data. This is of special local interest, since before 2000, the information related to their geographic distribution was scarce (Ghira et al., 2002). Generally, the faunistic information has contributed to the designation and afterwards to the management of the protected areas, leading to an increase of the number of protected areas in the past years in Romania (Iojă et al., 2010). In this respect, Cefa Nature Park is one of the protected natural areas from western Romania that has been recently founded. Therefore, it is imperious to know its biodiversity, the herpetofauna being a fundamental group from this point of view, following the large number of species protected by the national legislation (O.U.G. 57/2007), fact which has also been previously underlined (Covaciu-Marcov et al., 2009b). Although recently declared a protected area, data regarding the herpetofauna of this region can be found in older faunistic studies concerning the herpetofauna of some wider areas from western Romania (Covaciu-Marcov et al., 2000, Ghira et al., 2002). In this respect, our study aimed to combine the present data found in the scientific literature with our own recent investigations, in order to update de knowledge upon the herpetofauna from Cefa Nature Park.

MATERIAL AND METHODS

The study took place in the summer of 2010 and was continued in the spring of 2011. The investigations comprised a larger area around Cefa locality, situated in the south-western part of Bihor County, near the border with Hungary. We strengthen the search in the most important area from the region, respectively forest, which represents the only natural forest that has survived in the area. The amphibians were captured with the help of nets fixed on long metallic rods. However, the terrestrial amphibians and reptiles were captured directly by hand. Afterwards, all of the captured individuals were released in their habitats. Sometimes we even determined the animals that were killed on the roads from the region. Thus, the work methods were similar to the ones used in the past in the herpetologic studies from other natural protected areas from Romania (eg: Ghira, 2007; Covaciu-Marcov et al., 2008a, 2009a,c, Strugariu and Gherghel, 2008).

RESULTS AND DISCUSSION

In the Cefa Nature Park studied area we identified a total of 13 herpetofauna species. Among them, the amphibians are dominant, represented by 9 species: *Lissotriton vulgaris, Triturus dobrogicus, Bombina bombina, Bufo bufo, Epidalea viridis, Pelobates fuscus, Hyla arborea*, *Rana dalmatina* and *Pelophylax ridibundus*. The reptiles are represented by 4 species: *Emys orbicularis, Lacerta agilis, Anguis fragilis* and *Natrix natrix*. *Rana arvalis* was also identified in the region in the past; however, we did not manage to find it again.

Overall, the herpetofauna from Cefa Nature Park seems to comprise a smaller number of taxa in comparison to other natural protected areas from western Romania (Covaciu-Marcov et al., 2008a, 2009a). However, this situation is only apparent, and is rather explainable as a consequence of the position of the studied region in a lowland area, where the herpetofauna diversity is generally low. Thus, in Cefa Nature Park we identified almost all of the species that were theoretically possible to be found to exist in this region. The composition of Cefa Nature Park is generally similar to the one from other plain regions from western Romania (Ghira et al., 2002, Covaciu-Marcov et al., 2006, 2008b,c). What is of great importance from a conservative point of view is the presence of protected species in the area, of a significant conservative interest, sometimes represented by large populations.

Lissotriton vulgaris is well represented in Cefa Nature Park, being frequently signalled in the Western Plain (Ghira et al., 2002, Covaciu-Marcov et al., 2008b,c). The species is present both in forest, as well as in the non-forested areas. In the former case it is more abundant, populating different bogging areas with low depth formed during spring, but also deeper canals. The populations are more reduced outside the forest, being limited to different canals.

Triturus dobrogicus is much rarer than the previous one, despite the fact that it is a species characteristic to lowlands (Cogălniceanu et al., 2000), and the investigated habitats could fulfil its ecological requirements. Previously, the species was found in several places from the Western Plain (Covaciu-Marcov et al., 2008a,b,c, 2009a), being identified in new areas in the past years (Covaciu-Marcov et al., 2010). We encountered *Triturus dobrogicus* only inside forest, in the wider bogging areas, together with the common newt. The rarity of the species is probably a consequence of the modification of many terrestrial habitats from the non-forested areas of the studied region. The low abundance of the crested newts has also been explained in other areas from Romania due the anthropogenic modification of the terrestrial habitats necessary after the ending of the reproduction period (Covaciu-Marcov et al., 2009d). Unfortunately, the reproduction habitats of the newts found in non-forested areas, which are limited to canals, are entirely surrounded by agricultural fields. These facts underline once more the importance of forest in order to assure the survival of this extremely important species from Cefa Nature Park.

Bombina bombina is a common species, widely distributed in Cefa Nature Park. The species occupies the entire surface of the studied region, being represented through large populations. In forest, *Bombina bombina* is present in a large diversity of aquatic habitats, being encountered in temporary puddles during spring. In the rest of the area, the species is very well represented in ditches and canals localised on the road edges or in the bogging areas formed during spring.

Bufo bufo is a much rarer species than the previous one. It was exclusively identified in forest, where the population seems to be stable.

Epidalea viridis is better represented than the previous one, being distributed in the entire studied region. Although it is also present in forest, numerous individuals are also distributed in the non-forested areas that are affected by man, which are generally occupied by agricultural fields. The species' abundance in the region is during the reproduction period, where numerous individuals are present in canals or bogging areas. Individuals that have been found dead on the road have also been observed, fact also signalled in other regions from the country (Sos, 2007).

Pelobates fuscus is also common in Cefa Nature Park, being present in the entire studied area, as the previous one.

Hyla arborea is much rarer in the region, being recorded only in forest, where it seems to be common, relatively many individuals being observed during spring.

Rana dalmatina is a species connected to forest, as is the previous one. Despite the fact that an overwhelming majority of individuals was observed in the forest, the species occasionally appears outside of it too. Thus, a low number of samples was recorded in the grassy, wet areas, neighbouring the forest, or at the level of the wet areas bordering on some canals and water courses, with the condition that they are surrounded by natural, characteristic vegetation.

Pelophylax ridibundus is extremely common in the region, being advantaged by the large number of wet areas. It is present both in the canals from the non-forested sectors, in the basins of the piscicultural farm, as well as in the wet areas from inside forest. In the forest it can be noticed in the wet periods, especially during spring. Not only it does occupy the entire region, but the number of observed *Pelophylax ridibundus* individuals was extremely high. The fact is in accordance with the previous records from the Western Plain (Covaciu-Marcov et al., 2008b,c), being the most well represented form from the green frog complex from western Romania (Sas, 2010).

Emys orbicularis is a rare species in the region, being observed at the level of the wide canals from the area and in the basins of the piscicultural farms.

Lacerta agilis is common, being observed in the entire researched area. It populates both the outskirts as well as the opened areas from inside forest, but it also appears in large numbers in the vegetation from the margin of the canals and roads.

Anguis fragilis is probably the most rare reptile species from Cefa Nature Park. Only two individuals were observed exclusively inside forest.

Natrix natrix is common in the region, being identified on its entire surface. As *Lacerta agilis,* the species is present both at the level of forest as well as in the canals from the region. In some cases this species has fallen victim to the road traffic.

Together with the above mentioned species, another amphibian species was mentioned in the past at Cefa, namely *Rana arvalis* (Covaciu-Marcov et al., 2000, Ghira et al., 2002). During our field activity, we did not observe this species, probably due to the reduced time spent on the field, or because it has disappeared as a result of the habitat modification. *Rana arvalis* was also very rare in the region in the past, forest having been anthropogenically affected in the past 10 years, while some wet areas from outside of it have been completely eliminated. For example, a construction was realised right in the area in which the species has been observed in the past in forest. The chances that this species should survive in the area are realistic only at the level of forest, where there should be taken future studies in this direction. Moreover, any intervention upon the forest should be stopped, fact which is also important in the case of other herpetofauna species.

The presence of forest is extremely important to the herpetofauna of Cefa Nature Park. The forest is a refuge to some species, inexistent in the non-forested field sectors from the vicinity. This is the case of *Hyla arborea* and *Bufo bufo* from the amphibians and of *Anguis fragilis* from the reptiles. Moreover, there are many other species that have much larger populations in the forest than in the non-forested areas from the vicinity. This is the case of *Lissotriton vulgaris* or *Rana dalmatina*. The situation is also valid in other protected areas from western Romania, such as Tur Inferior Reservation, where the most important herpetofauna sectors are situated inside the forested areas (Covaciu-Marcov et al., 2008a). These data confirm the previous affirmations regarding the role of the forest strips in the plain in maintaining the biodiversity (Digiovinazzo et al., 2011).

Although many species, from which many are conservatively important ones, are represented in Cefa Nature Park through large populations, being distributed on wide surfaces, the herpetofauna of this area is, however, on a whole, affected by man. Thus, forest interventions have been performed in forest in the last years, which have led to the cutting down of some trees. The fact is apparently meaningless, but it must be regarded as very important in relation with the reduced surface of this forest. Meanwhile, at the limit of the forest there are sheepfolds with animal herds that affect some of the wet areas or the forest frogs. In the areas neighbouring the forest, agriculture and constructions negatively affect the few species present in these regions. In addition, the road system negatively affects the herpetofauna, but presently the phenomenon seems to have a reduced its proportions.

CONCLUSIONS

We identified 9 amphibian species and 4 reptile species in Cefa Nature Park. The herpetofauna of the protected area is characteristic of the Western Plain. Although the number of species is reduced, among them there are many species important from a conservative point of view (*Triturus dobrogicus, Bombina bombina* or *Emys orbicularis*). The most important area for the amphibians and reptiles is forest, which shelters the largest populations from all of the species. Moreover, there are species that were observed only in this forest. In the non-forested areas, which are highly affected by man, few species are present, being represented through populations with a low number of individuals.

In perspective, the anthropogenic interventions upon forest and the wet areas bordering it will have to be limited and strictly supervised. These represent an essential requirement for the herpetofauna protection from Cefa Nature Park.

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CONTRIBUTION TO THE KNOWLEDGE OF THE BAT FAUNA (CHIROPTERA) FROM THE CEFA NATURE PARK (CRIŞANA, ROMANIA);

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ABSTRACT

The objective of this study was to complete the faunistic list of bats (Chiroptera) in the Cefa Nature Park in north-western Romania. The study site lies on the border of Hungary and Romania near the Körös-Maros/Criş-Mureş National Park. Surveys of bat fauna were only possible by using a combination of several methods. Based on the results in the study area, 21 bat species were identified (from a total of 6314 samples). During the study, 11 new species were found, which had not been were not noted in the Natura 2000 site ROSCI0025 Cefa. These species are *Barbastella barbastellus* (Schreber, 1774), *Eptesicus nilssonii* (Keyserling and Blasius, 1839), *Hypsugo savii* (Bonaparte, 1837), *Miniopterus schreibersii* (Kuhl, 1819), *Myotis bechsteinii* (Kuhl, 1817), *Myotis brandtii* (Eversmann, 1845), *Myotis emarginatus* (Geoffroy, 1806), *Myotis nattereri* (Kuhl, 1817), *Nyctalus leisleri* (Kuhl, 1817), *Plecotus austriacus* (Fischer, 1829) and *Vespertilio murinus* (Linnaeus, 1758). Due to the fact that six of the species found at the study site are listed in Annex II and IV of the EU Habitats Directive [*Barbastella barbastellus* (Schreber, 1774), *Miniopterus schreibersii* (Kuhl, 1819), *Myotis bechsteinii* (Kuhl, 1817), *M. dasycneme* (Boie, 1825), *M. emarginatus* (Geoffroy, 1806) and *Rhinolophus ferrumequinum* (Schreber, 1774)], we conclude that this habitat should be protected and better managed for wildlife conservation in the future.

ZUSAMMENFASSUNG: Beiträge zur Kenntnis der Fledermausfauna (Chiroptera) des Naturparks Cefa (Crisana/Kreischgebiet/Rumänien).

Hauptziel dieser Arbeit war, dass Vorkommen und die Verbreitung der Fledermausarten (Chiroptera) in der Region um Cefa (Rumänien) zu dokumentieren. Das untersuchte Gebiet (UG) befindet sich im Nord-Westen Rumäniens an der Grenze zu Ungarn, nähe des Körös-Maros/Criş-Mureş Nationalparks. Anhand der Ergebnisse, konnten bis zu diesem Zeitpunkt 21 Fledermausarten nachgewiesen werden (insgesamt 6314 Kontakte). Im UG konnten 11 neue Arten nachgewiesen werden, die bislang vom Natura 2000-Gebiet ROSCI0025 Cefa nicht bekannt waren. Es handelt sich um die Arten *Barbastella barbastellus* (Schreber, 1774), *Eptesicus nilssonii* (Keyserling and Blasius, 1839), *Hypsugo savii* (Bonaparte, 1837), *Miniopterus schreibersii* (Kuhl, 1819), *Myotis bechsteinii* (Kuhl, 1817), *Myotis brandtii* (Eversmann, 1845), *Myotis emarginatus* (Geoffroy, 1806), *Myotis nattereri* (Kuhl, 1817), *Nyctalus leisleri* (Kuhl, 1817), *Plecotus austriacus* (Fischer, 1829) und *Vespertilio murinus* (Linnaeus, 1758). Ferner gelang der Nachweis von sechs FFH-Arten, *Barbastella barbastellus* (Schreber, 1774), *Miniopterus schreibersii* (Kuhl, 1819), *Myotis bechsteinii* (Kuhl, 1817), *Myotis dasycneme* (Boie, 1825), *Myotis emarginatus* (Geoffroy, 1806) und *Rhinolophus ferrumequinum* (Schreber, 1774), die sowohl im Anhang II als auch im Anhang IV der FFH-RL gelistet sind. Um den Schutz dieser Arten zu gewährleisten, müssen Gebiete von Gemeinschaftlicher Bedeutung gemeldet und ausgewiesen werden.

