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The Retezat National Park

Editors

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IN MEMORIAM

Alexandru Borza
(1887 - 1971)

The great Romanian botanist Alexandru Borza was born on 21 May 1887 in Alba Iulia, Transylvania, where he attended primary and secondary school. He carried out his university studies in Wroclaw, Budapest and Berlin, graduated in theology (1908) and natural sciences (1911), and took his Ph.D. in Natural Sciences (1913).

After completing his university studies he return in his country. He was appointed professor at the boy's high school Blaj, where he remained until 1919 when he became a founding professor of the "Dacia Superioară" University, Cluj-Napoca. He taught at the University at Cluj until 1947 when he retired. In the period 1935 - 1938 he was Dean of the Faculty of Sciences of Cluj-Napoca, and in 1944 - 1945 Rector of the University. In 1947, in the period of his full creative power, he was removed from the academic community because of his anti-communist political opinions (he was rehabilitated in 1962 when he was granted the title of Scientist Emeritus, and again in 1990 when he became, post-mortem, a member of the Romanian Academy).

He directed (from 1920) for a period of 28 years the Botanical Garden in Cluj-Napoca, the garden that now bears his name. In the period 1921 - 1948 he edited the Bulletin of the Botanical Garden and of the Botanical Museum of the University of Cluj-Napoca.

Founder of the Romanian phytocoenological school (modelled on the Western European school of Zurich-Montpellier), Alexandru Borza published dozens of papers in this field of studies, among which we should mention the phyto-sociological studies of the Retezat Mountains (1934), and the Flora and vegetation of the Sebeş Valley (1959), Introduction to the study of plant cover (1965), this last in collaboration with Nicolae Boşcaiu. He was the initiator of experimental ecology in Romania.

He made a significant contribution to knowledge of corology of cormophytes in Romania editing Conspectus florae Romaniae regionumque affinium, I - II (1947, 1949), Bibliography of Romanian botany (1921 - 1947) and the collection Flora Romaniae Exciccata (beginning in 1920) which formed the basis of the monumental works Flora of the People's Republic of Romania / Flora of the Socialist Republic of Romania in 13 volumes, which appeared (1952 - 1976) under the auspices of the Romanian Academy. He described, alone or in collaboration, 85 plant taxa new to science. His extensive herbarium is found in the Natural History Museum in Sibiu.

His research themes in corology and ecology of plants intersected with phytocoenology, phylogeny, popular culture and ethnobotany. This last area had interested him since adolescence (he published his first contribution in 1908). He wrote dozens of works on the subject, the most representative being the Dictionary of Ethnobotany published in 1968, which includes nearly 11,000 Romanian plant names.

He reunited the great personalities in the field at the first Congress of Romanian naturalists (1928).

He was a tireless activist in the realm of nature protection. He contributed to the drafting of the first law for the protection of natural monuments in Romania. He initiated the first steps for the protection of natural areas in Romania, fighting for their transfer to state property. He edited the Bulletin of the Commission for Natural Monuments (1933 - 1944); and he organized the first national park in Romania, Retezat National Park.

He was member of several academies and societies in the country and abroad (in France, Germany, Switzerland, Czechoslovakia and Finland).

His research works were published in over 500 scientific publications.

The results of his work place him, without doubt or equivocation, among the most valuable of Romanian naturalists.

The Editors

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Preface

The Retezat National Park, the first Romanian National park was established in 1935.

The long-lasting efforts that proceeded its founding are tied to the prestigious scientific and nature protection activity of the great botanist prof. Alexandru Borza (1887 - 1971), who emphasized, in 1916, and later, in 1928, that "the Retezat Mountains are predestined by nature to hold a real national park, representative of large area". "This massif has been, until now, state and private property, and has been well protected as a hunting ground. The complex of peaks, alpine hollows, mountain lakes, alpine lawns, precipices and woods are comprised of the Păpuşii Peak, Stînişoara, Groapa Şesele and Tăul Zănoaga and cover an area of about 1,000 ha. This area is completely exempt from grazing, hunting, clearing and fishing, because it is a sanctuary of nature. Chamois, vulture, lynx, bear and wolf are still to be found here in large numbers. The vegetation has large areas of dwarf pines, large groups of swiss stone pine (*Pinus cembra*) and a flower-rich carpet, i.e. tens of species and varieties or hybrids of *Hieracium*, which grow only here, and are often named in science after the local topography. Retezat is also a real centre of tertiary botanical relics".

Retezat National Park is one of three model project sites chosen in the Biodiversity Conservation Management Project; it is located in the Southern Carpathians and contains 38,138 hectares of pristine mountain forest and alpine ecosystems. Retezat's unspoiled forests are home to a variety of species: more than 1,100 species of plants; thousands of invertebrates species; over 55 species of mammals, including wolf, lynx, bear, chamois, red deer and otter; around 185 bird species including golden eagle, lesser spotted eagle owl, tengmalm's owl, pygmy owl, three-toed woodpecker, and white-backed woodpecker; nine species of repiles; ten species of amphibians; nine species of fish; 13 species of bats, etc.

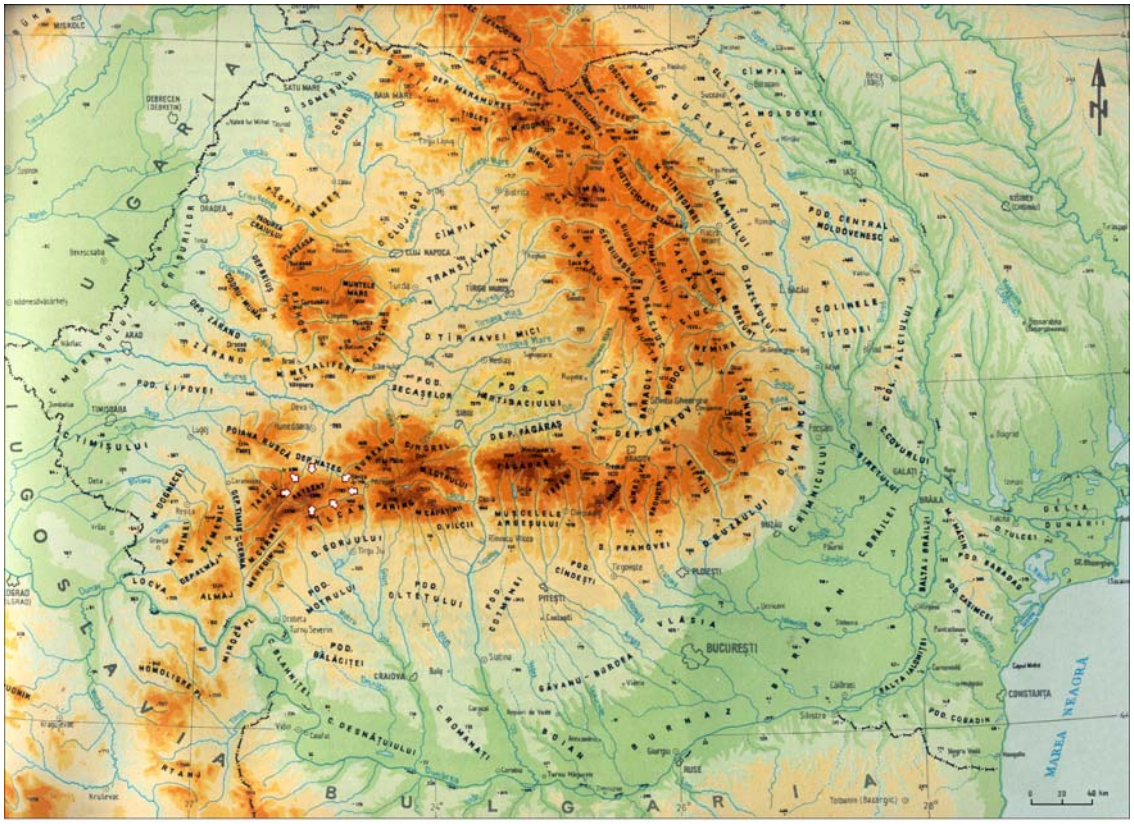
Within the park, there are more than twenty mountain peaks over 2,000 meters in altitude; the highest being the Peleaga Peak at 2,509 meters, which is centrally located and in close proximity to Lake Bucura. Lake Bucura is the largest lake, 8.9 hectares, and is only one of eighty lakes, most of them glacial in origin. Zănoaga Lake, the deepest Retezat National Park lake is 29 m deep. A small portion of the park in the south is made up of limestone; this section is called "The Small Retezat". There are several caves in this area formed from the naturally occurring chemical breakdown of the soft stone. The park offers visitors the chance to view a wide variety of landscapes, as well as, the flora and fauna living in these diverse ecosystems. There is much to do and see in Retezat National Park, but more importantly, there is much to be protected and conserved so that it may exist for years to come.

Although not included within park boundaries, the historical sites and cultural traditions surrounding Retezat make this park unique. While wandering through the countryside around the park, one might see a shepherd grazing his sheep nearby, families making traditional cuisine, farmers planting crops with a horse and plow, and a number of medieval churches, monasteries, castles, and fortresses. The history of the area dates back to the dinosaurs; archeologists have found the remains of the smallest dinosaur on the outskirts of the park. The Romans also lived here leaving behind ruins of their castles and fortresses. It is through this historical and cultural heritage that the park is defined.

In few words the Retezat Mountains represented always "The Mountain of Mountains" for the Romanian and south-eastern researchers, the interest for this fascinating mountain was spreading continuously over much of this part of Europe. Ecologists, biologists, geographers, geologists etc., find in this "natural kingdom" a huge "spring" of professional satisfaction, their hard work being from time to time put together between a publication covers, in the interest and satisfaction of all which love the nature.

Well known till now are: Parcul Național Retezat, studii ecologice - Braşov 1993 and Entomofauna Parcurilor Naționale Retezat şi Valea Cernei - Cluj-Napoca 1997, both in Romanian.

Inspired by the value of the area and the perseverence and work of previous researchers, the *Transylvanian Review of Systematical and Ecological Research* editors, generously sustained with the necesary printing funds by the Retezat National Park Administration - „Biodiversity Conservation Management" Project, dedicated a first volume, of this series, to the Retezat National Park.



The Retezat Mountains location (Badea et al., 1983 - modified).

No doubt that this new data will develop knowledge and understanding of the ecological status of this special area and will continue to evolve.

Acknowledgements

The editors would like to express their sincere gratitude to the authors and the scientific reviewers whose work made the appearance of this volume possible, and to the Retezat National Park Administration, which supported the field work on which a part of the necessary research was based, and also this volume printing expences. This volume came in to being through the „Biodiversity Conservation Management" Project, a project suported by: Global Environmental Facility, World Bank, Romanian Government and National Forest Administration.

The Editors

BACTERIA AND PELAGIC FOOD WEBS IN PRISTINE ALPINE LAKES (RETEZAT MOUNTAINS, ROMANIA)

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, Biosphere Reserve, alpine lakes, pelagic bacteria, chlorophyll, zooplankton.

ABSTRACT

Nine lakes located above the timber line in the Retezat National Park were investigated for pelagic biota (2000 - 2001): bacterial abundances and biomasses, chlorophyll, and zooplankton species structure. In autumnal samples, bacterial abundances were in the range of 0.049 - 1.67 millions ml^{-1}, bacterial mean cell volumes in the range of 0.083 - 0.176 μm^3 and bacterial biomasses expressed in carbon between 1.25 and 61.21 $\mu g\ l^{-1}$ C. Chlorophyll concentrations varied from 0.70 to 7.18 $\mu g\ l^{-1}$. In all lakes *Daphnia rosea* Sars and *Chydorus sphaericus* Müller were found. In summer and autumnal samples, cladocerans prevailed above copepods in all lakes except two. Cyclopids (copepodits and spp. div.) were found in all lakes but one, whereas diaptomids were absent in four lakes and apart from copepodits only one taxon was determined - *Arctodiaptomus* sp. Two lakes, Gemenele and Negru, were investigated four times during the ice-free season. In Gemenele, primary production of phytoplankton was measured in August 2001 and found to be rather high, corresponding to an oligo-mesotrophic lake. The Retezat lakes pelagic biota status was compared with the findings from other European mountain lakes.

RÉSUMÉ: Chaînes trophiques bactériennes et pélagiques dans des lacs alpines non pollues (Les Montagnes Retezat, Romania).

Les communautés biotiques de neuf lacs alpins situes au dessus de la limite de la forêt dans les Parc National Retezat ont été investigues durant 2000-2001, considérant l'abondance et la biomasse bactérienne, la chlorophylle et la structure spécifique du zooplankton. Dans les échantillons prélevés dans l'automne, l'abondance bactérienne a été dans le domaine 0,049 - 1,67

millions bactéries ml^{-1}, le volume moyen des cellules bactériennes dans le domaine 0,083 - 0,176 μm^3 et la biomasse bactérienne entre 1,25 et 61,21 $\mu g\ l^{-1}$ C. La concentration de chlorophylle a varié entre 0,70 et 7,18 $\mu g\ l^{-1}$. Dans tout les lacs on a trouvé les espèces *Daphnia rosea* Sars et *Chydorus sphaericus* Müller. Dans les échantillons d'été et d'automne les cladoceres ont dominé sur les copepodes dans sept lacs. Les cyclopides ont ete trouves dans huit lacs et les diaptomides dans cinq. Les copepodites sont représentées par une seule espèce - *Arctodiaptomus* sp. Gemenele et Negru, ont été investigues quatre fois durant la période libre de glace. Dans le lac Gemenele la production primaire du phytoplankton a ete mesure en août 2001 et a permis de classifier le lac comme oligo-mesotrophe. La situation des communautés biotiques des lacs du Retezat est comparée avec la situation des autres lacs alpins européens.

REZUMAT: Rețele trofice bacteriene şi pelagice din lacuri alpine nepoluate (Munții Retezat, România).

Au fost studiate comunitățile biotice din nouă lacuri, situate mai sus de limita pădurii, din Parcul Național Retezat în anii 2000 şi 2001, respectiv abundența şi biomasa bacteriană, clorofila şi structura specifică a zooplanctonului. În probele din toamnă, abundența bacteriană a fost în domeniul 0,049 - 1,67 milioane bacterii ml^{-1}, volumul mediu al celulelor bacteriene în domeniul 0,083 - 0,176 μm^3 iar biomasa bacteriană exprimată în carbon între 1,25 şi 61,21 $\mu g\ l^{-1}$ C. Concentrațiile de clorofilă au variat între 0,70 şi 7,18 $\mu g\ l^{-1}$. În toate lacurile au fost găsite *Daphnia rosea* Sars şi *Chydorus sphaericus* Müller. În probele din vară şi toamnă, cladocerele au dominat asupra copepodelor în toate lacurile cu excepția a două. Cyclopidele au fost găsite în toate lacurile cu excepția unuia, în timp ce diaptomidele au lipsit din patru lacuri. Dintre copepodiți a fost găsit un singur taxon - *Arctodiaptomus* sp. Două lacuri, Gemenele şi Negru, au fost investigate de patru ori pe parcursul perioadei fără gheață. În lacul Gemenele producția primară a fitoplanctonului a fost determinată în august 2001 şi a permis încadrarea lacului în categoria oligo-mezotrofă. Situația comunităților biotice din lacurile din Retezat este comparată cu cea din alte lacuri alpine europene.

INTRODUCTION

Mountain lakes located above the timberline are characterized by lower temperatures, and shorter ice-free periods compared to lowland lakes at similar latitude. They have comparatively low soil coverage in the catchment and are strongly affected by extreme meteorological and hydrological processes (including air pollution). Direct human impact in their watersheds is usually low and they are oligotrophic or ultraoligotrophic. The structure of pelagic food webs at low trophy is shifted towards a less complexity, with a higher share of unicellular organisms (pico- and nanoplankton) and a higher bacterial to phytoplankton biomass ratio (Riemann and Søndergaard, 1986; Straškrábová and Šimek, 1993).

Pelagic food webs in alpine lakes of six European mountain districts were studied intensely during 1996 - 1997 (Straškrábová et al., 1999). During 2000 - 2001, another broad survey was carried on in nine mountain districts (Straškrábová et al., submitted), including Retezat Mountains. The aim of this paper is to present the data on pelagic food webs including bacteria in the lakes of Retezat Mountains and to characterize them in relation to other European mountain lakes.

MATERIALS AND METHODS

The study was performed during the ice-free seasons of 2000 and 2001 in the Retezat National Park and Biosphere Reserve located in the western part of Romania. The climate is moderately cold and humid, with average yearly temperatures of 2°C in the alpine area, and annual rainfall in the range of 900 - 1300 m. Of the 58 permanent glacial lakes, nine were investigated for pelagic food webs (at least once) and four of them were studied frequently. All of them are located between 45.35 to 45.37 N, and 22.81 to 22.88 E, in the Râul Mare River catchment. The highest studied lake Porţii, was located 350 m higher than the lowest Gemenele. Morphometry varied considerably as shown in table 1. For detailed information on the region and lakes see Cogălniceanu et al. (2004). All lakes were temperature stratified during summer, except for shallow Radeş (Tab. 1). In Gemenele and Negru, *Salmo trutta* occurred (may be a natural population); in Ştirbu and Porţii the fish were introduced in the sixties, but recently not found. Chemical composition of lake water did not vary among lakes (Tab. 2); the highest located lake Porţii only showed exceptionally high conductivity, alkalinity and dissolved phosphorus content, and in lake Gemenele a very high dissolved organic carbon concentration was observed.

Table 1: Location, morphometry and selected parameters in lakes. Maximum measured temperatures at the surface (Temper. max. surf.) and in the depth corresponding approx. to 2 x Secchi depth (Temp. max. deep). No investigations on fish - n.d.

Lake	Altitude m	Surface m^2	Depth max. m	Volume m^3	Temper. max. surf.	Temper. max. deep	Fish *Salmo trutta*
Lia	1910	13300	4.3	15926	17.3	15.9	n.d.
Gemenele	1920	24800	5.3	67284	19.1	17.3	+
Ana	1930	31380	11.6	169125	18.0	12.0	n.d.
Radeş	1940	3110	0.6	1071	17.7	17.7	n.d.
Viorica	2008	8000	2.2	7461	18.6	15.9	n.d.
Negru	2036	46480	24.8	446480	17.2	10.7	+
Bucura	2041	88612	15.7	625096	16.8	14.4	n.d.
Ştirbu	2082	9540	8.7	48106	12.3	8.6	no
Porţii	2260	4900	4.3	10348	14.6	5.3	no

Samples were taken at the deepest part of each lake. A van Dorn type sampler (one to three litres volume) was used for sampling all the components except large zooplankton. An Apstein type net (200 μm mesh size) was used for large zooplankton.

Bacterial (bac.) abundance and biomass were elaborated from formaldehyde preserved samples (final concentration 2% w/v) using 0.2 μm pore size black polycarbonate filters (Poretics or Nuclepore), DAPI stain and epifluorescence microscopy (Porter and Feig, 1993). Bacterial cells were sized by image analysis and volumes calculated according to Psenner (1993), and mean cell carbon calculated according to Norland (1993).

Chlorophylla was determined after concentrating on Whatman GF/C filter from absorbances in 96% alcohol extract and calculated according to Jefferey and Humphrey (1975).

Table 2: Chemistry of lake water, surface, sampling in July and August 2000 (DOC - dissolved organic C, DN - dissolved N, TP - total P).

Lake	Conduct. $\mu S\ cm^{-1}$	Alkal. $\mu eq\ l^{-1}$	DOC $mg\ l^{-1}$	DN $\mu g\ l^{-1}$	DP $\mu g\ l^{-1}$
Lia	13	36	0.61	335	3.8
Gemenele	12	29	1.55	375	5.3
Ana	12	22	0.61	523	2.1
Viorica	14	34	0.53	401	2.6
Negru	14	30	0.61	369	3.2
Bucura	12	31	0.82	211	2.9
Ştirbu	15	40	0.34	431	2.6
Porţii	19	62	0.58	436	9.4

Zooplankton "large" (> 200 μm) was concentrated from several vertical net hauls, zooplankton "small" (> 40 μm, < 200 μm) from samples taken in different depths and preserved by formaldehyde. Species were determined and their abundance counted in chambers and calculated per volume unit.

Primary production of phytoplankton was measured in Gemenele Lake in June 2001, using ^{14}C method. All methods were described in detail by Straškrábová, et al. (1999).

RESULTS AND DISCUSSIONS

For intercomparison among lakes the autumnal samples (end of September - beginning of October) were considered as representative, due to development of complex pelagic food web structure including zooplankton concentrated from the whole water column. The depth corresponding to 2 x Secchi disc (or above bottom if lake is transparent to the bottom) was sampled for chlorophyll (to avoid light inhibited surface layers), and bacteria were determined in the same depth. Table 3 shows the data of early October 2000 in all lakes together with the additional data of late September 2001 in three lakes.

Pelagic bacteria are characterized by total abundances, mean cell volumes (of 200 - 300 cells measured per each sample) and total biomass expressed in carbon. Bacteria were short rods, no filamentous bacteria occurred in any lake. Only in three lakes did bacterial abundances surpasse 900 thousand cells per ml (in Negru both years, in Porţii only in 2001). Bacterial mean cell volumes were very small, not exceeding 0.180 μm^3. Compared to the alpine lakes of European mountain districts (the Alps, Tatra, Pyrenees, Scotland, North Finland and Rila) these are the lowest abundances and bacterial cell volumes found (Straškrábová et al., submitted).

Bacterial biomasses expressed in carbon (based both on abundance and on mean cell carbon with allometric relation to cell volume) fluctuated more among the lakes, but still are rather low compared to other mountain lakes. The maximum biomass was found in Negru Lake 2001 when the highest chlorophyll concentration was also observed. No clear relationship between bacteria and chlorophyll could be expected, though the extracellular algal products are bacterial food resource (Medina-Sánchez et al., 1999). At high cladoceran density chlorophyll is decreased, but, at the same time, the excrement of intensely grazing zooplankton are used by bacteria. Similarly like bacteria, chlorophyll concentrations in the Retezat lakes are rather low compared to other European mountain lake districts. They are only comparable with similarly low concentrations found in Scotland (Straškrábová et al., submitted).

Table 3: Pelagic food webs in lakes from autumnal sampling (October 2000, in three lakes also October 2001). Bacteria and chlorophyll from the depth corresponding to 2 x Secchi disc or above bottom, zooplankton from the whole water column.

Lake	bac. abund. 10^6 ml^{-1}	bac. cell vol. µm^3	bac. biom. µg l^{-1} C	Chloro-phylla µg l^{-1}	Clado-cera ind l^{-1}	Cope-poda ind l^{-1}
Lia	0.543	0.092	11.03	2.24	0.03	0
Gemenele 2000	0.206	0.083	3.88	2.26	1.80	0.80
Gemenele 2001	0.154	0.176	4.66	2.76	34.46	13.65
Ana	0.197	0.115	4.76	0.70	24.40	13.00
Radeş	0.159	0.105	3.63	1.43	3.30	0.60
Viorica	0.049	0.135	1.25	0.91	4.20	1.40
Negru 2000	0.901	0.099	19.60	0.70	6.00	7.60
Negru 2001	1.671	0.119	61.41	7.18	6.96	10.15
Bucura	0.321	0.105	7.20	2.05	5.30	1.70
Ştirbu	0.065	0.109	1.51	2.74	10.40	1.50
Porţii 2000	0.301	0.107	7.01	3.79	6.00	18.80
Porţii 2001	1.263	0.127	32.96	1.73	44.40	0.28

Zooplankton abundances (cladocerans and copepods together) varied in autumnal samples considerably among different lakes (Tab. 3). Extremely low values were detected in lake Lia. The other lakes showed values in the range of 2.6 to 37 ind l^{-1} in 2000. However, in three lakes sampled also one year later (Gemenele, Negru and Porţii), higher zooplankton abundances were found, up to 48 ind l^{-1}.

Compared to other European mountain lakes (Catalan et al., submitted), total zooplankton abundances, in general, are comparable with those found in lakes of the Alps Mountains, and they are higher than in the alpine lakes of Rila Mountains, Tatra Mountains and North Finland mountains. On the other hand, they do not reach zooplankton densities found in the lakes of Pyrenees Mountains and of Scotland mountainous area. The occurrence of the main groups - copepods and cladocerans in autumnal samples from the Retezat lakes is characterized by prevalence of cladocerans over copepods, as in the lakes of Rila, Scotland, Julian Alps and Tyrolian Alps. However, the species structure is different (Catalan et al., submitted). *Daphnia* species prevailed in Retezat (Tab. 4), Rila and Julian Alps, whereas *Bosmina* species are dominant among cladoceran in Scotland mountainous area and Tyrolian Alps.

Cladocerans species *Daphnia rosea* Sars and *Chydorus sphaericus* Müller occurred in all the investigated lakes (Tab. 4), whereas the representatives of Cyclopidae were detected in all lakes but one - Lia. Diaptomida were found only in Gemenele, Ana, Negru, Ştirbu and Porţii.

Table 4: Zoplankton taxa found in lakes (acronyms correspond to first two letters of the lake name).

Taxon \ Lake	Lia	Gemenele	Ana	Radeş	Viorica	Negru	Bucura	Ştirbu	Porţii
Daphnia rosea Sars	+	+	+	+	+	+	+	+	+
Daphnia obtusa Kurz								+	
Alona rustica Scott		+							+
Chydorus sphaericus Müller	+	+	+	+	+	+	+	+	+
Eurycercus lamellatus Müller	+	+		+	+	+		+	+
Cyclopidae - copepodits		+	+	+	+	+	+	+	+
Diaptomida - copepodits		+	+			+		+	+
Arctodiaptomus sp. Koelbel			+			+			+
Cyclops prealpinus Kiefer		+				+		+	+
Cyclops vicinus Uljanin		+		+			+	+	
Cyclops scutifer Sars					+	+			
Megacyclops robustus Sars						+			
Eucyclops serrulatus Fischer					+			+	
Acanthocyclops languidus Sars						+			

Table 5: Abundances of cladocerans and copepods (copepodites plus adults) during summer 2001 in two lakes (when more parallel samples were taken, a range is shown).

Lake	Group	June	August	September
Gemenele	Copepods	4 - 11	3 - 23	1
	Cladocerans	1	22 - 76	10
Negru	Copepods	2 - 8	7 - 19	7
	Cladocerans	0	3 - 20	4

In lakes Gemenele and Negru zooplankton were investigated monthly from June to September 2001. Changes in cladoceran and copepod abundances during the season are in table 5. An earlier development of copepods before cladocerans and a fast increase towards maximum in August (especially of cladocerans in Gemenele), as well as a fast decrease of both groups in September are apparent. Thus the timing of sampling is crucial, as well as the dynamics of temperature in the particular year: the autumnal samples of 2000 were taken after the first decade of October, whereas the 2001 sampling campaign was two weeks earlier, and thus still at high zooplankton abundances.

In August 1 - 2, 2001 pelagic primary production was measured in lake Gemenele at two depths - 0 m and 4.5 m, i.e. at the surface and above the bottom (3 hrs' in-lake exposition in quartz glass flasks). Both days were sunny without clouds, pH was 6.8 in both layers and temperature 16 - 17° at the surface and 16 - 16.5° in 4.5 m depth. Transparency was down to the bottom. After exposition, the sample was separated by filtration into phytoplankton (> 5 μm), picoplankton (> 0.2 to 5 μm) and dissolved (up to 0.2 μm). Two latter fractions are considered as extracellular primary production, both dissolved and taken up by picoplankton during the exposition. It is shown in table 6 that this fraction is quite negligible and insignificant.

Primary production was rather high for an oligotrophic lake (Nedoma et al., 2003), which might be explained by high temperature and fast turnover (thus a high availability) of limiting nutrient (dissolved P concentration see in table 2). In lake Gemenele a high abundance of cladocerans was observed (Tab. 3), which might indicate an intense grazing on phytoplankton and subsequent P excretion. Values of total primary production (TPP), both absolute and related to chlorophyll concentration surpass the values measured in oligotrophic lakes, i.e. up to 10 - 12 μg l^{-1} h^{-1} C and 0.2 - 1, respectively. A negligible percentage of extracellular production in TPP is in concordance with a high value of TPP. In oligotrophic lakes with lower TPP the percentage increases up to 40 - 60% (Nedoma et al., 2003).

The shallow lake Gemenele with a high transparency should have a significant primary production by periphytic autotrophic organisms at the bottom, which even might surpass the pelagic production as found in a shallow lake of Sierra Nevada Mountains (Reche et al., 1996).

Table 6: Pelagic primary production in Gemenele, June 2001. Extracellular primary production was calculated from the amount of carbon assimilated in the fraction < 5 μm.

Date	Depth m	Chlorophylla μg l^{-1}	Total PP μg l^{-1} h^{-1} C	Extracellular PP%	Total PP per chlorophylla
August 1	0	2.95	20.0	1	6.79
August 1	4.5	2.61	18.1	1	6.92
August 2	0	3.95	16.4	1	4.16
August 2	4.5	3.08	8.2	1	2.65

All the investigated lakes are not influenced by human activities in their catchments. Still, lake Gemenele could be classified as oligo-mesotrophic according to primary production, though the chlorophyll concentration was low (Tab. 3). In autumn 2001, the highest abundance of zooplankton of all lakes investigated was observed there. As shown in table 2, this is a lake with a high organic carbon content and with the second highest concentration of dissolved phosphorus. The reason for higher trophy is the type of catchment with a high percentage of soils and vegetation cover. Gemenele is located close to the timberline, 15% of catchment area is coniferous forest (dwarf-pine), 30% meadows, 5% shrubs and only 35% are bare rocks.

On the other hand, the catchment of the highest lake Porții consists of 65% bare rock, 25% meadow, 5% shrubs and no forest. In this lake, however, the highest dissolved phosphorus concentration (Tab. 2) and the second highest abundances both of bacteria and of zooplankton were found (Tab. 3).

The highest chlorophyll concentration and bacterial abundance were found in the deepest lake Negru (Tab. 3). Zooplankton abundances per unit of volume were not high. However, since the zooplankton was distributed through the whole water column, a better expression would be per unit of area than per volume. Related to maximum depth (Tab. 1), zooplankton abundances (cladocerans and copepods) under 1 m^2 in the autumn 2001 will be 254983, 424328 and 192124 ind. m^{-2} in Gemenele, Negru and Porții, respectively. Zooplankton abundances per area are thus better related to respective chlorophyll concentrations.

All three main components of pelagic food web, bacteria, phytoplankton and zooplankton, should be considered when evaluating trophic state of a mountain lake, since they have different seasonal development and interact. In the Retezat lakes, pelagic food webs are developed in complexity (often with fish as a top level), without any apparent human pressure. Lakes are pristine and naturally oligo- to mesotrophic, according to the type of catchment.

CONCLUSIONS

Nine lakes in the Retezat National Park and Biosphere Reserve, located above the timberline, were oligo- to mesotrophic, judging from the structure of pelagic food webs. All main components of plankton - bacteria, phytoplankton and zooplankton - are well developed. Differences in water chemistry among the lakes, which affect the pelagic biota, are mostly connected with the type of catchment, especially percent cover by soils and vegetation.

During the ice-free season, succession of pelagic organisms occurred, with a characteristic development of zooplankton. After copepods, cladoceran increase followed, and the highest peak of zooplankton abundance was observed in August, at maximum water temperature. Then the decrease towards autumn was rather fast. Chlorophyll concentration was low near the surface, where light inhibiton is probable due to high transparency of lake water. The interactions among pelagic organisms determine changes and share of abundances of particular groups. At high density of efficient cladoceran filtrators, chlorophyll concentration was kept low. Bacterial abundances grew high at high chlorophyll and organic carbon. On the other hand, they might be kept low at high grazing pressure by zooplankton filtrators, but, simultaneously, they profited from a fast turnover of nutrients at high abundances of zooplankton. Simple relations between plankton components could not be derived from the data available.

The most “trophic” lake is Gemenele, with part of catchment being forested, high organic carbon content in water and high pelagic primary production.

No signs of eutrophication or other adverse effect from human activities were detected.