REZUMAT: Contribuţii la cunoaşterea faunei de lilieci (Chiroptera) din Parcul Natural Cefa (Crişana, România).

Ţelul acestei lucrări a fost în primul rând documentarea asupra speciilor de lilieci şi a răspândirii lor în aria studiată. Suprafaţa studiată se află în Judeţul Bihor lângă localitatea Cefa, în apropierea graniţei cu Ungaria, respectiv în apropierea Parcului Naţional Körös-Maros/Criş-Mureş. Cercetarea faunei de lilieci era posibilă doar prin combinarea mai multor metode. Pe baza rezultatelor, din zona studiată, au putut fi identificate până în prezent 21 specii de chiroptere (în total 6314 contacte). Pentru zona cercetată, au fost gasite 11 specii noi, nesemnalate până în prezent din situl ROSCI0025 Cefa. Este vorba de speciile *Barbastella barbastellus* (Schreber, 1774), *Eptesicus nilssonii* (Keyserling and Blasius, 1839), *Hypsugo savii* (Bonaparte, 1837), *Miniopterus schreibersii* (Kuhl, 1819), *Myotis bechsteinii* (Kuhl, 1817), *Myotis brandtii* (Eversmann, 1845), *Myotis emarginatus* (Geoffroy, 1806), *Myotis nattereri* (Kuhl, 1817), *Nyctalus leisleri* (Kuhl, 1817), *Plecotus austriacus* (Fischer, 1829) si *Vespertilio murinus* (Linnaeus, 1758). Totodată au mai fost întâlnite speciile *Barbastella barbastellus* (Schreber, 1774), *Miniopterus schreibersii* (Kuhl, 1819), *Myotis bechsteinii* (Kuhl, 1817), *Myotis dasycneme* (Boie, 1825), *Myotis emarginatus* (Geoffroy, 1806) şi *Rhinolophus ferrumequinum* (Schreber, 1774), specii a căror conservare necesită desemnarea unor arii speciale de conservare.

INTRODUCTION

The purpose of this study is to contribute to the knowledge of the bat fauna (Chiroptera) in the Cefa Nature Park by identifying the number and distribution of species present in the study area. Management practices will be developed on biodiversity conservation and to strengthen public awareness.

The Cefa Nature Park is located in the northwestern part of the Romanian national territory near Cefa locality, in the relative proximity of the Hungarian border in close proximity to Körös-Maros/Criş-Mureş National Park (Fig. 1). The site is located in Bihor County at elevations ranging from 84 to 107 meters.

MATERIAL AND METHODS

Bats recordings took place on 05.07.2010, 25.03.2011, 15.04.2011, 09.06.2011, 29.06.2011 and 08.08.2011 (see Results). The following equipment was used for sound recordings: one detector type Batcorder 2, Pettersson D240x bat detector with a Edirol R-09HR MP3 recorder, a GPS/PDA (ASUS A636) and a thermometer (Atech). To document the habitats and species a PENTAX W90 camera was used. All known roosts for bats were inventoried. Verification of human shelters took place on 29.05.2010. Mist nets were not used to capture individuals. A roost colony inventory inside hollows of old trees did not occur.

Recordings made with a Batcorder 2 were performed throughout the night at two sites for two hours each site. Transects were partially completed by car and on foot. All transects were completed two times. On the first pass of the transect, foraging and roosting habitats of individuals were recorded. After sunset as second pass was conducted where bat species were identified and flight/foraging routes were noted. Recordings were made during the night at the fixed points set with a GPS device. Recordings were conducted in 31 points for 5 minutes with a Pettersson D240x bat detector as follows: 1-10 points on 09.06.2011, 11-20 on 29.06.2011, the remaining points (21-31) on 08.08.2011. Recordings were made about 25 min. after sunset during good weather.

Recordings of species on the Batcorder 2 detector were transferred to a MacBook. Using bcAdmin and batIdent, for critical species bcAnalyse and Skiba (2009). The publications by Dietz et al. (2007), Jére (2008), Jére and Szodoray-Parádi (2008, 2010) and Stutz et al. (2009) were used to identify species in roosts.

Figure 1: The studied area
(source: Google Earth, 2012).

RESULTS

Natural habitats adjacent to Cefa Nature Park

The present Natura 2000 habitats in the study area are: Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*) (6510), Pannonic loess steppic grasslands (6250*), Hydrophilous tall herb fringes communities of plains and of the montane to alpine levels (6430), Pannonic salt steppes and salt marshes (1530*), Natural dystrophic lakes and ponds (3160) and Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, and along the big rivers (*Ulmenion minoris*). Two of these are priority habitats (*) in need of protection; it is recommended that they be designated as natural protected areas (Figs. 2-7).

Figure 2: The Cefa Nature Park is partially surrounded by pasture and the forest (Hoffmann, 2011).

Figure3: Flooded forest during the spring (Hoffmann, 2011).

Figure 4: Wet meadow in the Forest (Hoffmann, 2011).

Figure 5: Pasture near Ateaş. The highest point in the study area (Hoffmann, 2011).

Figure 6: Drainage canal near the ornithological observation tower. Important foraging area for several bat species (Hoffmann, 2011).

Figure 7: View from the ornithological observation tower of the fish ponds and the forest (Hoffmann, 2012).

The results obtained with the Batcorder 2 detector

Based on the results obtained in the study area, 21 bat species were identified for this study. Among them, 11 new species were not registered previously in the Natura 2000 site ROSCI0025 Cefa (Tab. 1). Some of the species are *Barbastella barbastellus* (Schreber, 1774), *Eptesicus nilssonii* (Keyserling and Blasius, 1839), *Hypsugo savii* (Bonaparte, 1837), *Miniopterus schreibersii* (Kuhl, 1819), *Myotis bechsteinii* (Kuhl, 1817), *Myotis brandtii* (Eversmann, 1845), *Myotis emarginatus* (Geoffroy, 1806), *Myotis nattereri* (Kuhl, 1817), *Nyctalus leisleri* (Kuhl, 1817), *Nyctalus noctula* (Schreber, 1774), *Plecotus austriacus* (Fischer, 1829) and *Vespertilio murinus* (Linnaeus, 1758). Furthermore the species *Barbastella barbastellus* (Schreber, 1774), *Miniopterus schreibersii* (Kuhl, 1819), *Myotis bechsteinii* (Kuhl, 1817), *Myotis emarginatus* (Geoffroy, 1806) and *Rhinolophus ferrumequinum* (Schreber, 1774), are not included in the standard list from the site ROSCI0025.

In the period between 05.07.2010-09.08.2011, 6163 contacts with individuals of several species (21 bat species) were recorded (see the table number 1 and the figures number 8-22). A high abundance of the species *Nyctalus noctula* (1319), followed by species like *Pipistrellus nathusii* (783), *Pipistrellus pygmaeus* (727), *Pipistrellus kuhlii* (124), *Miniopterus schreibersii* (109), *Vespertilio murinus* (65), *Pipistrellus pipistrellus* (60), *Eptesicus nilssonii* (56), *Hypsugo savii* (53), *Eptesicus serotinus* (46), *Myotis dasycneme* (43), *Myotis daubentonii* (33), *Nyctalus leisleri* (27), *Myotis nattereri* (19), *Barbastella barbastellus* (8), *Myotis bechsteinii* (8), *Myotis brandtii* (7), *Myotis mystacinus* (7), *Rhinolophus ferrumequinum* (3), *Plecotus austriacus* (2) and *Myotis emarginatus* (1) were observed (only individuals determined to species level, obtained with the program batIdent respectively bcAnalyse).

Table 1: Species present in the study area. The species marked with * are listed in annex II of the Habitate Directive. Abbr.: Abbreviations: S.P.: Nature Park Administration; T.O.: Ornithological observation tower; Tot.: Total; *Myotis sp.:* individuals belonging to the genus *Myotis*; ind.: individuals; Mbart: *Myotis brandtii/mystacinus*; Nyctief: ind. belonging to *Nyctalus noctula* or *Nyctalus lasiopterus* or *Tadarida tiniotis*; Phoch: ind. belonging to *Miniopterus schreibersii* or *Pipistrellus pipistrellus* or *Pipistrellus pygmeus;* Pmid: ind. belonging to *Pipistrellus nathusii* or *Pipistrellus kuhlii;* Spec.= Individuals of some batspecies that could not be determined because of large distance from detector.

Scientific Name	Abbr.	S.P. 05.07. 2010	S.P. 25.03. 2011	T.O. 15.04. 2011	S.P. 15.04. 2011	S.P. 09.06. 2011	S.P. 29.06. 2011	S.P. 08.08. 2011	Tot.
* *Barbastella barbastellus* (Schreber, 1774)	Bbar	-	-	3	-	2	1	2	8
Eptesicus nilssonii (Keys. and Blasius, 1839)	Enil	4	-	48	-	-	3	1	56
Eptesicus serotinus (Schreber, 1774)	Eser	2	2	39	-	1	1	1	46
Hypsugo savii (Bonaparte, 1837)	Hsav	4	-	28	8	2	11	-	53
* *Miniopterus schreibersii* (Kuhl, 1819)	Misch	21	6	34	11	20	15	2	109

Table 1 continued.

Scientific Name	Abbr.	S.P. 05.07. 2010	S.P. 25.03. 2011	T.O. 15.04. 2011	S.P. 15.04. 2011	S.P. 09.06. 2011	S.P. 29.06. 2011	S.P. 08.08. 2011	Tot.
* *Myotis bechsteinii* (Kuhl, 1817)	Mbec	4	-	3	-	-	1	-	8
Myotis brandtii (Eversmann, 1845)	Mbra	-	-	-	1	2	4	-	7
* *Myotis dasycneme* (Boie, 1825)	Mdas	7	-	4	1	6	25	-	43
Myotis daubentonii (Kuhl, 1817)	Mdau	12	-	2	1	5	13	-	33
* *Myotis emarginatus* (Geoffroy, 1806)	Mema	-	-	-	-	1	-	-	1
Myotis mystacinus (Kuhl, 1817)	Mmys	5	-	2	-	-	-	-	7
Myotis nattereri (Kuhl, 1817)	Mnat	-	14	-	3	-	2	-	19
Nyctalus leisleri (Kuhl, 1817)	Nlei	-	-	18	1	6	2	-	27
Nyctalus noctula (Schreber, 1774)	Nnoc	189	57	509	83	366	102	13	1319
Pipistrellus kuhlii (Kuhl, 1817)	Pkuh	70	4	18	18	10	1	3	124
Pipistrellus nathusii (Keys. and Blasius, 1839)	Pnat	165	23	93	298	112	85	7	783
Pipistrellus pipistrellus (Schreber, 1774)	Ppip	3	3	8	2	39	2	3	60
Pipistrellus pygmaeus (Leach, 1825)	Ppyg	60	223	113	88	156	71	16	727
Plecotus austriacus (Fischer, 1829)	Paus	2	-	-	-	-	-	-	2
* *Rhinolophus ferrumequinum* (Schreber, 1774)	Rfer	-	-	-	-	2	1	-	3
Vespertilio murinus (Linnaeus, 1758)	Vmur	-	-	56	1	6	1	1	65
Mbart	-	-	3	-	1	-	-	-	4
Myotis sp.	-	2	8	-	-	1	2	-	13
Nyctaloid	-	4	3	56	1	52	2	1	119
Nyctief	-	7	1	2	1	-	1	-	12
Pipistrelloid (soc.)	-	83	12	2	39	12	6	1001	1155
Phoch	-	-	4	-	-	-	-	-	4
Pmid	-	-	20	-	268	-	-	-	288
Spec.	-	11	31	90	52	65	6	813	1068
Total:	-	655	414	1125	878	864	357	1864	6163

To demonstrate bat activity, two figures were created for each night. The figures show the activity of the individuals during the recording period (Figs. 8 and 9).

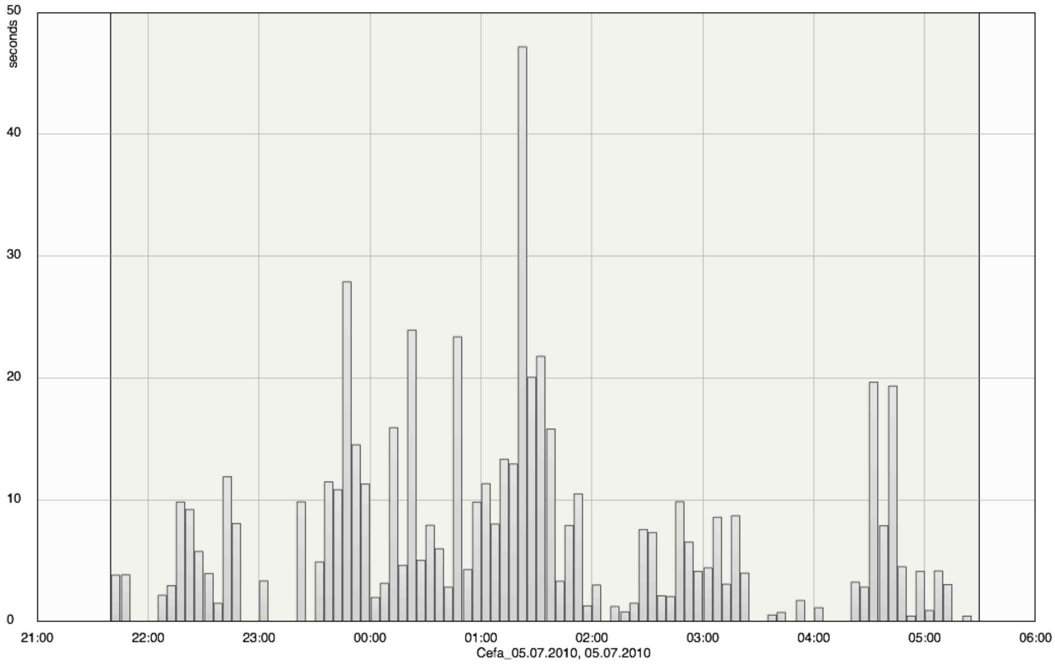


Figure 8: Diagram with the detected individuals in the court of the Cefa Nature Parc Administration during a night (05.07.2010).

The figure number 9 shows the species and analysis for identification that occurred for each night's worth of data. The BatIdent program can carry out identification to 4 stages.

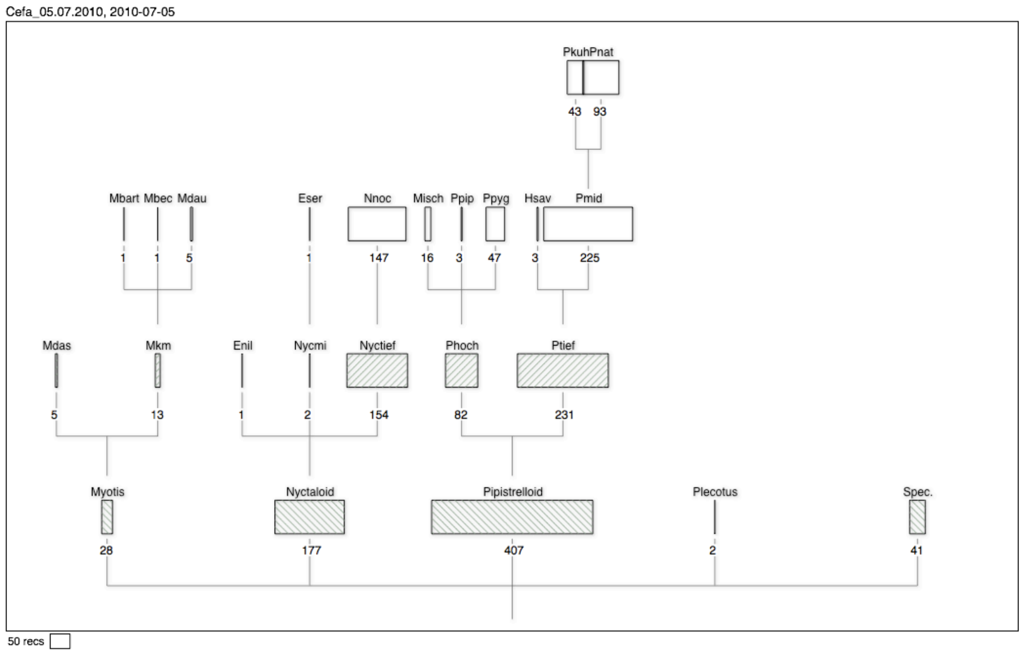


Figure 9: The diagram indicates the species and stages (05.07.2010). Spec. = Individuals that could not be determined due to long distance from the detector.

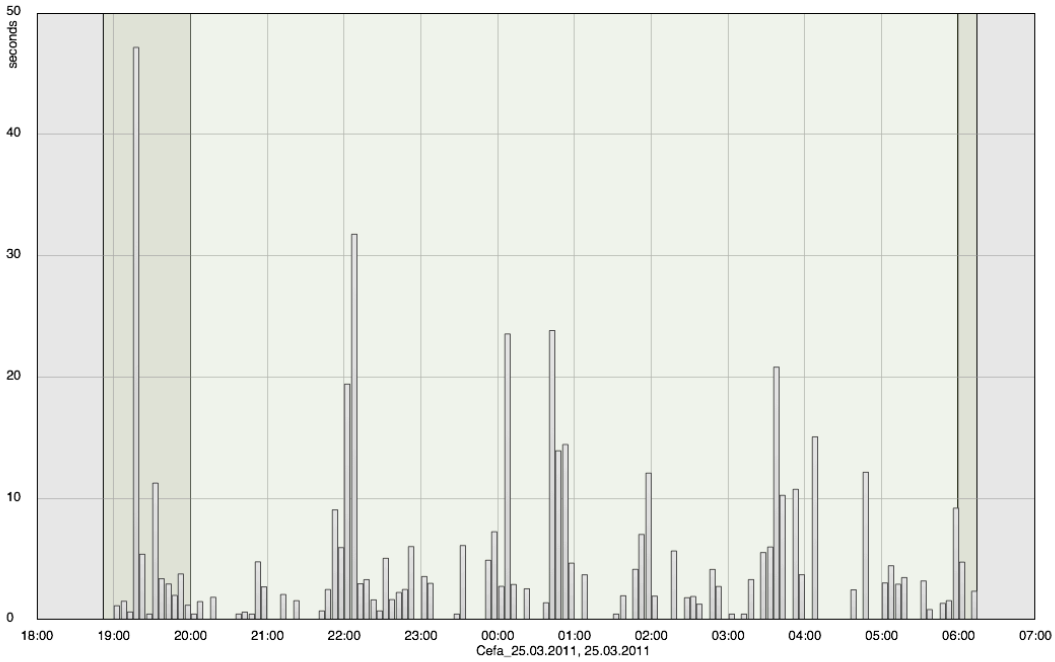


Figure 10: All detected individuals at one site at the Cefa Nature Park over one night (25.03.2011).

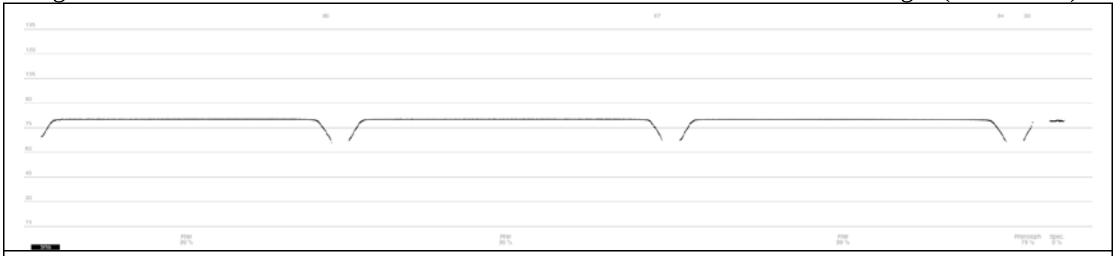
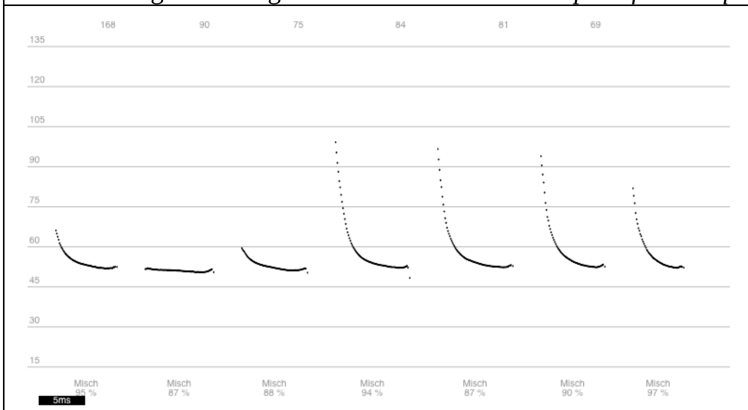


Figure 11: Figure with calls from *Rhinolophus ferrumequinum* (Schreber, 1774).



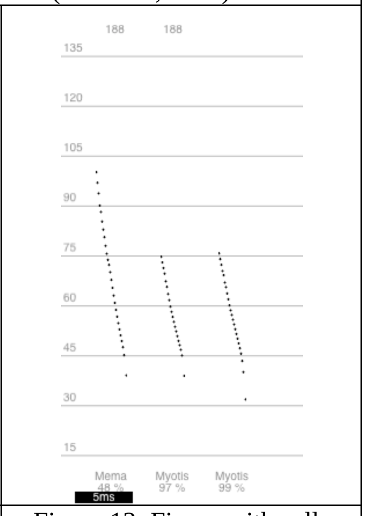


Figure 12: Figure with calls from *Miniopterus schreibersii* (Kuhl, 1819).

Figure 13: Figure with calls from *Myotis emarginatus* (Geoffroy, 1806)

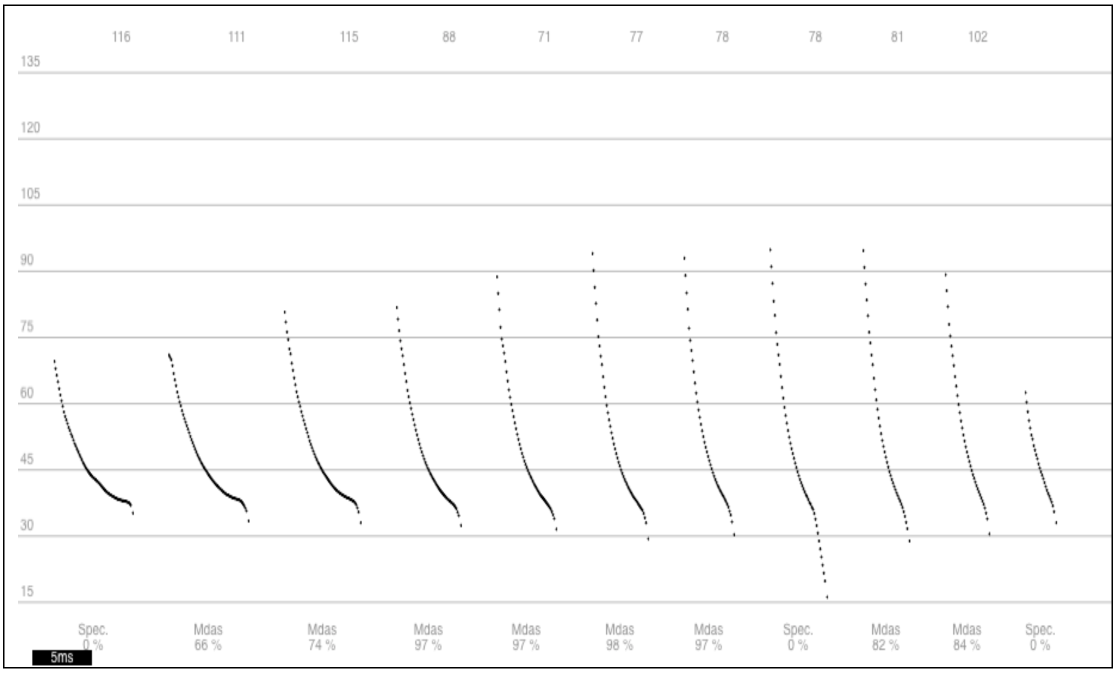


Figure 14: Figure with calls from *Myotis dasycneme*
(Boie, 1825).