AKNOVLEDGEMENTS

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THE CORMOFLORA FROM THE SOUTH-EASTERN AREA OF RETEZAT NATIONAL PARK (ROMANIA)

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, species' list, chorology, protected species.

ABSTRACT

The present paper represents a synthesis of the data on the cormoflora from the south-eastern area of Retezat National Park. It presents the chorology of the 654 species and 18 hybrids mentioned in the literature or encountered by the authors in the last five years. Among them are some rare species from the subalpine area, not cited by other authors, notably: *Astragalus alpinus, Cardaminopsis neglecta*, *Taraxacum fontanum*, *Taraxacum nigricans*, *Pedicularis exaltata* and *Herminium monorchis*. The investigated zone represents an important conservation area for plants, sheltering several protected species. Among them, *Campanula serrata*, included in the Annex II of 92/43/EEC Habitat Directive is abundant and widely distributed in the area.

RÉSUMÉ: La cormoflore de la part sud-estique du Parc National Retezat (Roumanie).

Ce travail représente une synthèse des informations sur la cormoflore de la part sud-estique du Parc National Retezat. Il présente la chorologie de 654 espèces et 18 hybrides mentionnés dans la littérature ou rencontrés par les auteurs durant les cinque années. On peut remarquer quelques espèces rares de la zone subalpine que n'ont pas été mentionnées par d'autres auteurs: *Astragalus alpinus, Cardaminopsis neglecta*, *Taraxacum fontanum*, *Taraxacum nigricans*, *Pedicularis exaltata* et *Herminium monorchis*. La zone investiguée représente une importante aire conservative pour plantes, abritant plusieurs espèces protégées. Entre elles, *Campanula serrata*, inclue dans l' Annexe II de la Directive Habitâtes 92/43/EEC est abondante et répandue dans la zone.

REZUMAT: Cormoflora din sud-estul Parcului Național Retezat (România).

Lucrarea reprezintă o sinteză a datelor existente asupra cormoflorei din sectorul sud-estic al Parcului Național Retezat. Este prezentată corologia celor 654 specii şi 18 hibrizi, citate în literatură sau întâlnite de autori în ultimii cinci ani. Dintre acestea se remarcă o serie de specii rare din etajul subalpin care nu au fost citate în literatură: *Astragalus alpinus, Cardaminopsis neglecta*, *Taraxacum fontanum*, *Taraxacum nigricans*, *Pedicularis exaltata* şi *Herminium monorchis*. Sectorul investigat reprezintă şi o importantă arie conservativă, adăpostind numeroase specii protejate, dintre care *Campanula serrata*, inclusă în Anexa II a Directivei Habitate 92/43/EEC este abundentă şi larg răspândită.

INTRODUCTION

Data regarding the flora and vegetation of the cormoflora from the Southern part of Retezat National Park area can be found in several papers beginning at the end of the XIXth century. In 1898 Pax published the first data on the calciphilous flora from the area in a paper on the plants' distribution in the Carpathian Mountains. Ten years later the second part of the work was published. More specific studies were carried out by Jávorka (1911, some of these data being taken over in his synthetic paper from 1922), Csűrös et al. (1956), and Boşcaiu et al. (1977). The most important work on the flora of Piule-Iorgovan limestone area was published by Csűrös et al. (1962). The paper includes 426 species with 73 varieties and 41 forms, belonging to 208 genera from 56 families, dealing mostly with the flora from beyond the forest upper limit. Among the lower species are mentioned only the rare ones. In his monograph on the flora and vegetation of the Retezat Mountains (including only the northern granitic area) Nyárády (1957) also mentions 73 species from the neighboring Piule-Borăscu calcareous mountains. This information is partly based on original data, partly cited according to Jávorka (1911) and Pax (1908). The monograph on the flora and vegetation from Țarcu, Godeanu and Cernei mountains (Boşcaiu, 1971) includes also some cormophytes from Paltina Peak, Paltina and Soarbele valleys. Data regarding the presence of some species or infraspecific taxa in the south-eastern sector of Retezat National Park can be found in "Flora R.P.R." (1952 - 1976) and in some other papers: Prodan and Csűrös (1953), Pócs (1957), Nyárády and Nyárády (1964 a, b), Resmeriță (1971), Negrean (1975), Negrean and Oltean (1989), Sanda and Fişteag (1992).

Between 2000 and 2005 the authors carried out a survey on the cormophytes from the mentioned area. These investigations were part of the flora and fauna inventory programme co-coordinated by the Retezat National Park's Administration. The research aimed to complete the bibliographical list of cormophytes from the area.

STUDY AREA AND METHODS

The investigated area lies in the southern part of the Retezat National Park (Retezat and Godeanu mountains, the Southern Romanian Carpathians), northwards up to Lăpuşnicul Mare Valley and westwards to Paltina Valley. The altitude ranges from 950 m in Buta Gorges to 2081 m - the Piule Peak. From a geological point of view it is divided into two areas. The northern part, comprising Drăgşanu and Scorota ridges as far as Scocu Drăgşan, and a small area around Buta Chalet is geologically similar to the northern part of the park. The substratum is formed of magma and metamorphic rocks, especially of granodiorite with massive texture and granitoid gnaise, covered in part by crystalline schist, traversed by a system of lamprophyre veins (Muntihac and Ionesi, 1974). The granodiorite presents characteristics between those of the acid granite and the more basophile diorite. The southern part includes Piule-Pleşa Ridge, Scorota, Albele, Piatra Iorgovanului, Stănuleții Mari, eastwards to Paltina Valley and southwards to Jiul de Vest Valley (Fig. 1), where the substratum is formed mainly of Mesozoic limestone.

The species list is presented by families, given in systematic order, according to Oprea (2005). In order to facilitate finding the information, within the families the species and their distribution sites are presented in alphabetical order. Old species' names are preserved as they were cited in order to avoid information loss in case of further changes of their systematical status. For the same purpose subspecies, varieties and forms are also given as cited, although most of them are not recognized in the present. Polytypical species for which we do not have the subspecific framing are noted as sensu lato (s.l.).

RESULTS

The species identified by the authors in the field between 2000 and 2005, or cited in the mentioned papers are listed below. The authors are coded as: Cs - Csűrös et al. (1962); Cs (Jav.1) - Jávorka (1911) cited by Csűrös at al. (1962); Cs (Jav.2) - Jávorka (1922) cited by the same authors; Cs (Pawl) - Pawlowski (1939) cited by Csűrös and coll. (1962); Pr. - Prodan and Csűrös (1953); Pcs - Pócs (1957); Ny - E. I. Nyárády and A. Nyárády (1964); Ny1 - E. I. Nyárády (1958); Ny2 - E. I. Nyárády (1957); ANy - A. Nyárády (1966); Bs1 - Boşcaiu (1971); Bs - Boşcaiu and coll. (1977); Fl. I - XII - volumes I - XII of the Flora R.P.R. (1952 - 1976); Rs - Resmeriță (1971); Ng1 - Negrean (1975); Sn - Sanda and Fişteag (1992); ! - original data. The toponyms are codes as: Alb. - Albele; Buta - Buta and Buta Mică Valleys up to Buta Lake and Peak; Buta G. - Buta Gorges; Câmp. - Câmpuşel and the upper sector of Jiul de Vest Valley, on the slope up to the spruce forest's limit; Dâlma - Dâlma Mare Peak; Drăg. - Drăgşanu Ridge except Scorota Peak; Iorg. - Piatra Iorgovanului, down to the forest limit; Palt. - Paltina; Piule - Piule-Pleşa Ridge except Pleşa Peak, down to the forest limit; Piept - Mount Piept in Piule Massif (mentioned by Pawlowski, cited by Csűrös et al. (1962); Pleşa - Pleşa Peak; Scor. - Scorota Valley, in case of literature data including also Scorota Gorges and Peak; Scor. G. - Scorota Gorges for the original data; Soar. - Soarbele Valley; Stăn. - Stănuleții Mari.

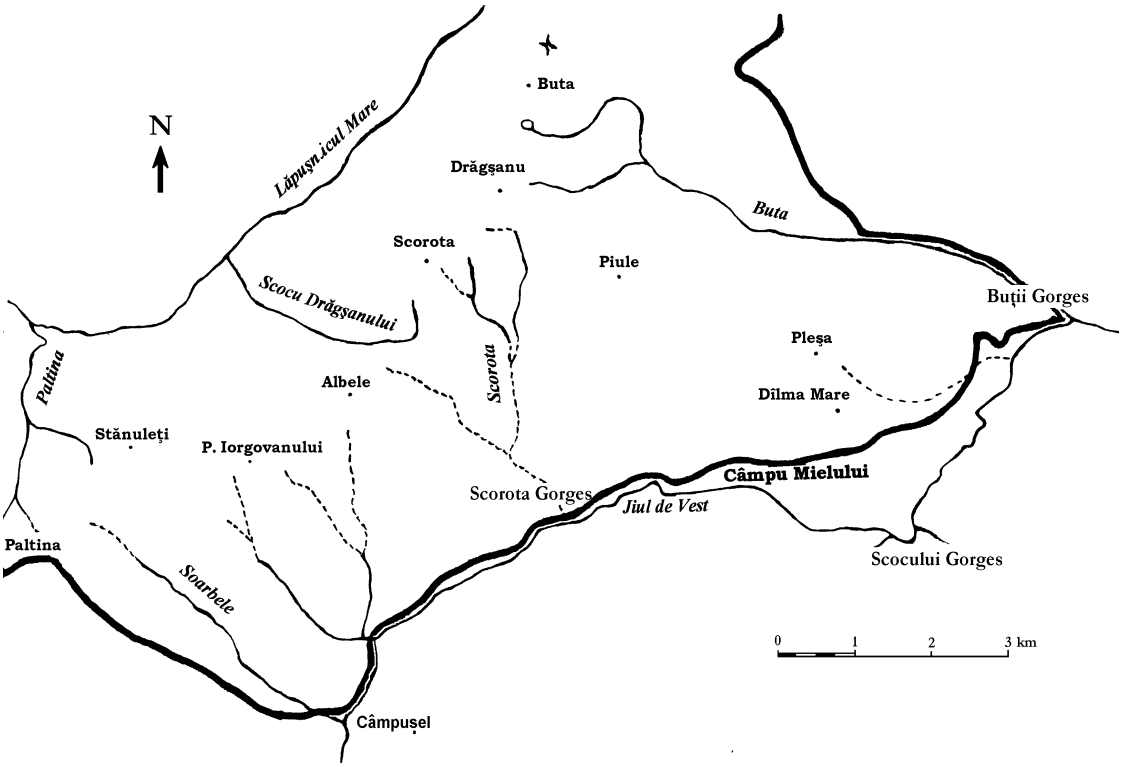

Fig. 1: The south-eastern area
of the Retezat National Park.

Fam. Lycopodiaceae Pal. ex Mirb.

Diphasiastrum alpinum (L.) Holub: Alb. (!), as *Lycopodium alpinum* L.: Buta (Cs), Piule (Cs); *Huperzia selago* (L.) Bernh. ex Schrank and Mart.: Alb. (!), Buta (!), as f. *recurvum* (Kit.) Desv.: Buta (Cs); *Lycopodium annotinum* L.: Drăg. (Fl. I);

Fam. Selaginellaceae Willk.

Selaginella helvetica (L.) Spring: Alb. (Cs), Buta (Cs), Piule (!); *S. selaginoides* (L.) P. Beauv. ex Schrank and Mart.: Iorg. (Cs), Palt. (Bs1), Piule (Cs);

Fam. Equisetaceae Mich. ex DC.

Equisetum arvense L.: Buta (!), Câmp. (!);

Fam. Ophioglossaceae (R. Br.) C. Agardh

Botrychium lunaria (L.) Sw.: Alb. (Cs), Câmp. (!), Dâlma (Fl. I), Piule (Cs), Scor. (Cs), Soar. (Bs1), Stăn. (Bs);

Fam. Thelipteridaceae P. Sermolli

Oreopteris limbosperma (Bellardi ex All.) Holub: Scor. (!); *Phaegopteris connectilis* (Michx.) Watt: Buta (!), Piule (!), as *Ph. polypodioides* Fée: Piule (Cs);

Fam. Aspleniaceae Newman

Asplenium ruta-muraria L.: Alb. (Cs), Buta G. (!), Câmp. (!), Iorg. (Bs, !), Piule (Cs, !), as f. *brunfelsii* Heuff.: Piule (Cs); *A. scolopendrium* L.: Buta (!), Câmp. (!), as *Phyllitis scolopendrium* (L.) Newman: Buta (Cs); *A. septentrionale* (L.) Hoffm.*:* Buta (Cs, !); *A. trichomanes* L. ssp. *quadrivalens* D. E. Mey.: Alb. (!), Buta G. (!), Câmp. (!), Iorg. (!), Scor. G. (!); *A. trichomanes-ramosum* L.: Alb. (!), Câmp. (!), Iorg. (!), Piule (!), Scor. (!), as *A. viride* Huds.: Alb. (Cs), Iorg. (Cs, Ny1, Bs), Palt. (Bs1), Piule (Cs, Ny1), Scor. (Cs, Ny1), Soar. (Bs1), Stăn. (Cs, Ny1), f. *microphyllum* Christ.: Iorg. (Cs);

Fam. Woodsiaceae (A. Gray) Herter

Athyrium disentifolium Tausch ex Opiz: Iorg. (!), Palt. (Bs1), as *A. alpestre* (Hoppe) Rylands ex T. Moore, non Clairv.: Iorg. (Cs); *A. filix-femina* (L.) Roth: Buta (Cs, !), Câmp. (!), Iorg. (Cs, !), Piule (!), Scor. G. (!), Soar. (!), as var. *dentatum* (Döll) Milde: Iorg. (Cs); *Cystopteris fragilis* (L.) Bernh.: Alb. (!), Buta (Cs, !), Câmp. (!), Iorg. (Bs, !), Palt. (Bs1), Piule (Cs, !), Soar. (Bs1), as ssp. *hutteri* (Milde) Grinț.: Palt. (Fl. I), as f. *anthriscifolia* (Hoffm.) Koch: Piule (Cs); *C. montana* (Lam.) Desv.: Piule (Cs, !); *C. sudetica* A. Braun and Milde: Iorg. (!), Piule (!), as *C. regia* (L.) Desv.: Alb. at 2000 m (Pcs), Iorg. (Cs, Bs) at 2000 m (Pcs), Piule (Cs, Bs); *Gymnocarpium dryopteris* (L.) Newman: Buta (!), Câmp. (!), Iorg. (!), Palt. (Bs1), Piule (!), Scor. G. (!), as *Phegopteris dryopteris* (L.) Fée: Iorg. (Cs), Piule (Cs); *G. robertianum* (Hoffm.) Newman: Palt. (Bs1), as *Phegopteris robertiana* (Hoffm.) A. Braun: Piule (Cs);

Fam. Dryopteridaceae Herter

Dryopteris carthusiana (Vill.) H.P. Fuchs: Buta (!), Stăn. (Cs), as *D. spinulosa* (O. F. Müll.) Kuntze: Stăn. (Cs); *D. dilatata* (Hoffm.) A. Gray: Buta (!), Iorg. (!), Piule (!), as *D. austriaca* (Jacq.) Woyn.: Iorg. (Cs); *D. filix-mas* (L.) Schott: Buta (!), Câmp. (!), Iorg. (!), Scor. G. (!), Palt. (Bs1), Soar. (!); *Polystichum aculeatum* (L.) Roth: Buta (!), Dâlma (!), Piule (!), Scor. G. (!), as *P. lobatum* (Huds.) Chevall.: Iorg. (Cs); *P. lonchitis* (L.) Roth: Buta (!), Iorg. (Bs, !), Palt. (Bs1), Piule (!); *P. setiferum* (Forssk.) Woyn.: Piule (Cs); *P.* × *illyricum* (Borbás) Hahne (*lonchitis* × *aculeatum*): Piule (Cs);

Fam. Blechnaceae (C. Presl) Copel.

Blechnum spicant (L.) Roth: Buta (Cs);

Fam. Polypodiaceae Bercht. and J. Presl

Polypodium vulgare L.: Buta (!), Câmp. (!), Iorg. (Cs, !), Scor. G. (!);

Fam. Pinaceae Lindl.

Abies alba Mill.: Buta (!), is less frequent than in other neighbouring mountains (Fl. I); *Larix decidua* Mill. ssp. *carpatica* (Domin) Šiman: Buta (!); *Picea abies* (L.) H. Karst.: Alb. (!), Buta (!), Câmp. (!), Dâlma (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (!), Scor. (!); *Pinus cembra* L.: Buta (!), Palt. (Bs1), Piule (Cs, !); *P. mugo* Turra: Alb. (!), Buta (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (!), Scor. (!), Stăn. (!), as *P. montana* Mill.: Alb. (Pr), ssp. *mughus* (Scop.) Willk.: Alb. (Cs), Iorg. (Cs), Piule (Cs), Scor. (Cs); *P. nigra* Arnold: Câmp. (!); *P. sylvestris* L.: Buta G. (!), Iorg. (!);

Fam. Cupressaceae Rich. ex Bartl.

Juniperus communis L. ssp. *communis*: Buta (!), Iorg. (!), Piule (!), Scor. (!), ssp. *alpina* (Suter) Čelak: Buta (!), Drăg. (!), Iorg. (!), Piule (!), as *J. sibirica* Lodd. in Burgsd.: Palt. (Bs1), Piule (Cs);

Fam. Salicaceae Mirb.

Populus tremula L.: Buta (!), Dâlma (!), Iorg. (!), Piule (!); *Salix alpina* Scop.: Buta (!), Iorg. (!), Piule (!), as *S. jaquinii* Host: Alb. (Pr, Cs), Iorg. (Cs), Piule (Cs, Ny1), Scor. (Cs, Ny1), Stăn. (Cs (Jav1), Ny1); *S. aurita* L.: Piule (Cs, !); *S. caprea* L.: Alb. (!), Buta (!), Câmp. (!), Iorg. (!), Piule (Cs, !), Scor. (!); *S. fragilis* L.: Buta G. (!); *S. hastata* L.: Piule (Cs); *S. purpurea* L. ssp. *purpurea*: Buta G. (!); *S. retusa* L.: Buta (!), Piule (!), as *S. retusa* var. *kitaibeliana* (Willd.) Rchb.: Piule (Cs), Scor. (Cs); *S. silesiaca* Willd.: Buta (!), Iorg. (Cs,!), Palt. (Bs1), Piule (Cs, !); *S.* × *multinervis* Döll (*aurita* × *cinerea*): Piule (Cs); *S.* × *retusoides* J. Kern. (*alpina* × *retusa*): Piule (Cs); *S.* × *subaurita* Andersson (*aurita* × *silesiaca*): Piule (Cs); *S.* × *tatrae* Woł. (*alpina* × *silesiaca*): Drăg. at 1800 m (Pcs);

Fam. Betulaceae S. F. Gray

Alnus incana (L.) Moench: Buta (!); *A. viridis* (Chaix) DC.: Buta (!), Palt. (Bs1), Piule (Cs, !); *Betula pendula* Roth: Buta G. (!), Câmp. (!), Dâlma (!), Iorg. (!), Piule (!);

Fam. Corylaceae Mirb.

Corylus avellana L.: Buta (!), Dâlma (!), Piule (!);

Fam. Fagaceae Dum.

Fagus sylvatica L.: Buta (!), Buta G. (!), Câmp. (!), Dâlma (!), Piule (!);

Fam. Ulmaceae Mirb.

Ulmus glabra Huds.: Buta (!), Câmp. (!);

Fam. Urticaceae Juss.

Urtica dioica L.: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (!), Soar. (!), Scor. G. (!), Stăn. (!); *U. kioviensis* Rogow.: Buta (!);

Fam. Santalaceae R. Br.

Thesium alpinum L.: Alb. (Cs), Iorg. (!), Piule (Cs);

Fam. Aristolochiaceae Juss.

Asarum europaeum L.: Buta (!), Câmp. (!);

Fam. Polygonaceae Juss.

Polygonum bistorta L.: Iorg. (!), Piule (!); *P. viviparum* L.: Alb. (Pr, Cs, Bs, !), Iorg. (Cs, Fl. I, !), Palt. (Bs1), Piule (Cs, !), Scor. (Cs), Stăn. (Cs); *Rumex acetosa* L.: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Piule (Cs), Scor. G. (!); *R. acetosella* L. ssp. *acetoselloides*

(Balansa) de Nijs: Buta (!); *R. alpestris* Jacq.: Alb. (Cs, !), Drăg. (!), Iorg. (!), Piule (Cs, !), as *R. arifolius* All.: Palt. (Fl. I, Bs1); *R. alpinus* L.: Buta (Cs, !), Câmp. (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (!); *R. crispus* L.: Buta (!); *R. obtusifolius* L. ssp. *obtusifolius*: Alb. (!), Buta (!), Câmp. (!), Scor. G. (!); *R. scutatus* L.: Alb. (Rs), Iorg. (Cs (Jav1), Ny1, Bs, !), Piule (Cs, !);

Fam. Chenopodiaceae Vent.

Chenopodium bonus-henricus L.: Buta (!), Piule (!);

Fam. Caryophyllaceae Juss.

Cerastium alpinum L.: Alb. (Cs, !), Iorg. (Cs, !), Piule (Cs, !), Scor. (Cs,), Stăn. (Cs); *C. arvense* L. ssp. *arvense*: Câmp. (!), Iorg. (!), Palt. (Bs1), Soar. (Bs1), ssp. *lerchenfeldianum* (Schur) Asch. and Graebn.: Câmp. (!), Iorg. (Bs), Piule (Bs), as *C. lerchenfeldianum* Schur: Alb. (Pr., Cs, Ny1), Iorg. (Cs, Fl. II, Ny1), Palt. (Fl. II), Piule (Ny1) at 1700 - 1800 m (Cs (Pawl)), Scor. (Cs, Ny1), Stăn. (Cs, Ny1), ssp. *molle* (Vill.) Arcang.: Alb. (!), Câmp. (!), Iorg. (!), Piule (!), Stăn. (!), as ssp. *calcicola* (Schur) Borza: Alb. (Bs), Iorg. (Cs, Bs), Stăn. (Bs), as f. *turfosum* Nyár. and Prod.: Stăn. (Fl. II); *C. cerastoides* (L.) Britton: Drăg. (!); *C. fontanum* Baumg. ssp. *fontanum*: Buta (!), Drăg. (!), Iorg. (Cs), Piule (!), Scor. (!), ssp. *vulgare* (Hartm.) Greuter and Burdet: Alb. (!), as *C. caespitosum* Gilib. f. *alpinum* (Koch) Prod.: Iorg. (Cs); *C. transsilvanicum* Schur: Alb. (Sn), Iorg. (Cs, Ny1), Piule (!) at 1700 - 1800 m (Cs (Pawl)), as var. *lanatiforme* Borza: Piule (Cs), var. *acutifolium* (Schur) Borza: Iorg. (Sn), Piule (Cs (Pawl.), Sn), f. *nyárádyanum* Borza: Iorg. (Sn), f. *lanatiforme* Borza: Iorg. (Sn), Piule (Sn), var. *petrosum* (Schur) Borza: Piule (Cs (Pawl.)); *Dianthus carthusianorum* L.: Alb. (Cs), Buta (!), Iorg. (Cs, !), Piule (Cs, !); *D. petraeus* Waldst. and Kit. s. l.: Alb. (Bs), Iorg. (Bs), Palt. (Bs1), Piule (Bs), ssp. *petraeus* as *D. kitaibelii* Janka: Alb. (Ny1), Iorg. (Cs, Ny1), Piule (Ny1), Scor. (Ny1), Stăn. (Cs (Jav.1 as *D. petraeus*), Ny1), var. *hunyadensis* Jáv.: Alb. (Cs), Iorg. (Cs (Jav.2)), Piule (Cs (Pawl. as *D. petraeus* var. *hunyadensis* at 1830 m)), Stăn. (Cs); *D. spiculifolius* Schur: Alb. (Pr), Câmp. (!), Iorg. (Ny1, !), Piule (!), Stăn. (Ny1); *D. tenuifolius* Schur: Drăg. (Fl. II); *Gypsophila petraea* (Baumg.) Rchb.: Alb. (Cs, Ny1), Iorg. (Cs, Ny1, Bs, Sn), Palt. (Sn), Piule (Ny1) at 1830 m (Cs (Pawl), Scor. (Cs); *Lychnis flos-cuculi* L.: Buta (!); *Minuartia sedoides* (L.) Hiern.: Piule (!); *M. setacea* (Thuill.) Hayek ssp. *banatica* (Rchb.) Nyár.: Iorg. (Bs), Palt. (Bs1), Soar. (Bs1); *M. verna* (L.) Hiern.: Alb. (Cs, Ny1, !), Câmp. (!), Iorg. (Cs, !), Piule (Cs, Ny1, Bs, !), Scor. (Cs, Ny1), Stăn. (Cs, Ny1), as var. *ramosissima* (Willd.) A. and G.: Alb. (Cs), f. *leptophylla* (Rchb.) A. and G.: Alb. (Cs), var. *montana* (Fenzl.) A. and G.: Piule (Cs), as *Minuartia caespitosa* (Ehrh.) Degen: Alb. (Pr, Ny1), Piule (Ny1), Scor. (Ny1), Stăn. (Ny1); *Moehringia muscosa* L.: Alb. (!), Buta (!), Câmp. (!), Piule (Cs); *M. trinervia* (L.) Clairv.: Buta (!), Câmp. (!), Iorg. (!), Piule (Cs), Scor. G. (!); *Myosoton aquaticum* (L.) Moench: Buta (!); *Sagina procumbens* L.: Buta (Cs), Piule (Cs); *Saponaria pumilio* (L.) Fenzl ex A. Braun: Palt. (Sn); *Scleranthus uncinatus* Schur: Buta (Fl. II); *Stellaria graminea* L.: Buta (!); *S. media* (L.) Vill.: Câmp. (!); *S. nemorum* L.: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Palt. (Bs1), Piule (!), Scor. (!), Soar. (!), Stăn. (!); *Silene dioica* (L.) Clairv.: Buta (!); *S. italica* (L.) Pers. ssp. *nemoralis* (Waldst. and Kit.) Nyman as *S. nemoralis* Waldst. and Kit.: Palt. (Bs1); *S. latifolia* Poir. ssp. *alba* (Mill.) Greuter and Burdet: Buta (!); *S. lerchenfeldiana* Baumg.: Buta (Cs), Piule (Cs); *S. nutans* L. ssp. *nutans*: Câmp. (!), ssp. *dubia* (Herbich) Zapał.: Buta (!), Piule (!), as *S. dubia* Herb.: Alb. (Pr.), Buta (Cs), Palt. (Bs1), Stăn. (Bs); *S. pusilla* Waldst. and Kit. ssp. *pusilla*: Alb. (!), Buta (!), Iorg. (!), Palt. (Bs1), Piule (Bs, !), as *Heliosperma quadrifidum* (L.) Rchb: Palt., also specimens with quadrifids petals (Fl. II); *S. uniflora* Roth ssp. *prostrata* (Gaudin) Chater and Walters as *Behen alpinus* (Lam.) Guşul. var. *glareosus* (Jord.) Guşul.: Piule (Cs); *S. vulgaris* (Moench) Garcke: Buta (!), Palt. (Bs1); *Spergularia rubra* (L.) J. Presl. and C. Presl.: Buta (Cs), Stăn. (Cs);

Fam. Ranunculaceae Juss.

Aconitum anthora L.: Alb. (Cs), Iorg. (Cs), Piule (Cs), Scor. (Ny1); *A. moldavicum* Hacq. ssp. *moldavicum*: Buta (!), Palt. (Bs1), Piule (!), Stăn. (Fl. II), as var. *hacquetianum* G. Grinț.: Stăn. (Fl. II), as f. *australe* Rchb.: Buta (Cs), Piule (Cs), also as *A. hosteanum* Schur: Buta (Fl. II), Palt. (Fl. II), Piule (Cs); *A. napellus* L. ssp. *tauricum* (Wulf.) Gáyer: Alb. (!), Buta (!), Drăg. (!), Piule (Cs, !), Scor. (!), as *A. tauricum* Wulf. ssp. *taurericum* (Rchb.) Gáyer: Pleşa (Fl. II), ssp. *microstachyum* (Rchb.) Gáyer: Drăg. (Fl. II); *A. toxicum* Rchb. as ssp. *schurii* Beck.: Buta (Fl. II), f. *crispulum* (Nyár.) G. Grinț: Piule (Cs); *A. variegatum* L. ssp. *variegatum*: Piule (!); *A.* × *patentipilum* Gáyer (*hosteanum* ssp. *geraniifolium* × *lasianthum*): Palt. (Fl. II); *Actaea spicata* L.: Buta (!), Câmp. (!), Scor. G. (!); *Anemone narcissiflora* L. ssp. *narcissiflora*: Iorg. (Cs), Palt. (Ny1), Piule (Cs, Bs); *A. nemorosa* L.: Buta (!), Câmp. (!); *Caltha palustris* L.: Buta (!), Câmp. (!), Drăg. (!); *Clematis alpina* (L.) Mill.: Buta G. (!), Câmp. (!), Piule (!), Scor. G. (!), as *Atragene alpina* L.: Iorg. (Cs), Piule (Cs), Stăn. (Fl. II); *Delphinium elatum* L. ssp. *elatum*: Buta (!), Palt. (Bs1), Piule (!), as *D. intermedium* Soland. var. *alpinum* (Waldst. and Kit.) DC.: Buta (Cs), Buta G. (Cs), Piule (Cs (Pawl. as *D. elatum* var. *alpinum*) at 1700 m), var. *pubicaule* (Borbás) A. Nyár.: Piept at 900 m (Cs (Pawl. as *D. elatum* var. *pubicaule*)), Stăn. (Fl. II), as *D. alpinum* Waldst. and Kit.: Palt. (Ny1), Piule (Ny1); *Hepatica transsilvanica* Fuss: Buta G. (Cs), Palt. (Ny1), Scor. (Cs); *Isopyrum thalictroides* L.: Buta (!); *Pulsatilla alba* Rchb.: Drăg. (!); *P. vulgaris* Mill. ssp. *grandis* (Wender.) Zämelis: Alb. (Cs), Piule (Cs); *Ranunculus acris* L. ssp. *acris*: Buta (!), Câmp. (!); *R. crenatus* Waldst. and Kit.: Palt. (Ny1); *R. oreophilus* M. Bieb.: Alb. (Cs, Ny1, Bs, !), Iorg. (Cs, Ny1, Bs, !), Palt. (Bs1), Piule (Cs, Ny1, Bs), Scor. (Cs, Ny1), Soar. (Bs1), Stăn. (Cs, Ny1), as *R. hornschuchii* Hoppe: Alb. (Pr); *R. platanifolius* L.: Buta (Cs, !), Piule (Cs, !); *R. polyanthemos* L. ssp. *polyanthemoides* (Boreau) Ahlfv.: Buta (!), as *R. polyanthemos*: Buta (Cs); *R. pseudomontanus* Schur: Alb. (!), Buta (!), Drăg. (!), Iorg. (!), Piule (!), Stăn. (!), as *R. montanus* Willd.: Iorg. (Cs), Piule (Cs); *R. repens* L.: Buta (!), Câmp. (!), Iorg. (!), Scor. G. (!); *R. serpens* Schrank ssp. *nemorosus* (DC.) G. López: Buta (!), as *R. nemorosus* DC.: Palt. (Bs1), Piule (Cs); *Thalictrum aquilegifolium* L.: Buta (!), Câmp. (!), Piule (Cs, !), Scor. G. (!), as var. *pauciflorum* (Schur) A. Nyár.: Piule (Cs); *Th. minus* L.: Alb. (Cs), Buta G. (!), Palt. (Bs1), Piule (Cs, !), Scor. (Cs), as var. *saxatile* (DC.) Borza: Alb. (Cs), Piule (Cs), Scor. (Cs); *Trollius europaeus* L. ssp. *europaeus*: Alb. (Cs), Iorg. (Cs, !), Piule (Cs);

Fam. Papaveraceae Juss.