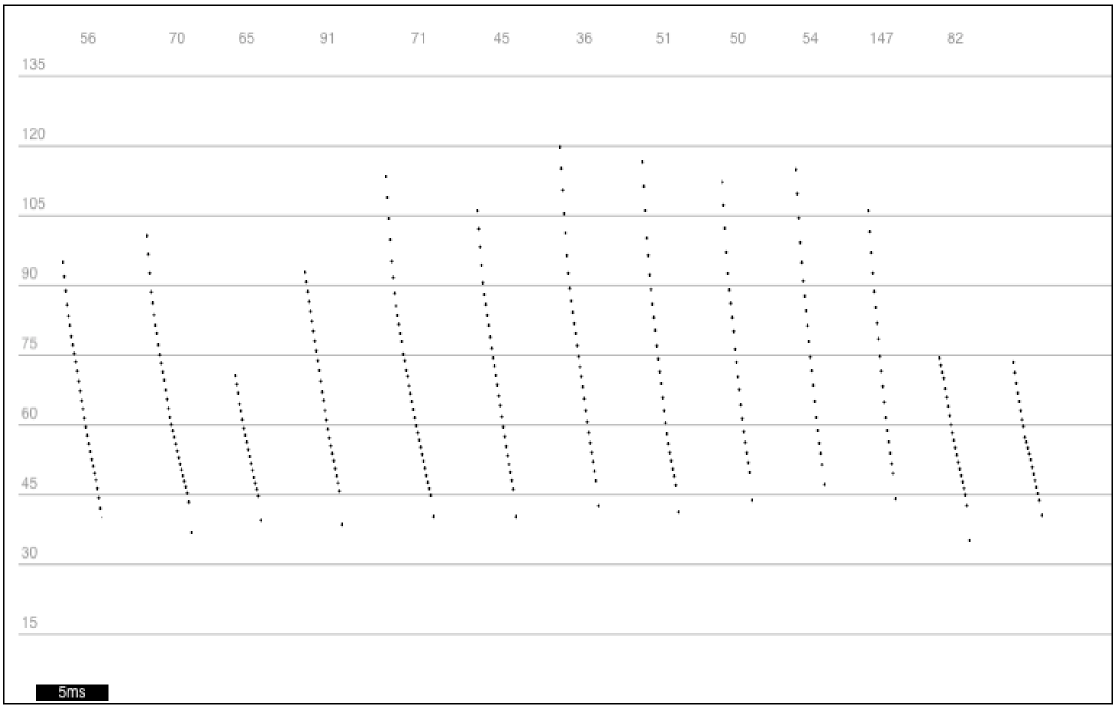


Figure 15: Calls from *Myotis bechsteinii*
(Kuhl, 1817).

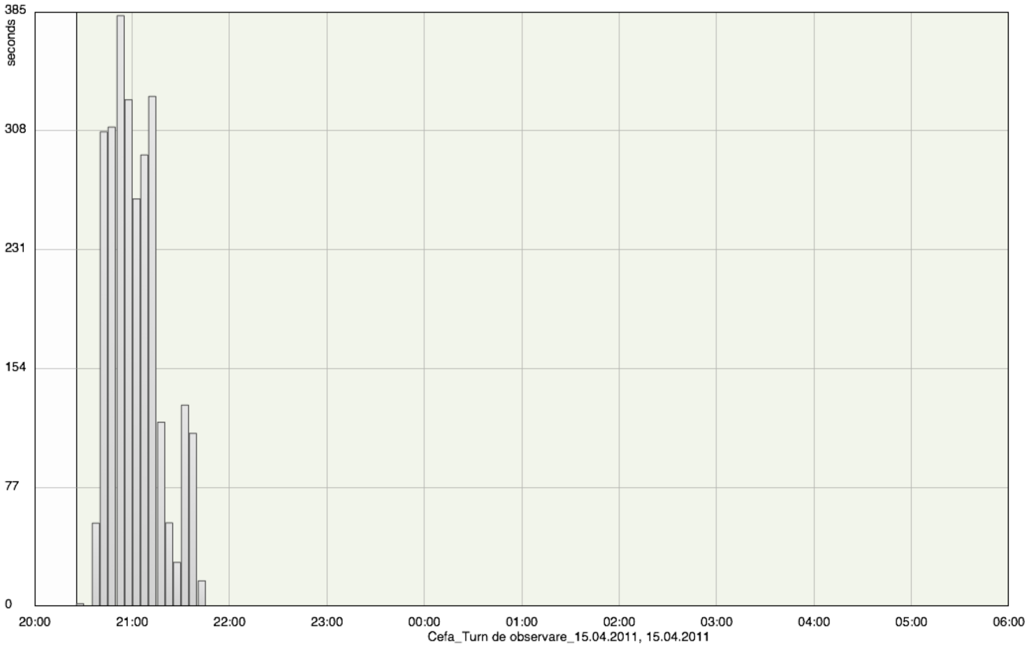


Figure 16: Diagram with the detected individuals from the ornithological observation tower during a two hour period (15.04.2011).

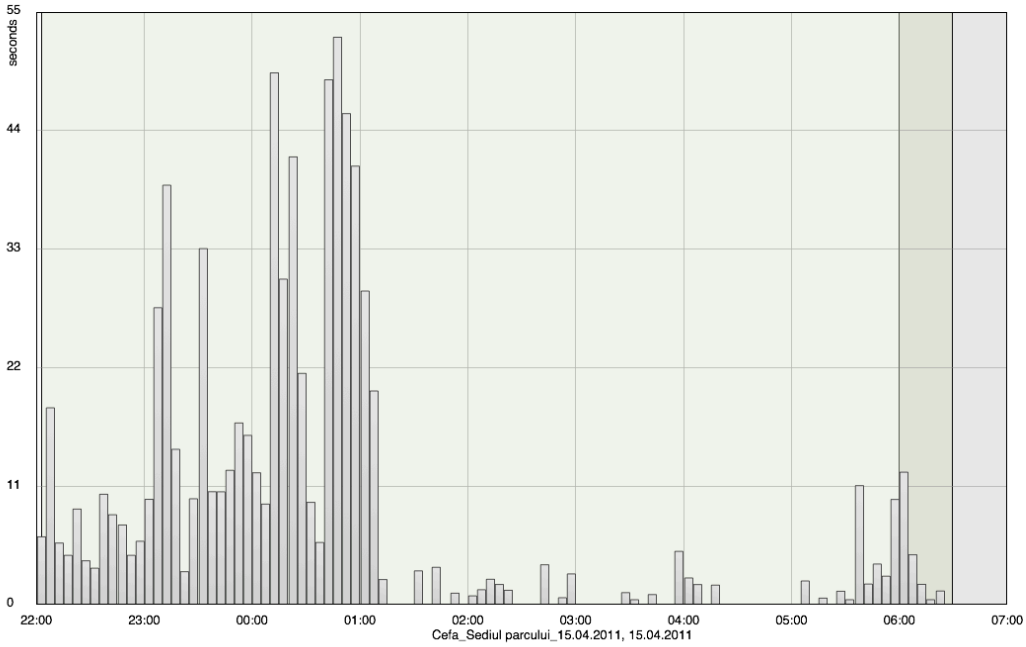


Figure 17: Diagram with the detected individuals in the study site at the Cefa Nature Park over a one night period (15.04.2011).

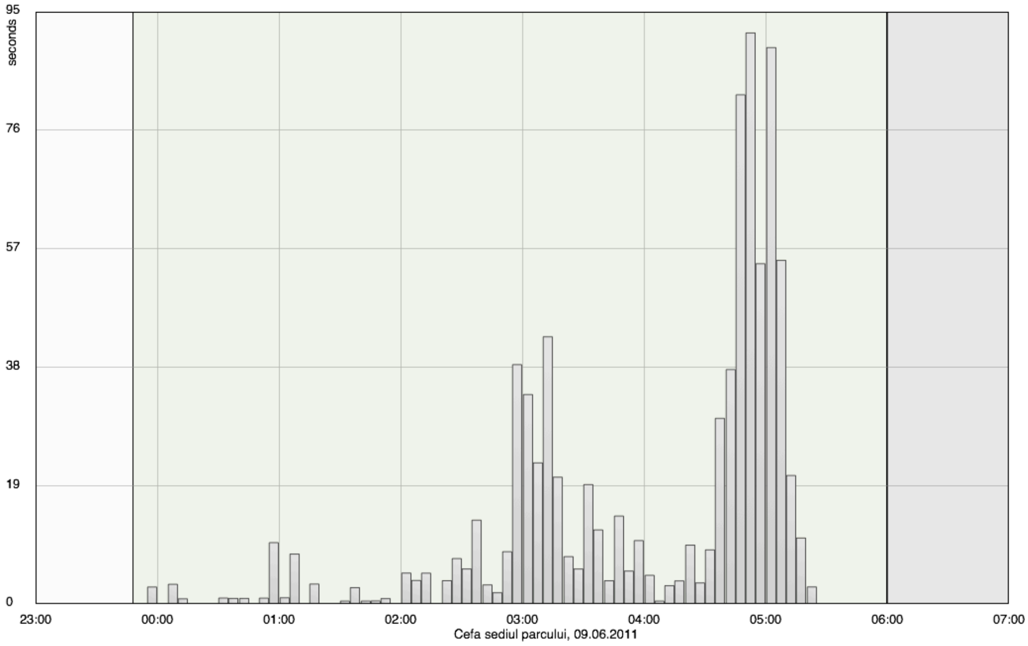


Figure 18: Diagram with the detected individuals in the study site at the Cefa Nature Park over a one a night period (09.06.2011).

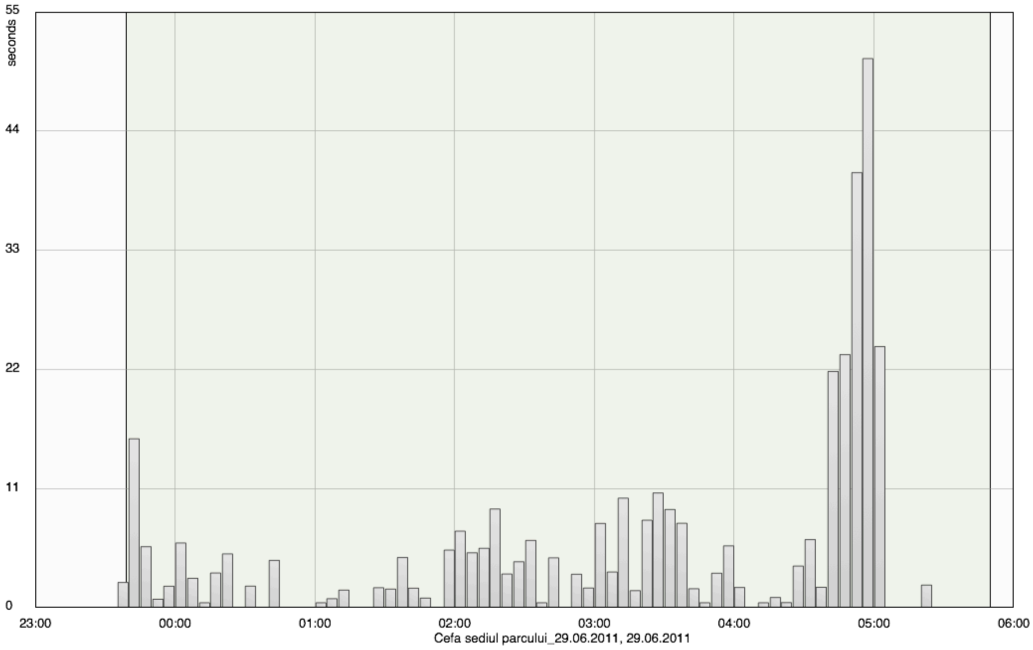


Figure 19: Diagram with the detected individuals in the Cefa Nature Park over a one night period (29.06.2011).

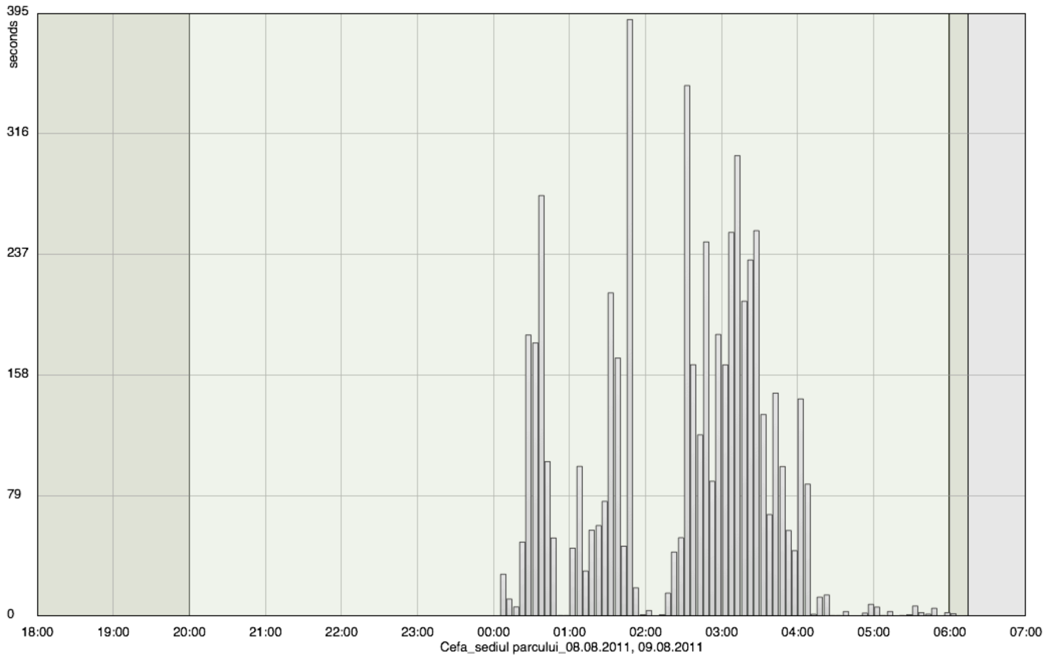


Figure 20: Diagram with the detected individuals in the study site at the Cefa Nature Park over a one a night period (08.08.2011).

The diagram below shows us the total number of recordings taken with the Batcorder 2 detector during nights spent in the field (Figure 21).

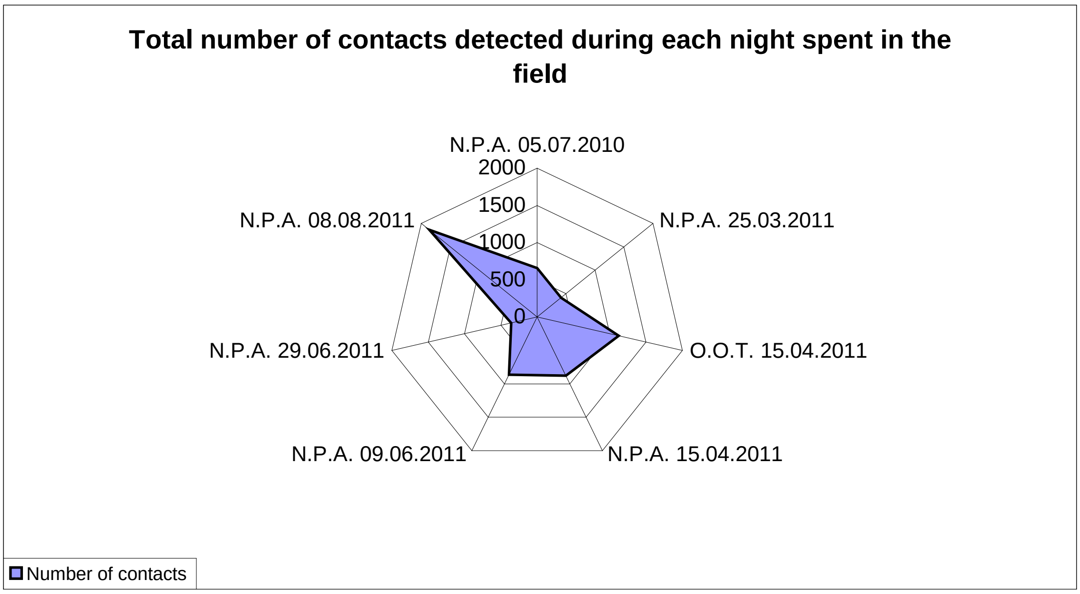


Figure 21: Diagram with the number of contacts detected with the Batcorder 2 during each night spent in the field. N.P.A=Nature Park Administration, O.O.T=Ornithological Observation Tower.

The figure number 22 indicate the number of recorded species and individuals detected in the field, displayed in the table number 1.

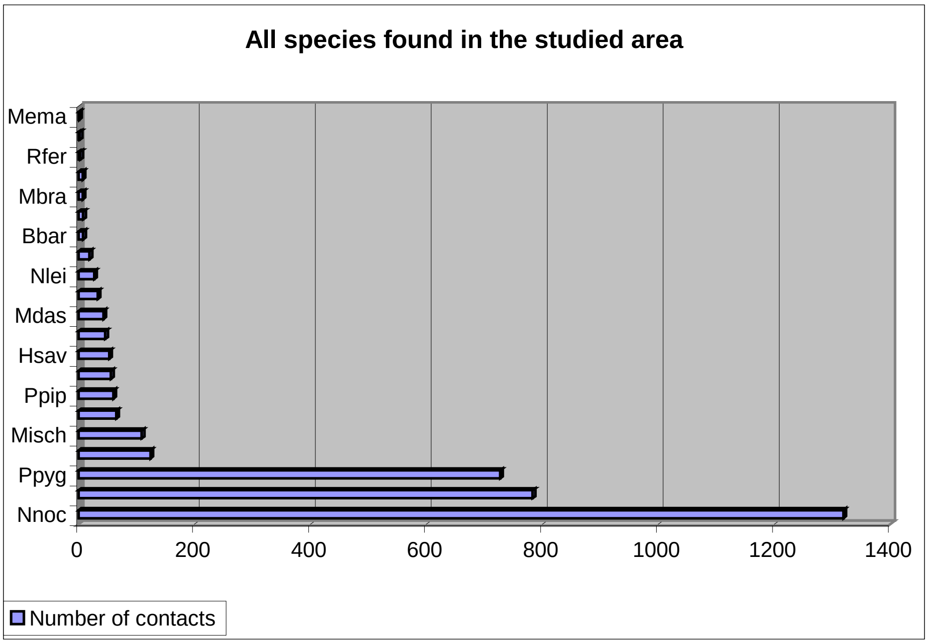


Figure 22: All species found in the studied area.

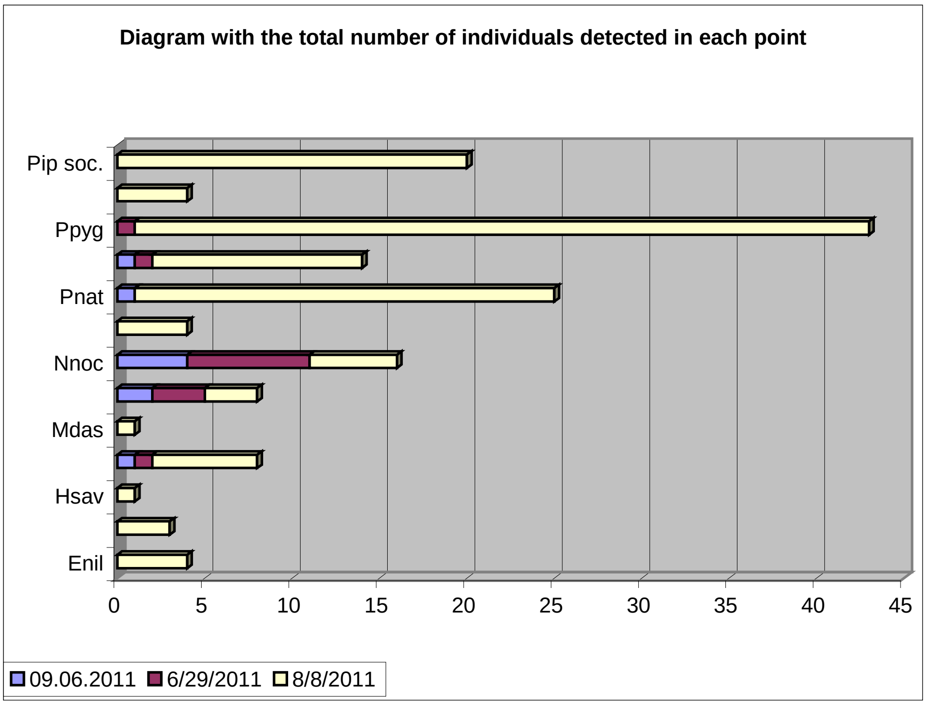


Figure 23: Diagram with the total number of individuals and species recorded in each point with a Pettersson D240x detector.

Results of transects (fixed points)

A total of 151 recordings of individuals belonging to several species (11 bat species) were recorded on 06.09.2011, 06.29.2011 and 08.08.2011. (Figs. 23 and 24). Based on the results (only individuals determined to species level), we observed the highest abundance of *Pipistrellus pygmaeus* (43) which is dominant, followed by *Pipistrellus nathusii* (25), *Nyctalus noctula* (16), *Pipistrellus pipistrellus* (14), *Myotis daubentonii* (8), *Myotis mystacinus* (8), *Pipistrellus kuhlii* (4), *Eptesicus nilssonii* (4), *Eptesicus serotinus* (3), *Myotis dasycneme* (1) and *Hypsugo savii* (1).

Figure 24: Map with fixed points (source: Google Earth, 2011).

Location GPS-fixed points

P1: (coordinates: 46.9137216666667, 21.696005, alt:53) drainage canal
P2: (coordinates: 46.91272, 21.6855583333333, alt:66,1) fish restaurant in a forest
P3: (coordinates: 46.91272, 21.67943, alt:53,2) solitair *Populus alba* near drainage canal
P4: (coordinates: 46.9118016666667, 21.6732383333333, alt: 58,8) *Salix spec.* near drainage canal
P5: (coordinates: 46.909575, 21.6645016666667, alt: 60,5) Ornithological observation tower
P 6: (coordinates: 46.9078083333333, 21.6573666666667, alt: 55,3) near fishpond
P7: (coordinates: 46.90635, 21.65126, alt: 64,3) Group of trees at the entrance to the fishpond
P8: (coordinates: 46.9048916666667, 21.6456066666667, alt: 58) end of the fishponds, pasture
P9: (coordinates: 46.9090716666667, 21.6436016666667, alt: 59,3) drainage canal
P10: (coordinates: 46.912805, 21.64159, alt: 60,1) turning path near drainage canal
P11: (coordinates: 46.9000233333333, 21.647425, alt: 60,5) forest limit near drainage canal
P12: (coordinates: 46.8978666666667, 21.647715, alt: 58,5) forest limit near drainage canal bifurcation
P13: (coordinates: 46.9036966666667, 21.64087, alt: 53,6) solitair *Pyrus piraster* near drainage canal
P14: (coordinates: 46.9019533333333, 21.6339233333333, alt: 58,1) solitair *Pyrus piraster* near drainage canal on the roadside

P15: (coordinates: 46.9006666666667, 21.628765, alt: 53,7) Bushes near drainage canal
P16: (coordinates: 46.8992, 21.6222233333333, alt: 61,5) Turning at the cross road,
P17: (coordinates: 46.9032083333333, 21.6198066666667, alt: 50,1) limit of the village Ateaş
P18: (coordinates: 46.9092216666667, 21.6175383333333, alt: 57,2) the highest point from the study area (Fig. 5)
P19: (coordinates: 46.91386, 21.6147866666667, alt: 56,1) near kindergarten
P20: (coordinates: 46.91712, 21.618225, alt: 56,8) near church
P21: (coordinates: 46.9205316666667, 21.614215, alt: 60,5) the end of the village Ateaş
P22: (coordinates: 46.9035866666667, 21.6562183333333, alt: 45,6) Cefa Nature Park Admi istration
P23: (coordinates: 46.9026616666667, 21.6593433333333, alt: 79,8) meadow in the forest of
P24: (coordinates: 46.9041783333333, 21.65444, alt: 60) pasture between drainage canal and forest
P25: (coordinates: 46.9004916666667, 21.654175, alt: 66,3) pasture between drainage canal and forest 2
P26: (coordinates: 46.89747, 21.6538016666667, alt: 73,1) meadow in the forest of 2
P27: (coordinates:: 46.8953466666667, 21.6537816666667, alt: 78,5) path bifurcation in the forest of
P28: (coordinates: 46.8924016666667, 21.6536366666667, alt: 67) forest limit
P29: (coordinates:: 46.8963766666667, 21.6578733333333, alt: 62,9) drainage canal in the forest of
P30: (coordinates: 46.8985557870371, 21.6584727314815, alt: 67,6) drainage canal in the forest of 2
P31: (coordinates: 46.9004066666667, 21.65905, alt: 75,5) bridge over the drainage canal in the forest of

Results from checking roosts

All known roosts were checked in 29.05.2010. One colony was located in the attic of the Fisherman's Inn (Fig. 25). We found a maternity colony of at least 420 females in the attic consisting of *Pipistrellus pipistrellus* (Fig. 26).

Figure 25: Fisherman's Inn Cefa (Hoffmann, 2012).

Figure 26: Female individual of *Pipistrellus pipistrellus* (Schreber, 1774) (Hoffmann, 2010).

Legislation

The Cefa Nature Park was declared a site of Community interest (ROSCI 0025), because it comprises many species and habitats protected by the EU and at the national level. A large number of these listed taxa is represented by bats (Tab. 2). In fact of the 13 bat species listed in Annex II of the EU Habitats Directive, 6 are present in the study area. All the 32 bat species known to date in Romania require **strict protection** (Borda and Borda, 2008).

Table 2: The species present in the study area. Nomenclature (after Mitchell-Jones et al.,1999). Red List after Botnariuc and Tatole (2005). IUCN Red List 2010 (http://www.iucnredlist.org); Abbreviations**:** - Red List species are absent. The marked species with * are listed in Annex II of the EU Habitats Directive. LC=Least Concern, NT=Near Threatened.