Corydalis solida (L.) Clairv. ssp. *solida*: Alb. (Cs), Iorg. (Bs); *Papaver alpinum* L. ssp. *corona-sancti-stephani* (Zapał.) Borza: Piule (!), as *P. corona-sancti-stephani* Zapał.: Iorg. (Bs), Piule (Bs), as *Papaver pyrenaicum* (L.) A. Kern. ssp. *corona-sancti-stephani* (Zapał.) Borza: Alb. (Cs), Iorg. (Cs (Jav.1 as *P. aurantiacum* Lois.) Ny1, Fl. III), Piule (Cs (Pawl. as *P. aurantiacum* Lois. ssp. *corona-sancti-stephani* (Zapał.) Borza at 1700 - 1800 m), Ny1, Fl. III), Palt. (Ny1), as var. *retezaticum* A. Nyár.: Iorg. (Cs, Fl. III), Piule (Cs), Pleşa (Fl. III);

Fam. Brassicaceae Burnett

Alyssum repens Baumg. ssp. *repens*: Alb. (Pr, Ny1, Bs, !), Buta (!), Iorg. (Ny1, Bs, !), Palt. (Ny1, Bs1), Piule (Ny1, Bs, !), Scor. (Ny1), Soar. (Bs1), Stăn. (Bs), as ssp. *eurepens* Baumg.: Dâlma (Fl. III), Iorg. (Fl. III), Stăn. (Fl. III), f. *orbiculare* Zapał.: Alb. (Cs), Piule (Cs), ssp. *transsilvanicum* (Schur) Baumg.: Drăg. (Fl. III); *Arabis allionii* DC. as *A. hirsuta* ssp. *glabra* (L.) Thell.: Alb. (Cs), Piule (Cs); *A. alpina* L.: Buta (!), Iorg. (Cs, Ny1, Bs, !), Palt. (Ny1, Bs1), Piule (Cs, Bs, !); *A. hirsuta* (L.) Scop.: Alb. (Cs), Iorg. (Cs), Stăn. (Cs); *A. hornungiana* Schur as *A. hirsuta* ssp. *hornungiana* (Schur) Simonk.: Alb. (Cs), Stăn. (Cs);

Aurinia petraea (Ard.) Schur as *Alyssum petraeum* Ard.: Pleşa (Fl. III), Scor. G. (Fl. III); *Barbarea lepuznica* Nyár.: Buta (Ng1, !); *Biscutella laevigata* L.: Alb. (Pr, Cs, Ny1, Bs), Câmp. (!), Iorg. (Cs, Ny1, !), Palt. (Ny1), Piule (Cs, Ny1, Bs, !), Scor. (Cs), Stăn. (Bs), as var. *vulgaris* Gaud.: Iorg. (Cs), Piule (Cs), f. *dentata* Gr. and Gord.: Piule (Cs); *Capsella bursa-pastoris* (L.) Medik.: Alb. (!), Buta (!), Câmp. (!), Iorg. (!), as var. *integrifolia* DC.: Alb. (Cs); *Cardamine amara* L. ssp. *amara*: Buta (!), Drăg. (!), Palt. (Fl. III); *C. bulbifera* (L.) Crantz: Buta (!), Câmp. (!), Scor. G. (!); *C. glanduligera* O. Schwarz: Buta (!), Câmp. (!), Piule (!), Scor. G. (!); *C. impatiens* L.: Buta (!), Câmp. (!); *C. resedifolia* L.: Buta (Cs); *Cardaminopsis arenosa* (L.) Hayek s.l.: Alb. (Pr), Iorg. (Cs), Palt. (Bs1), Piule (Cs), ssp. *arenosa*: Buta (!), Iorg. (!), Piule (!), ssp. *borbasii* (Zapał.) Pawl. as var. *dependens* Borbás: Iorg. (Cs), var. *perturbata* Nyár.: Piule (Cs); *C. halleri* (L.) Hayek ssp. *ovirensis* (Wulfen) Hegi and Em. Schmid: Iorg. (!), Piule (Cs, !), Scor. (Cs); *C. neglecta* (Schult.) Hayek: Piule (!), Iorg. (!); *Draba lasiocarpa* Rochel: Alb. (Bs, !), Iorg. (Fl. III), Palt. (Bs1), Piule (Cs, Bs, !), Scor. G. (Fl. III), Soar. (Bs1), Stăn. (Bs), as ssp. *rocheliana* (Stur) Nyár var. *glabrata* Schott: Alb. (Cs), Iorg. (Cs), Piule (Cs), Scor. (Cs), ssp. *elongata* (Host.) Jáv.: Alb. (Cs, Ny1), Iorg. (Cs, Ny1), Piule (Cs (Pawl. as *D. elongata* Host at 2000 - 2080 m), Ny1, Fl. III), Scor. (Cs, Ny1), Stăn. (Cs, Ny1); *Erysimum comatum* Pančič as *E. saxosum* Nyár.: Iorg. (Ny1, Cs) at 1950 m (Fl. III), Scor. (Cs (Jav1 as *E. silvestre* (Dr.) Kern.)), Scor. G. at 1400 m (Fl. III), Stăn. (Cs); *E. odoratum* Ehrh. as *E. pannonicum* Crantz var. *speciosum* Nyár.: Iorg. (Cs), Piule (Cs), Stăn. (Cs); *E. witmannii* Zaw. ssp. *transsilvanicum* (Schur) P. W. Ball as *E. transsilvanicum* Schur: Câmp. (!), Iorg. (Ny1, !), Pleşa (Ny1) at 1500 m (Fl. III), Scor. (Ny1), f. *luxurians* Nyár.: Iorg. (Cs), Scor. (Cs); *Hesperis matronalis* L. ssp. *cladotrichia* (Borbás) Hayek as *H. obtusa* Moench: Alb. (Cs), Iorg. (Cs); *Hutchinsia alpina* (L.) R. Br. ssp. *brevicaulis* (Hoppe) Arcang.: Piule (Cs (Pawl. as *H. alpina* (L.) R. Br. ssp. *brevicaulis* (Hoppe) Br. - Bl.), Ny1, Fl. III, Bs, !), var. *transsilvanica* Nyár.: Piule (Cs); *Kernera saxatilis* (L.) Rchb.: Alb. (Pr, Cs, Ny1), Iorg. (Cs, Cs (Jav.1), Ny1, Fl. III, Bs), Piule (Cs, Ny1, !), Scor. (Cs, Ny1), Stăn. (Fl. III); *Lunaria rediviva* L.: Buta (!), Câmp. (!); *Rorippa pyrenaica* (Lam.) Rchb.: Buta (!); *Thlaspi dacicum* Heuff.: Alb. (Cs), Palt. (Bs1), Piule (Cs (Pawl. at 1970 m), !), Scor. (Cs);

Fam. Crassulaceae DC.

Jovibarba heuffelii (Schott) Á. Löve and D. Löve as *Sempervivum heuffelii* Schott: Buta (Cs), Piule (Cs); *Sedum acre* L.: Buta (!); *S. album* L.: Palt. (Bs1); *S. alpestre* Vill.: Câmp. (!), Iorg. (Cs, !), Piule (Cs, !), Scor. (Cs), Stăn. (Cs); *S. annuum* L.: Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Piule (Cs), Scor. G. (!); *S. atratum* L.: Alb. (!), Iorg. (Cs, Bs, !), Palt. (Bs1), Piule (Cs, Bs, !), Soar. (Bs1), Stăn. (Bs); *S. hispanicum* L.: Buta G. (!), Câmp. (!), Iorg. (!), Scor. G. (!), as var. *glanduloso-pubescens* Feicht.: Alb. (Cs); *S. maximum* (L.) Hoffm.: Buta G. (!); *S. telephium* L. ssp. *fabaria* (W. D. J. Koch) Kirschl. as *S. fabaria* Koch: Piule (Cs), var. *carpaticum* (Reuss.) Domin: Piule (Cs); *Sempervivum marmoreum* Griseb. as *S. schlehani* Schott: Piule (Cs);

Fam. Saxifragaceae Juss.

Chrysosplenium alternifolium L.: Buta (!), Drăg. (!), Piule (!); *Saxifraga adscendens* L. ssp. *adscendens*: Alb. (Pr, Cs, Ny1, Bs, !), Câmp. (!), Iorg. (Cs, Ny1, Fl. IV, !), Palt. (Bs1), Piule (Cs, Bs, !), Scor. (Cs, Ny1), Soar. (Bs1), Stăn. (Cs, Ny1, Bs), as f. *integrifolia* (Gaud.) Engl. and Irmsch.: Piule (Cs), f. *ramosissima* (Schur) Simonk.: Alb. (Cs), Iorg. (Cs); *S. aizoides* L.: Alb. (!), Iorg. (Cs, Bs, !), Palt. (Ny1, Bs1), Piule (Cs, Ny1, Bs, !), Scor. (Cs, Ny1), Stăn. (Cs, Ny1), f. *autumnalis* (L.) Răv.: Iorg. (Fl. IV), Piule (Cs); *S. androsacea* L.: Alb. (!), Iorg. (Cs, Ny1, Fl. IV, !), Piule (Cs, !), Stăn. (Cs, Ny1), as f. *longifolia* (Gaud.) Răv.: Piule (Cs); *S. bryoides* L.: Palt. (Fl. IV); *S. corymbosa* Boiss.: Piule (!), as *S. luteo-viridis* Schott and

Kotschy: Piule (Cs); *S. exarta* Vill. ssp. *moschata* (Wulfen) Cavill.: Alb. (!), Iorg. (!), Piule (!), as *S. moschata* Wulfen: Alb. (Cs, Bs), Iorg. (Cs, Ny1, Fl. IV, Bs), Palt. (Bs1), Piule (Cs), Soar. (Bs1), Stăn. (Bs); *S. marginata* Sternb.: Piule (!), as *S. marginata* ssp. *rocheliana* (Sternb.) Sternb.: Iorg. (Bs), Piule (Bs), as *S. rocheliana* Sternb.: Alb. (Pr, Cs, Ny1), Iorg. (Cs, Ny1), Palt. (Bs1), Piule (Cs (Pawl. at 1730 - 1900 m), Ny1, Fl. IV), Scor. (Cs, Ny1), Stăn. (Cs, Ny1), f. *coryophylla* (Griseb.) Răv.: Piule (Cs), f. *rubescens* (Rohlena) Răv.: Piule (Cs); *S. paniculata* Mill.: Alb. (!), Buta G. (!), Câmp. (!), Iorg. (Bs, !), Palt. (Bs1), Piule (Bs, !), Scor. G. (!), Soar. (Bs1), Stăn. (Bs), as *S. aizoon* Jacq.: Alb. (Pr, Cs), Iorg. (Cs), Piule (Cs), Scor. (Cs), Stăn. (Cs), var. *montana* Engl. and Irmsch. f. *recta* (Lap.) Ser.: Iorg. (Cs), f. *brevifolia* (Engl.) Răv.: Piule (Cs); *S. pedemontana* All. *ssp. cymosa* Engl. as *S. cymosa* Walst. and Kit.: Iorg. (Cs), although according to Ciocârlan (2000) it is a calcifugal species; *S. rotundifolia* L. ssp. *rotundifolia*: Alb. (!), Buta (Cs, !), Câmp. (!), Dâlma (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (Cs, !), Scor. G. (!), as *S. heucherifolia* Griseb and Schenk: Alb. (Cs), Iorg. (Cs), Palt. (Bs1), Piule (Cs); *S. stellaris* L. ssp. *alpigena* Schönb. - Tem.: Buta (!), Piule (!), as *S. stellaris*: Iorg. (Cs), Palt. (Bs1), Piule (Cs); *S. tridactylites* L.: Piule (Cs);

Fam. Parnassiaceae S. F. Gray

Parnassia palustris L.: Alb. (Cs, !), Buta (!), Iorg. (Cs, !), Palt. (Bs1), Piule (Cs, !), Scor. (Cs), Stăn. (Cs, !);

Fam. Rosaceae Juss.

Alchemilla flabellata Buser: Palt. (Ny1) as *A. hibrida* (L.) L. ssp. *flabellata* (Buser) Palitz: Palt. (Fl. IV); *A. glabra* Neygenf.: Alb. (!), Câmp. (!), Piule (!), as *A. vulgaris* L. ssp. *alpestris* (Schmidt) Camus: Piule (Cs), as *A. alpestris* Schmidt: Palt. (Bs1); *A. glaucescens* Wallr. as *A. hybrida* (L.) Mill.: Alb. (Cs), Iorg. (Cs), Palt. (Fl. IV); *A. pyrenaica* Dufour as *A. glaberrima* Schmidt: Palt. (Fl. IV, Bs1), Piule (Cs), ssp. *glabra* Gams: Piule (Cs), ssp. *incisa* (Buser) Briq.: Alb. (Cs), Iorg. (Cs, Bs), Piule (Cs); *A. xanthochlora* Rothm. as *A. vulgaris* L. ssp. *pratensis* (Schmidt) Camus: Piule (Cs), Scor. (Cs); *A. vulgaris* L. agg.: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Piule (!), Stăn. (!); *Aremonia agrimonoides* (L.) D.C.: Câmp. (!), Dâlma (!), Scor. G. (!), Soar. (!); *Cotoneaster integerrimus* Medik.: Piule (Cs); *C. nebrodensis* (Guss.) K. Koch as *C. tomentosa* (Aiton) Lindl.: Piule (Cs); *Crataegus monogyna* Jacq.: Buta G. (!), Câmp. (!); *Dryas octopetala* L.: Alb. (Pr, Cs, Bs), Iorg. (Cs, Fl. IV, !), Palt. (Bs1), Piule (Cs, !), Scor. (Cs), Stăn. (Cs); *Filipendula ulmaria* (L.) Maxim. ssp. *ulmaria*: Câmp. (!), Scor. G. (!); *Fragaria vesca* L.: Alb. (!), Buta (!), Câmp. (!), Dâlma (!), Iorg. (!), Palt. (Bs1), Piule (!), Scor. G. (!); *Geum montanum* L.: Alb. (!), Buta (!), Drăg. (!), Iorg. (Cs, !), Palt. (Bs1), Piule (Cs, !), Scor. (!), Stăn. (!); *G. rivale* L.: Alb. (Cs, !), Buta (Cs, !), Câmp. (!), Iorg. (Cs), Palt. (Bs1), Piule (Cs, !); *G. urbanum* L.: Buta (!), Câmp. (!); *Potentilla anserina* L.: Alb. (!); *P. argentea* L.: Buta G. (!); *P. aurea* L. ssp. *chrysocraspeda* (Lehm.) Nyman: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Piule (!), Scor. (!), Stăn. (!), as *P. ternata* K. Koch: Drăg. (Cs), Iorg. (Cs), Palt. (Fl. IV, Bs1), Piule (Cs); *P. crantzii* (Crantz) Beck ex Fritsch: Iorg. (Cs), Piule (Bs); *P. erecta* (L.) Räusch.: Buta (!); *P. recta* L. ssp. *recta*: Buta G. (!); *P. thuringiaca* Bernh. ex Link: Alb. (Ny1), Buta (!), Iorg. (!), Piule (Ny1), as var. *hunyadensis* Jáv.: Alb. (Cs), Piule (Cs (Pawl. as *P. thuringiaca*) at 1930 m)), Scor. (Cs); *Rosa canina* L. s. str.: Buta (!); *R. pendulina* L.: Buta (!), Câmp. (!), Iorg. (Cs), Piule (Cs, !), as var. *setosa* (Ser.) R. Kell.: Piule (Cs), f. *alpina* (L.) H. Br.: Buta (Cs); *Rubus hirtus* Waldst. and Kit.: Buta (!), Câmp. (!); *R. idaeus* L.: Buta (!), Câmp. (!), Iorg. (!), Palt. (Bs1), Piule (!), Scor. G. (!); *R. saxatilis* L.: Piule (Cs), Scor. (Cs); *Sorbus aucuparia* L. ssp. *aucuparia*: Alb. (!), Buta (!), Câmp. (!), Dâlma (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (!), Scor. G. (!); *S. austriaca* (Beck) Hedl. ssp. *austriaca*

as *S. mougeotii* Soy.-Willem. and Godr. var. *austriaca* Beck: Piule (Cs); *S. chamaemespilus* (L.) Crantz: Piule (Cs); *S. graeca* (Spach) Kotschy as *S. cretica* (Lindl.) Fr. var. *hungarica* (Bornm.) Soó: Piule (Cs); *Spiraea chamaedrifolia* L.: Buta (!), Câmp. (!), Piule (!), as *S. ulmifolia* Scop.: Palt. (Bs1), Piule (Cs);

Fam. Fabaceae Lindl.

Anthyllis vulneraria L. ssp. *alpestris* (Hegetschw.) Asch. and Graebn.: Alb. (Cs, Ny1), Câmp. (!), Iorg. (Cs, !), Piule (Cs, !), Scor. (Cs), as *A. alpestris* Hegetschw.: Alb. (Pr, Ny1), Palt. (Bs1); *Astragalus alpinus* L.: Iorg. (!); *A. glycyphyllos* L.: Buta G. (!); *Chamaecytisus ciliatus* (Wahlenb.) Rothm. ssp. *ciliatus*: Buta (!), Câmp. (!), Iorg. (!); *Chamaespartium sagittale* (L.) P. E. Gibbs: Buta (!); *Genista tinctoria* L. ssp. *oligosperma* (Andrae) Borza: Buta (!), Iorg. (!), Piule (!), as *G. oligosperma* (Andrae) Simonk.: Buta (Cs), Iorg. (Cs), Piule (Cs); *Hedysarum hedysaroides* (L.) Schinz and Thell.: Iorg. (Cs (Jav1 as *H. obscurum* L. at 1900 m), Ny1, Fl. V), Piule (Cs, Ny1), Scor. (Cs, Ny1) at 1800 m (Pcs), Stăn. (Cs, Ny1); *Hippocrepis comosa* L.: Drăg. at 1680 m (Rs), Iorg. (!); *Lathyrus pratensis* L.: Buta G. (!), Câmp. (!); *Lotus corniculatus* L.: Alb. (!), Buta (!), Câmp. (!), Iorg. (!), Palt. (Bs1), Piule (!), Stăn. (Bs), as var. *alpestris* Lamotte: Piule (Cs), Stăn. (Cs); *Medicago lupulina* L.: Buta (!); *Onobrychis montana* DC. as *O. transsilvanica* Simonk.: Alb. (Pr, Cs, Ny1), Iorg. (Cs (Jav1), Fl. V, Ny1), Piule (Cs (Pawl. as *O. montana* Lam. and DC. at 1990 m), Fl. V, Ny1), Scor. (Cs, Ny1); *Oxytropis carpatica* R. Uechtr.: Alb. at 1800 - 1900 m (Pr); *O. halleri* Bunge ex W. D. J. Koch: Piule (!); *O. pyrenaica* Godr. and Gren.: Iorg. (!), Piule (!), as *O. neglecta* Ten.: Piule (Cs (Pawl.)), Scor. (Cs), as *O. montana* (L.) DC. ssp. *retezatensis* Pawl.: Alb. (Cs, Ny1, Bs), Iorg. (Cs (Jav1 as *O. carpatica* Jáv non Uechtr.), Fl. V, Ny1), Piule (Cs (Pawl. at 1830 m), Fl. V, Ny1), Scor. (Cs, Ny1), Stăn. (Ny1); *Trifolium alpestre* L.: Iorg. (!), Piule (Cs); *T. badium* Schreb.: Alb. (Cs, !), Iorg. (Cs, !), Piule (Cs, !), Scor. (Cs); *T. medium* L. s.l.: Buta (!), Câmp. (!), Scor. (Cs); *T. montanum* L.: Buta (!); *T. pallescens* Schreb.: Alb. (Bs), Iorg. (Bs), Stăn. (Bs), although according to Ciocârlan (2000) it is a calcifugal species; *T. pratense* L. ssp. *pratense*: Buta (!), Câmp. (!), Iorg. (!), Piule (!), ssp. *nivale* (Koch) Cesati as ssp. *frigidum* (Gaudin) Simonk. var. *frigidiforme* A. Nyár. f. *aberrans* Nyár.: Alb. (Cs), Palt. (Fl. V), Piule (Cs); *T. repens* L. ssp. *repens*: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Piule (!), Scor. (!), Stăn. (!), as var. *obcordatum* Nyár.: Iorg. (Cs), Piule (Cs), Scor. (Cs); *Vicia sepium* L.: Buta (!), Câmp. (!), Dâlma (!);

Fam. Oxalidaceae R. Br.

Oxalis acetosella L.: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (!), Scor. (!), Soar. (!), Stăn. (!);

Fam. Geraniaceae Juss.

Geranium phaeum L.: Buta (Cs, !), Câmp. (!), Scor. G. (!); *G. robertianum* L.: Buta (!), Câmp. (!), Dâlma (!), Palt. (Bs1), Scor. G. (!), Soar. (!); *G. sylvaticum* L. ssp. *sylvaticum*: Buta (!), Iorg. (!), Piule (!), as var. *alpestre* Schur: Alb. (Cs), Drăg. (Cs), Iorg. (Cs), Piule (Cs), Stăn (Cs), as *G. alpestre* Schur: Palt. (Bs1);

Fam. Linaceae S. F. Gray

Linum catharticum L.: Iorg. (!); *Linum uninerve* (Rochel) Jáv.: Piule (Cs), Alb. (Cs, !), Stăn. (Cs, !), as f. *croceum* Jáv.: Stăn. (Cs);

Fam. Euphorbiaceae Juss.

Euphorbia amygdaloides L.: Buta (!), Câmp. (!), Dâlma (!), Iorg. (!), Piule (Cs, !), Scor. G. (!), Soar. (!); *E. carniolica* Jacq.: Buta (!); *E. cyparissias* L.: Alb. (Cs), Buta (!), Iorg. (!), Piule (Cs), Scor. (Cs); *Mercurialis perennis* L.: Buta (!), Câmp. (!);

Fam. Polygalaceae Juss.

Polygala alpestris Rchb.: Alb. (Cs), Iorg. (!), Scor. (Cs), Soar. (Bs1), Stăn. (Cs, Bs); *P. amara* L.: Alb. (Pr), *P. vulgaris* L.: Alb. (!), Buta (!), Câmp. (!), as var. *retezatensis* Pawl.: Alb. (Cs, Ny1), Iorg. (Cs, Ny1), Piule (Cs, Cs (Pawl. at 1990 m), Ny1, Fl. VI), Stăn. (Cs, Ny1);

Fam. Aceraceae Juss.

Acer platanoides L.: Câmp. (!); *Acer pseudoplatanus* L.: Buta (!) up to 1650 m (Fl. VI), Câmp. (!), Dâlma (!), Palt. up to 1570 m (Fl. VI), Piule (Cs, !), Scor. G. (!), Scor. up to 1520 m (Fl.VI), Soar. (!);

Fam. Balsaminaceae DC.

Impatiens noli-tangere L.: Buta (!), Câmp. (!), Scor. G. (!), Soar. (!);

Fam. Celastraceae R. Br.

Euonymus europaeus L.: Buta G. (!);

Fam. Thymelaeaceae Juss.

Daphne cneorum L.: Alb. (Pr, Cs, Ny1), Iorg. (Cs), Piule (Cs, Ny1); *D. mezereum* L.: Alb. (Cs), Buta (!), Câmp. (!), Iorg. (Cs, !), Piule (Cs, !), Scor. G. (!);

Fam. Guttiferae Juss.

Hypericum hirsutum L.: Buta G. (!); *H. maculatum* Crantz ssp. *maculatum*: Alb. (!), Buta (!), Câmp. (!), Iorg. (!), Palt. (Bs1), Piule (!), Scor. (!); *H. perforatum* L.: Buta (!), Câmp. (!), Scor. G. (!), as var. *angustifolium* DC.: Buta G. (Cs); *H. tetrapterum* Fr.: Palt. (Bs1);

Fam. Violaceae Batsch.

Viola alpina Jacq.: Iorg. (Cs, Ny1), Piule (Cs); *V. biflora* L.: Buta (!), Câmp. (!), Palt. (Bs1), Piule (!); *V. dacica* Borbás: Alb. (Cs), Buta (Cs, !), Piule (Cs, !); *V. declinata* Waldst. and Kit.: Alb. (!), Buta (!), Câmp. (!), Iorg. (!), Piule (!); *V. reichenbachiana* Jord. ex Boreau as *Viola sylvestris* Lam.: Palt. (Bs1), *V. tricolor* L. ssp. *tricolor*: Buta (!);

Fam. Cistaceae Juss.

Helianthemum canum (L.) Baumg.: Alb. (!), Iorg. (!), Piule (!); *H. nummularium* (L.) Mill. ssp. *nummularium*: Alb. (!), Buta (!), Iorg. (!), Piule (Cs, !), ssp. *tomentosum* (Scop.) Schinz and Thell. as *H. tomentosum* Scop.: Palt. (Bs1), as var. *tomentosum* (Scop.) Schinz and Thell. f. *scopolii* (Willk.) Janch.: Piule (Cs), ssp. *obscurum* (Čelak.) Holub as *H. hirsutum* (Thuill.) Mérat.: Alb. (Cs), Iorg. (Cs), Piule (Cs), Scor. (Cs), Stăn. (Cs) and as *H. ovatum* (Viv.) Dun.: Alb. (Ny1), Iorg. (Ny1), Piule (Ny1), Scor. (Ny1), Stăn. (Ny1); *H. oleandicum* (L.) DC. ssp. *alpestre* (Jacq.) Breistr.: Alb. (Bs, !), Iorg. (Bs, !), Palt. (Bs1), Piule (Bs, !), Stăn. (!), as *H. alpestre* (Jacq.) DC.: Alb. (Pr, Cs, Ny1), Iorg. (Cs (Jav1 at 1900 m), Ny1), Palt. (Ny1, Bs1), Piule (Cs), Scor. (Cs), Stăn. (Cs), f. *glabratum* Dun.: Piule (Cs), f. *hirtum* (Koch) Pascher: Alb. (Cs), ssp. *rupifragum* (A. Kern.) Breistr.: Alb. (!), Iorg. (!), Piule (!), Stăn. (!);

Fam. Onagraceae Juss.

Circaea alpina L.: Buta (!); *C. lutetiana* L.: Buta (Cs, !); *Epilobium alpestre* (Jacq.) Krock.: Piule (Cs, !); *E. alsinifolium* Vill.: Buta (!), Piule (Cs, !), as var. *villarsi* (Lévl.) Thell.: Palt. (Fl. V); *E. anagallidifolium* Lam.: Piule (!), as *E. alpinum* L.: Alb. (Fl. V); *E. angustifolium* L.: Alb. (!), Buta (!), Câmp. (!), as *Chamaenerion angustifolium* (L.) Scop.: Palt. (Bs1); *E. collinum* C. C. Gmel.: Buta (Fl. V), as var. *ramosissimum* (Hegetschw.) Morariu: Buta (Fl. V); *E. montanum* L.: Buta (!), Câmp. (!), Scor. G. (!); *E. nutans* F. W. Schmidt: Buta (!), Stăn. (Fl. V);

Fam. Apiaceae Lindl.

Aegopodium podagraria L.: Buta (!), Câmp. (!); *Angelica sylvestris* L.: Buta (!); *Anthriscus nemorosa* (M. Bieb.) Spreng.: Buta (!); *A. sylvestris* (L.) Hoffm.: Buta (!), Câmp. (!); *Athamanta turbith* (L.) Brot. ssp. *hungarica* (Borbás) Tutin as *A. hungarica* Borbás: Alb. (Cs), Iorg. (Cs), Palt. (Cs (Jav), Ny1), Piule (Cs), Scor. (Cs), Stăn. (Cs, Ny1, Fl. VI); *Bupleurum falcatum* L. ssp. *cernuum* (Ten.) Arcang.: Piule (!), as *B. diversifolium* Rochel: Alb. (Cs), Drăg. (Fl. VI), Iorg. (Cs), Piule (Cs); *Carum carvi* L.: Buta (!); *Chaerophyllum aromaticum* L.: Buta (!), Câmp. (!); *Ch. aureum* L.: Alb. (Cs), Buta (!), Iorg. (Cs, !), Piule (Cs, !), Scor. (Cs); *Ch. hirsutum* L.: Alb. (!), Buta (!), Câmp. (!), Iorg. (!), Piule (!), as *Ch. cicutaria* Vill.: Palt. (Bs1), var. *glabrum* (Lam.) Briq.: Palt. (Fl. VI); *Heracleum sphondylium* L. ssp. *sphondylium*: Iorg. (!), Piule (!), ssp. *transsilvanicum* (Schur) Brummitt: Alb. (!), Piule (!), as *Heracleum palmatum* Baumg.: Alb. (Cs), Buta (Cs (Pawl. at 1370 m), Fl. VI), Iorg. (Cs), Piule (Cs), Stăn. (Cs); *Laserpitium archangelica* Wulfen: Drăg. (Fl. VI), Piule (Cs); *L. krapfii* Crantz: Piule (Cs), Scor. (Cs), as *L. alpinum* Waldst. and Kit.: Palt. (Bs1), as var. *alpinum* (Waldst. and Kit.) Rchb.: Piule (Cs), Scor. (Cs), var. *marginatum* (Waldst. and Kit.) Todor: Palt. (Fl. VI); *L. latifolium* L.: Piule (Cs, !); *Ligusticum mutellina* (L.) Crantz: Alb. (!), Buta (!), Drăg. (!), Iorg. (!), Piule (Cs, !), Scor. (!); *Peucedanum austriacum* (Jacq.) W. D. J. Koch: Buta G. (!), as var. *montanum* (Schleich.) Borbás: Alb. (Cs), Scor. (Cs); *P. carvifolia* Vill.: Câmp. (!); *Pimpinella major* (L.) Hudson: Buta G. (!), Câmp. (!); *P. saxifraga* L. s. l.: Piule (Cs) - possible ssp. *alpestris* (Spreng.) Koch, ssp. *saxifraga*: Buta (!); *Sanicula europaea* L.: Buta (!), Câmp. (!), Soar. (!); *Seseli libanotis* (L.) W. D. J. Koch s. l.: Iorg. (Bs), as *Libanotis montana* Crantz: Piule (Cs), Scor. (Cs), var. *humilis* (Schur) Todor: Scor. (Cs), ssp. *libanotis*: Buta (!), Piule (!), as *Libanotis pyrenaica* (L.) Bourg.: Palt. (Bs1), ssp. *intermedium* (Rupr.) P. W. Ball. as *Libanotis montana* var. *sibirica* (L.) Patze: Alb. (Cs), Piule (Cs), Scor. (Cs); *Trinia glauca* (L.) Dumort. s. l.: Piule (Cs), Scor. (Cs), Stăn. (Cs) - possible ssp. *carniolica* (A. Kern. ex Janch.) H. Wolff;

Fam. Pyrolaceae Dumort.

Moneses uniflora (L.) A. Gray: Buta (!), Câmp. (!), Iorg. (!), as *Pyrola uniflora* L.: Buta (Cs), Iorg. (Cs, Fl. VII), Piule (Cs); *Orthilia secunda* (L.) House as *Pyrola secunda* L.: Piule (Cs);

Fam. Ericaceae Juss.

Bruckenthalia spiculifolia (Salisb.) Rchb.: Buta (Cs, !), Drăg. (Cs), Iorg. (Cs, !), Piule (!); *Loiseleuria procumbens* (L.) Desv.: Drăg. (Cs, !), Palt. (Bs1), Piule (Cs); *Rhododendron myrtifolium* Schott and Kotschy: Alb. (!), Buta (!), Drăg. (!), Iorg. (!), Piule (!), Scor. (!), as *Rh. kotschyi* Simonk.: Iorg. (Cs, Fl. VII), Palt. (Fl. VII, Bs1), Piule (Cs); *Vaccinium myrtillus* L.: Alb. (Cs, !), Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (Cs, !), Scor. (!); *V. uliginosum* L. ssp. *microphyllum* Lange: Drăg. (!), as *V. gaultherioides* Bigelow: Palt. (Bs1), as *V. uliginosum*: Iorg. (Fl. VII), Piule (Cs); *V. vitis-idaea* L.: Alb. (!), Buta (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (Cs, !), Scor. (!), Stăn. (!);

Fam. Primulaceae Vent.