Scientific name of the species	Species name in english	Directive 92/43/EEC	IUCN Red List (2010)	Red List
* *Barbastella barbastellus* (Schreber, 1774)	Barbastelle	Anexa II,IV	NT	vulnerable
Eptesicus nilssonii (Keyserling and Blasius, 1839)	Northern bat	Anexa IV	LC	critically endangered
Eptesicus serotinus (Schreber, 1774)	Serotine bat	Anexa IV	LC	vulnerable
Hypsugo savii (Bonaparte, 1837)	Savi`s pipistrelle	Anexa IV	LC	vulnerable
* *Miniopterus schreibersii* (Kuhl, 1819)	Schreibers` bat	Anexa II, IV	NT	vulnerable
* *Myotis bechsteinii* (Kuhl, 1817)	Bechstein`s bat	Anexa II, IV	NT	endangered
Myotis brandtii (Eversmann, 1845)	Brandt`s bat	Anexa IV	LC	endangered
* *Myotis dasycneme* (Boie, 1825)	Pond bat	Anexa II, IV	NT	critically endangered
Myotis daubentonii (Kuhl, 1817)	Daubenton´s bat	Anexa IV	LC	critically endangered
* *Myotis emarginatus* (Geoffroy, 1806)	Geoffroy´s bat	Anexa II, IV	LC	endangered
Myotis mystacinus (Kuhl, 1817)	Whiskered bat	Anexa IV	LC	endangered
Myotis nattereri (Kuhl, 1817)	Natterer´s bat	Anexa IV	LC	endangered
Nyctalus leisleri (Kuhl, 1817)	Leisler`s bat	Anexa IV	LC	endangered
Nyctalus noctula (Schreber, 1774)	Noctule bat	Anexa IV	LC	-
Pipistrellus kuhlii (Kuhl, 1817)	Kuhl`s pipistrelle	Anexa IV	LC	-
Pipistrellus nathusii (Keyserling and Blasius, 1839)	Nathusius` pipistrelle	Anexa IV	LC	endangered
Pipistrellus pipistrellus (Schreber, 1774)	Common pipistrelle	Anexa IV	LC	-
Pipistrellus pygmaeus (Leach, 1825)	Midge bat	Anexa IV	LC	-

Table 2 (continued): The species present in the study area. Nomenclature (after Mitchell-Jones et al.,1999). Red List after Botnariuc and Tatole (2005). IUCN Red List 2010 (http://www.iucnredlist.org); Abbreviations**:** - Red List species are absent. The marked species with * are listed in Annex II of the EU Habitats Directive. LC=Least Concern, NT=Near Threatened.

Scientific name of the species	Species name in english	Directive 92/43/EEC	IUCN Red List (2010)	Red List
Plecotus austriacus (Fischer, 1829)	Grey long-eared bat	Anexa IV	LC	endangered
* *Rhinolophus ferrumequinum* (Schreber, 1774)	Greater horseshoe bat	Anexa II, IV	LC	vulnerable
Vespertilio murinus (Linnaeus, 1758)	Parti-coloured bat	Anexa IV	LC	endangered

All reported species are listed in the IUCN Red List 2010 (Tab. 2).

All the species highlighted in the table number 2 are listed in Annex II of the EU Habitats Directive. These species are of community interest and require special conservation designation**.**

Additionally, if one considers the red list of vertebrates (Botnariuc and Tatole, 2005), five species were considered vulnerable (*Barbastella barbastellus*, *Eptesicus serotinus*, *Hypsugo savii*, *Miniopterus schreibersii* and *Rhinolophus ferrumequinum*), nine species as endangered (*Myotis bechsteinii*, *Myotis brandtii*, *Myotis emarginatus*, *Myotis mystacinus*, *Myotis nattereri*, *Nyctalus leisleri*, *Pipistrellus nathusii*, *Plecotus austriacus* and *Vespertilio murinus*), and three critically endangered (*Eptesicus nilssonii*, *Myotis daubentonii* and *Myotis dasycneme*).

DISCUSSION

Some species of bats travel long-distances during migration, without regard for state borders. As a result of their conservation requires the involvement of all States. Bats have been the subject of several international conventions, which protect their roosts and feeding habitats.

In Natura 2000 sites, that have been chosen for protection are not allowed to incur habitat degradation or a decrease in population of the protected species. In the standard list of Natura 2000, only one bat species was listed for this site [*Myotis dasycneme* (Boie, 1825)] and two others were placed in the section "Other important species of flora and fauna" [*Pipistrellus kuhlii* (Kuhl, 1817) and *Pipistrellus nathusii* (Keyserling and Blasius, 1839)]. In addition to *Myotis dasycneme* (Boie, 1825), five other species were found *Barbastella barbastellus* (Schreber, 1774), *Miniopterus schreibersii* (Kuhl, 1819), *Myotis bechsteinii* (Kuhl, 1817), *Myotis emarginatus* (Geoffroy, 1806) and *Rhinolophus ferrumequinum* (Schreber, 1774), which demonstrates that a bat survey was not conducted as required by the European Commission. Additionally, there are few published papers on bats in the study area (for ex. Gheorghiu and Murariu, 2002). Gheorghiu and Murariu (2002) only reported seven species *Rhinolophus ferrumequinum* (Schreber, 1774), *Eptesicus serotinus* (Schreber, 1774), *Myotis daubentonii* (Kuhl, 1817), *Nyctalus noctula* (Schreber, 1774), *Pipistrellus pipistrellus* (Schreber, 1774), *Pipistrellus pygmaeus* (Leach, 1825) and *Pipistrellus kuhlii* (Kuhl, 1817).

CONCLUSIONS

It would have been desirable and imperative that the duration of this study be at least two years, taking into account the migration routes of bats. The bat fauna survey was possible only by combining several methods such as:

- analysis of existing data in literature;
- visual observations in human houses throughout the year (summer maternity colonies);
- use of ultrasonic detectors while walking transects and during an entire night at stationary points (active and passive methods).

Among the factors that adversely affect the conservation status of bat species, the uncontrolled cutting of trees with hollows in the forest was listed. Irrational and/or illegal deforestation of old trees irreversibly destroy hundreds of roosts (hollows or attics) occupied by bats, birds and other small mammals. Most of the hollows are made by woodpeckers and if there are no roosts in the area, bats leave the affected area. Although management should call for all roosts listed above to be protected directly or indirectly, this has not been done yet and will require raising public awareness of bat conservation methods and importance.

Public awareness about cultural and natural values of the area in which people live and maintain traditional methods of land management should be supported. This could then be merged with an understanding of the benefits that bats in the Natura 2000 site “Cefa” contribute to these values.

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ECTOPARASITES OF SMALL MAMMALS (RODENTS) FROM CEFA NATURE PARK (CRIŞANA, ROMANIA);

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KEYWORDS: mites, ticks, fleas, lice, *Apodemus agrarius*, host preferences, co-occurrence.

ABSTRACT

Between 2005 and 2011 a survey was carried out on small mammal communities in Cefa Nature Park. Some of the captured specimens were examined for the identification of external parasites taxa. The dependence of ectoparasites' prevalence on different space (habitat), time (year), and host (species, sex, age) variables was tested. Of 133 small mammals examined belonging to 6 species, 92 were found to be parasitized, giving a prevalence of 69.17%. The prevalence was found to be significantly dependent upon species, the highest value being calculated for *Apodemus sylvaticus* and the prevailing *A. agrarius*, while a surprisingly low value (29.4%) was found in *A. uralensis*. The community structure causes the difference between the prevalence in various habitats, while among the research years the differences indicate a significant temporal dynamics of ectoparasites taxa, independent of the hosts’ community structure.

RĖSUMĖ: Ectoparasites des petits mammifères du Parc Naturel Cefa.

Entre les années 2005 et 2011 une étude sur les communautés de petits mammifères du Parc Naturel Cefa a été réalisée. Quelques-uns des spécimens capturés ont été examinés pour l'identification des groupes des parasites externes. La dépendance de la prévalence des ectoparasites sur des variables de l'espace (l'habitat), du temps (l'année), et d'hôte (l'espèce, le sexe, l'âge) a été testée. Parmi les 133 petits mammifères examinés, appartenant à 6 espèces, 92 ont été trouvés parasités, ce qui entraîne une prévalence de 69,17%. La prévalence est dependente de l'espèce, la valeur la plus élevée étant calculé pour *Apodemus sylvaticus* et *A. agrarius* (l' espèce dominante), tandis qu'une valeur étonnamment faible (29,4%) a été observée dans le cas de *A. uralensis*. La structure de la communauté determine les différences entre la prévalence de divers habitats, pendant que les différences entre les années d’étude indique une dynamique temporaire indépendent des ectoparasites.

REZUMAT: Ectoparaziţi ai mamiferelor mici din Parcul Natural Cefa (Crişana, România).

Între anii 2005 şi 2011 s-a desfăşurat în Parcul Natural Cefa un studiu asupra comunităţilor de mamifere mici. O parte dintre exemplarele capturate au fost examinate în vederea identificării grupelor de paraziţi externi. Lucrarea de faţă prezintă rezultatele analizei datelor obţinute, urmărind dependenţa prevalenţei de o serie de variabile spaţiale (habitatul), temporale (anul), sau de gazdă (specia, sexul, vârsta). Din cele 133 de mamifere mici examinate, aparţinând la 6 specii, 92 au fost găsite parazitate, rezultând o prevalenţă de 69.17%. Prevalenţa s-a dovedit a fi semnificativ dependentă de specie, cea mai mare valoare, fiind calculată pentru *Apodemus sylvaticus* şi pentru specia predominantă, *A. agrarius,* în timp ce o valoare surprinzător de scăzută (29,4%) a fost găsită în cazul speciei *A. uralensis*. Structura comunităţii determină diferenţele între prevalenţa din diverse habitate, în timp ce diferenţele dintre anii de studiu indică o dinamică temporală independentă a ectoparaziţilor.

INTRODUCTION

Most papers dealing with external parasites on small mammals from Romania are based on studies from the southern part of the country, especially the Danube Delta and Dobrogea (Solomon, 1968, 1969; Suciu, 1971; Wegner, 1970). There is only one reference in the literature concerning ectoparasites from the area (Câmpia Crişurilor - Criş Plain), belonging to Suciu (1973), in her catalogue of the Siphonaptera from Romania. In this paper *Leptopsylla taschenbergi* is mentioned from Tinca, on *Microtus arvalis*, collected by M. Hamar in May 1967. The data published up to the present on small mammals ectoparasites from Romania are mainly faunistic, few mentions are made on the ecology of parasites, on their spatial distribution and temporal dynamics. One study on lice parasitizing small mammals from Dobrogea (Wegner, 1970) presents some data on co-occurrence of lice and other ectoparasites groups.

Between 2005 and 2011 the authors carried out field surveys on the small mammals' communities from Cefa Nature Park. During this study, using the CMR method, some of the specimens were examined for external parasites. The investigations were part of the flora and fauna voluntary inventory program coordinated by the Apuseni Nature Park's Administration.

MATERIAL AND METHODS

Small mammals were captured by live trapping using 50 Polish traps set in line in several habitats from Cefa Nature Park: in the forest, along the forest edge, along the canal bank, in the *Crataegus monogyna* shrubs in the pasture from the vicinity of the forest, and along the dam separating one of the fishponds from the canal bordering the forest. The trapping was done beginning with the year 2005, in different seasons. Traps were baited with sunflower seeds and apple pieces and provided with hay as bedding material. The captured specimens were identified to species, weighted, sex and age category was determined, and ectoparasites were collected or noted. For some parasite groups data on their position on the host was also noted. The parasite species are considered according to their taxonomic framing, five groups being distinguished: Acarina (mites), Ixodidae (ticks) – although part of Acarina, are considered as a separate group due to their importance as vectors for various diseases and also to the lack of data from Romania, Siphonaptera (fleas), and Anoplura (lice). Ectoparasites' prevalence was calculated by means of number of specimens hosting parasites / total number of examined specimens from that category. The significance of the dependence of ectoparasites' prevalence on different host, time, and space variables was verified using Pearson chi-square test for independence. The difference between the prevalence of external parasites on the prevailing species, *Apodemus agrarius*, and on all the species was tested by means of Z test for one proportion.

RESULTS AND DISCUSSION

During the research period a total of 133 specimens belonging to 6 small mammals species (one insectivore – *Sorex araneus* - and five rodents) were examined for external parasites. The most numerous were the species of *Apodemus* genus, and among them *A. agrarius*, with 80 individuals, followed by *A. flavicollis* with 25 and *A. uralensis* with 17 specimens. The taxonomical identitiy of the species within the subgenus *Sylvaemus* (*A. uralensis*, *A. sylvaticus*, and partly *A. flavicollis*) was confirmed by using molecular markers (de Mendonça and Benedek, 2012). Out of the 133 examined small mammals 92 were found to be parasitized, resulting in a prevelence of 69.17%. The results of the parasitologic examination are given in the table number 1.