Androsace arachnoidea Schott, Nyman and Kotschy*:* Iorg. (Ny1, Fl. VII), Alb. (Ny1), Piule (Ny1), Scor. (Ny1), as *A. villosa* L. ssp. *arachnoidea* (Schott, Nyman and Kotschy) Nyman: Alb. (Pr), as *A. villosa* var. *arachnoidea* (Schott, Nyman and Kotschy) Knuth: Alb. (Cs), Iorg. (Cs), Piule (Cs (Pawl. at 2080 m)), Scor. (Cs); *A. lactea* L.: Iorg. (Fl. VII, Bs), Palt. (Ny1, Bs1), Piule (Ny1), Scor. (Ny1), Stăn. (Ny1, Fl. VII), as f. *carpatica* Jáv.: Alb. (Cs), Iorg. (Cs), Piule (Cs), Scor. (Cs); *Lysimachia nummularia* L.: Buta (!); *L. vulgaris* L.: Buta (!); *Primula elatior* (L.) Hill: Iorg. (Cs), Palt. (Bs1), Piule (!); *P. minima* L.: Drăg. (!), Palt. (Bs1),

Piule (Cs, !), Scor. Peak (!); *P. veris* L.: Buta G. (!); *Soldanella hungarica* Simonk. ssp. *hungarica*: Buta (!), Drăg. (!), Iorg. (!), Piule (Cs, !), Scor. (!), ssp. *major* (Neilr.) Pawłowska.: Piule (!), as *S. major* (Neilr.) Vierh. f. *hungarica* (Simonk.) Jáv.: Palt. (Bs1), Piule (Cs); *S. montana* Willd.: Palt. (Bs1); *S. pusilla* Baumg.: Drăg. (!), Iorg. (!), Piule (Cs, !), as var. *biflora* Borbás f. *obliqua* Győrffy: Drăg. (Fl. VII);

Fam. Oleaceae Hoffmgg. and Link

Fraxinus excelsior L.: Buta (!), Câmp. (!); *Syringa vulgaris* L.: Buta G. (Cs, !), Iorg. (Cs), Piept (Cs (Pawl. at 900 - 950 m));

Fam. Gentianaceae Juss.

Gentiana acaulis L.: Drăg. (!); *G. asclepiadea* L.: Buta (!), Câmp. (!), Dâlma (!); *G. cruciata* L.: Buta G. (Cs); *G. lutea* L.: Alb. (Cs), Iorg. (Cs), Piule (Cs), Scor. (Cs), Stăn. (Cs); *G. nivalis* L.: Alb. (Cs, !), Iorg. (Cs, Ny1, Fl. VIII, !), Piule (Cs, !); *G. praecox* A. Kern. and Jos. Kern.: Alb. (!), Buta (!), Iorg. (!), Palt. (Bs1), Piule (Cs, !), Stăn. (!); *G. utriculosa* L.: Piule (Cs, !), Stăn. (Cs); *G. verna* L. ssp. *verna*: Buta (!), Iorg. (Cs), Piule (Cs, !), as f. *alata* (Griseb.) Ţopa: Piule (Cs); *Swertia punctata* Baumg.: Piule (Cs);

Fam. Rubiaceae Juss.

Asperula capitata Kit. ex Schult.: Alb. (Pr, Cs, Ny1, !), Iorg. (Cs, Ny1, Bs), Palt. (Bs1), Piule (Cs, Ny1, Bs, !), Scor. (Cs, Ny1), Stăn. (Cs, Ny1); *Cruciata glabra* (L.) Ehrend.: Buta (!), Soar. (Bs1); *C. laevipes* Opiz: Buta (!), Câmp. (!); *Galium album* Mill. ssp. *album*: Iorg. (Bs), as *G. erectum* Huds.: Palt. (Bs1), as *G. mollugo* L. ssp. *erectum* (Huds.) Briq.: Alb. (Cs), Iorg. (Cs), Piule (Cs); *G. anisophyllon* Vill.: Alb. (Pr, Cs, Ny1, Bs, !), Buta (!), Iorg. (Cs, Ny1, Bs, !), Palt. (Bs1), Piule (Cs, Ny1, Bs, !), Soar. (Bs1), Stăn. (Cs, Ny1, !), var. *tenue* Briq.: Stăn. (Fl. VIII); *G. aparine* L.: Buta (!); *G. lucidum* All.: Alb. (Cs), Iorg. (Cs, !), Palt. (Bs1), Piule (Cs, !), Soar. (Bs1); *G. odoratum* (L.) Scop.: Buta (!), Câmp. (!), Scor. G. (!), Soar. (!);

Fam. Boraginaceae Juss.

Echium vulgare L.: Buta (!); *Erytrichium nanum* (L.) Schrad. ex Gaudin: Alb. (Pr, Cs, Ny1), Iorg. (Cs, Ny1, Fl. VII), Palt. (Ny1), Piule (Cs, Ny1), ssp. *jankae* (Simonk.) Jáv.: Iorg. (Bs); *Myosotis alpestris* F. W. Schmidt: Alb. (Pr, Cs, Bs, !), Buta (!), Iorg. (Cs, Fl. VII, Bs, !), Piule (Cs, Bs, !), Soar. (Bs1), Scor. (Cs), Stăn. (Fl. VII, Bs); *M. scorpioides* L.: Buta (!), Câmp. (!); *M. stenophylla* Knaf: Iorg. (!), Piule (!); *M. sylvatica* Ehrh. ex Hoffm.: Iorg. (Cs); *Pulmonaria filarskyana* Jáv. as *P. rubra* Schott ssp. *filarskyana* (Jáv.) Domin: Buta (Cs) - the presence of this species in the area is doubtful, as in present it is considered as endemic to the NE Romanian Carpathians (Oprea, 2005); *P. officinalis* L.: Buta G. (!); *P. rubra* Schott: Buta (!), Câmp. (!); *Symphytum cordatum* Waldst. and Kit. ex Willd.: Buta (!), Câmp. (!), *S. tuberosum* L. ssp. *tuberosum*: Buta (!), Câmp. (!), Iorg. (Cs), Piule (Cs);

Fam. Lamiaceae Lindl.

Acinos alpinus (L.) Moench ssp. *alpinus*: Alb. (!), Iorg. (!), Piule (Cs (Pawl. as var. *hirsuta* Pant. at 1750 - 1990 m), !), as *Calamintha alpina* ssp. *baumgarteni* (Simonk.) Borza: Alb. (Bs), Drăg. (Fl. VIII), Iorg. (Bs), Palt. (Bs1), Piule (Bs), Soar. (Bs1), Stăn. (Bs), as *Satureja baumgarteni* Simonk: Iorg. (Ny1), ssp. *majoranifolius* (Mill.) P. W. Ball as ssp. *hungarica* (Simonk.) Hayek: Alb. (Cs), Piule (Cs), Scor. (Cs), as *Satureja hungarica* Simonk.: Alb. (Pr, Ny1), Piule (Ny1), Scor. (Ny1); *Ajuga genevensis* L.: Buta (!), Câmp. (!), Iorg. (!), Piule (!); *A. reptans* L.: Buta (!), Iorg. (!), Piule (Cs); *Clinopodium vulgare* L.: Buta G. (!), Câmp. (!); *Galeopsis ladanum* L.: Buta (!); *G. speciosa* Mill.: Buta (!), Palt. (Bs1); *Scutellaria alpina* L.: Piule (Cs, Ny1, !); *Glechoma hederacea* L.: Buta (!), Câmp. (!), Iorg. (!), Piule (!), Scor. G. (!), Soar. (!); *Lamiastrum galeobdolon* (L.) Ehrend. and Polatschek: Alb. (!), Buta (!),

Câmp. (!), Iorg. (!), Piule (!), Scor. G. (!), Soar. (!); *Lamium album* L.: Alb. (Cs); *L. garganicum* L. ssp. *laevigatum* Arcang.: Câmp. (!), Piule (Cs), as *L. inflatum* Heuff.: Pleşa (Ny1), as *L. bithynicum* Benth.: Iorg. (Cs), Piule (Cs); *L. maculatum* L. ssp. *maculatum*: Buta (!), Câmp. (!), Piule (Cs), Scor. G. (!), Soar. (!), ssp. *cupreum* (Schott, Nyman and Kotschy) Hadač: Buta (!), as var. *cupreum* (Schott) Kotschy: Piule (Cs); *Lycopus europaeus* L.: Buta G. (!); *Melittis melissophyllum* L. ssp. *melissophyllum* as var. *grandiflorum* (Smith) Grinţ.: Iorg. (Cs), Piule (Cs); *Mentha longifolia* (L.) Huds.: Buta (!), Câmp. (!); *Origanum vulgare* L. ssp. *vulgare*: Iorg. (!); *Prunella vulgaris* L.: Buta (!), Câmp. (!), Iorg. (!), Piule (!); *Salvia glutinosa* L.: Buta G. (!); *Scutellaria alpina* L. ssp. *alpina*: Piule (Cs, Ny1, Fl. VIII); *Stachys alpina* L.: Dâlma (!); *S. recta* L. ssp. *recta* as var. *glabra* Simonk.: Piule (Cs); *S. sylvatica* L.: Buta G. (!); *Thymus bihoriensis* Jalas: Alb. (!); *Th. comosus* Heuff. ex Griseb.: Buta G. (!), Soar. (Bs1), Stăn. (!), as var. *transsilvanicus* (Schur) Borbás: Piept (Cs (Pawl. at 900 m); *Th. glabrescens* Willd. ssp. *urumovii* (Velen.) Jalas: Buta (!); *Th. praecox* Opiz ssp. *polytrichus* (A. Kern. ex Borbás) Jalas: Buta (!), Iorg. (!), Piule (!), Scor. (!), Stăn. (!), as *Thymus balcanus* Borbás: Alb. (Pr, Cs), Iorg. (Cs), Palt. (Bs1), Piule (Cs, Ny1), Scor. (Cs, !), Soar. (Bs1), var. *kerneri* (Borbás) Guşul.: Piule (Cs (Pawl. as *Th. kerneri* Borbás et var. *serroricus* Ronn. at 1750 - 1850 m), as *Th. kerneri*: Piule (Ny1); *Th. pulcherrimus* Schur: Alb. (Bs, !), Iorg. (Bs, !), Palt. (Bs1), Piule (Cs, Bs, !), Stăn. (Bs, !); *Th. pulegioides* L.: Buta (!), Piule (!), as ssp. *montanus* (Benth.) Ronn.: Piule (Cs), as ssp. *subcitratus* (Schreb.) Guşul.: Buta (Cs (Pawl as *Th. pulegioides* var. *clandestinus* (Schur) Ronn. at 1360 m));

Fam. Scrophulariaceae Juss.

Bartsia alpina L.: Buta (!), Iorg. (Cs, Fl. VII, !), Piule (Cs, !), Soar. (Bs1), Scor. (Cs); *Digitalis grandiflora* Mill.: Alb. (Cs), Buta (!), Iorg. (Cs), Palt. (Bs1), Stăn. (Cs); *Euphrasia minima* Jacq. ex DC.: Drăg. (Cs, !), Iorg. (!), Palt. (Bs1), Piule (!); *E. rostkoviana* Hayne ssp. *rostkoviana*: Buta (!), as *E. officinalis* L. ssp. *pratensis* Schübler and Martens: Buta (Cs), ssp. *montana* (Jord.) Wettst. as var. *montana* (Jord.) Wettst.: Buta (Cs); *E. salisburgensis* Funck: Alb. (Pr, Cs, Ny1, !), Iorg. (Cs, Ny1, !), Palt. (Cs, Ny1, Bs1), Piule (Cs, Ny1, !), Scor. (Cs, Ny1, !), Soar. (Bs1), Stăn. (Cs, Ny1, Fl. VII); *E. stricta* J. P. Wolff ex J. F. Lehm. ssp. *stricta*: Alb. (!), Iorg. (!), Stăn. (!); *Lathraea squamaria* L.: Câmp. (!); *Melampyrum sylvaticum* L.: Buta (!), Palt. (Bs1), Piule (!), as ssp. *transsilvanicum* (Schur) Paucă and Nyár.: Drăg. (Cs), Iorg. (Cs), Piule (Cs), var. *carpaticum* (Schult.) Paucă and Nyár.: Palt. (Fl. VII); *Pedicularis baumgartenii* Simonk.: Alb. (Pr, Cs, Ny1), Iorg. (Cs), Piule (Cs (Pawl. at 1990 m), Ny1), Scor. (Cs, Ny1); *P. comosa* L. ssp. *comosa*: Iorg. (Cs), Palt. (Bs1); *P. exaltata* Besser: Piule (!); *P. hacquetii* Graf: Alb. (Cs), Iorg. (Cs), Piule (Cs), Scor. (Cs); *P. verticillata* L.: Alb. (!), Buta (!), Iorg. (Cs, !), Piule (Cs, !), Scor. (Cs, !), Stăn. (!); *Rhinanthus alecterolophus* (Scop.) Pollich as *Rh. gracilis* Schur var. *transsilvanicus* (Soó) Paucă and Nyár.: Stăn. (Fl. VII); *Rh. angustifolius* C. C. Gmel.: Buta (!), Câmp. (!), as *Rh. glaber* Lam.: Buta (Cs); *Rh. rumelicus* Velen.: Palt. (Ny1), Piule (Cs); *Scrophularia hetereophylla* Willd. ssp. *laciniata* (Waldst. and Kit.) Maire and Petitm. as *S. laciniata* Waldst. and Kit. ssp. *lasiocaulis* (Schur) Borza: Piule (Cs), as *S. lasiocaulis* Schur: Palt. (Ny1); *S. nodosa* L.: Buta (!), Câmp. (!), Palt. (Cs); *S. scopoli* Hoppe: Alb. (Cs), Buta (!), Câmp. (!), Palt. (Bs1), Piule (Cs); *S. vernalis* L.: Iorg. (Bs) - is not mentioned by more recent authors from the Carpathians (Ciocârlan, 2000; Oprea, 2005); *Tozzia alpina* L. ssp. *carpathica* (Woł.) Dostál as *T. alpina*: Piule (Cs); *Verbascum glabratum* Friv. ssp. *glabratum* as ssp. *euglabratum* Murb.: Pleşa (Fl. VII); *Veronica alpina* L.: Buta (Cs, !), Iorg. (Cs), Palt. (Bs1), Piule (Cs, !), Stăn. (Fl. VII), as f. *serratifolia* Roch.: Piule (Cs); *V. aphylla* L.: Alb. (!), Drăg. (Cs), Iorg. (Cs, Ny1, Fl. VII, Bs), Palt. (Bs1), Piule (Cs, Bs), Stăn. (Cs, Ny1, Fl. VII); *V. austriaca* L. ssp. *teucrium* (L.) D. A. Webb: Buta (!), Iorg. (!), Piule (!),

as *V. teucrium* L.: Iorg. (Cs), Piule (Cs), as *V. crinita* Kit.: Buta G. (Cs); *V. bachofenii* Heuff.: Buta G. (Cs, !); *V. baumgartenii* Roem. and Schult.: Piule (Cs); *V. beccabunga* L.: Câmp. (!); *V. bellidioides* L.: Iorg. (Cs); *V. chamaedrys* L. ssp. *chamaedrys*: Alb. (!), Buta (Cs, !), Câmp. (!), Iorg. (!), Piule (Cs, !), Scor. (Cs, !); *V. officinalis* L.: Buta (!), Câmp. (!), Piule (Cs, !); *V. serpyllifolia* L. ssp. *serpyllifolia*: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Piule (!), as f. *rotundifolia* (Schrank) Ghişa: Iorg. (Cs), Piule (Cs); *V. urticifolia* Jacq.: Buta (!), Buta G. (Cs, !), Câmp. (!), Dâlma (!), Iorg. (Cs, !), Piule (Cs, !), Scor. G. (!), as *V. latifolia* L.: Palt. (Bs1);

Fam. Orobanchaceae Vent.

Orobanche alba Stephan ex Willd.: Buta (Cs, !), Piule (Cs); *O. caryophyllacea* Sm.: Iorg. (Cs);

Fam. Lentibulariaceae Rich.

Pinguicula vulgaris L.: Piule (Cs);

Fam. Plantaginaceae Juss.

Plantago atrata Hoppe ssp. *carpatica* (Pilger) Soó: Drăg. (!), as *P. atrata*: Scor. (Cs); *P. gentianoides* Sibth. and Sm.: Buta (!), Drăg. (!), Piule (!); *P. lanceolata* L.: Buta (!), Câmp. (!); *P. major* L. ssp. *major*: Alb. (!), Buta (!), Câmp. (!), Piule (!); *P. media* L.: Buta (!), Câmp. (!), Scor. G. (!);

Fam. Caprifoliaceae Juss.

Sambucus nigra L.: Buta (!); *S. racemosa* L.: Buta (!), Câmp. (!), Piule (!); *Lonicera nigra* L.: Buta (!), Piule (Cs, !); *L. xylosteum* L.: Buta G. (!), Câmp. (!), Piule (!), Scor. G. (!);

Fam. Adoxaceae Trautv.

Adoxa moschatellina L.: Piule (Cs, !);

Fam. Valerianaceae Batsch.

Valeriana officinalis L. ssp. *officinalis*: Buta G. (!), Câmp. (!), Scor. G. (!), as var. *tenuifolia* Vahl.: Piule (Cs), ssp. *sambucifolia* (J. C. Mikan) Čelak as *V. sambucifolia* J. C. Mikan: Iorg. (Cs), Palt. (Bs1); *V. tripteris* L.: Buta (!), Câmp. (!), Iorg. (!), Palt. (Bs1), Piule (!), Scor. G. (!), as var. *heterophylla* Baumg.: Iorg. (Cs), Piule (Cs), Stăn. (Cs);

Fam. Dipsacaceae Juss.

Knautia arvensis (L.) Coult. ssp. *arvensis*: Piule (!), Iorg. (!), Stăn. (!); *K. dipsacifolia* Kreutzer ssp. *dipsacifolia*: Piule (Cs, !), ssp. *lancifolia* (Heuff.) Ehrend. as var. *lancifolia* Heuff.: Piule (Cs); *K. longifolia* (Waldst. and Kit.) W. D. J. Koch: Alb. (Cs), Dâlma (!), Iorg. (Cs, !), Piule (Cs, !), as var. *kochii* Brügg.: Piule (Cs (Pawl.)); *Scabiosa lucida* Vill. ssp. *barbata* Nyár.: Piule (!), as *S. lucida*: Alb. (Cs), Iorg. (Cs, Bs), Piule (Cs), Soar. (Bs1), Stăn. (Cs);

Fam. Campanulaceae Juss.

Campanula alpina Jacq.: Drăg. (Cs, Fl. IX, !), Iorg. (Cs, !), Palt. (Bs1), Piule (!); *C. cochleariifolia* Lam.: Alb. (!), Buta (Cs), Iorg. (Cs, Ny1, !), Piule (Cs, !), Scor. (Cs, Ny1), as ssp. *reflexa* (Schur) Hruby f. *reflexa* Morariu: Iorg. (Fl. IX); *C. glomerata* L. ssp. *glomerata*: Alb. (Cs), Iorg. (Cs), Piule (Cs), Soar. (Bs1); *C. kladniana* (Schur) Witašek: Iorg. (Bs), Palt. (Bs1), Piule (Cs), as var. *racemosa* Kraš.: Piule (Cs); *C. patula* L. ssp. *patula*: Buta (!), ssp. *abietina* (Griseb.) Simonk.: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Piule (!), Scor. (!), as *C. abietina* Griseb.: Buta (Cs), Palt. (Bs1), Scor. (Cs); *C. rapunculoides* L.: Buta G. (!); *C. rotundifolia* L. ssp. *rotundifolia*: Piule (Cs); *C. serrata* (Kit.) Hendrych: Alb. (!), Buta (!), Drăg. (!), Iorg. (!), Piule (!), Scor. (!), Stăn. (!), as *C. napuligera* Schur: Buta (Fl. IX), var. *arcuata* (Schur) Săvul. f. *transsilvanica* Săvul.: Palt. (Fl. IX), as *C. pseudolanceolata* auct. non Pant.: Drăg. (Cs), Piule (Cs); *C. transsilvanica* Schur ex Andrae: Drăg. (Cs); *Edraianthus*

graminifolius (L.) A. DC. ssp. *graminifolius*: Câmp. (!), Iorg. (!), Piule (!), as *E. graminifolius* ssp. *kitaibelii* (Waldst. and Kit.) A. DC.: Alb. (Pr, Cs), Iorg. (Cs), Palt. (Cs), Piule (Cs (Pawl. at 1700 - 2080 m)), Scor. (Cs), Stăn. (Cs), as *E. kitaibelii* (Waldst. and Kit.) A. DC.: Alb. (Bs, Ny1), Drăg. (Fl. IX), Iorg. (Ny1, Fl. IX, Bs), Palt. (Ny1, Bs1), Piule (Ny1, Fl. IX), Scor. (Fl. IX), Stăn. (Ny1); *Jasione laevis* Lam. ssp. *orbiculata* (Griseb. ex Velen.) Tutin as *J. orbiculata* Griseb. ex Velen.: Buta (Fl. IX (Pawl.)); *Phyteuma confusum* A. Kern.: Alb. (!), Drăg. (!), Iorg. (!), Piule (!), Scor. (!), as *Ph. nanum* Schur: Palt. (Bs1), Piule (Cs); *Ph. orbiculare* L. ssp. *orbiculare*: Alb. (Pr, Cs, Ny1, !), Iorg. (Cs also f. terrat. tetrafasc., Ny1, !), Piule (Cs, Ny1, !), Scor. (Cs, Ny1), Stăn. (Cs, Ny1); *Symphyandra wanneri* (Rochel) Heuff.: Drăg. (Fl. IX);

Fam. Asteraceae Dumort.

Achillea distans Waldst. and Kit. ex Willd. ssp. *distans*: Alb. (!), Buta (Cs, !), Câmp. (!), Dâlma (!), Scor. G. (!), as var. *pseudotanacetifolia* Wierzb.: Alb. (Cs), ssp. *stricta* (W. D. J. Koch) Schleich. ex Gremli: Buta (!), Iorg. (!); *A. lingulata* Waldst. and Kit.: Alb. (Cs), Piule (Cs), Scor. (Cs), Stăn. (Cs); *A. millefolium* L. ssp. *millefolium*: Buta (!), Câmp. (!), ssp. *sudetica* (Opiz) Oborny: Alb. (Cs); *Adenostyles alliariae* (Gouan) A. Kern. ssp. *alliariae*: Alb. (!), Buta (!), Drăg. (!), Piule (Cs, !), var. *kerneri* (Simonk.) G. Beck. as *A. kerneri* Simonk.: Palt. (Bs1); *Antennaria dioica* (L.) Gaertn.: Iorg. (Cs, !), Piule (!); *Arctium lappa* L.: Buta G. (!); *A. tomentosum* Mill.: Câmp. (!); *Artemisia vulgaris* L.: Buta G. (!); *Aster alpinus* L.: Alb. (Pr, Cs, Ny1, Fl. IX), Iorg. (Cs, Ny1, Bs), Piule (Cs), Scor. (Cs, Ny1); *Carduus kerneri* Simonk ssp. *kerneri*: Iorg. (Bs), Soar. (Bs1), Stăn. (Bs), ssp. *lobulatoformis* (Csűrös and Nyár.) Soó: Buta (!), as *C. lobulatiformis* Csűrös and Nyár.: Alb. (Cs, Fl. IX, Ny1), Piule (Cs, Fl. IX, Ny1), Stăn. (Ny2, Fl. IX, Ny1), f. *basiramosus* Csűrös and Nyár.: Piule (Ny2, Fl. IX), f. *procerus* Csűrös and Nyár.: Scor. (Ny2, Fl. IX); *C. personata* (L.) Jacq. ssp. *personata*: Buta (Cs, !), Piule (Cs, !); *C.* × *csűrösi* Nyár. (*kerneri* ssp. *kernei* × *kerneri* ssp. *lobulatiformis*): Alb. (Cs, Fl. IX), Piule (Ny2, Fl. IX); *Carlina acaulis* L. ssp. *acaulis*: Buta (!), Iorg. (!); *C. vulgaris* L ssp. *vulgaris*: Scor. (Cs); *Centaurea kotschyana* Heuff. ex W. D. J. Koch: Alb. (Cs), Iorg. (Cs), Piule (Cs), Scor. (Cs); *C. triumfetti* All. s. l.: Iorg. (Cs), Scor. (Cs), ssp. *aligera* (Gugler) Dostál as *C. axillaris* Willd.: Alb. (Cs), Iorg. (Cs), Piule (Cs), Scor. (Cs), f. *transsilvanica* Hay: Scor. (Cs); *C. uniflora* Turra ssp. *nervosa* as *C. nervosa* Willd.: Alb. (Cs), Drăg. (Cs), Buta (Cs); *Chrysanthemum alpinum* L.: Drăg. (Cs), as f. *cuneifolium* (Murr) Vierh.: Buta (Fl. IX); *Cicerbita alpina* (L.) Wallr.: Buta (!), Piule (Cs, !); *Cirsium arvense* (L.) Scop.: Buta (!), Câmp. (!); *C. erisithales* (Jacq.) Scop.: Buta (!), Câmp. (!), Dâlma (!), Iorg. (!), Palt. (Bs1), Piule (Cs, !), Scor. G. (!); *C. oleraceum* (L.) Scop.: Buta (!); *C. vulgare* (Savi) Ten.: Buta (!); *Crepis paludosa* (L.) Moench: Palt. (Bs1); *C. viscidula* Froel.: Palt. (Fl. X); *Doronicum austriacum* Jacq.: Alb. (!), Buta (!), Câmp. (!), Piule (!); *D. columnae* Ten.: Alb. (!), Buta G. (!), Câmp. (!), Iorg. (Cs, Bs, !), Palt. (Bs1), Piule (Cs, !), Scor. (!), Stăn. (Cs); *Erigeron acris* L.: Buta G. (!); *E. alpinus* L.: Alb. (Cs), Iorg. (Cs); *Hieracium alpinum* L.: Palt. (Bs1), Piule (Cs, !), Scor. (!), as var. *gymnogenum* Zahn: Piule (Cs); *H. atrellum* (Zahn) Üksip as *H.* × *atratum* var. *atrellum* (Zahn) Nyár. f. *atrellum*: Paltina (Fl. X); *H. aurantiacum* L. ssp. *carpathicola* Nägeli and Peter: Alb. (!), Buta (!), Iorg. (!), Piule (!), as *H. aurantiacum*: Iorg. (Cs), Piule (Cs), Scor. (Cs), ssp. *croceum* (Zahn) Nyár. var. *carpathicola* (Nägeli and Peter) Nyár.: Palt. (Fl. X), var. *subkajanense* (Zahn) Nyár.: Palt. (Fl. X), f. *longifolium* Nyár. and Zahn: Palt. (Fl. X); *H. banaticola* Sudre as *H.* × *oreophilum* Heuff. (*alpicola* < *cymosum*): Alb. (Fl. X), Piule (Fl. X), as *H. oreophilum* Heuff.: Alb. (Cs), Piule (Cs), as f. *albeleanum* Csűrös and Prod.: Alb. (Cs, Pr, Fl. X), Piule (Fl. X), Scor. (Fl. X); *H. bifidum* Kit. s. l.: Alb. (Pr, Cs, Fl. X), Iorg. (Cs), Palt. (Bs1), Piule (Cs), Stăn. (Cs), ssp. *bifidum*: Piule (!), as ssp. *bifidum* var. *biharicum* (Zahn) Nyár.: Alb. (Cs, Fl. X), Iorg. (Cs, Fl. X), Piule (Cs, Fl. X), Stăn. (Cs, Fl. X),

var. *saxigenum* (Wiesb.) Nyár.: Piule (Cs, Fl. X), Stăn. (Cs, Fl. X), var. *minutiflorum* Nyár. and Csűrös: Alb. (Cs, Fl. X); *H. bupleurifolioides* (Zahn) Üksip as *H. prenanthoides* Vill. var. *bupleurifolium* (Tausch) W. and Gr.: Scor. G. (Fl. X); *H. caesiiflorum* Almq. ex Norrl. as *H. bifidum* var. *caesiiflorum* (Almq.) Nyár. f. *alpigenum* Zahn: Palt. (Fl. X); *H. calvifolium* (Nägeli and Peter) Prain as *H. villosum* Jacq. var. *calvifolium* Nägeli and Peter: Iorg. (Cs (Jav.1)); *H. cymosum* L. s.l.: Buta (Fl. X), Piule (Fl. X), ssp. *cymosum*: Buta (Cs, !), Piule (Cs); *H. filarszkyi* Jáv. and Zahn as *H.* × *fritzeiforme* Zahn (*alpinum* > *prenanthoides* - *sparsum*): Drăg. (Fl. X); *H. glaucifrons* (Nägeli and Peter) Prain as *H. villosum* Jacq. var. *glaucifrons* Nägeli and Peter: Alb. (Cs), Piule (Cs); *H. laevigatum* Willd.: Alb. (!); *H. lonchopodum* (Zahn) Schljakov as *H. bifidum* var. *lonchopodum* (Zahn) Nyár.: Piule (Cs, Fl. X); *H. lubricicaule* (Nyár.) Borza: Alb. (Cs, Fl. X), Buta (Cs, Fl. X); *H. magocsyanum* Jáv.: Piule (Fl. X); *H. paltinae* Jáv. and Zahn: Buta (Fl. X), as var. *paltinae*: Palt. (Fl. X); *H. paxianum* Nyár. and Zahn as var. *paxianum*: Piule (Cs, Fl. X); *H. pietroszense* Degen and Zahn ssp. *pietroszense*: Piule (Cs, Fl. X), ssp. *spathophorum* Nyár. and Zahn as var. *spathophorum* (Nyár. and Zahn) Nyár.: Iorg. (Fl. X), Piule (Cs, Fl. X); *H. pilosella* L. ssp. *pilosella*: Buta (!), Câmp. (!), Iorg. (!); *H. pilosum* Froel. as *H. morisianum* Rchb. f.: Alb. (Cs), var. *villosiceps* (Nägeli and Peter) Nyár.: Alb., also f. *calvulum* Nägeli and Peter (Cs, Fl. X); *H. pisaturense* Nyár. as *H.* × *pisaturense* Nyár.: Buta (Cs, Fl. X), also var. *pisaturense* f. *valderamosum* Csür. and Nyár. between Buta and Piule (Cs, Fl. X); *H. pseudobifidum* Schur ssp. *pseudobifidum*: Piule (!), as *H.* × *pseudobifidum*: Alb. (Cs), Piule (Cs), ssp. *diversifloccum* (Degen and Zahn) Zahn as var. *diversifloccum* Degen and Zahn f. *transiens* Nyár. and Zahn: Palt. (Fl. X), ssp. *paucifidum* (Rohlena and Zahn) Zahn as var. *paucifidum* (Rohlena and Zahn) Nyár. f. *paucifidum* Nyár.: Palt. (Fl. X); *H. sericotrichum* (Nägeli and Peter) Prain as *H. morisianum* ssp. *serichotrichum* Nägeli and Peter f. *normale* Nägeli and Peter: Alb. (Cs), var. *sericotrichum* (Nägeli and Peter) Nyár.: Alb. (Fl. X), Scor. Peak at 1800 m in *Seslerietum* (Fl. X); *H. sinuosifrons* (Dahlst.) Dahlst. as *H. bifidum* var. *sinuosifrons* (Almq.) Nyár.: Piule (Cs, Fl. X); *H. sparsum* Friv. ssp. *borbasii* (R. Uechtr.) as *H. borbasii* R. Uechtr.: Drăg. (Fl. X), var. *zanogae* (Pax) Nyár. f. *nomophilum* Zahn: Palt. (Fl. X); *H. stenolepis* Lindeb. as *H. bifidum* var. *stenolepis* (Lindeb.) Nyár.: Drăg. (Fl. X); *H. tubulare* Nyár.*:* Buta (Cs); *H. villosissimum* Nägeli as *H. villosum* var. *villosissimum* Nägeli: Alb. (Cs), Iorg. (Cs), f. *villosissimum* Nyár.: Alb. (Fl. X), Iorg. (Fl. X); *H. villosum* Jacq.: Alb. (Pr, Cs, Fl. X, Ny1), Drăg. (Fl. X), Iorg. (Cs, Fl. X, Ny1), Palt. (Ny1, Bs1), Piule (Cs, !), Scor. (Cs, Ny1), Stăn. (Cs, Fl. X, Ny1), as var. *villosum*: Alb. (Cs), f. *elliptisquamum* (Nägeli and Peter) Nyár.: Stăn. (Fl. X), f. *involucratum* (Roch.) Nägeli and Peter: Iorg. (Fl. X); *H. vulgatum* Fr.: Iorg. (!), Piule (!), as *H. laevicaule* Jord.: Buta (Fl. X), Iorg. (Fl. X), Stăn. (Fl. X), as *H.* × *laevicaule* Jord. (*bifidum-lachenalii*): Iorg. (Cs); *H.* × *atratiforme* Simonk. (*sparsum* - *transsilvanicum*) as var. *basipellitum* Nyár. and Zahn: Palt. (Fl. X); *H.* × *chloribracteum* Degen and Zahn (*alpinum* - *transsilvanicum* - *murorum*) as var. *chloribracteum*: Palt. at 1700 m (Fl. X), also f. *megaladenophorum* (Nyár. and Zahn) Nyár.; *H.* × *floribundum* Wimm. and Grab. as *H.* × *longiscapum* Boiss. and Kotschy (*auricula* - *caespitosum*) var. *spathophyllum* (Nägeli and Peter) Nyár.: Palt. (Fl. X); *H.* × *fritzei* F. W. Schultz (*alpinum* > *prenanthoides*) as ssp. *fritzei*: Piule (Fl. X), var. *fritzei*: Drăg. (Fl. X), Piule (Fl. X); *H.* × *fuscum* Vill. (*aurantiacum* > *auricula*): Iorg. (Cs, Fl. X), Piule (Cs, Fl. X) - this hybrid is not recognized by Ciocârlan (2000) and Oprea (2005); *H.* × *krasanii* Woł. (*alpinum* < *transilvanicum*): Iorg. (Fl. X), as var. *krašanii*: Palt. (Fl. X); *H.* × *napaeum* Zahn (*alpinum* ≤ *bifidum* - *transsilvanicum*): Piule (Cs), as var. *napaeum*: Piule (Fl. X); *H.* × *nigrescens* Willd. (*alpinum* ≥ *murorum*) as var. *nigrescens*: Palt. (Fl. X), var. *gymnogeniforme* (Zahn) Nyár.:

Piule (Fl. X), as *H. nigrescens* Willd. var. *gymnogeniforme* Zahn: Piule (Cs), as *H.* × *atratum* Fr. (*alpinum* < *murorum*): Piule (Cs); *H.* × *rohacsense* Kit. ex Kanitz (*alpinum* < *bifidum*) ssp. *rohacsense*: Piule (Cs, Fl. X), as var. *rohacsense* f. *rătezaticum* (Nyár. and Zahn) Nyár.: Piule (Cs, Fl. X); *H.* × *stoloniflorum* Waldst. and Kit. (*aurantiacum* ≤ *pilosella*): Piule (Cs, Fl. X); *H.* × *sudeticum* Sternb. (*alpinum* - *prenanthoides*): Piule (Cs), as var. *jávorkae* (Zahn) Nyár.: Palt. (Fl. X); *Homogyne alpina* (L.) Cass.: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Iorg. (Cs, !), Piule (Cs, !), Scor. (!), Stăn. (!); *Hypochoeris maculata* L. as var. *carpatica* (Pax) Nyár. f. *ramosa* Deg.: Iorg. (Cs), Scor. (Cs); *H. uniflora* Vill.: Alb. (Cs), Palt. (Pcs), Piule (Cs), Scor. (Cs), as f. *crepidifolia* (Wimm.) Weiss: Palt. (Fl. X); *Jurinea glycacantha* (Sibth. and Sm.) DC. as *J. macrocalathia* K. Koch: Alb. (Cs), Stăn. (Cs); *Lapsana communis* L. ssp. *communis*: Buta (!), Câmp. (!); *Leontodon autumnalis* L. ssp. *autumnalis*: Buta (!), Iorg. (!), Piule (!), ssp. *pratensis* (W. D. J. Koch) Arcang.: Alb. (!), as var. *alpigenus* Schur: Iorg. (Cs, Fl. X), f. *runcinatus* (Kit.) Bricq.: Drăg. (Fl. X); *L. crispus* Vill. ssp. *crispus*: Scor. (Cs, Ny1); *L. croceus* Haenke ssp. *croceus*: Iorg. (Cs, !), Piule (Cs), ssp. *rilaensis* (Hayek) Finch and P. D. Sell: Alb. (!), Piule (!); *L. hispidus* L.: Alb. (Cs, !), Buta (Cs, !), Iorg. (!), Piule (Cs), as *L. asper* (Waldst. and Kit.) Poir.: Scor. (Ny1), var. *subciliatus* Csűrös and Nyár.: Scor. (Cs); *L. montanus* Lam. subsp. *pseudotaraxaci* (Schur) Finch and P. D. Sell: Iorg. (Ny1), Piule (Ny1), Stăn. (Ny1), as *L. pseudotaraxaci* Schur: Iorg. (Cs (Jav.1 as *L. medius* (Host.) Simk.), Fl. X), Piule (Cs (Pawl. at 1730 - 1800 m), Fl. X), Stăn. (Cs, Fl. X); *Leontopodium alpinum* Cass.: Alb. (Pr, Cs, Ny1, Fl. IX), Iorg. (Cs, Ny1, Bs, !), Piule (Cs, !), Scor. (Cs, Ny1), Stăn. (Cs, Fl. IX); *Leucanthemum rotundifolium* (Willd.) DC.: Buta (!), Piule (!), as *Chrysanthemum rotundifolium* Waldst. and Kit.: Palt. (Bs1), Piule (Cs); *L. vulgare* (Vaill.) Lam.: Buta (!), Iorg. (!), as *Chrysanthemum leucanthemum* L. ssp. *saxicola* (Koch) Briq.: Alb. (Cs); *Mycelis muralis* (L.) Dumort.: Buta (!), Câmp. (!), Soar. (!); *Omalotheca norvegica* (Gunnerus) Sch. Bip. and F. W. Schultz as *Gnaphalium norvegicum* Gunnerus: Buta (Cs), Piule (Cs); *O. supina* (L.) DC.: Piule (!), as *Gnaphalium supinum* L.: Alb. (Cs), Drăg. (Cs), Palt. (Bs1), Piule (Cs); *O. sylvatica* (L.) Sch. Bip. and F. W. Schultz: Buta (!), Iorg. (!), Piule (!), Scor. (!), as *Gnaphalium sylvaticum* L.: Buta (Cs), Scor. (Cs); *Petasites albus* (L.) Gaertn.: Buta (!), Câmp. (!); *Picris hieracioides* L. ssp. *villarsi* (Jord.) Nyman as *P. sonchoides* Vest: Iorg. (Cs, Fl. X), Piule (Cs, Fl. X), Scor. (Cs, Fl. X), var. *tatrae* (Borbás) Jáv.: Piept (Cs (Pawl. at 900 m), Scor. (Cs, Fl. X); *Prenanthes purpurea* L.: Buta (Cs, !), Câmp. (!), Piule (Cs, Fl. X, !); *Saussurea discolor* (Willd.) DC.: Piule (Cs); *Scorzonera purpurea* L. ssp. *rosea* (Waldst. and Kit.) Nyman: Câmp. (!), Drăg. (!), as *S. rosea* Waldst. and Kit.: Alb. (Cs, Fl. X), Piule (Cs, Fl. X); *Senecio jacobaea* L.: Alb. (!), Iorg. (!), Piule (!); *S. nemorensis* L.: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (!), Scor. G. (!); *S. papposus* (Rchb.) Less.: Piule (!), as var. *sulphureus* (Baumg.) Cuf.: Alb. (Cs), Piule (Cs); *S. squalidus* L. ssp. *rupestris* (Waldst. and Kit.) Greuter: Piule (!), as *S. rupestris* Waldst. and Kit.: Alb. (Cs), Palt. (Ny1, Bs1), Piule (Cs, Bs), Iorg. (Bs), Soar. (Bs1), Stăn. (Bs), var. *sinuato-dentatus* Evers: Palt. at 1800 m (Fl. IX); *S. subalpinus* W. D. J. Koch: Alb. (!), Buta (Cs, !), Iorg. (!), Palt. (Fl. IX, Bs1), Piule (Cs, !), as var. *lyratus* (Koch) Beck: Piule; *Solidago virgaurea* L. ssp. *virgaurea*: Buta G. (!), Piule (!), ssp. *minuta* (L.) Arcang. as *S. alpestris* Waldst. and Kit.: Piule (Cs); *Tanacetum corymbosum* (L.) Sch. Bip.: Buta (!), Câmp. (!), Iorg. (!), Piule (!), as *Chrysanthemum corymbosum* L: Piule (Cs), var. *subcorymbosum* Schur: Piule (Cs); *Taraxacum alpinum* Hegetschw.: Alb. (Bs, !), Buta (Cs, Fl. X, !), Drăg. (Cs), Iorg. (Cs, Fl. X, Bs), Piule, (Cs, Fl. X, Bs, !), Stăn. (Bs); *T. fontanum* Hand.-Mazz.: Buta (!); *T. nigricans* (Kit.) Rchb.: Iorg. (!), Piule (!); *T. officinale* Weber: Buta (!); *Telekia speciosa* (Schreb.) Baumg.: Buta (!), Câmp. (!); *Tripleurospermum inodorum* (L.) Sch. Bip. (syn. *Matricaria inodora* L.): Câmp. (!); *Tussilago farfara* L.: Buta (!), Câmp. (!), Piule (Cs), Soar. (!);

Fam. Liliaceae Juss.

Allium oleraceum L.: Alb. (Cs), Piule (Cs); *A. senescens* L. ssp. *montanum* (F. W. Schmidt) Holub as *A. montanum* F. W. Schmidt: Piule (Cs); *A. victorialis* L.: Piule (Cs); *Lilium carniolicum* Bernh. ex W. D. J. Koch ssp. *jankae* (A. Kern.) Hayek as *L. jankae* A. Kern.: Piule (Cs, Ny1, Fl. XI), Stăn. (Cs, Fl. XI); *L. martagon* L.: Alb. (Cs, Fl. XI), Buta (!), Piule (Cs, Fl. XI, !); *Ornithogalum collinum* Guss. as *O. gussonei* Ten: Piule (Cs); *Paris quadrifolia* L.: Buta (!), Câmp. (!), Iorg. (Cs), Palt. (Bs1), Piule (!), Scor. G. (!); *Polygonatum verticillatum* (L.) All.: Buta (!), Iorg. (Cs, Fl. XI, !), Palt. (Bs1), Piule (Cs, Fl. XI, !); *Scilla bifolia* L. ssp. *bifolia*: Alb. (Cs), Piule (!); *Streptopus amplexifolius* (L.) DC.: Piule (Cs, Fl. XI, !); *Veratrum album* L. ssp. *album*.: Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (!), Scor. (!), ssp. *lobelianum* (Bernh.) Rchb. as var. *lobelianum* (Bernh.) Koch.: Scor. (Cs, Fl. XI);

Fam. Amaryllidaceae J. St.-Hil.

Narcissus poeticus L. ssp. *radiiflorus* (Salisb.) Baker as *N. angustifolius* Curt.: Drăg. (Fl. XI);

Fam. Iridaceae Juss.

Crocus vernus (L.) Hill ssp. *vernus*: Alb. (Cs), Piule (!), as *C. heuffelianus* Herb.: Soar. (Bs1); *Iris pumila* L. as var. *scapifera* Borbás: Scor. (Fl. XI); *I. reichenbachii* Heuff.: Piule (Cs);

Fam. Juncaceae Juss.

Juncus alpinus Vill. ssp. *alpinus*: Buta (Fl. XI); *Juncus articulatus* L.: Buta G. (!); *J. compressus* Jacq.: Buta G. (!); *J. effusus* L.: Buta (!), Câmp. (!); *J. filiformis* L.: Buta (Cs, Fl. XI), Piule (Cs, Fl. XI); *J. inflexus* L.: Buta G. (!); *J. trifidus* L. ssp. *trifidus*: Drăg. (Cs, !), Palt. (Bs1), Scor. Peak (!); *Luzula luzuloides* (Lam.) Dandy and Wilmott: Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Piule (!), Scor. (!), as *L. nemorosa* (Pollich) E. Mey. var. *cuprina* Roch: Alb. (Cs), Buta (Cs), Iorg. (Cs), Piule (Cs), Scor. (Cs); *L. multiflora* (Retz.) Lej: Alb. (Cs), Piule (Cs, !); *L. spicata* (L.) DC. ssp. *mutabilis* Chrtek and Křisa: Iorg. (!), as *L. spicata*: Iorg. (Cs, Fl. XI), Palt. (Bs1); *L. sudetica* (Willd.) DC.: Alb. (!), Drăg. (!), Iorg. (!), Piule (!), Scor. (!), Soar. (Bs1), Stăn. (!); *L. sylvatica* (Huds.) Gaudin: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (Cs, !), Scor. (!);

Fam. Poaceae (R. Br.) Barnh.

Agrostis alpina Scop.: Iorg. (Fl. XII), Piule (Cs, Fl. XII), Scor. (Cs, Fl. XII), as f. *aurata* (All.) Beldie: Iorg. (Fl. XII); *A. canina* L. ssp. *canina*: Buta (!); *A. capillaris* L.: Buta (!), Iorg. (!), Piule (!), Stăn. (!), as *A. tenuis* Sibth.: Scor. (Cs); *A. rupestris* All.: Alb. (!), Buta (!), Drăg. (!), Iorg. (Cs, !), Palt. (Bs1), Piule (Cs, !), Scor. (!), Soar. (Bs1), Stăn. (!), as f. *straminea* (Schur) A. and G.: Drăg. (Cs), Scor. (Cs), f. *viridula* (Beck.) Beldie: Drăg. (Fl. XII), Palt. (Fl. XII), Scor. (Fl. XII); *A. stolonifera* L. ssp. *stolonifera*: Buta (!), as *A. alba* L.: Buta (Cs); *Alopecurus pratensis* L. ssp. *pratensis*: Buta G. (!); *Anthoxanthum alpinum* Á. Löwe and D. Löwe: Soar. (Bs1); *A. odoratum* L.: Alb. (Cs), Buta (!), Drăg. (!), Iorg. (!), Piule (!), Scor. (!), Stăn. (Cs); *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl. and C. Presl.: Piule (Cs), Scor. (Cs); *Avenula planiculmis* (Schrad.) W. Sauer and Cmel. as *Avenastrum planiculme* (Schrad.) Jess.: Alb. (Cs), Iorg. (Cs), Piule (Cs), as *Helichtotrichon planiculme* (Schrad.) Pilg.: Alb. (Fl. XII), Iorg. (Fl. XII), Piule (Fl. XII); *A. praeusta* (Rchb.) Holub as *Avenastrum adsurgens* (Schur) Jáv.: Alb. (Cs); *A. pubescens* (Huds.) Dumort.: Piule (!), ssp. *laevigata* (Schur) Holub as *Avenastrum pubescens* (Huds.) Jess. ssp. *laevigatum* (Schur) Jáv.: Alb. (Cs), Piule (Cs), as *Helichtotrichon laevigatum* (Schur) Potztal: Alb. (Fl. XII), Iorg. (Fl. XII), Piule (Fl. XII); *A.*

versicolor (Vill.) M. Lainz: Alb. (!), Buta (!), Drăg. (!), Scor. (Cs, !); *Bellardiochloa violacea* (Bellardi) Chiov.: Piule (!), as *Poa violacea* Bellardi: Alb. (Cs, Fl. XII), Iorg. (Cs, Fl. XII), Piule (Cs, Fl. XII), Scor. (Cs, Fl. XII); *Bromus barcensis* Simonk. as var. *magnobarcensis* Nyár.: Scor. (Cs); *Bromus riparius* Rehmann ssp. *riparius*: Alb. (Cs, Fl. XII), Piule (Cs, Fl. XII), Scor. (Cs, Fl. XII); *Calamagrostis arundinacea* (L.) Roth: Alb. (!), Buta (!), Dâlma (!), Drăg. (!), Iorg. (!), Palt. (Bs1), Piule (Cs, !), Scor. (!); *C. villosa* (Chaix) J. F. Gmel.: Buta (!), Drăg. (!), Palt. (Fl. XII, Bs1), Piule (!), Scor. (!); *Cynosurus cristatus* L.: Buta (!); *Dactylis glomerata* L. ssp. *glomerata*: Buta (!), Câmp. (!), Dâlma (!), Iorg. (!), Piule (!), as var. *hispida* Terrac.: Stăn. (Cs), ssp. *aschersoniana* (Graebn.) Thell. as *D. aeschersoniana* Graebn.: Buta G. (Cs); *Deschampsia caespitosa* (L.) P. Beauv.: Alb. (!), Buta (!), Câmp. (!), Drăg. (!), Palt. (Bs1), Piule (!), Scor. (!), as var. *caespitosa* f. *aurea* (Wimm. and Grab.) Borza: Buta (Cs), Iorg. (Fl. XII); *D. flexuosa* (L.) Trin.: Buta (Cs, !), Drăg. (!), Palt. (Bs1), Piule (!), Scor. (!); *Festuca airoides* Lam.: Alb. (!), Buta (!), Piule (!), Scor. (!), as *F. ovina* L. var. *sudetica* f. *pubiflora* (Hack.) Nyár.: Stăn. (Fl. XII), f. *grandiflora* (Hack.) Nyár.: Iorg. (Fl. XII); *F. arundinacea* Schreb. ssp. *subalpina* (Hack.) Beldie as var. *subalpina* (Hack.) A. and G. Syn.: Palt. (Fl. XII); *F. carpatica* F. Dietr.: Alb. (Cs, Fl. XII), Iorg. (Fl. XII), Stăn. (Fl. XII), as var. *pseudolaxa* (Schur) Nyár.: Palt. (Ny1), Stăn. (Ny1), f. *pseudolaxa* (Schur) Jáv.: Stăn. (Cs (Jav1 at 1300 m)); *F. gigantea* (L.) Vill.: Buta G. (!); *F. nigrescens* Lam. as *F. rubra* ssp. *commutata* Gaudin f. *subheterophylla* (Nyár.) Beldie: Alb. (Fl. XII), Iorg. (Fl. XII), Piule (Fl. XII), Scor. (Fl. XII), Stăn. (Fl. XII); *F. pachyphylla* Degen ex. Nyár.: Alb. (Cs, Bs) at 1800 m (Ny), Iorg. (Cs, Bs) at 2100 m (Ny), Palt. (Bs1), Piule (Cs, Bs) at 2000 m (Ny), Pleşa (Cs, Ny1) at 1700 - 1800 m (Ny), Scor. (Cs, Ny), Stăn. (Bs), as f. *nyárádyana* Csűrös: Scor. (Cs), as *F. rupicola* Heuff. ssp. *pachyphylla* (Degen) Beldie, var. *pachyphylla*: Alb. (Fl. XII), Iorg. (Fl. XII), Piule (Fl. XII), Pleşa (Fl. XII), Scor. (Fl. XII); *F. panciciana* (Hack.) K. Richt.: Alb. (Cs), Piule (Cs), as *F. dalmatica* (Hack.) K. Richt. ssp. *pančiciana* (Hack.).: Alb. (Fl. XII), Piule (Fl. XII); *F. picta* Kit.: Drăg. (Cs, Fl. XII), Piule (Cs, Fl. XII, !); *F. porcii* Hack.: Alb. (Cs, Fl. XII, A.Ny), Iorg. (A. Ny, Fl. XII), Piule (Cs, A. Ny); *F. pratensis* Huds. ssp. *pratensis*: Scor. (Cs), ssp. *apennina* (De Not.) Hegi: Alb. (Fl. XII), Iorg. (Fl. XII), Palt. (Fl. XII, Bs1), Piule (Fl. XII), as var. *apennina* (De Not.) Beldie: Piule (Cs), Alb. (Cs); *F. rubra* L. ssp. *rubra*: Alb. (!), Buta (!), Drăg. (!), Iorg. (Cs, !), Piule (Cs, !), Scor. (Cs, !), Soar. (Bs1), Stăn. (!), var. *commutata* Gaudin as ssp. *commutata* Gaudin: Palt. (Bs1), as f. *fallax* (Thuill.) Hack.: Alb. (Cs), Piule (Cs); *F. rupicola* Heuff. ssp. *rupicola*: Stăn. (!), ssp. *saxatilis* (Schur) Rauschert as *F. saxatilis* Schur: Alb. (Cs, Ny1), Iorg. (Cs, Ny1), Piule (Cs), Stăn. (Cs, Ny1); *F. supina* Schur: Alb. (Cs), Palt. (Bs1), as var. *supina* f. *pubiflora* (Hack.) Nyár.: Stănuleți at 1950 m (Ny), f. *grandiflora* (Hack.) Nyár.: Iorg. at 2100 m (Ny); *F. versicolor* Tausch ssp. *versicolor*: Alb. (Pr, Cs, Ny1), Iorg. (Cs, Ny1, Bs), Piule (Cs, Ny1, Bs), Scor. (Cs, Ny1), ssp. *dominii* Krajina as var. *domini* Krajina f. *chrysantha* (Krajina): Alb. (Fl. XII), Iorg. (Fl. XII), f. *pallidula* Hack.: Alb. (Cs), Iorg. (Cs); *F. violacea* Schleich. ex Gaudin: Piule (Cs, Fl. XII); *F. xanthina* Roem. and Schult.: Scor. (Fl. XII), Stăn. (Fl. XII), as var. *klasterskyi* Krajina: Soar. (Fl. XII); *Holcus lanatus* L.: Buta G. (!); *Koeleria macrantha* (Ledeb.) Schult. ssp. *transsilvanica* (Schur) A. Nyár.: Scor. (Cs, Ny1), as *K. transsilvanica* Schur: Scor. (Cs, Ny1, Fl. XII); *K. pyramidata* (Lam.) P. Beauv.: Alb. (Cs, Fl. XII), Iorg. (Cs), Scor. (Fl. XII), Stăn. (Cs, Fl. XII), as var. *hirsuta* Csűrös, Gerg. and S. Pap: Alb. (Cs, Fl. XII), Iorg. (Cs, Fl. XII), Stăn. (Cs, Fl. XII); *Lolium perenne* L.: Buta (!); *Milium effusum* L.: Buta (!); *Nardus stricta* L.: Alb. (!), Buta (!), Drăg. (!), Piule (Cs, !), Scor. (!); *Phleum alpinum* L.: Alb. (!), Buta (!), Drăg. (!), Iorg. (!), Piule (!), Scor. (!), Stăn. (!), as ssp. *commutatum* (Gaudin) K. Richt.: Alb. (Cs), Palt. (Bs1), Piule (Cs); *Ph. montanum* K. Koch: Alb. (Cs), Piule (Cs); *Ph. pratense* L. ssp. *bertoloni* (DC.) Bornm., as var. *nodosum* (L.) Schreb.: Buta G. (Cs); *Poa alpina* L.: Alb. (Pr, Cs, !), Buta (!), Drăg. (!), Iorg. (Cs, !), Palt.

(Bs1), Piule (Cs, !), Scor. (Cs), Soar. (Bs1), Stăn. (Cs), as ssp. *gelida* (Schur) Borza: Palt. (Bs1), as *P. gelida* Schur: Alb. (Cs), Piule (Cs), as f. *vivipara* L.: Piule (Cs); *P. annua* L.: Buta (!), Câmp. (!), Piule (Cs), as ssp. *varia* Gaudin, f. *viridis* (Nyár.) Ghişa and Beldie: Buta Peak (Fl. XII); *P. chaixi* Vill.: Scor. (Cs); *P. hybrida* Gaudin: Piule (Cs, Fl. XII); *P. laxa* Haenke as *P. tremula* Schur: Iorg. (Fl. XII), Piule (Fl. XII), Scor. (Fl. XII); *P. media* Schur: Buta (!), Iorg. (Cs, !), Piule (Cs, !), Scor. (Cs, !), as var. *macrospiculata* Nyár.: Alb. (Cs); *P. minor* Gaudin: Iorg. (Cs), Piule (Cs), Scor. (Cs); *P. molinerii* Balb. ssp. *molinerii*: Alb. (Fl. XII, Bs), Iorg. (Bs), Piule (Fl. XII, Bs), Stăn. (Bs); *P. nemoralis* L.: Alb. (Cs), Buta (!), Iorg. (!), Palt. (Bs1), Piule (Cs, !), Scor. (Cs, !), as var. *montana* Gaudin: Alb. (Cs); *P. palustris* L. as var. *fertilis* Rchb.: Alb. (Cs), Iorg. (Cs); *P. pratensis* L.: Scor. (Cs); *P. supina* Schrad.: Piule (Cs, !); *Sesleria bielzii* Schur: Palt. (Bs1); *S. rigida* Heuff. ex Rchb.: Alb. (Pr, Cs, Ny1), Buta (!), Iorg. (Cs, Ny1, Bs, !), Piule (Cs (Pawl. at 2080 m), Ny1, !, Bs), Scor. (Cs, Ny1), Stăn. (Cs, Ny1, Bs), as var. *haynaldiana* (Schur) Beldie: Palt. (Bs1), Piule (Cs (Pawl. as *S. rigida* f. *subplanifolia* Pawl. at 1700 - 1850 m); *Trisetum fuscum* (Kit. ex Schult.) Schult.: Piule (Cs (Pawl. as *T. fuscum*)), Pleşa (Ny1), Scor. (Cs), as *Trisetum ciliare* (Kit. ex Schult.) Domin: Piule (Fl. XII);

Fam. Sparganiaceae F. Rudolphi

Sparganium erectum L.: Buta (Cs);

Fam. Cyperaceae Juss.

Carex atrata L. ssp. *atrata*: Alb. (Cs), Piule (Cs), Stăn. (Cs), ssp. *aterrima* (Hoppe) Čelak. as *C. aterrima* Hoppe: Palt. (Fl. XI); *C. capillaris* L. ssp. *capillaris*: Alb. (Cs, Ny1), Palt. (Fl. XI), Piule (Cs (Pawl.), Ny1), Stăn. (Cs, Ny1, Fl. XI); *C. curta* Gooden.: Buta (!), as *C. canescens* L.: Buta (Cs); *C. curvula* All.: Palt. (Bs1); *C. echinata* Murray: Iorg. (Cs), Piule (Cs); *C. fuliginosa* Schkuhr: Piule (!); *C. ovalis* Gooden.: Buta (!), Piule (!), as *C. leporina* L. var. *alpestris* (A. and G.) Borza: Buta (Cs); *C. ornithopoda* Willd. ssp. *ornithopoda*: Scor. (Cs); *C. remota* L.: Buta (Cs); *C. rupestris* All.: Alb. (Pr, Cs, Ny1), Iorg. (Cs), Piule (Cs, !), Scor. (Cs, Ny1); *C. sempervirens* Vill.: Alb. (Pr, Ny1, Bs, !), Iorg. (Cs, Ny1, Bs, !), Palt. (Bs1), Piule (Cs, Ny1, !), Scor. (Cs, Ny1), Stăn. (Cs, Ny1, !); *C. sylvatica* Huds.: Buta (!), Câmp. (!); *Scirpus sylvaticus* L.: Buta (!);

Fam. Orchidaceae Juss.

Cephalanthera longifolia (L.) Fritsch.: Câmp. (!), Iorg. (!); *Coeloglossum viride* (L.) Hartm.: Iorg. (Cs), Palt. (Bs1), Piule (Cs, !), as f. *bracteatum* (Willd.) Richt.: Piule (Cs); *Corallorrhiza trifida* Châtel.: Câmp. (!), Iorg. (!); *Cypripedium calceolus* L.: Alb. (Cs, Fl. XII); *Dactylorhiza maculata* (L.) Soó: Buta (!), Câmp. (!), as *Orchis maculata* L.: Buta (Cs); *Epipactis atrorubens* (Hoffm.) Besser: Alb. (Fl. XII), Buta (Fl. XII, !), Iorg. (Fl. XII), Piule (Fl. XII), as *E. atropurpurea* Raf.: Alb. (Cs), Buta (Cs), Iorg. (Cs), Piule (Cs); *E. helleborine* (L.) Crantz as *E. latifolia* (L.) All.: Buta (Cs), Palt. (Bs1); *Gymnadenia conopsea* (L.) R. Br. ssp. *conopsea*: Buta (!), Câmp. (!), Iorg. (Cs, !), Piule (Cs, !); *Herminium monorchis* (L.) R. Br.: Buta (!), Iorg. (!); *Listera cordata* (L.) R. Br.: Buta (Cs) at 1000 m (Pcs), Iorg. (Fl. XII), Scocu Mare (Fl. XII); *L. ovata* (L.) R. Br.: Buta (Cs), Câmp. (!); *Neottia nidus-avis* (L.) Rich.: Buta (!), Câmp. (!); *Nigritella nigra* (L.) Rchb. f. ssp. *nigra*: Alb. (Cs, Fl. XII), Iorg. (Cs, Fl. XII, !), Scor. (Cs, Fl. XII); *Orchis mascula* (L.) L. ssp. *signifera* (Vest) Soó: Palt. (Bs1), as *O. signifera* Vest.: Piule (Cs); *O. militaris* L.: Câmp. (!); *Platanthera bifolia* (L.) Rich.: Alb. (Cs), Buta G. (!), Câmp. (!), Iorg. (Cs, !), Piule (Cs); *Pseudorchis albida* (L.) Á. Löwe and D. Löwe: Buta (!), as *Leucorchis albida* (L.) E. Mey.: Alb. (Cs), Drăg. (Cs).

DISCUSSIONS

Up to the present 654 species (one aggregate) and 18 hybrids of cormophytes are known from the south-eastern part of the Retezat National Park. As the previous works focused mainly on the subalpine flora, most of the species newly identified in the area by the authors in the recent years are forest plants (*Anemone nemorosa, Lunaria rediviva, Cardamine bulbifera, Mercurialis perennis, Galium aparine, Gentiana asclepiadea, Pulmonaria rubra, Salvia glutinosa, Stachys alpina, Stachys sylvatica, Sambucus racemosa, Stachys nigra, Sanicula europaea, Lonicera xylosteum, Symphytum cordatum, Lathraea squamaria, Pulmonaria rubra, Lapsana communis, Scirpus sylvaticus, Carex sylvatica, Neottia nidus-avis, Corallorrhiza trifida,* etc) or inhabit lower mountain meadows (*Carlina acaulis, Lychnis flos-cuculi, Silene vulgaris*, etc) or spring and river banks at lower altitudes (*Caltha palustris, Veronica beccabunga, Petasites albus, Lysimachia nummularia, Lysimachia vulgaris* etc.). However, some new species were also recorded beyond the upper limit of the forest, including: *Polygonum bistorta, Chenopodium bonus-henricus, Minuartia sedoides, Linum catharticum*, *Gentiana acaulis*, etc. The rarer species *Astragalus alpinus* was found on Piatra Iorgovanului, *Cardaminopsis neglecta* was identified on Piule and Piatra Iorgovanului, *Taraxacum fontanum* on Buta rivulet bank, next to Buta Lake, *Taraxacum nigricans* from Piule and Piatra Iorgovanului, *Pedicularis exaltata* at the base of the northern vertical slope of Piule Peak and *Herminium monorchis*, inhabiting the meadows on Buta Mică Valley and below Câmpuşel and Piatra Iorgovanului.