Table 1: Number of the small mammals examined and found to be parasitized from each species.

Species	Number of examined specimens	Number of infested specimens	Ectoparasites' prevalence (%)
Sorex minutus Linnaeus, 1766	2	2	100.00
Microtus arvalis (Pallas, 1778)	4	4	100.00
Apodemus agrarius (Pallas, 1771)	80	62	77.50
Apodemus flavicollis (Melchior, 1834)	25	15	60.00
Apodemus sylvaticus (Linnaeus, 1758)	5	4	80.00
Apodemus uralensis (Pallas, 1811)	17	5	29.41
Total	133	92	69.17

Considering the most abundant species (belonging to *Apodemus* genus) the total prevalence was found to be very significantly dependent ($p < 0.001$) on the species (Fig. 1). Thus, the highest prevalence was calculated for *A. sylvaticus* (80%), very similar to that for *A. agrarius* (77.5%), while an unexpected low value was found for *A. uralensis* (29.41%). In this species the highest prevalence was recorded by mites (23.52%), followed by lice (17.64%). However, in case of lice no adults or larvae were collected, only eggs on the hairs.

However, the significance of prevalence dependence on species is not given only by *A. uralensis*, with its outstanding low value. Considering only *A. agrarius* and *A. flavicollis* their ectoparasites' prevalence is also different, but only at a level of significance of 90% ($p = 0.084$).

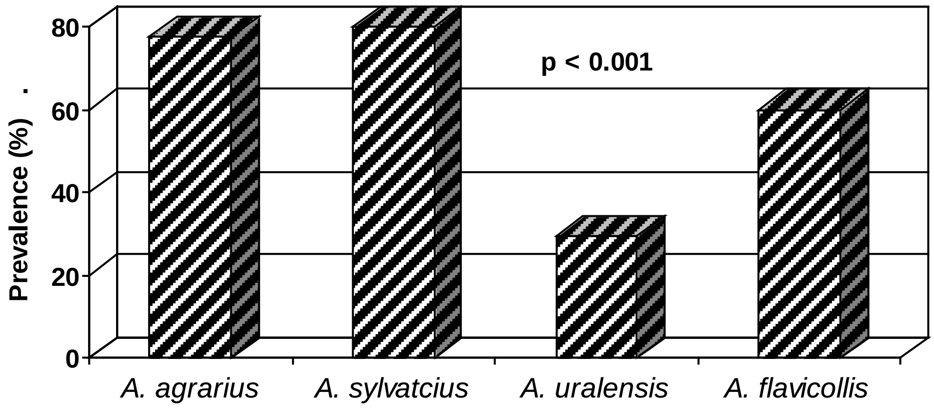

Figure 1: Prevalence of ectoparasites on *Apodemus* species from Cefa Nature Park.

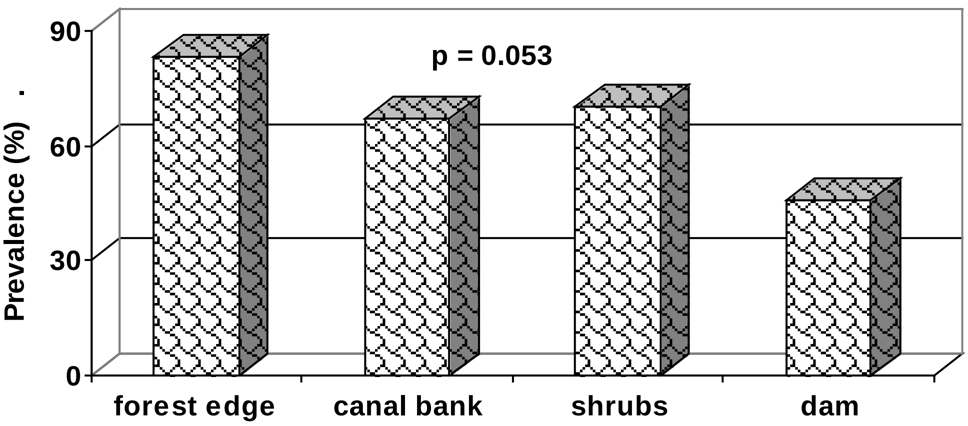

Figure 2: Prevalence of external parasites on small mammals captured in Cefa Nature Park

Prevalence of ectoparasites was found to be significantly (p = 0.053) different also between the investigated habitats (Fig. 2), the highest value being calculated for the forest edge (83.8%), and the lowest on the dam between the fishpond and the canal (46.2%).

The structure of small mammals' communities in different habitats varies according to several characteristics, especially the structure of vegetation and the humidity. Thus, in the forest only *A. flavicollis* was captured. In all the other habitats *A. agrarius* was present and dominant, except for the dam, where it was outnumbered by *A. uralensis*. Accordingly, the ratio of species within the investigated specimens varied among habitats (Fig. 3).

The dependence of the prevalence on habitat is mostly indirect, influenced by the structure of small mammals' community. Thus, the low prevalence on the dam is mainly due to the high ratio of *A. uralensis* in this habitat (Fig. 3), most of the examined specimens of pygmy field mouse being captured here. Its ratio and the ectoparasites prevalence in different habitat types are in strong and negative correlation (r = -0.926) at a level of significance of 90% (p = 0.074). The positive, weaker (r = 0.869) correlation between the prevalence and ratio of the striped field mouse is not significant (p = 0.131).

Another argument is that for the prevailing species, *A. agrarius*, the prevalence of ectoparasites in Cefa Park area was not found to be significantly dependent ($p = 0.355$) on the habitat type.

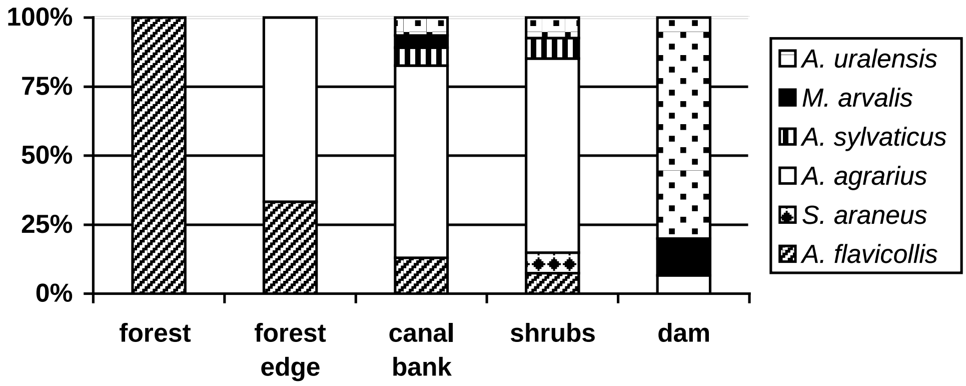

Figure 3: Relative abundance (%) of the examined small mammals species in the researched habitats from Cefa Nature Park.

The annual dynamics of prevalence (Fig. 4) also shows significant differences ($p < 0.001$) among the research years. As in case of habitats, these differences are partly caused by the annual dynamics of small mammals' community, both in terms of abundance and specific structure. The striped field mouse was a constant presence in Cefa Nature Park along the research period, together with the yellow-necked mouse being the only two species captured in every field campaign during the study (Benedek and Sîrbu, 2009). The other species have lower abundance and a sporadic presence. Among them, the pygmy field mouse registered in 2010 a high ratio.

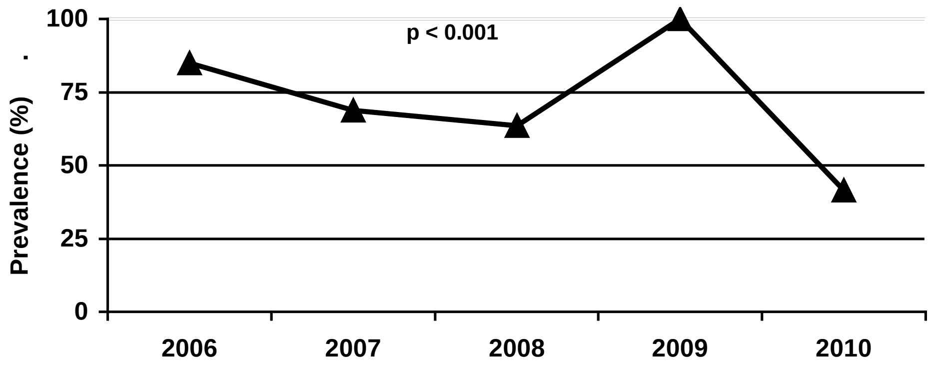

Figure 4: Prevalence of ectoparasites on small mammals species from Cefa Nature Park.

Thus, the low prevalence recorded in 2010 is mainly due to the high ratio of *A. uralensis* within the examined specimens. However, in this case, the correlation between the relative abundance of *A. uralensis* and the total prevalence is much weaker ($r = -0.711$) and not significant ($p = 0.178$).

These results suggest that the spatial dynamics of ecoparasites' prevalence on small mammals from Cefa Nature Park is determined mainly indirectly by the habitat characteristics, through the variations of the community structure, while in case of annual dynamics, there is also an important intrinsic component, indicating a significant temporal dynamics of ectoparasites taxa, independent of the hosts' community structure.

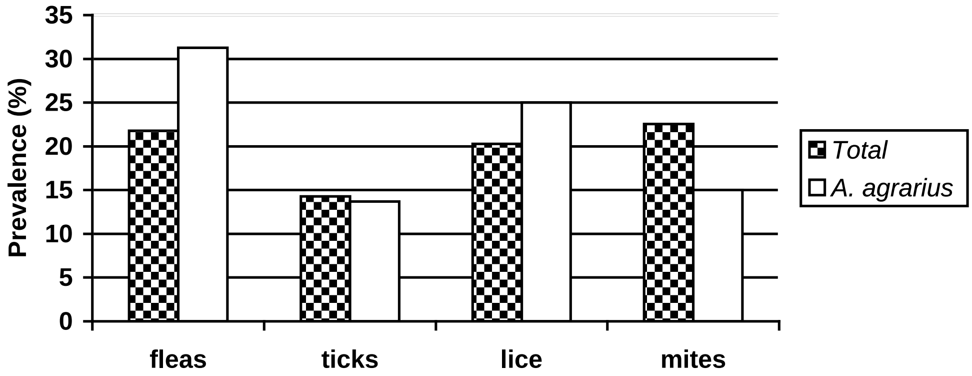

Figure 5: Prevalence of ectoparasites taxa on all the small mammals and on *A. agrarius* in particular.

Among the parasites taxa similar values of prevalence was calculated for mites (22.5%), fleas (21.8%), and lice (20.30%) (Fig. 5). Among mites, only 6.01% of the specimens hosted *Neotrombicula autumnalis*, a parasite very common and abundant on small mammals from other areas (Benedek, unpubl. data). This low value is probably determined by the very low abundance of Microtinae rodents, the preferred hosts of *N. autumnalis*, according to our data from other areas (idem). The lowest prevalence was recorded for ticks (14.28%).

Considering only the most abundant rodent species, *A. agrarius*, the values calculated for mites were lower (15%), while those for lice (25%) and fleas (31.3%) were higher. However, the Z test for one proportion showed a significant difference ($p < 0.05$) only for fleas, indicating a clear preference of fleas, at least within the genus *Apodemus*.

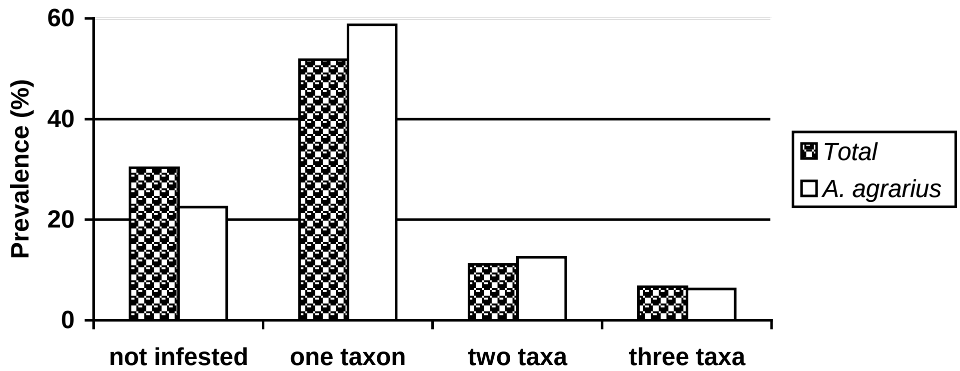

Figure 6: Co-occurrence of ectoparasites taxa on all the small mammals and on *A. agrarius* in particular.