The investigated flora area presents some characteristic biogeographical features, especially in the calcareous sector (Piule-Iorgovanului Mountains). Due to its geographical position, geomorphologic and geological features, and climatic history, the investigated area presented favorable conditions for establishing and maintaining plant species of very different origin. The cryophilic species of alpine (formed in the Alps and Carpathians), arctic (migrated from North) and Siberian (from the North-East) origin, dominant during the last ice age, survived the warming of the climate in some shady and cool microhabitats. Some of these species in this area are in the most southern station of their range, including *Agrostis alpina*, *Trisetum fuscum*, *Festuca porcii*, *Hepatica transsilvanica, Pulsatilla vulgaris* ssp. *grandis*, *Pedicularis exaltata, Hypochoeris uniflora*, *Saussurea discolor*, etc. The gradual warming of climate and the withdrawal of glaciers permitted the immigration of thermophilic species of balcanic and moessic origin along the Cerna Valley. Some of them reach here the most northern point of their ranges (*Iris reichenbachii*, *Ornithogalum collinum, Hieracium* × *banaticola*), other passing into the Apuseni Mountains or into the limestone areas from other massifs from the Southern Carpathians, including *Syringa vulgaris*, *Festuca panciciana*, *Laserpitium archangelica*, *Athamantha hungarica*, etc (idem).

Due to its rich flora of different origins, the south-eastern part of the Retezat National Park is an important conservation area for plants, sheltering several protected species. Four species are included in the Annex of Bern Convention, namely: *Campanula patula* ssp. *abietina*, *Cypripedium calceolus, Lilium carniolicum* ssp. *jankae,* and *Pulsatilla vulgaris* ssp. *grandis*. *Plantago atrata* ssp. *carpatica* is part of the Global Red List of IUCN, 1997, *Larix decidua* ssp. *carpatica* of the World List of Trees 1998 and other six species of the 92/43/EEC Habitat Directive's annexes. *Campanula serrata, Cypripedium calceolus, Pulsatilla vulgaris* ssp. *grandis* and *Tozzia alpina* ssp. *carpathica* are included in Annex II b, *Lycopodium annotinum* and *Gentiana lutea* in Annex V b. Among them, *Campanula serrata* is abundant and widely distributed in the area, in most of the meadows from 1200 to 2000 m altitude.

Considering the ecological features, there is a clear differentiation between the flora and vegetation of similar habitats situated on the two investigated geological substrata, namely granodiorite (in the north-eastern area) and limestone (in the south-western area). This is valid for the plant communities' structure regarding the response to the soil reaction and humidity, and also for the specific composition and the diversity. From these points of view, the rocky vegetation followed by the subalpine meadows present the most "calcareous" character (Benedek et al., 2004).

The cormophyte communities in habitats situated on magma and metamorphic substratum present an acidophilous character, which registers a maximum in the subalpine shrubs. The most basophile character of the vegetation was revealed in the rocky habitats on limestone. The same opposition of the two groups of habitat types can be seen in the species' reaction to the humidity. The plant communities on limestone present a more xenophilic character, among them the subalpine meadows represents the single habitat type dominated by xero-mesophytes, not by the mesophytes, as the rest of habitats. All the cormophytes communities are dominated by hemi cryptophytes, which represent between 55 and 80% of the total species number. The relative abundance of this life-form category is negatively correlated to the relative abundance of the chamaephytes, which present an affinity for the limestone. In forested habitats the phanerophytes reach a relative high percentage, exceeding 25%. The diversity of plant communities from calcareous substratum is higher than on granodiorites, reaching the maximum value on limestone rocks. The highest similarity between the floras of different habitat types in the area was observed in case of subalpine shrubs, subalpine and mountain meadows on granodiorite substratum. On limestone the highest resemblance was recorded for subalpine meadows and rocks (idem).

CONCLUSIONS

The cormoflora from the south-eastern area of Retezat National Park comprises 654 species (one aggregate) and 18 hybrids identified up to the present. Most of the newly identified species inhabit forests and other low altitude habitats, but some interesting plant species were also found in the subalpine area: *Astragalus alpinus, Cardaminopsis neglecta*, *Taraxacum fontanum*, *Taraxacum nigricans*, *Pedicularis exaltata* and *Herminium monorchis*. The flora of the investigated area presents favorable conditions for establishing and maintaining of plant species of very different origin, the cryophilic species of alpine, arctic and Siberian origin cohabit with the thermophilic species of balcanic and moessic origin, migrating in along the Cerna Valley. The south-eastern part of the Retezat National Park is an important conservative area for plants, sheltering several protected species. Among them, *Campanula serrata*, included in the Annex II of 92/43/EEC Habitat Directive is abundant and widely distributed in the area, in most of the meadows from 1200 to 2000 m altitude.

The study area comprises both magma and calcareous geological substrata and in many aspects, there is a clear differentiation between similar vegetation types on the two substrata. This is valid not only for the plant communities' structure regarding the response to the soil reaction and humidity, but also for the life-forms specters, diversity and the specific composition. On limestone the vegetation presents a more basophilic and xenophilic character compared with the plant communities on eruptive substratum, as well as a higher diversity, illustrated both by a higher number of species and higher values of the diversity indices. From these points of view, the rocky vegetation followed by the subalpine meadows present the most "calcareous" character.

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ZĂNOAGA AND JUDELE (RETEZAT NATIONAL PARK, ROMANIA), BIODIVERSITY VALUE AND EVIDENCE OF ANTHROPOGENIC IMPACTS ON ALPINE VEGETATION

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, alpine vegetation, biodiversity, anthropogenic impact.

ABSTRACT

Vegetation in the alpine zone is liable to many natural stresses that determine its special character and composition. In addition to these stresses, in the past 15 years the high mountains of Romania have become more subject to anthropogenic change i.e. altered climate, increased grazing by domestic stock and greater numbers of visiting tourists. The impact of these changes is apparent even in those parts of the Carpathians designated as protected areas (e.g. the Retezat National Park). The present study sought to describe the biodiversity value of one area of the Retezat and assess the effects of stock-grazing and trekking on the vegetation. The Zănoaga-Judele area was described in terms of its altitudinal zones, habitat types and plant communities. Evidence of impact from sheep, horses and people was considered, and research was suggested that could test these impacts and provide advice for the park authorities. Zănoaga-Judele was shown to have considerable biodiversity value, but to have clear signs of local degradation. The study proposed a four-point programme of research, focussed on the Zănoaga-Judele area but extending to other parts of the Retezat and using the adjacent Rezervaţia Ştiinţifică Gemenele as a control.

ZUSAMMENFASSUNG: Gebiet um den Zanoaga und Judele (Nationalpark-Retezat, Rumänien), der Wert seiner Artenvielfalt und die menschlichen Eingriffe in die alpine Vegetation.

Die Vegetation in der alpinen Zone unterliegt natürlichen Stressfaktoren, die ihren speziellen Character and ihre Zusammensetzung bestimmen. Zusätzlich zu den natürlichen Stressfaktoren wirkten in den letzten 15 Jahren auf die rumänischen Hochgebirgslagen anthropogene Faktoren ein, wie z. B. ein verändertes Klima, intensivierte Beweidung durch Vieh und eine zunehmende Zahl von Touristen. Der Einfluß dieser Veränderungen macht sich selbst in den besonders geschützten Gebieten der Karpathen bemerkbar (z. B. im Retezat Nationalpark). Diese Studie beschreibt den Biodiversitätswert eines Gebietes im Retezat-Park und erfaßt Effekte durch Beweidung und Wandertourismus auf die Vegetation. Das Zănoaga-Judele Gebiet wird durch seine Höhenzonen, Habitattypen und Pflanzengemeinschaften beschrieben. Nachweisliche Auswirkungen von Schaf- und Pferdebeweidung und durch Wanderer wurden erfaßt, und ein Forschungsansatz vorgeschlagen, der diese Auswirkungen erfassen kann und die Parkbehörde informieren kann. Zănoaga-Judele hat beachtlichen Biodiversitätswert, aber auch eindeutige Anzeichen von lokaler Degradierung. Diese Studie beschreibt ein beantragtes Vierpunkte-Forschungsprogramm, um das Zănoaga-Judele Gebiet und andere Teile des Retezat-Parks zu untersuchen und mit dem angrenzenden Gebiete der Rezervaţia Ştiinţifică Gemenele als Kontrollfläche zu vergleichen.

REZUMAT: Valoarea biodiversităţii şi dovezi ale impactului antropic asupra vegetaţiei alpine a ariei Zănoaga şi Judele (Parcul Naţional Retezat, România).

Vegetaţia zonei alpine este expusă unor factori de stres natural care îi determină caracterul special şi compoziţia. În plus faţă de acest stres, în ultimii 15 ani, munţii înalţi ai României au devenit mai mult subiectul modificărilor antropice ex. modificarea climei, intensificarea păşunatului şi creşterea numărului de turişti. Impactul acestor modificări este evident chiar şi în acele părţi ale Carpaţilor desemnate ca arii protejate (ex. Parcul Naţional Retezat). Prezentul studiu îşi propune să descrie valoarea biodiversităţii în aria Retezatului şi evaluează efectele păşunatului şi a turismului asupra vegetaţiei. Aria Zănoaga - Judele a fost descrisă în termenii zonării sale altitudinale, a tipurilor de habitate şi a comunităţilor de plante. Au fost luate în considerare dovezi ale impactului oilor, cailor şi oamenilor şi au fost sugerate cercetări prin care se pot evidenţia aceste impacturi iar rezultatele pot fi oferite autorităţilor parcurilor. Zona Zănoaga - Judele s-a dovedit a avea o valoare considerabilă a biodiversităţii, dar şi semne clare de degradare locală. Acest studiu propune un program de cercetare în patru puncte, concentrate pe aria Zănoaga - Judele, cu extindere către alte părţi ale Retezatului şi utilizând Rezervaţia Ştiinţifică Gemenele din proximitate ca zonă martor.

INTRODUCTION

Much of the native vegetation of the alpine zone (> 2000 m altitude in the Romanian Carpathians) is adapted to conditions (Körner, 2003) where: periods of available water for growth are severely limited (frozen for at least six months and with excess evapotranspiration in summer); temperatures for much of the year preclude vegetative growth, and during the summer, the diurnal temperature range at the soil surface may vary from sub-zero to > 50^{o}C; consequent reduced vegetation productivity results in low soil organic content and severely restricted nitrogen and phosphorus availability, as well as that of other major and micro-nutrients; there are complex interactions between high summer insolation, severe winds and variation in duration of snow-lie; soil C:N ratios tend to be high; soils are shallow, unstable, stony and with high mineral content, with low water retention; steep gradients further contribute to soil instability; populations of larger mammal are relatively low (compared to forest and lowland situations), and hence plant species are not normally subject to mechanical damage from trampling; and conditions have prevented continual human habitation.

Consequently the habitats of alpine plant communities tend to be very fragile and prone to change from altered global climates and other anthropogenic activities, such as tourism and agriculture and forestry intensification. These considerations make the successful conservation of alpine vegetation a challenging activity, even within protected areas that have been designated for a considerable time, as within the Retezat National Park.

The post-Communist development of Romania poses a number of opportunities and problems for effective nature conservation. For example, privatisation of lands and resources may markedly alter management practices. Secondly, increased mobility of people both within Romania and especially from abroad coupled to higher disposable incomes may lead to greater visitor pressure in what were until recently relatively remote and unfrequented landscapes. Thirdly, until recently biodiversity protection measures in Romania were very limited, and there still remain fewer controls on the use and movement within wilderness by visitors than would be the case in many other parts of Europe.

The Retezat National Park has numerous designations under Romanian and European biodiversity protection law, and since ca 1998 the Retezat National Park Administration (RNPA) has been engaged in developing and implementing an effective management plan for the park based upon best practice and a detailed knowledge of the biota of the park. The first

comprehensive identification and mapping of the main habitats of Retezat National Park followed the "Biological Baseline Survey Manual" (Patriquin et al., 2000) prepared as part of the GEF-World Bank project Biodiversity Conservation Management in Romania. This approach attempted to describe the present habitats and communities of the park together with their composition and use these data to inform the zoning and management of the park (Mountford et al. 2005). However, there remain specific questions about the use of the park and the biodiversity value of particular areas that demand a focussed site-specific approach. To that end the Park Administration asked the author to visit the Zănoaga and Judele area and make a preliminary survey of the vegetation communities and to assess the impact of tourist and grazier use of the alpine zone. Mountford (2002) reported the results of this work to the Park Administration, and the present paper is largely derived from this report, stressing the phytosociological aspects and relevance to management.

OBJECTIVES AND METHODS

As required by the Park Administration, there were three primary objectives for this study: to provide an outline description of the flora and vegetation types in the neighbourhood of Zănoaga and Judele lakes; within the context of the Retezat National Park, to assess whether this area is of exceptional biodiversity interest; to comment on any observed management issues that may need to be addressed by the park authority.

The survey took place over three days in late July 2002. Given the constraints of time and the specific objectives, the overriding consideration was to cover as much ground as possible and investigate any areas of potential botanical diversity. To that end, it was decided not to use a systematic approach, despite the clear desirability of such methods and their application in baseline survey within Retezat (Patriquin et al., 2000). Instead, the study took the following structure:

I. Wide-ranging reconnaissance within the area to cover the full range of altitudes from ca 1950 m upward, aspect and gradient.

II. Identification of all discrete vegetation zones.

III. Location of these zones with Global Positioning Systems (GPS) and cross-referencing to the park map (Jancsik, 2000).

IV. Inventory of main plant species within each vegetation zone, together with estimates of their relative abundance. For this rapid survey, the "DAFOR" scale (D: dominant; A: abundant; F: frequent; O: occasional; R: rare) was employed, sometimes qualified to indicate local trends.

These survey lists (relevés) were systematically compared with vegetation types described for the Retezat, and elsewhere in the Romanian Carpathians (Coldea 1991, 1993, 2003) in order to relate the results of this reconnaissance to previous descriptions of the region's montane vegetation. Where possible, such phytosociological categories were then categorised in terms of standard European approaches to biotope description (Davies and Moss, 1999; Devillers et al., 1999).

In this account, species nomenclature follows Ciocârlan (2000), although where this differs from Flora Europaea (Tutin et al., 1964 - 80), both names are listed for comparison in Appendix 1. The earlier classic work of Săvulescu et al., (1952 - 76) was also useful in providing very useful information on the distribution of Carpathian plants, including some reference to the Zănoaga and Judele sites themselves.

Geographical extent of survey

The study area was bounded to the north by an alpine ridge running west to east including the peaks of Şesele Mici, Şesele Mari, Bârlea and Judele. From Judele, the boundary of the study area ran south and then west along the Muchia Ascuțită spur. No formalised recording took place below 1950 m, and the southern boundary approximately followed the 2000 m contour west toward the Zănoaga campsite. The slopes around several alpine lakes were an important focus for the survey, including Zănoaga (1997 m), Judele (2135 m) and the five larger tarns between. Finally the western and southwestern boundary of the study area was the plateau of Fața Zănoguței at ca 2100 m. The results presented below were recorded between the steep slope on the west side of Zănoaga Lake (45°20.767' North and 22°49.204' East) and those slopes east above Judele Lake (45°21.153' North and 22°50.899' East), mostly within grid squares F9 and G9 of the Retezat Mountains map (Jancsik, 2000).

RESULTS

Summary of vegetation from Zănoaga and Judele

Five main vegetation zones were distinguished, ordered by ascending altitude: I. Lakes and bogs north of Muchia Ascuțită (Judele etc); II. Boggy slopes and streamsides near Zănoaga; III. Rocky slopes surrounding Zănoaga Lake; IV. Other more open rocky dry grassland; V. High montane slopes to 2350 m. Some data were gathered from the Fața Zănoguței plateau (VI). The results are presented individually for each zone, with summary species composition (DAFOR), together with location and altitude range (GPS data) and incidental notes:

I. Lakes and bogs north of Muchia Ascuțită (Judele Lake etc) - see table 1.

Table 1: Species from lakes and bogs north of Muchia Ascuțită.

Species	DAFOR	Species	DAFOR	Species	DAFOR
Sphagnum sp. (*e.g. S. compactum, S. girgensohnii, S. recurvum* etc.) on boggy shores.					D
Species	DAFOR	Species	DAFOR	Species	DAFOR
Deschampsia cespitosa	A	*Juncus filiformis*	A	*Philonotis seriata*	A
Polytrichum commune	A	*Saxifraga stellaris*	A	*Aconitum tauricum* *	F
Carex curta	F	*Cerastium cerastoides*	F	*Drepanocladus ?exannulatus* (pools)	F
Nardus stricta	F	*Plantago gentianoides*	F	*Caltha palustris*	O
Carex echinata	O	*Carex nigra alpina*	O	*Carex nigra dacica*	O
Eriophorum scheuchzeri	O	*Geum montanum*	O	*Leontodon autumnalis pratensis*	O
Luzula alpinopilosa obscura	O	*Poa rehmannii*	O	*Centaurea pseudo-phrygia ratezatensis* *	R
Dryopteris carthusiana	R	*Epilobium nutans*	R	*Juncus alpinoarticulatus* *	R
Poa alpina	R	*Ranunculus crenatus*	R	*Rumex alpestris*	R
Senecio subalpinus	R				

Note: For species marked * see Appendix 1 for nomenclature according to Flora Europaea.

The area recorded was a well-defined zone occupying the valley from Lac Judele westward toward Zănoaga Lake from ca 45°21.153' North and 22°50.899' East to ca 45°20.988' North and 22°50.271' East, and from ca 2050 - 2150 m altitude. The survey focussed on five major alpine lakes, several smaller pools and the boggy margins of these water-bodies. The drier rocky and *Pinus mugo* habitats that surround the lakes (also on bluffs and ridges within the wet valley) have essentially the same vegetation as characterised in sections IV and V. However, in crevices on a few boulders within the valley, some species were found that were otherwise apparently rare in the area covered by the survey - *Carex pyrenaica, Kobresia myosuroides* and *Sedum atratum.* Much smaller montane pools occurred very rarely in Zone IV. Their flora comprised an emergent marginal zone of *Juncus filiformis*, with sparse floating/submerged *Callitriche palustris* and *Drepanocladus exannulatus*.

II. Boggy slopes and streamsides near Zănoaga - see table 2.

The recorded area was centred on 45°20.705' North and 22°49.193' East (≥ 2000 m altitude), and comprised the gentle slopes above the south shore of lake Zănoaga, together with the margins of streams draining zone III. Similar communities occurred on broader wet terraces on the rocky slopes, and to the east of Zănoaga. The composition of the communities was clearly related to the lakeshore stands (section I). Community descriptions of the *Soldanello pusillae-Ranunculuetum crenatii* for the Retezat (Coldea, 1993) cite Zănoaga as an important locality.

Table 2: Species from boggy slopes and streamsides near Lac Zănoaga.

Species	DAFOR	Species	DAFOR	Species	DAFOR
Philonotis seriata	A	*Sphagnum* spp. (locally)	A	*Eriophorum vaginatum*	F
Luzula alpinopilosa obscura	F	*Plantago gentianoides*	F	*Saxifraga stellaris*	F
Anthoxanthum odoratum	O	*Carex curta*	O	*Carex echinata*	O
Dactylorhiza maculate schurii	O	*Leontodon autumnalis pratensis*	O	*Parnassia palustris*	O
Caltha palustris	R	*Carex nigra dacica*	R	*Carex pauciflora*	R
Ranunculus crenatus	R	*Saxifraga rotundifolia*	R	*Soldanella hungarica hungarica*	R

III. Rocky slopes surrounding Lac Zănoaga - see table 3.

The recorded area centred on 45°20.767' North and 22°49.204' East, and between 2000 - 2100 m altitude, including the predominantly east-facing steep slopes by the lake. Similar habitats were found to the north and to the south of this lake. These slopes comprised grassland with many rock outcrops (with ledges and crevices), together with scattered boulders. Many of the species were patchily distributed through a rather heterogeneous habitat.

Table 3: Species from rocky slopes surrounding Lac Zănoaga.

Species	DAFOR	Species	DAFOR	Species	DAFOR
Deschampsia cespitosa	D	*Festuca xanthina*	D	*Geum montanum*	A
Thymus pulcherrimus	A	*Campanula kladniana* *	F	*Deschampsia flexuosa*	F
Festuca pachyphylla	F	*Festuca versicolor*	F	*Hypericum maculatum*	F
Luzula luzuloidesrubella	F	*Nardus stricta*	F	*Potentilla aurea*	F
Rhododendron myrtifolium	F	*Vaccinium myrtillus*	F	*Achillea stricta*	O
Aconitum tauricum	O	*Agrostis rupestris*	O	*Alchemilla fissa*	O
Homogyne alpine	O	*Juncus trifidus*	O	*Juniperus sibirica* *	O
Poa molinerii	O	*Sempervivum marmoreum*	O	*Solidago virgaurea*	O
Campanula abietina *	R	*Centaurea pseudo-phrygia ratezatensis*	R	*Dryopteris expansa*	R
Euphrasia stricta	R	*Festuca supina* *	R	*Ligusticum mutellina*	R
Phleum alpinum	R	*Phyteuma confusum*	R	*Pseudorchis albida*	R
Rumex alpestris	R	*Sedum atratum*	R	*Senecio glaberrimus* *	R
Tanacetum alpinum *	R	*Vaccinium vitis-idaea*	R	*Veratum album*	R
Veronica bellidioides	R				

Note: For species marked * see Appendix 1 for nomenclature according to Flora Europaea.

IV. Montane (sub-alpine) grassland, rocky like Zone III but more open - see table 4.

A distinct zone of drier grassland occurred on undulating stony land at lower altitudes (ca 2000 m - 2100 m) east of Zănoaga lake from 45°20.697' North and 22°49.340' East to 45°20.914' North and 22°49.837' East. The grassland is variable with drier *Festuca*-dominated areas and moister patches with much *Deschampsia cespitosa*. On steep slopes to the north, a mosaic of Stone Pine scrub and high altitude rocky swards (see Zone V) replaced this grassland. Another area of Stone Pine scrub occurred in the valley of the Zănoaga and Judele streams below this grassland, at altitudes < 2000 m.

Table 4: Species of rocky sub-alpine grassland.

Species	DAFOR	Species	DAFOR	Species	DAFOR
Festuca spp. (Including *F. pachyphylla, F. versicolor, F. xanthina*)					D
Species	DAFOR	Species	DAFOR	Species	DAFOR
Agrostis rupestris	A	*Avenula versicolor*	*A*	*Potentilla aurea*	A
Campanula kladniana	F	*Deschampsia cespitosa*	F	*Homogyne alpina*	F
Nardus stricta	F	*Phyteuma confusum*	*F*	*Campanula abietina*	O
Campanula alpina	O	*Euphrasia stricta*	O	*Geum montanum*	O
Gnaphalium supinum	O	*Ligusticum mutellina*	O	*Phleum alpinum*	O
Poa media	O	*Vaccinium vitis-idaea*	O	*Carex panicea*	R
Centaurea pseudo-phrygia ratezatensis	R	*Cerastium cerastoides*	R	*Hieracium aurantiacum carpathicola*	R
Juniperus sibirica	R	*Luzula spicata*	R	*Oreochloa disticha*	R
Pinus mugo	R	*Pulsatilla alba*	R	*Trifolium repens*	R
Vaccinium gaultherioides *	R				

Note: For species marked * see Appendix 1 for nomenclature according to Flora Europaea.

V. High montane slopes to 2350 m (alpine zone) - see table 5.

In many respects, this was the most diverse and interesting of the characterised zones. It occupied the mainly south-facing slopes of Şesele Mici, Şesele Mari, Bârlea and Judele from the ridge at ca 2300 m down to about 2150 m, where it abutted the dry grassland (IV) and lake (I) zones. The bounds of the recorded area were ca 45°21.101' North and 22°49.962' East and ca 45°21.240' North and 22°50.433' East. A considerable part of this zone, especially at lower altitudes, comprised dense *Pinus mugo* scrub, but even there, gaps in the scrub held varied rocky alpine vegetation. The second most extensive cover-type was scree, both of boulders and finer material. In addition, several grassy areas occurred in the mosaic, notably in the cwm around Lac Judele where the notable local endemic *Centaurea pseudophrygia* ssp. *ratezatensis* was often abundant.

Table 5: Species from high montane slopes (2100 - 2350 m).

Species	DAFOR	Species	DAFOR	Species	DAFOR
Pinus mugo	D	*Festuca* spp. (as III/IV)	A	*Juncus trifidus*	A
Agrostis rupestris	F	*Cetraria* spp.	F	*Hieracium alpinum s. l.*	F
Homogyne alpina	F	*Ligusticum mutellina*	F	*Loiseleuria procumbens*	F
Oreochloa disticha	F	*Phyteuma confusum*	F	*Potentilla aurea*	F
Rhododendron myrtifolium	F	*Vaccinium gaultherioides*	O	*Centaurea pseudo-phrygia ratezatensis*	O
Anthoxanthum odoratum	O	*Avenula versicolor*	O	*Calamagrostis villosa*	O
Nardus stricta	O	*Veratrum album*	O	*Gentiana punctata*	R
Hieracium spp.	R	*Kobresia myosuroides*	R	*Pulsatilla alba*	R
Leucanthemum waldsteinii	R	*Senecio carniolicus* *	R	*Silene vulgaris* ssp. *glareosa* *	R
Sesleria coerulans	R	*Tanacetum alpinum*	R		

Note: For species marked * see Appendix 1 for nomenclature according to Flora Europaea.

Similar vegetation, but with much less *Pinus mugo* scrub, also occurred along the north-facing part of the Muchia Ascuțită spur, enclosing the lakes zone (I).

VI. Plateau of Fața Zănoguței.

A full community list was not prepared for the plateau, though incidental notes were compiled. This area surrounded the junction of two major tourist trekking paths, between about 1900 m and 2100 m altitudes. The gentle surrounding slopes had more Pinus mugo scrub. One large area by the path up from Gura Zlata was completely dominated by *Rumex alpinus*, and similar patches of *Rumex*, often well in excess of a hectare were a feature of the gentler slopes in the Zănoaga area. These were the most species-poor assemblages present in the survey area. Amongst the other species found in the undulating moist grassland of the plateau were:

Achillea millefolium *Alchemilla fissa* *Antennaria dioica*
Centaurea pseudophrygia ratezatensis *Geum montanum*
Hieracium aurantiacum carpathicola *Hypericum maculatum*
Luzula sylvatica *Nardus stricta* *Phyteuma confusum*
Pseudorchis albida *Rhododendron myrtifolium* *Saxifraga stellaris*

Phytosociological and habitat interpretation

Phytosociological communities

Although insufficient data were taken for the classic relevé approach, a provisional phytosociological description could still be made comparing the survey results with those plant communities described by Coldea (1993). However, it is important to realise that the six zones outlined above are not themselves equivalent to plant communities. Rather, these zones represent broad habitats or areas within which occur a mosaic of plant communities (Tab. 6).

Table 6: Plant communities (after Coldea, 1993) probably present in Zănoaga and Judele area, together with the described zone(s) within which they are likely to occur.

a) Aquatic and mire communities from Zones I and II	
Philontido-Saxifragetum stellaris	*Calthetum laetae*
Carici dacicae-Drepanocladetum exannulati	*Eriophori vaginati-Sphagnetum recurvi*
Luzuletum alpino-pilosae	
Luzuletum alpino-pilosae	*Soldanello pusillae-Plantaginetum gentianoidi*
b) Communities confined to Zone III	
Senecioni glaberrimi-Silenetum lerchenfeldianae	*Rhododendo myrtifolii-Vaccinietum*
b) Communities found in Zones III and IV [(5) - also in Zone V]	
Potentillo chrysocraspedae-Festucetum airoidis	*Phleo alpini-Deschampsietum cespitosae*
Poa molinerii-Festucetum pachyphyllae (5)	*Festucetum xanthinae*(5)
c) Communities found in Zone IV [(6) - also in Zone VI]	
Nardo-Gnaphalietum supini	*Senecioni-Rumicetum alpinii* (6)
d) Communities found mainly in higher altitude habitats of Zones IV and V	
Aconitetum taurici	*Cetrario-Loiseleuretum procumbentis*
Rhododendro myrtifolii-Pinetum mugi	

Habitat types

The survey results from the Zănoaga and Judele area were then compared with the habitat classifications given in i) Annex I of the European Union's Habitats Directive, and ii) Annex C of the EUNIS list (Davies and Moss, 1999; Devillers et al., 1999; Patriquin et al., 2000). Table 7 lists the habitat types (under the two classification systems) to which this procedure allocates the vegetation in the Zănoaga and Judele region.

DISCUSSION

Conservation and management aspects

During the vegetation survey, no systematic recording of visitor numbers was made. During the summer of 2002, Salvamont maintained a camp by Lac Zănoaga that has since become the site of a refuge. Thus some direct measurement of visitors and grazing is now possible. However, examination of the vegetation revealed a marked anthropogenic impact in some areas. The Zănoaga and Judele area receives considerable visitor numbers, as well as attention from itinerant graziers, particularly driving sheep, but also locally with numerous horses.

Table 7: Habitat types of the Zănoaga-Judele area as classified by the Habitats Directive and the EUNIS (with corresponding code numbers for the two systems) and the Zones within which they occurred.

I) Annex I of the European Union's Habitats Directive		
3160	Natural dystrophic lakes and ponds	Zone I
3220	Alpine rivers and the herbaceous vegetation along their banks	Zone II
4070	Bushes with *Pinus mugo* and *Rhododendron*	Zone V
6140	Siliceous alpine and boreal grasslands	Zones III and IV
6230	Species-rich *Nardus* grasslands on siliceous substrates in mountains	Zones III, IV and V
6430	Hydrophilous tall herb fringe communities of montane/alpine levels	Zone VI
7140	Transition mires and quaking bogs	Zone II
8110	Siliceous scree of the montane to snow levels	Zone IV and V
8220	Siliceous rocky slopes with chasmophytic vegetation	Zone V
II) Annex C of EUNIS		
C1.1	Permanent oligotrophic lakes, ponds and pools	Zone I
C2.1	Springs, spring-brooks and geysers	Zone II
C3.6	Unvegetated or sparsely vegetated shores with soft or mobile sediments	Zone I
C3.7	Unvegetated or sparsely vegetated shores with non-mobile substrates	Zone I
C3.8	Inland spray- and stream-dependent habitats	Zone II
D2.3	Transition mires and quaking bogs	Zone II
E1.7	Non-Mediterranean dry acid and neutral closed grasslands	Zone IV and VI
E4.1	Snow-patch grassland	Zone IV
E4.2	Moss/lichen dominated mountain summits, ridges and exposed slopes	Zone V
E4.3	Acid alpine and subalpine grassland	Zones III, IV and V
E4.5	Alpine and subalpine enriched grassland	Zone VI
E5.5	Subalpine moist or wet tall-herb and fern habitats [Especially E5.5/P-37.88 Alpine *Rumex* communities]	Zone III
F2.2	Evergreen alpine/subalpine heath and scrub [Including *Rhododendron, Juniperus* and *Bruckenthalia* types]	Zone V
F2.4	*Pinus mugo* scrub [In particular Carpathian type]	Zone V
H2.3	Temperate-montane acid siliceous screes	Zone V
H3.1	Acid siliceous inland cliffs	Zone III

The grazing impact over the whole site is striking, and where animals rest for long periods (such as on the Fața Zănoguței plateau) the fertilisation of the sward is locally excessive. Even in the short period of this reconnaissance survey, several different flocks were encountered, and there were several large patches of the strongly nitrophilous *Rumex alpinus*, dominating the vegetation almost to the exclusion of all other vascular plants (Erschbamer et al., 2003). In areas where the fertilisation was less pronounced, the evidence of sheep-browsing and grazing was still extensive. Zones IV and VI were most obviously shaped by the grazing, favouring *Poaceae*, limiting palatable species and preventing the regrowth of *Pinus mugo*. Even in the rockier zones where grazing intensity was apparently lower, the local abundance of *Aconitum tauricum* was suggestive of fertilisation. Fertilisation around camp sites was also apparent.

Inputs of nitrogen from domestic animals and people are by no means the only sources of fertilisation in the mountains (Nagy, 2003). Detailed studies of plant competition at high altitudes have shown a decline in *Bryophyta* with an associated spread of *Poaceae*, which has been linked to atmospheric N deposition (Baddeley et al., 1994). A national study of an upland grassland community of the alliance *Violion caninae* (*Nardetalia strictae*) clearly showed a reduction in species diversity related to the level of atmospheric N deposition (Stevens et al., 2004). Such extensive background fertilisation of the landscape makes nutrient-poor sites such as the Zănoaga area even more vulnerable to nutrient input from stock and humans.

The impact of camping and trekking appeared more restricted in the Zănoaga-Judele area, and most visitors remained on the marked trails, with consequent trampling and local erosion confined to the path and its marginal strips. Some campers at Zănoaga were less disciplined in their use of the site and the lake, and required advice and guidance to ensure that there was no adverse environmental impact (Salvamont staff, pers. comm.). The addition of a Salvamont refuge in late 2002 has allowed some control of such damaging activity, although it is acknowledged that more rangers are needed to provide the supervision and, where necessary, enforcement of park rules. Trampling does alter the species composition of the sward, favouring some species at light to medium intensities (for example *Poaceae* at the expense of *Bryophyta*), but causing sward death at high impact levels (Nagy, 2003). The reconnaissance survey of the vegetation ranged very widely over the Zănoaga-Judele area, but did not suggest that there was a litter problem away from the trails.

Reviewing those environmental conditions that determine the character of montane vegetation (Körner, 2003), it is possible to predict a number of present and potential threats to the mountain flora of the Retezat. Changes in climate leading to shorter winters will affect the competitive balance of some communities. Increased organic content of the soil (resulting from fertilisation and higher productivity) combined with higher nutrient levels will favour competitive and even ruderal species but disadvantage stress-tolerators (Grime, 1979). Much higher populations of larger mammals than are normal at high altitudes will cause mechanical damage. Finally, the presence of people on most days throughout the summer months will have impacts not only on soil nutrients and trampling of vegetation, but also affect those wild mammals and birds that are intolerant of disturbance.

CONCLUSION

Assessment of the sites and recomandations

The evidence of such a brief visit cannot be used alone to provide adequate management prescriptions. However, there is sufficient evidence of over-grazing and excessive nutrient inputs to register concern. Observations of other parts of the Romanian Carpathians, as well as discussion with the managers of protected areas allow some preliminary suggestions to be made. In addition, the renewed programmes of survey, monitoring and research from 2000 onward are now sufficiently advanced so as to inform the management of the national parks (e.g. Mountford et al., in press). The vegetation survey (Mountford, 2002) made four recommendations for targeted research to help answer the key issues of stock and visitor management in the higher mountains of the Retezat:

I. The extent of *Senecioni-Rumicetum alpinii* should be assessed at a range of sites in the Retezat National Park (and elsewhere in the Romanian Carpathians), and compared with quantitative data on the number of visitors and the number of sheep grazing days.

II. From this comparison, a correlation could be made between the extent of degraded habitat and sheep population. This could be used to help set a threshold level for stock numbers, above which grazing flocks might be diverted to other sites.

III. A similar exercise comparing site degradation with human visitor numbers could be conducted, and multivariate analysis used to assess the relative impact of people and domestic stock on the vegetation. Should the results suggest damage from visitors, then some diversion of visitors away from areas perceived as sensitive to less vulnerable sites could be necessary.

IV. Some monitoring of the Zănoaga-Judele site (and comparable alpine areas) is desirable in order to map whether the degraded habitats are spreading, contracting or stable, and to assess the success of any nature conservation management that is applied following the results of the studies I - III.

The Zănoaga-Judele site is very representative of the higher portions of the Retezat National Park (and similar siliceous parts of the Romanian Carpathians), and its biodiversity quality is comparable with adjacent parts of the Gemenele Scientific Reserve. However, there is a lack of geological variety and little evidence that the Zănoaga-Judele site holds any unique habitats that merit special nature conservation attention i.e. that are absent elsewhere in the National Park. In addition the use of the site by domestic animals and tourists makes the area vulnerable to change. Thus, the present paper suggests that the Zănoaga-Judele area be the subject of applied research on the impact of stock-grazing and trekking, using the Gemenele Scientific Reserve as a control.

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Appendix 1 Corresponding taxonomy - Ciocârlan (2000) and Tutin et al. (1964 - 1980)

Ciocârlan	Tutin et al.
Aconitum tauricum	*Aconitum napellus* ssp. *tauricum*
Campanula abietina	*Campanula patula* ssp *abietina*
Campanula kladniana	*Campanula rotundifolia* ssp *kladniana*
Centaurea pseudophrygia ssp *ratezatensis*	*Centaurea phrygia* ssp *ratezatensis*
Festuca supina	*Festuca airoides*
Juncus alpinoarticulatus	*Juncus alpinus*
Juniperus sibirica	*Juniperus communis* ssp *alpina*
Senecio carniolicus	*Senecio incanus* ssp *carniolicus*
Senecio glaberrimus	*Senecio doronicum*
Silene vulgaris ssp *glareosa*	*Silene uniflora* ssp *glareosa*
Tanacetum alpinum	*Leucanthemopsis alpina*
Vaccinium gaultherioides	*Vaccinium uliginosum* ssp *microphyllum*

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RETEZAT MOUNTAINS (ROMANIA) GLACIAL LAKES ZOOPLANKTON BIODIVERSITY

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, freshwater, glacial lakes, zooplankton, diversity, density, biomass.

ABSTRACT

Zooplankton diversity was studied in some glacial lakes of the Retezat Mountains (Pietrele, Tăul din Valea Rea 1, Stânişoara, Lia, Ţapului, Bucura, Galeşul, Zănoaga) and a pool - Tăul dintre Brazi. Only holoplanktonic species belonging to Rotatoria (seven taxa), Cladocera (three) and Copepoda - Cyclopoida (two) were found. Seven of them (*Rotaria* sp., *Keratella quadrata*, *Lecane crenata, Trichocerca insignis, Polyarthra dolichoptera, Synchaeta pectinata* between Rotifers and the Cladoceran *Alona quadrangularis*) are reported for the first time from Retezat. The highest zooplankton species richness was found in Bucura and Ţapului lakes. The Cladoceran *Chydorus sphaericus* was the characteristic taxa for the studied lakes. The zooplanktonic density ranged between 480 individuals on m^{-3} in Zănoaga Lake and 24,280 individuals on m^{-3} in Pietrele Lake, the biomass between 3,874 mg on m^{-3} in Bucura Lake and 216,622 mg on m^{-3} in Pietrele Lake.

RÉSUMÉ: La biodiversité du zooplancton des lacs glaciaires des Montagnes Retezat.

Le papier présente des données concernant la biodiversité du zooplancton des certaines lacs glaciaires des Montagnes Retezat (les Lacs Pietrele, Tăul din Valea Rea 1, Stânişoara, Lia, Ţapului, Bucura, Galeşul, Zănoaga) et de l'étang marécageux Tăul dintre Brazi. on a trouvé seulement des espèces holoplanctoniques appartenant aux Rotifères (sept espèces), aux Cladocères (troi) et aux Copépodes cyclopoides (deux). Sept d'entre eux (*Rotaria* sp., *Keratella quadrata*, *Lecane crenata, Trichocerca insignis, Polyarthra dolichoptera, Synchaeta pectinata* parmi les Rotifères et le Cladocère *Alona quadrangularis*) sont pour la première fois citées dans les basins du Retezat. La plus remarquable biodiversité est celle des lacs Bucura et Ţapului, tandis que, le plus petit nombre des espèces - dans le lac Tăul din Valea Rea 1. Selon les valeurs de l'indice de signifiance écologiques, *Chydorus sphaericus* peut être considérée l'espèces caractéristique du zooplancton des lacs glaciaires du Retezat. La densité a variée entre 480 ex m^{-3}dans le Lac Zănoaga et 24.280 ex m^{-3} dans le Lac Pietrele**,** et la biomasse entre 3.874 mg m^{-3} dans le Lac Bucura et 216.622 mg m^{-3} dans le Lac Pietrele.

REZUMAT: Biodiversitatea zooplanctonului în lacurile glaciare din Munţii Retezat.

Diversitatea zooplanctonului a fost studiată în unele lacuri glaciare din Retezat (Pietrele, Tăul din Valea Rea 1, Stânişoara, Lia, Ţapului, Bucura, Galeşul, Zănoaga) şi în Tăul dintre Brazi. S-au găsit doar specii holoplanctonice aparţinând la Rotatoria (şapte taxoni), Cladocera (trei) şi Copepoda - Cyclopoida (doi). Şapte dintre ele (*Rotaria* sp., *Keratella quadrata*, *Lecane crenata, Trichocerca insignis, Polyarthra dolichoptera, Synchaeta pectinata* dintre rotifere şi cladocerul *Alona quadrangularis*) sunt prima dată semnalate în Retezat. Cel mai ridicat număr de specii a fost găsit în lacurile Bucura şi Ţapului. Cladocerul *Chydorus sphaericus* a fost taxonul caracteristic pentru lacurile studiate. Densitatea zooplanctonului variază între 480 indivizi pe m^{-3} în Lacul Zănoaga şi 24.280 în Lacul Pietrele, biomasa între 3.874 mg pe m^{-3} în Lacul Bucura şi 216.622 în Lacul Pietrele.

INTRODUCTION

Retezat National Park, located in the western part of Romania, is the oldest national park, being established by law in 1935. The park has a surface area of 38.047 ha, of which 1.630 ha have been declared as strictly protected area called "Gemenele". The largest single area of pristine mixed forest in Europe covers the lower levels of the strictly protected area. The Man and Biosphere Program of UNESCO recognised the universal value of the park in 1979 through its inclusion in the international network of biosphere reserves. The glacial and cryonival relief are extremely widespread, allowing lakes to form in the deeper parts of the moraines (Schreiber and Sorocovschi, 1992). A number of 58 permanent glacial lakes and an almost equal number of temporary lakes are recorded between 1700 - 2300 m (Pişotă, 1971).

The literature dedicated to the fauna identified in the Retezat Mountains glacial lakes is rather poor compared with that dedicated to the terrestrial ecosystems. The first papers were published by Daday (1883, 1885, 1893), Szilady (1900) and Gebhardt (1932) (cited by Negrea, 1962 and Tittizer, 1968). They focused on zooplanktonic crustaceans from the most important lakes in Retezat (Zănoaga, Tăul Negru and Gemenele). Codreanu (1956) describes Tricladida and Botoşăneanu (1959) Trichoptera larvae from some glacial lakes. Later, Vasiliu (1964) presents the results from his hydrological studies of Retezat Mountain's glacial lakes and Tittizer (1968) studied Zănoaga Lake, giving dates concerning the zooplankton. The team Prunescu-Arion and Toniuc (1967) contributed with the study of Gemenele and Tăul Negru lakes, also making remarks on the zooplankton. Mack-Firă and Onciu (1973) collected data on turbellarian fauna from six lakes, adding three new taxa to the knowledges about Romanian fauna. Godeanu (1974) provides a detailed description of the Gemenele Lake and marsh.

Alpine lakes, due to their isolation, are good indicators of global changes and their monitoring is highly recommended. The lakes from Retezat proved to be some of the most pristine in Europe (Curtis et al., 2005). In the present study we decided to provide additional information on the status of zooplankton communities in alpine lakes from Retezat National Park and detect changes in species richness.

MATERIALS AND METHODS

The quantitative samples were obtained in summer 2000, between 5 and 14 August. Eight glacial lakes were studied: Stânişoara, Pietrele, Tăul din Valea Rea 1, Lia, Ţapului, Bucura, Galeşul, Zănoaga and a pool - Tăul dintre Brazi (Tab. 1).

Table 1: Geographic and hydrographic parameters of some basins from Retezat Mountains (Pişotă, 1971).

Lake	Catchment basin	Geographical coordonates	Altitude (m)	Depth (m)	Volume (m)	Perimeter (m)	Area (ha)
Ţapului	Bărbat River	N 45.3769 E 22.9257	2160	5.9	65,506.0	648	2.3
Zănoaga	Râul Mare River	N 45.3467 E 22.8238	1997	29	693,152.0	975	6.5
Lia	Râul Mare River	N 45.3530 E 22.8787	1910	4.3	15,926.0	512	1.3
Pietrele	Râul Mare River	N 45.3765 E 33.8838	2070	0.9	1,250.0	275	0.4
Bucura	Râul Mare River	N 45.3624 E 22.8765	2041	15.7	625,096.0	1390	8.8
Stânişoara	Râul Mare River	N 45.3758 E 22.8628	1990	0.8	2,199.5	450	1.0
Tăul Valea Rea 1	Râul Mare River	N 45.3756 E 22.9066	2220	4.1	14,840.0	380	0.7
Galeşul	Nucşoara River	N 45.3870 E 22.9111	2040	20.5	378,420.0	818	3.7
Tăul dintre Brazi	Râul Mare River	N 45.3977 E 22.9020	2100	1.0	-	-	0.1

A quantity of 50 or 100 l of littoral water from each lake was filtered through a silk net with mesh size of 90 μm. The samples were preserved immediately with 40% formaldehyde solution to reach a 4% final concentration.

The samples were examined with a Nikon - SMZ-2T - stereomicroscope and a Nikon Alphaphot - 2YS2 type microscope.

The quantitative data are presented as density (number of individuals per cubic meter - ind/m^{-3}) and biomass (wet weight, in mg/m^{-3}).

For the species identification we used several identification guides: Damian-Georgescu (1963, 1996), Dussart and Defaye (1995), Harding and Smith (1974), Kiefer (1960), Negrea (1983), Nogrady et al. (1993) and Rudescu (1960). Calculated analytical and synthetical indices were used to observe relationships characterising zooplanktonic taxa and the hierarchy established between them. (Gomoiu and Skolka, 2001).

RESULTS AND DISCUSSIONS

In these studied aquatic basins, only 12 holoplanktonic species are present in the zooplankton group. Seven of this species are Rotatoria, belonging to two orders: Bdelloidea and Ploima, and five crustaceans, of which three Cladocera taxa and two Cyclopoida taxa (Tab. 2).

Table 2: Species diversity and quantitative data (D - density = ind/m^{-3} and B - biomass = mg/m^{-3}) of the zooplankton in some aquatic basins from Retezat, in August 2000.

Lake / pool Species		Țapului	Zănoaga	Lia	Pietrele	Bucura	Stânișoara	Valea Rea 1	Galeșul	Tăul dintre Brazi
Primary consumers										
Rotatoria	D	180	80	40	40	740	-	-	-	-
	B	0.25	0.10	0.39	0.06	0.97	-	-	-	-
Order Bdelloidea										
Rotaria sp.	D	-	-	20	-	-	-	-	-	-
	B	-	-	0.34	-	-	-	-	-	-
Order Ploima										
Keratella quadrata	D	-	-	-	-	10	-	-	-	-
	B	-	-	-	-	0.01	-	-	-	-
Lecane luna	D	40	-	20	-	-	-	-	-	-
	B	0.09	-	0.05	-	-	-	-	-	-
Lecane crenata	D	20	-	-	-	10	-	-	-	-
	B	0.05	-	-	-	0.02	-	-	-	-
Trichocerca insignis	D	-	-	-	10	-	-	-	-	-
	B	-	-	-	0.02	-	-	-	-	-
Polyarthra dolichoptera	D	40	-	-	-	-	-	-	-	-
	B	0.01	-	-	-	-	-	-	-	-
Synchaeta pectinata	D	80	80	-	30	720	-	-	-	-
	B	0.10	0.10	-	0.04	0.94	-	-	-	-
Crustacea										
Order Cladocera	D	680	200	1220	24040	170	12400	5000	11060	15600
	B	7.68	4.14	10.98	216.36	2.31	111.6	45.00	99.54	183.33
Daphnia longispina	D	40	60	-	-	20	-	-	-	1100
	B	1.92	2.88	-	-	0.96	-	-	-	52.80
Chydorus sphaericus	D	600	140	320	22240	120	5000	600	11000	11800
	B	5.40	1.26	2.88	200.16	1.08	45.00	5.40	99.00	106.20
Alona quadrangularis	D	40	-	900	1800	30	7400	4400	60	2700
	B	0.36	-	8.10	16.20	0.27	66.60	39.60	0.54	24.30

Order Cyclopoida	D	1760	200	120	200	280	400	-	480	3460
	B	1.81	0.56	0.12	0.20	0.59	0.88	-	3.10	7.13
Nauplia varia	D	1720	-	120	200	120	-	-	-	1000
	B	1.72	-	0.12	0.20	0.12	-	-	-	1.00
Copepodits (C1)	D	40	40	-	-	140	400	-	140	2300
	B	0.09	0.09	-	-	0.31	0.88	-	0.31	5.06
Secondary consumers										
Eucyclops serrulatus	D	-	-	-	-	20	-	-	340	100
	B	-	-	-	-	0.16	-	-	2.79	0.82
Copepodits (C 2)	-	-	-	-	-	20	-	-	300	60
female	-	-	-	-	-	-	-	-	40	20
male	-	-	-	-	-	-	-	-	-	20
Cyclops rubens	D	-	160	-	-	-	-	-	-	60
	B	-	0.47	-	-	-	-	-	-	0.25
Copepodits (C 2)	-	-	140	-	-	-	-	-	-	40
Female	-	-	20	-	-	-	-	-	-	20
Male	-	-		-	-	-	-	-	-	-
Total	D	2620	480	1380	24280	1190	12800	5000	11540	19060
	B	9.74	4.80	11.49	216.62	3.87	112.48	45.00	102.64	190.46

The organisms found are, generally, ubiquitous and resistant. Rotifers are efficient filter feeders, straining planktonic alga, but also particles of organic matter. *Keratella quadrata, Lecane luna* are common in freshwater ecosystems, *Lecane crenata* is euplanktonic, living in the littoral zone of large lakes. *Trichocerca insignis* prefers cold waters and resists also in the acid waters of swamps. *Polyarthra dolichoptera* is a small Rotifer, well adapted both to float (due to its six characteristic extensions) and to survive in zones with a harsh climate due to its overwintering resting eggs a twofold cover, the distance between strata being maintained by forked sclera (Nogrady et al.; 1993, Rudescu, 1960).

Cladocera (*Daphnia longispina, Chydorus sphaericus* and *Alona quadrangularis*) are also primary consumers, predominantly herbivorous, but can consume organic debris including bacterial clumps. Like Rotatoria, they are parthenogenic and during summer realise remarkable densities (Negrea, 1983).

Only two Cyclopoida copepod taxa are present in the studied glacial lakes from Retezat (*Eucyclops serrulatus serrulatus* and *Cyclops rubens*). The adults are considered omnivorous, having a facultative predaceous feeding (Dussart and Defaye, 1995, Kiefer, 1960).

The highest number of zooplankton species was found in Bucura and Ţapului lakes, the deepest among the studied lakes and both with rich allochthonous detritus supply. The opposite situation was in Valea Rea 1 Lake, a smaller lake, situated at the highest altitude where only two Cladocera species (*Chydorus sphaericus* and *Alona quadrangularis*) were present (Fig. 1).

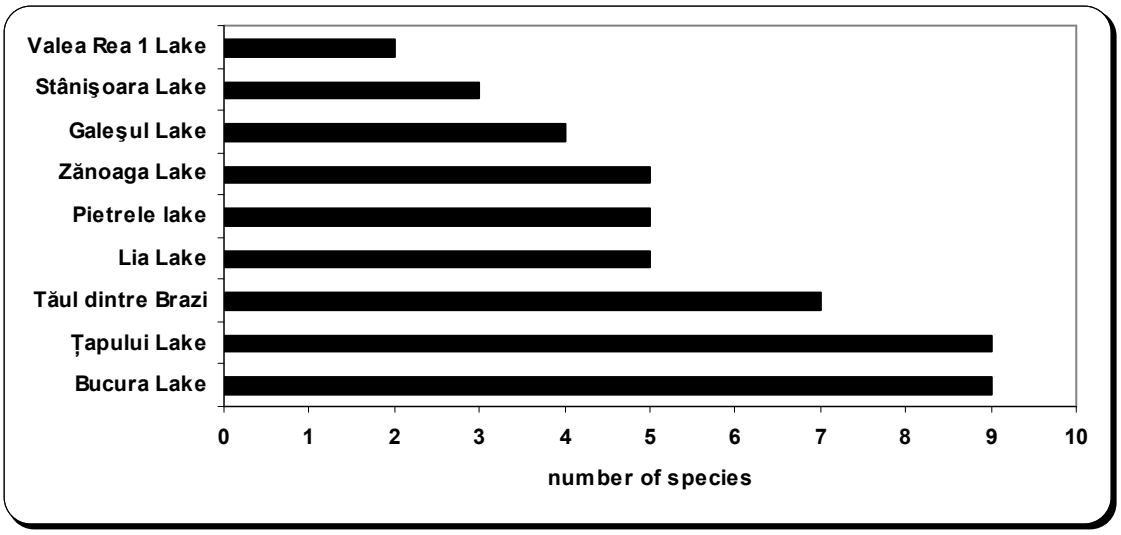

Fig. 1: Zooplankton species number identified in August 2000 in some lakes from Retezat.

The zooplanktonic taxa richness is linked to the lake's area. The number of species increased in accordance with the lake's surface (Fig. 2). A particular situation, (i.e. a greater number of taxa in a rather small lake) is in Pietrele Lake, which is permanently enriched with water and detritus inflows. The species diversity from Ţapului Lake (nine species) is higher than in Galeşul Lake (four taxa), even if the latter water surface is higher. The same situation can be observed also in Bucura and Zănoaga Lakes, in which the number of zooplanktonic species is not correlated with the lake's surface. The above mentioned basins are very deep and the existence of a vertical stratification (epilimnion, metalimnion and hypolimnion) could explain the lack of harmony between the lake's area and the species diversity.

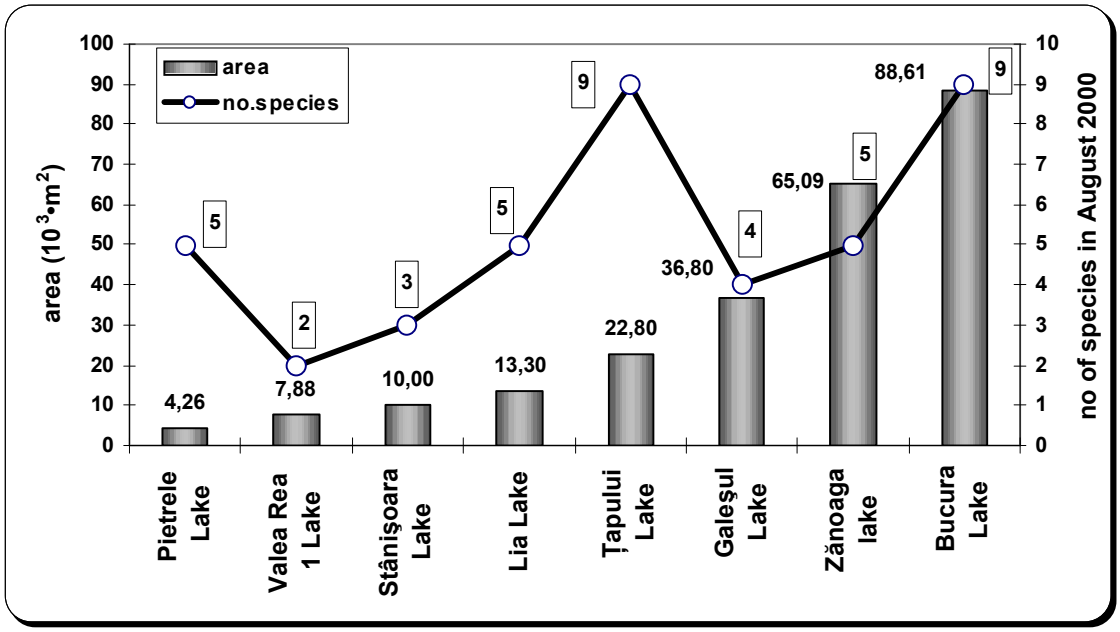

Fig. 2: Area and zooplanktonic species diversity characterising some lakes from Retezat.

Tittizer (1968) describes Zănoaga Lake, stating that he found two species of zooplankton (*Chydorus sphaericus* and *Alona affinis*) and ephippia from *Daphnia longispina.* Studying other lakes (Tăul Negru and Gemenele), Prunescu-Arion and Toniuc (1967) have mentioned nine species for each lake.

Table 3: Quantitative and qualitative structure of the zooplankton communities from some glacial lakes from Retezat (August, 2000).

Organisms	%	D_{med}	D_{eco}	D_D%	D_D %	Rk_D	B_{med}	B_{eco}	D_B%	W_B	Rk_B
		Ind m^{-3}					mg m^{-3}				
Primary consumers											
Keratella quadrata	11	1.1	10.00	0.01	0.38	13	0.00	0.01	0.00	0.14	13
Lecane crenata	22	3.3	15.00	0.04	0.92	10	0.01	0.03	0.01	0.47	11
Lecane luna	22	6.7	30.00	0.08	1.30	9	0.02	0.07	0.02	0.66	10
Polyarthra dolichoptera	11	4.4	40.00	0.05	0.75	11	0.00	0.01	0.00	0.14	14
Rotaria sp.	11	2.2	20.00	0.03	0.53	12	0.04	0.34	0.05	0.74	9
Synchaeta pectinata	44	101.1	227.5	1.16	7.18	6	0.13	0.30	0.17	2.75	7
Trichocerca insignis	11	1.1	10.00	0.01	0.38	14	0.00	0.02	0.00	0.19	12
Alona quadrangularis	89	1925.6	2166.3	22.12	44.34	2	17.33	19.50	22.37	44.60	2
Chydorus sphaericus	100	5757.8	5757.8	66.14	81.33	1	51.82	51.82	66.91	81.80	1
Daphnia longispina	44	135.6	305.0	1.56	8.32	5	6.51	14.64	8.40	19.32	3
Cyclopoida - nauplia	56	351.1	632.0	4.03	14.97	4	0.35	0.63	0.45	5.02	5
Cyclopoida copepodits (C1)	67	340.0	510.0	3.91	16.14	3	0.75	1.12	0.97	8.02	4
Secondary consumers											
Cyclops rubens	22	24.4	110.0	0.28	2.50	8	0.08	0.36	0.10	1.52	8
Eucyclops serrulatus	33	51.1	153.3	0.59	4.42	7	0.42	1.26	0.54	4.25	6
Rotatoria		120.0		1.38	-	-	0.20	-	0.26	-	-
Cladocera	7818.9	-	89.81	-	-	75.66		97.68	-	-	-
Cyclopoida		766.7		8.81	-	-	1.60	-	2.06	-	-
Total	8705.6	-	100	-	-	77.45		100	-	-	-

The density ranged between 480 ind/m^{-3} in Zănoaga Lake and 24,280 ind/m^{-3} in Pietrele Lake, with comparable values in Stânişoara Lake (12,800 ind/m^{-3}) and Galeşul Lake (11,540 ind/m^{-3}) (Tab. 2). Cladocera represent more than 90%, for instance: 99.01% in Pietrele Lake (*Chydorus sphaericus* with a participation of 91.59%, respectively 7.42% *Alona quadrangularis*), 95.84% in Galeşul Lake (of which 95.32% is *Chydorus sphaericus*), respectively 96.87% in Stânişoara Lake (of which 39.06% *Chydorus sphaericus* and 57.81% *Alona quadrangularis*). The summer density peak of Cladocera is reflected also in the biomass values. The lowest were calculated in Bucura Lake (3.87 mg/m^{-3}) and the highest (56 times higher), in Pietrele Lake (216.62 mg/m^{-3}) (Tab. 2).

Using values of ecologically significant indices based on density (W_D) and biomass values of zooplankters (W_B) (Tab. 3), the Cladoceran *Chydorus sphaericus* (W_D = 81.33; W_B = 81.80) appears to be the characteristic zooplanktonic taxa for the lakes from Retezat. It is associated with *Alona quadrangularis*, *Daphnia longispina* and the first ontogenetic stages of the Cyclopoida copepods.

Comparing our data with the published data (Tab. 4), several observations can be made:

- until 2000, (in more than a century of research), 77 taxa were inventoried, of which 49 species of Rotatoria (63.64%), 17 species to Cladocera (22.08%) and 11 to Copepoda (14.28%), Cyclopoida represents 10.39% and Calanoida 3.89%;
- the highest number of Rotatoria taxa (43) were determined by Godeanu (1974) only in Gemenele Lake and marsh, where another Cyclopoida taxa (*Acanthocyclops crassicaudis*) was observed, so that the number of zooplanktonic species strictly speaking identified in the glacial lakes from Retezat Mountains is only 33;
- the present study adds to the list of zooplanktonic species from glacial lakes seven new taxa for Retezat (six Rotatoria and one Cladocera).

Table 4: Taxonomical data concerning the zooplankton in lakes from Retezat.