Most of the small mammals (51.8%) were infested with parasites belonging to only one group (Fig. 6). A smaller proportion of individuals (11.1%) were found to host parasites belonging to two groups. Co-occurrence of parasites, at least on higher taxonomic level, appears to be a stochastic event, illustrating the parasites' frequency rather than their interspecific relations. More groups of parasites are rarely encountered on one rodent host (6.6%), and this is characteristic for the *Apodemus* species. No specimen was found to host representatives from all four taxa. The values calculated for the striped field mouse are not significantly different.

These results do not confirm the data published earlier on the co-occurrence of lice and other ectoparasites groups on rodents from Dobrogea, which show a higher co-occurrence, especially of lice and mites (Wegner, 1970).

In the prevailing species, *A. agrarius*, no significant dependence of the ectoparasites' prevalence was found on the population structure's parameters, neither on the host sex ($p = 0.117$), nor on host age ($p = 0.528$).

CONCLUSIONS

Out of the 133 examined small mammals belonging to 6 species (one insectivore and five rodents) 92 were found to be parasitized, resulting in a prevalence of 69.17%. The prevalence was found to be significantly dependent on species, the highest value being calculated for *Apodemus sylvaticus* and the prevailing *A. agrarius*, while a surprisingly low value (29.4%) was found in case of *A. uralensis*. This difference between the species determines a significant dependence of the prevalence on the investigated habitats, through the community structure. In case of the temporal (annual) dynamics, there is also an important intrinsic component, indicating a significant temporal dynamics of ectoparasites taxa, independent of the hosts' community structure. Among the parasites taxa similar values of prevalence was calculated for mites, fleas, and lice (above 20%), while the lowest prevalence was recorded for ticks (14.28%).

ACKNOWLEDGMENTS

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PRESENCE OF THE HAZEL DORMOUSE - *MUSCARDINUS AVELLANARIUS* (LINNAEUS, 1758) (*RODENTIA*, *GLIRIDAE*) IN THE CEFA NATURE PARK (CRIŞANA, ROMANIA) WITH NOTES ON THE BIOLOGY OF THE SPECIES

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KEYWORDS: common dormouse, *Muscardinus avellanarius*, live-trapping, nest boxes, Rădvani forest, Cefa Nature Park.

ABSTRACT

A live trap and nest box grids were used to assess the presence of the hazel dormouse (*Muscardinus avellanarius*, Linnaeus 1758) in the forests of the Cefa Nature Park, during 2010 and 2011. The live-trapping campaigns, using traps placed both on the ground and on tree branches, proved to be inefficient in detecting the presence of this species. This was especially the case during the first two months after installation, as they were completely empty. This species was finally found during the live-trapping campaigns from September 2010 to April 2011, when live individuals of hazel dormouse were found inside the nest boxes.

ZUSAMMENFASSUNG: Das Vorkommen der Haselmaus (*Muscardinius avellanarius* Linnaeus, 1758/ Rodentia, Gliridae) im Naturpark Cefa (Crişana/Kreischgebiet/ Rumänien) mit Anmerkungen zur Biologie der Art.

Um das Vorkommen der Haselmaus (*Muscardinius avellanarius* Linnaeus, 1758) und ihrer Verteilung im Rădvani Wald des Naturparks Cefa während der Jahre 2010 und 2011 zu ermitteln, wurden Lebendfallen und Nistkästen verwendet. Für erstere wurden sowohl Bodenfallen, als auch solche an Baumästen angebrachte verwendet, die sich jedoch als ungeeignet für die Feststellung des Vorkommens der Art erwiesen. Die Ineffizienz dieser Fallenmethode in der Aufspürung der Art wurde während der ersten Untersuchungsmonate ab dem Auslegen der Fallen festgestellt, da diese die ganze Zeit über leer blieben. Die Art wurde schließlich während der Felduntersuchungen im September 2010 und April 2011 festgestellt, als lebende Individuen von Haselmäusen in den Nistkästen vorgefunden wurden.

REZUMAT: Prezenţa pârşului de alun (*Muscardinius avellanarius* Linnaeus, 1758/ Rodentia, Gliridae) în Parcul Natural Cefa (Crişana, România) cu remarci asupra biologiei speciei.

Pentru a documenta prezenţa pârşului de alun (*Muscardinius avellanarius* Linnaeus, 1758) în decursul anilor 2010 şi 2011, în perimetrul pădurii Rădvani a Parcului Natural Cefa au fost folosite capcane pentru specimene vii şi boxe de cuibărit. În timpul campaniilor de cercetări cu capcane pentru specimene vii, acestea fiind amplasate atât pe sol, cât şi pe ramuri de copaci, s-a constatat ineficienţa acestora în detectarea prezenţei speciei. Acest fapt a fost constatat după primele luni de la instalarea lor, ele rămănând complet goale. Specia a fost în sfârşit găsită, în timpul campaniei din septembrie 2010 şi aprilie 2011, când indivizi vii ai pârşului de alun au fost găsiţi în interiorul boxelor de cuibărit.

INTRODUCTION

The study was conducted during 2010 and 2011 in the Cefa Nature Park (Crişurilor Plain, Romania). The Rădvani forest (223.65 ha, 70 years old) is the only remaining forest patch in the area, the remnant of the old alluvial forests that use to cover a much larger area in the past. The dominant species of trees are the English oak *Quercus robur, the* field elm *Ulmus minor* and ash *Fraxinus excelsior*. The turkey oak *Querus cerris*, hornbeam *Carpinus betulus*, field maple *Acer campestre*, locust tree *Robinia pseudaccacia*, wild cherry *Prumus avium* and aspen *Populus tremula* are less frequent. The forest has a well developed shrub layer, composed mainly of *Crataegus monogyna* and *Prunus spinosa.*

In the North-Western part of the Rădvani forest we installed, in the early April 2010, three superimposed hollow grids, each of 20 passive detectors (one of nestboxes and two of live-traps), placed at successive heights (see below for details). The distance between two successive detectors in a grid was 20 meters. The first live trap grid was set on the ground, at the base of a tree trunk or shrub. The second grid of live traps was set on tree or shrub branches, 1.5 - 2 m above the first grid. We used Fitch live-traps, with hay bedding and baited with apple pieces, sunflower seeds and jam. The last grid consisted of 20 small wooden nest boxes (14x14x21, entrance 3.5 cm), placed facing the tree trunk, at heights of 2.5 - 3 m. The nest boxes were checked in June and September 2010, and again in April 2011, and the live-traps were active for five consecutive nights, between 6-11 April and 13-20 June 2010, resulting in a total of 400 trap-nights. The captured dormice were not marked, as the purpose of this preliminary study was only to document the presence of the species in the area.

MATERIAL AND METHODS

The study was conducted during 2010 and 2011 in the Cefa Nature Park (Crişurilor Plain). Rădvani forest (223.65 ha, 70 years old) is the remaining forest patch in the area, the remnant of the old alluvial forests that covered a larger area in the past. The dominant trees are English oak *Quercus robur*, field elm *Ulmus minor* and ash *Fraxinus excelsior*; less frequent are turkey oak *Querus cerris*, hornbeam *Carpinus betulus*, field maple *Acer campestre*, locust tree *Robinia pseudaccacia*, wild cherry *Prumus avium* and aspen *Populus tremula*. The forest has a well-developed shrub layer, composed mainly of *Crataegus monogyna* and *Prunus spinosa*.

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RESULTS AND DISCUSSION

During the two trapping campaigns in April and June 2010, no dormice were captured by the live-traps. A comparative study in England suggested that hazel dormice abundance revealed by live-trapping was 4.17 lower than those from nest boxs checks, and that on average, the capture rate was 2.37/100 trap nights (Bright and Morris, 1990). In Sweden, it was found that 175 trap-nights per hectare were enough to capture most of the adults, but also that the trapping efficiency was significantly higher in autumn, before of the hibernation period, when an even lower number of trap-nights might be required (Berg and Berg, 1999). The numbers of trap-nights used in Rădvani forest slightly exceeded the recommended number. Although the trapping sessions took place earlyier in the season, the trapping effort should have been enough to, prove the presence of the species in the area.

During the first check of nest boxes in the middle of June 2010, none of the nest boxes were occupied by *Muscardinus avellanarius*. We found no evidence of the nest boxes being visited by hazel dormice, as no signs of the presence, like nests, droppings or food remains, were detected. The hazel dormouse builds easily identifiable nest, woven among branches or inside nest boxes. The nests are ball - shaped, with diameters of 8-12 cm (Berg and Berg, 1998), and are made of leaves and grasses.

Usually, the *M. avellanarius* individuals can find and use nest boxes within a very short time after their installation. In Sicily, using fairly the same array of nest boxes/site as ours, the colonization started on average after 36 days (± 23; min-max: 7-72; n=5) (Sara, 2001). In Lithuania, out of 85 new nest boxes placed in April, seven boxes were already used by dormice by May (Juškaitis, 2008). In the Transylvanian Plain, nest boxes installed in spring (April, May), in line transects of 50/site, were first occupied in June (Sevianu, 2009). All mentioned studies used larger numbers of nest boxes in a given area, even when the number per site was similar to our study, and the first occupied nest boxes were recorded for the whole area. The lack of recording this species during the first two months after nest boxes installation, could therefore be explained by the limited number of nest boxes used. Given a larger number of nest boxes employed in this study, their efficiency would have been most likely higher. It worthy mentioning that the nest boxes were not occupied by any other small mammal species during the first check. Therefore, We can conclude that, although dormice find relatively quickly newly installed nest boxes, the absence of any sign of their activity in this area is mainly due to, a small number of nest boxes employed.

We obtained the confirmation of the species presence in Rădvani forest during the September check, when four nest boxes were already occupied by six individuals. Two of these nest boxes were occupied by one individual and two of them by other two. Other two nest boxes were occupied by *Apodemus flavicollis* (Melchior, 1834).

In 2011, the nest boxes were checked at the beginning of April, and three nest boxes were already occupied by five individuals. Two nest boxes were occupied by one individual each and one by other three. In 12 more nest boxes we found *M. avellanarius* nests, showing that the species used the available nest boxes in high numbers.

The only other small mammal found was *A. flavicollis.* We found one individual in a nest box, and three others nest boxes were used as store rooms, being fillet up to the top with acorns. The habit of filling nestboxes installed for dormice with acorns has been documented in literature for this species (Juškaitis, 1999).

By checking the nest boxes early in the spring, we were able to determine that the onset of hazel dormice activity in the Rădvani forest corresponds to other findings in Romanian lowlands (Duma, 2007; Sevianu, 2009). In fact, the first record in the spring, inside nest boxes, might have been later than the actual beginning of the activity (Juškaitis, 2008). The first observation did not correspond to the exact moment of the end of hibernation end, considering that in the 8^{th} of April the nests were already built inside nest boxes. It is only fair to suppose that the end of hibernation occurred by the end of March, or late in the first days of April.

The hazel dormice very rarely hibernate inside nest boxes (Juškaitis, 2008). A multiannual study in the Transylvanian Plain showed that hazel dormouse never used nest boxes for hibernation in the area (Sevianu, 2009). The species hibernates in tightly woven nests, placed on the forest floor, under moss layer or loose leaf litter (Bright et al., 1996). Further investigations are required to uncover the hibernation sites of the hazel dormouse in the Rădvani forest, given the fact that the forest floor is very wet during the spring and early summer, almost completely flooded. The groundwater is very close to the surface, and hibernation nests placed on the forest floor would have been completely submerged in the spring.

The adults are territorial during the breeding season (Juškaitis, 1997), and during one year, they use about 1 ha of forest, with different parts exploited seasonally (Bright and Morris, 1996). Taking into consideration the isolation of the forest patch, and the fact that dormice are reluctant to cross open spaces (Bright and Morris, 1991), it seemed unlikely that the individuals immigrated into the Rădvani forest after the installation of the nest boxes and traps. More likely, the species was previously present, but it was not captured in the first half of the active season in 2010 due to the absence in that particular part of the forest, perhaps due to the flooded forest floor, or because the species lives at very low densities.

The installation of specially designed wooden nest boxes proved to be an efficient method in detecting *Muscardinus avellanarius* in an area. This latter method is more expensive but is more advantageous. The initial time and money investment is greater than when using live-traps, but it has several advantages. The time needed to check the traps is highly reduced to only a few hours, as compared to several days needed for the former method. Hazel dormice can use particular areas of a forest seasonally, so their presence could be missed, even with repeated live-trapping sessions. Nest boxes will detect the presence of the dormouse species in an area either by the signs of their presence (e.g. droppings, nests, gnawed food), albeit the individuals were not using the nest boxes permanently. The use of these boxes is prone as well for population studies, allowing the employment of mark-recapture methods. The use of this method makes possible the gathering of information on the biology of the species, the number of litters per season, number of pups/litter and the survival rate and so on.

The record of the presence of *Muscardinus avellanarius* in the Rădvani forest is very important, considering the protected status of the species by national and European laws (Habitats Directive 92/43/EEC), the isolation of the population in a forest surrounded by open habitats: meadows, cultivated fields and fish ponds, and the survival problems posed by the flooded forest floor by the end of the hibernation period.

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