Crt. no.	Species	Author	Lake
	Rotatoria		
1.	*Adinetta gracilis*	Godeanu, 1974	Gemenele lake and marsh
2.	*Adineta vaga*		
3.	*Cephalodella catelina*		
4.	*Cephalodella gibba*		
5.	*Cephalodella sterea*		
6.	*Cephalodella* sp.		
7.	*Collotheca* sp.		
8.	*Colurella colurus*		
9.	*Colurella gastracantha*		
10.	*Colurella obtusa*		
11.	*Elosa woralli*		
12.	*Habrotrocha angusticollis*		
13.	*Habrotrocha bidens*		
14.	*Habrotrocha lata*		
15.	*Habrotrocha roeperi*		
16.	*Habrotrocha* sp.		
17.	*Keratella hiemalis*	Prunescu-Arion and Toniuc, 1967	Tăul Negru
18.	*Keratella quadrata*	present paper	Pietrele

19.	*Keratella tropica*	Prunescu-Arion and Toniuc, 1967	Gemenele
20.	*Lecane acus*	Godeanu, 1974	Gemenele lake and marsh
21.	*Lecane arcuata*		
22.	*Lecane closterocerca*		
23.	*Lecane crenata*	present paper	Țapului, Bucura
24.	*Lecane elegans*	Godeanu, 1974	Gemenele lake and marsh
25.	*Lecane elongata*		
26.	*Lecane flexilis*		
27.	*Lecane furcata*		
28.	*Lecane lauterboni*		
29.	*Lecane luna*	Godeanu, 1974 present paper	Gemenele lake and marsh, Țapului, Lia
30.	*Lecane lunaris*	Godeanu, 1974	Gemenele lake and marsh
31.	*Lecane monostyla*		
32.	*Lecane scutata*		
33.	*Lepadella acuminata*		
34.	*Lepadella costata*		
35.	*Lepadella patela*		
36.	*Lepadella* sp.		
37.	*Lepadella ovalis*	Prunescu-Arion and Toniuc, 1967	Gemenele
38.	*Macrotrochela quadricornifera*	Godeanu, 1974	Gemenele lake and marsh
39.	*Macrotrochela* sp.		
40.	*Mytilina bicarinata*	Godeanu, 1974	Gemenele lake and marsh
41.	*Notommata pseudocerberus*		
42.	*Philodina citrina*	Godeanu, 1974	Gemenele lake and marsh
43.	*Proalinopsis caudatus*		
44.	*Polyarthra dolichoptera*	present paper	Țapului
45.	*Polyarthra remata*	Prunescu-Arion and Toniuc, 1967	Gemenele
46.	*Rotaria elongata*	Godeanu, 1974	Gemenele lake and marsh
47.	*Rotaria rotatoria*		
48.	*Rotaria* sp.	present paper	Lia
49.	*Squatinella microdactyla*	Godeanu, 1974	Gemenele lake and marsh
50.	*Squatinella microps*		
51.	*Synchaeta pectinata*	present paper	Țapului, Pietrele, Bucura, Zănoaga
52.	*Synchaeta tremula*	Prunescu-Arion and Toniuc, 1967	Gemenele, Tăul Negru
53.	*Testudinella parva*	Godeanu, 1974	Gemenele lake and marsh
54.	*Trichotria tetractis*		
55.	*Trichocerca insignis*	present paper	Pietrele
	Cladocera		
56.	*Alona quadrangularis*	present paper	Stânișoara, Pietrele, Tăul dintre Brazi, Lia, Valea Rea, Bucura, Țapului, Galeșul, Zănoaga

57.	*Alona rectangula*	Negrea, 1962	different lakes
58.	*Biapertura (Alona) affinis*	Prunescu-Arion and Toniuc, 1967 Tittizier, 1968 Negrea, 1962, 1983	Tăul Negru, Zănoaga, Gemenele, Zănoaga, Tăul Negru, Bucura, Galeşul, Stânişoara, Zănoaga
59.	*Camptocercus lilljeborgi*	Negrea, 1962 Daday, 1885, 1897	Gemenele, Tăul Negru
60.	*Chydorus sphaericus*	Prunescu-Arion and Toniuc, 1967 Tittizer, 1968 Godeanu, 1974 Negrea, 1983 present paper	Tăul Negru, Gemenele, Zănoaga, Gemenele Pool, Zănoaga, Bucura, Galeşul, Judele, Iezer, Stânişoara, Tăul Negru Stânişoara, Pietrele, Tăul dintre Brazi, Valea Rea 1, Lia, Ţapului, Bucura, Galeşul, Zănoaga
61.	*Chydorus globosus*	Szilady, 1900 Negrea, 1962	Zănoaga Zănoaga, Păpuşa, Iezer
62.	*Chydorus ovalis*	Negrea, 1983	Galeşul
63.	*Daphnia hyaline* var. *lacustris*	Daday, 1883 Negrea, 1962	Gemenele, Bucura, Tăul Negru, different lakes
64.	*Daphnia longispina*	Prunescu-Arion and Toniuc, 1967 Tittizer, 1968 Negrea, 1962 Daday, 1883 present paper	Gemenele, Tăul Negru, Zănoaga, different lakes, Bucura, Zănoaga, Tăul dintre Brazi, Ţapului, Bucura, Zănoaga
65.	*Daphnia longispina* var. *caudata*	Szilady, 1900 Negrea, 1962	Zănoaga
66.	*Daphnia longispina* var. *leydigi*	Szilady, 1900 Negrea, 1962	Zănoaga Zănoaga, Stânişoara, Bucura, Tăul Negru, Judele, Peleaga, Gemenele
67.	*Daphnia magna*	Daday, 1883 Negrea, 1962, 1983	Gemenele, different lakes
68.	*Daphnia obtuse*	Godeanu, 1974 Negrea, 1983	Gemenele lake and marsh Gemenele Pool, plash near Zănoaga
69.	*Daphnia pulex* var. *obtusa*	Daday, 1883 Negrea, 1962	different lakes
70.	*Daphnia pulex* var. *schoedleri*	Negrea, 1962	different lakes
71.	*Daphnia rosea*	Negrea, 1983	Zănoaga, Bucura, Galeşul, Viorica, Tăul Negru
72.	*Daphnia zschokkei*	Negrea, 1962	Judele
73.	*Leydigia leydigi*	Negrea, 1962 Daday, 1885, 1897	Gemenele, Tăul Negru
	Cyclopoida		
74.	*Acanthocyclops crassicaudis*	Godeanu, 1974	Gemenele lake and marsh
75.	*Acanthocyclops bicuspidatus*	Prunescu-Arion and Toniuc, 1967	Tăul Negru

76.	*Acanthocyclops vernalis*	Gebhardt, 1932 Godeanu, 1974	Zănoaga Gemenele lake and marsh
77.	*Acanthocyclops viridis*	Damian-Georgescu, 1963	different lakes
78.	*Eucyclops serrulatus*	Szilady, 1900 Gebhardt, 1932 Damian-Georgescu, 1963 Prunescu-Arion and Toniuc, 1967 Godeanu, 1974 present paper	Zănoaga Zănoaga, Bucura, Gemenele, Iezerul, Tăul Negru Gemenele, Tăul Negru Gemenele Pool Tăul dintre Brazi, Bucura, Galeşul
79.	*Cyclops rubens*	Tittizer, 1968 Damian-Georgescu, 1963 present paper	Zănoaga, Bucura, Gemenele, Tăul Negru, Zănoaga, Tăul dintre Brazi
80.	*Cyclops scutifer*	Prunescu-Arion and Toniuc, 1967	Tăul Negru, Zănoaga
81.	*Paracyclops affinis*	Damian-Georgescu, 1963	Different lakes
	Calanoida		
82.	*Arctodiaptomus bacillifer*	Prunescu-Arion and Toniuc, 1967	Tăul Negru
83.	*Diaptomus* sp.	Gebhardt, 1932	Zănoaga
84.	*Myxodiaptomus tartricus*	Damian-Georgescu, 1996	Zănoaga, Judele, Păpuşa, Gălbina, lake near Bucura

EVALUATION OF RESULTS

Based on the study of quantitative zooplankton samples, performed in August 2000, from eight glacial lakes (Stânişoara, Pietrele, Tăul din Valea Rea 1, Lia, Ţapului, Bucura, Galeşul and Zănoaga) and a pool - Tăul dintre Brazi in the Retezat Mountains and on the data offered by a quite poor literature concerning the aquatic basins from the mentioned mountains, have resulted some conclusions:

- the zooplankton consists of 12 holoplanktonic taxa belonging to Rotatoria (seven species), Cladocera (three species) and Cyclopoida Copepods (two species); all are ubiquitous, so none can be considered indicator species;

- seven of the 12 identified holoplanktonic taxa (*Rotaria* sp., *Keratella quadrata*, *Lecane crenata, Trichocerca insignis, Polyarthra dolichoptera, Synchaeta pectinata* between Rotifers and the Cladoceran *Alona quadrangularis*) are identified for the first time in the glacial lakes from Retezat; therefore the list of known zooplanktonic species from mentioned lakes counts 40 taxa, the number of identified species from all kind of aquatic basins from Retezat Mountains increasing to 84 taxa;

- excepting the deepest lakes, the species richness increases with the enlargement of the lake's surface;

- concerning the values of ecologically signifiant coefficients (W_D = 81.33; W_B = 81.80) the Cladoceran *Chydorus sphaericus* is the characteristic taxa from the glacial lakes; it is associated with *Alona quadrangularis*, *Daphnia longispina* and the first ontogenetic stages of the Cyclopoida copepods.

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THE DIVERSITY OF TRICLADIDS FAUNA (PLATYLMINTHES, TURBELLARIA) FROM RETEZAT NATIONAL PARK (ROMANIA)

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, tricladids, planarians, benthos, diversity.

ABSTRACT

This paper summarizes the results of a two year study (2003 - 2004, August) presenting data concerning the diversity of tricladids fauna from Retezat National Park. As a consequence of the examination of many samples collected from various aquatic biotops, 11 species of turbelarians were identified. The information presented in this paper represents an important contribution to the knowledge of the diversity of tricladids fauna from the Retezat Mountains, which till now are less studied in the aquatic ecosystems from this area, studies in this field being made only by Năstăsescu, Prunescu-Arion and Toniuc, and Godeanu.

RÉSUMÉ: La diversité de la faune de tricladide (Platelmintos, Turbelaria) du Parc National Retezat.

Le présent ouvrage synthétise les résultats d'un étude de deux ans (2003 - 3004, aoűt) en présentant des dates concernantes à la propagation des tricladide dans la Parc National Retezat. Par conséquent de l'examination de plusieurs preuves collectćes de divers biotopes aquatiques, ent été identifićes 11 espéces de turbelariate. Les informations présentćes dans cet ouvrage représentent une importante contribution pour la connaxssance de la diversité des tricladide du Massive Retezat, moins étudiécs au noveau des ecosistèmes aquatiques de cette région, des recherches dans ce sens étant faites seulement dans les Năstăsescu, Prunescu - Arion et Toniuc, et Godeanu.

REZUMAT: Diversitatea faunei de tricladide (Plathelminthes, Turbellaria) din Parcul Național Retezat.

Lucrarea de față sintetizează rezultatele unui studiu de doi ani (2003 - 2004, august) prezentând date referitoare la răspândirea tricladidelor în Parcul Național Retezat. Ca urmare a examinării mai multor probe colectate din diverse biotopuri acvatice, au fost identificate 11 specii de turbelariate. Informațiile prezentate în această lucrare reprezintă o contribuție importantă la cunoaşterea diversității tricladidelor din Masivul Retezat, mai puțin studiate la nivelul ecosistemelor acvatice din această zonă, cercetări în acest sens mai fiind făcute doar de Năstăsescu, Prunescu-Arion şi Toniuc, şi Godeanu.

INTRODUCTION

Tricladids represent one of the zoobenthonic groups, known as important indicators of fresh water due to their sensitivity to chemical factors (Radu and Radu, 1958).

These organisms are frequently found in alpine and sub alpine aquatic ecosystems. For the Retezat Mountains there were five species identified up to the present.

The aim of this work is to contribute to the knowledge of the diversity of fauna of tricladids from Retezat National Park.

MATERIALS AND METHODS

Qualitative samples of benthos were collected between 1 - 10 august 2003 - 2004 using a net with a mesh size of 360 µm. Samples were preserved in the field in 4% formaldehyde and after identification were stored in ethyl alcohol 70%, forming part of the authors collection. The material was identified under stereomicroscope using the works of following authors: Godeanu (2002), Brauer (1909), Mellanby (1963), Bellman et al. (1991), Udrescu and Chiriac (1965).

The following parameters were measured at each sampling site: water and air temperature, maxim and medium depth of water, substrate organization, width of the riverbed and grade of cover with riparian vegetation.

RESULTS AND DISCUSSIONS

After the investigation of the 34 rivers/springs and 20 lakes, 11 tricladids species from three families in the Tricladida order were identified: Family Bdellouridae - *Bdellocephala punctata*; Family Dendrocoelidae - *Dendrocoelum lacteum*; Family Dugesiidae - *Dugesia macrocephala, Dugesia gonocephala, Dugesia lugubris, Dugesia fusca, Phagocata albissima, Dugesia vitta, Dugesia torva, Dugesia polychroa, Dugesia alpina.* Nine out of the 11 species were identified for the first time in Retezat National Park. *Dugesia torva* and *Dugesia alpina* were mentioned in previous studies. After this study, *Bdellocephala punctata* and *Dugesia vitta* were identified for the first time in Romania. These results were established after collecting and determining 525 organisms.

The family with the highest number of species is the Dugesiidae family (nine species).

Until this study, in Retezat National Park only the following species had been identified: *Planaria torva* in Gemenele Lake and Negru Lake, *Dugesia* (syn. *Crenobia*) *alpina* in Gemenele Lake and Zanoaga Lake, *Dugesia gonocephala* in Gura Zlatna River, *Crenobia alpina montenegrina*in Gura Zlatna and *Fonticola* sp. in Gemenele Lake.

The study of these systems led us to conclusion that only 20 out of the 34 investigated rivers and brooks contained tricladids, and only two out of the 20 investigated lakes (Răsucit Lake and Peleaga Lake) contained tricladids. Although this study was based on qualitative data of the samples we collected, we noticed the fact that in Peleaga Lake just one tricladids was collected, and the sample collected from Răsucit Lake had 20 individuals. The samples that were collected from Peleaga Lake came out with the surprise finding of *Dugesia gonocephala* (one individual), although the literature presents this species as being specific to water with medium temperatures, at lower altitudes. *Dugesia gonocephala* was found at the altitude of 2122 m, and the water temperature was 15ºC.

The river with the biggest diversity of tricladids was Răsucit River (six species), followed by second brook tributary by left of Bucura River (five species).

The altitudinal limit at which tricladids were found was 2200 m.

CONCLUSIONS

54 stations were established on the rivers/brooks and lakes from Retezat National Park. 24 of them presented tricladids in their zoobenthonic community. Of these stations, 20 were located on rivers and brooks, and four on lakes.

11 species of tricladids were identified in rivers, brooks and lakes, with species belonging to three families: Bdellouridae, Dendrocoelidae and Dugesiidae. Of these families, the most representative one concerning the number of species is the Dugesiidae family (nine species).

Eight new species were identified for the first time in the fauna of the Retezat National Park.

Bdellocephala punctata, *Dugesia vitta*, *Dugesia macrocephala* and *Dugesia fusca* were identified for the first time as being part of the Romanian tricladids fauna.

Although this study was based on qualitative data, we could suggest the hypothesis that *Dugesia lugubris* (263 individuals collected) and *Dugesia fusca* (83 individuals collected) were the most representative species of tricladids from the Retezat National Park. *Dugesia macrocephala* (two individuals collected) and *Dugesia gonocephala* (two individuals collected) could be considered accidental for Retezat Mountains.

After the investigation into the tricladids environment, there is a preference for lotic systems over lentic ones. The only exception was Răsucit Lake where 23 individuals belonging to four species were identified.

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THE DIVERSITY OF CRUSTACEAN FAUNA (ARTHROPODA, CRUSTACEA) FROM RETEZAT NATIONAL PARK (ROMANIA)

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, fairy shrimp, amphipods, sowbugs, benthos, diversity.

ABSTRACT

Crustaceans from Retezat National Park, although less represented in terms of number of species, constitute an important chain in mountainous aquatic ecosystems because of the large number of individuals, taking part in matter recycling, and so ecosystem development. This paper presents the most recent data concerning the diversity of crustacean fauna, especially Branchiopoda (Phillopoda order) and Malacostraca (Amphipoda, Isopoda order) classes. Both lake and puddle ecosystems as well as the terrestrial ones were investigated during a two year period (2003 - 2004, august).

RÉSUMÉ: La diversité de la faune de crustacés (Arthropoda, Crustaceea) du Parc National Retezat.

Les crustacés du Parc National Retezat, quoique modiquement représentés comme nombre d'especes constituent un important anneau dans les ecosystèmes des habitats aquatiques montagneux résulté de leur nombre indiciblement grand comme individus, en contribuant à la reciclation de la matúre et ainn au developpement de l'ecosystème. Dans cet ouvrage sont présentées des dates récentes à l'égard de la diversité de la faune de crustacés, des classes Branchipoda (Ordre Phillopoda) et Malacostraca (Ordre Amphipoda). Ils ant été investigues tanť les ecosystèmes des lacs que ceux des ruisseaux durant deux annćes (2003 - 2004, aoűt).

REZUMAT: Diversitatea faunei de crustacee (Arthropoda, Crustaceea) din Parcul Naţional Retezat.

Crustaceele din Parcul Naţional Retezat, deşi modest reprezentate ca număr de specii constituie o verigă importantă în ecosistemele habitatelor acvatice montane rezultată din numărul lor deosebit de mare de indivizi, contribuind la reciclarea materiei şi astfel la dezvoltarea ecosistemului. În această lucrare sunt prezentate date recente cu privire la diversitatea faunei de crustacee, în special a claselor Branchipoda (ordinul Phillopoda) şi Malacostraca (ordinul Amphipoda, Isopoda). Au fost investigate atât ecosistemele lacurilor, ale pâraielor cât şi cele terestre pe o perioadă de doi ani (2003 - 2004, august).

INTRODUCTION

Crustaceans, invertebrates in the Arthropoda Phyllum, are almost exclusively aquatic organisms, populating marine habitats as well as fresh water ones.

These organisms are remarkable for the large number of individuals, being almost exclusively detritivores, they reincorporate decomposed organic matter into the biological circuit, therefore preventing energy loss. This earns them the title of „energy recoverers".

The study of surface water crustaceans reflects their spreading area and the quality of their habitat, but the subterrestrial amphipods give us information about the regional freatic system.

MATERIALS AND METHODS

Qualitative samples of benthos were collected between 1 - 10 august 2003 - 2004 using a net with a mesh size of 360 μm. The benthos samples were collected and stored in one mL Ependorf tubes. Samples were preserved in the field in 4% formaldehyde solution and after identification were stored in ethyl alcohol 70%, taking part from the authors collection.

The following parameters were measured at each sampling site: water and air temperature, maxim and medium depth of water, substrate organization, width of the riverbed and grade of cover with riparian vegetation.

The sampled biological material was identified using the paper works of the following authors: Brauer (1961), Botnariuc et al. (1953), Radu (1983) and Godeanu (2002).

During the two year period of study, permanent and temporary aquatic systems, glacial lakes, springs, brooks, puddles and tributaries were investigated, from Retezat National Park, except the NE area of Ţapului Lake - Custurii Lake.

RESULTS AND DISCUSSIONS

The investigation of the 38 rivers/springs and 32 lakes were made taking into account their geographic disposition, collecting more samples in the places where the relief presented habitat differences.

Information concerning the terrestrial sowbugs and fairy shrimps distributions from lakes and temporary puddles was obtained. The freatic amphipods collected at surface indicate the places where the freatic field approaches the surface.

Sowbugs were identified through the terrestrial species *Hyloniscus siculus* (Mehely, 1929), in Pietrele (1400 m) sprunce area.

In the following we present a brief description of fairy shrimps spreading area, with the identified species. In Bucura Valley we found fairy shrimps in the Agăţat Lake and in the lake from salvamount chalet, representatives being *Branchinecta orientalis* (G. O. Sars, 1901) and *Chirocephalus diaphanous* (Prevost, 1803) species. In the Lăpuşnicul Mare Valley we found fairy shrimps only in Lake Păpuşa I (upstream). In the Judele Mic Valley we found fairy shrimps only in Ascuns Lake, *Branchinecta orientalis*.

Concerning the amphipods, we identified a single species, *Niphargus carpaticus* (E. Dobrescu, C. Manolache, 1939), which lives in freatic waters. In Bucura Valley we found the same species in the spring that flows from Bucura II Peak into Bucura Lake, at 2047 m altitude. In Ştirbu Lake in the Gemenele Valley we found again the same species, at 2250 altitude. In Judelui Valley we found it in the springs that flow into Judele Lake (2135 m), Ascuns Lake (2200 m), Judele Mic Spring (2150 m) and Răsucit Lake (2100 m).

CONCLUSIONS

Sowbugs are represented by *Hyloniscus siculus* (Mehely, 1929) part of the Trichoniscidae Family.

The two species of fairy shrimp, *Branchinecta orientalis* (G. O. Sars, 1901), from the Branchinectidae Family, respectively *Chirocephalus diaphanous* (Prevost, 1803), from the Chirocephalidae Family, occupy a restricted area, in some glacial lakes from Bucura - Judele Valley, Agaţat Lake and Ascuns Lake, as well in cold lakes, Păpuşa I Lake and Bucura Lake.

Only freatic amphipods, *Niphargus carpaticus* (E. Dobrescu, C. Manolache, 1939) were identified at 2100 - 2200 m altitude, in different parts of Bucura - Judele Mountain, that certifies a high freatic activity under Bucura Gate, Judele Saddle and Sharp Edge.

AKNOWLEDGMENTS

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WATER MITES (ACARI, HYDRACHNIDIA) FROM THE RETEZAT NATIONAL PARK (ROMANIA)

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, water mites, Hydrachnidia, ecology, diversity.

ABSTRACT

The fauna of water mites (Acari, Hydrachnidia) was studied in the Retezat National Park (Romanian Carpathians). A total number of 800 specimens were collected in August 2001 and June 2002 at 48 sites (36 running water and 12 alpine lakes), including 24 species, of 12 genera and eight families. Five species (*Thyas palustris, Zschokkea oblonga, Lebertia dubia, Pionacercus leuckarti* and *Arrenurus zachariasi*) are new records for the Romanian fauna, two of them are also new for the Carpathian fauna (*Zschokkea oblonga* and *Arrenurus zachariasi*). The most frequent species, recorded at more then 20 sampling sites, are *Sperchon brevirostris, Sperchon thienemanni* and *Lebertia tuberosa*. The diversity, abundance and distribution habitat preference of the species are discussed. The studied lake- and stream-fauna are remarkable due to the high percentage of species in other areas found restricted to spring habitats (crenobionts).

ZUSAMMENFASSUNG: Wassermilben (Acari, Hydrachnidia) aus dem Retezat-Nationalpark (Karpathen, Rumänien).

Die Wassermilbenfauna (Acari, Hydrachnidia) des Retezat-Nationalparks (Rumänische Karpathen) wurde untersucht. Zwischen August 2001 and Juni 2002 wurden insgesamt 800 Exemplare von 48 Fundorten (36 Fließgewässer und 12 alpine Seen) gesammelt. Insgesamt 24 Arten aus 12 Gattungen und acht Familien wurden nachgewiesen, darunter fünf Neunachweise für die rumänische Fauna (*Thyas palustris, Zschokkea oblonga, Lebertia dubia, Pionacercus leuckarti* und *Arrenurus zachariasi*). Zwei dieser Arten, *Zschokkea oblonga* und *Arrenurus zachariasi*, wurden erstmals in den Karpathen gefunden. Die häufigsten, an mehr als 20 Untersuchungsstellen nachgewiesenen Arten sind *Sperchon brevirostris, Sperchon thienemanni* und *Lebertia tuberosa.* Die Diversiät, Häufigkeit und Habitatpräferenz der Arten wird diskutiert. Die untersuchte Fließ- und Stillgewässerfauna ist bemerknswert aufgrund des hohen Anteils von Arten, die in anderen Gebieten bislang ausschließlich in Quellen gefunden wurden (Krenobionten).

REZUMAT: Acarienii acvatici (Acari, Hydrachnidia) din Parcul Național Retezat (Munții Carpați, România).

Fauna de acarieni acvatici (Acari, Hydrachnidia) a fost studiată în Parcul Național Retezat (Carpați, România). Acarienii acvatici au fost prelevați în august 2001 şi iunie 2002 din 48 de stații (36 pe râuri şi 12 pe lacuri apline). Au fost colectați 800 de indivizi, fiind identificate 24 de specii care aparțin la 12 genuri şi opt familii. Cinci specii (*Thyas palustris*, *Zschokkea oblonga*, *Lebertia dubia*, *Pionacercus leuckarti* şi *Arrenurus zachariasi*) sunt semnalate pentru prima dată în România, iar două pentru prima dată în Carpați (*Zschokkea oblonga* şi *Arrenurus zachariasi*). Cele mai frecvente specii în această zonă, întâlnite în mai mult de 20 de stații sunt: *Sperchon brevirostris, Sperchon thienemanni* şi *Lebertia tuberosa*. Diversitatea, abundența şi distribuția acarienilor acvatici în diferite tipuri de habitate sunt discutate. Fauna lacurilor şi râurilor studiate se remarcă datorită procentului ridicat de specii care se găsesc în alte zone, strict în habitatele de izvoare (crenobionte).

INTRODUCTION

A huge amount of data concerning the diversity of water mites in Romania were obtained by Constantin Motaş and collaborators, but only two species of water mites were known so far from the Retezat Mountains, *Lebertia tuberosa,* found in Zănoaga River (Szalay, 1931) and *Hygrobates calliger* from Gemenele Lake (Prunescu-Arion and Toniuc, 1967). The main objective of this study is to provide information on the diversity of water mites (Acari, Hydrachnidia) in this area and to discuss ecological aspects of this fauna.

STUDY AREA, MATERIALS AND METHODS

The Retezat National Park is located in the western part of Romania (Fig. 1).

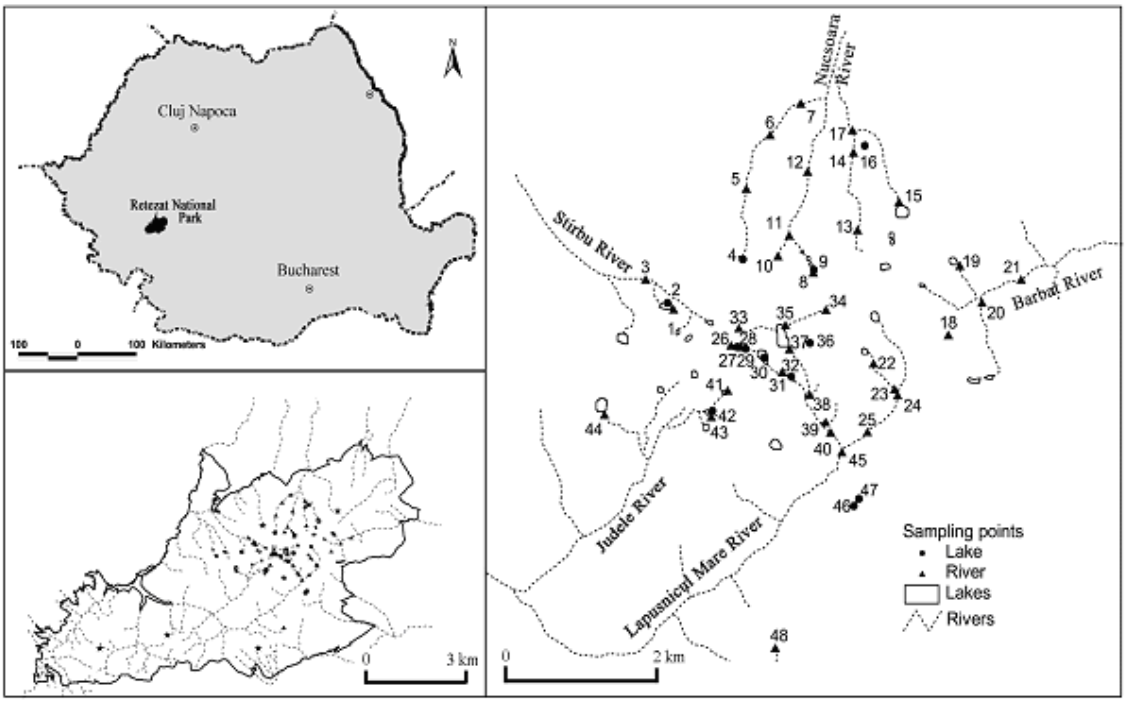

Fig. 1: The map of the Retezat National Park with the sampling sites localisation.

There are 48 sampling sites: 1 - Ştirbu River, upstream Gemenele Lake, 2 - Gemenele Lake, 3 - Ştirbu River, near Laboratory House, 4 - Stânişoara Lake and tributaries, 5 - Stânişoara River (*Juniperus* zone), 6 - Stânişoara River (Picea zone), 7 - Stânişoara River near Pietrele Chalet, 8 - Triburaty of the first Lake Pietricelele, 9 - The first Pietricelele Lake (from upstream to downstream), 10 - Pietrele River downstream of Pietrele Lake, 11 - Pietrele River near Bordul Tomii, 12 - Pietrele River near Genţiana Chalet, 13 - Valea Rea River (*Juniperus* zone), 14 - Valea Rea River (*Picea* zone), 15 - Galeş River downstream of Galeş Lake, 16 - Tăul below Brazi Lake, 17 - Galeş River downstream of Valea Rea River junction, 18 - Spring bellow of Custura Pass, 19 - River downstream of Ţapului Lake, 20 - Ciomfu Mare River, 21 - Bărbat River, 22 - Peleguţa River downstream of Peleguţa Lake, 23 - Peleguţa River, 24 - Peleaga River (*Juniperus* zone), 25 - Peleaga River (*Picea* zone), 26 - Tributary of Florica Lake, 27 - Florica Lake, 28 - Water fall between Florica and Viorica Lakes, 29 - Viorica Lake, 30 - Ana Lake, 31 - Ana River upstream Lia Lake, 32 - Lia Lake, 33 - Tributary of Bucura Lake, 34 - Berbecilor Valley, 400 m upstream of Bucura Lake, 35 - Berbecilor Valley, 100 m upstream of Bucura Lake, 36 - Lake near Refuge Bucura, 37 - Bucura River downstream of Bucura Lake, 38 - Left tributary (1) of Bucura Lake, 39 - Left tributary (2) of Bucura Lake, 40 - Bucura River upstream of junction with Peleaga River, 41 - Tributarie of Tăul Ascuns Lake, 42 - Puddle near Tăul Urât Lake, 43 - Brook between Tăul Urât and Tăul Răsucit Lakes, 44 - River Zănoaga downstream of Zănoaga Lake, 45 - Lăpuşnicul Mare River downstream of the old dam, 46 - Păpuşa I Lake, 47 - Păpuşa II Lake, 48 - Bolboroşi Spring.

The Retezat National Park is the country's oldest national park, established in 1935. It has a surface area of 38,047 ha, of which 1,800 ha have been declared strictly protected area called “Gemenele”. The universal value of the park was recognized by UNESCO in 1979 through its inclusion in the international network of biosphere reserves. The Retezat Mountains consist of Danubian metamorphic rocks dominated by slightly metamorphosed crystalline schists. The relative surface extensions of the park at different altitudinal levels are 47% below 1400 m, 15.5% (1400 - 1600 m), 13.7% (1600 - 1800 m), 12.3% (1800 - 2000 m), 8% (2000 - 2200 m) and 3.5% above 2200 m (Schreiber and Sorocovschi, 1993).

Water mites were sampled in August 2001 and June 2002 at 48 sites (36 running water and 12 alpine lakes) located between 1400 - 2200 meters asl (above sea level). (Tab. 1, Fig. 1, Annex 1). The mean annual temperature of the river water is 4°C at the 1600 m asl, and 2°C at 2000 m asl (Schreiber and Sorocovschi 1993).

A number of 800 specimens were collected using a hand-net (0.25 mm mesh size), sorted in the field and preserved in Koenike’s medium (6: 3: 1 glycerin: distilled water: acetic acid). Selected specimens were slide-mounted using Hoyer’s medium for microscopic analysis.

Table 1: Water mite collecting sites in the Retezat National Park, with altitude, catchment area and species numbers.

No.	Sampling sites	Altitude m	No. of species	Catchment
1.	Ştirbu River, upstream Gemenele Lake	2000	4	Dobrun
2.	Gemenele Lake	1920	4	
3.	Ştirbu River, near Casa Laborator (Laboratory House)	1760	2	

4.	Stânişoara Lake and tributaries	1990	3	Nucşoara
5.	Stânişoara River (*Juniperus* zone)	1800	3	
6.	Stânişoara River (*Picea* zone)	1600	3	
7.	Stânişoara River near Pietrele Chalet	1480	4	
8.	Tributary of the first Lake Pietricelele	2075	6	
9.	The first Pietricelele Lake (from upstream to downstream)	2080	2	
10.	Pietrele River downstream of Pietrele Lake	1990	2	
11.	Pietrele River near Bordul Tomii	1900	4	
12.	Pietrele River near Gențiana Chalet	1680	4	
13.	Valea Rea River (*Juniperus* zone)	1950	4	
14.	Valea Rea River (*Picea* zone)	1600	4	
15.	Galeş River downstream of Galeş Lake	1980	4	
16.	Tăul below Brazi Lake	1720	3	
17.	Galeş River downstream of junction with Valea Rea River	1550	2	
18.	Spring below Custura Pass	2070	1	Bărbat
19.	River downstream of Țapului Lake	2050	9	
20.	Ciomfu Mare River	1800	2	
21.	Barbat River	1550	2	
22.	Peleguța River downstream of Peleguța Lake	2050	2	Lăpuşnicul Mare
23.	Peleguța River	1750	4	
24.	Peleaga River (*Juniperus* zone)	1700	5	
25.	Peleaga River (*Picea* zone)	1620	4	
26.	Tributary of Florica Lake	2100	2	
27.	Florica Lake	2090	1	
28.	Water fall between Florica and Viorica Lakes	2080	2	
29.	Viorica Lake	2070	2	
30.	Ana Lake	1990	2	
31.	Ana River upstream Lia Lake	1915	5	
32.	Lia Lake	1910	5	
33.	Tributary of Bucura Lake	2060	5	
34.	Berbecilor Valley, 400 m upstream of Bucura Lake	2100	3	
35.	Berbecilor Valley, 100 m upstream of Bucura Lake	2050	6	
36.	Lake near Refuge Bucura	2080	1	
37.	Bucura River downstream of Bucura Lake	2000	1	
38.	Left tributaries (1) of Bucura Lake	1800	3	
39.	Left tributaries (2) of Bucura Lake	1650	5	
40.	Bucura River upstream of junction with Peleaga River	1620	7	
41.	Tributary of Tăul Ascuns Lake	2180	2	
42.	Puddle near Tăul Urât Lake	2080	1	
43.	Brook between Tăul Urât and Tăul Răsucit Lakes	2090	4	
44.	River Zănoaga downstream of Zănoaga Lake	1990	1	
45.	Lăpuşnicul Mare River downstream of the old dam	1600	2	
46.	Păpuşa I Lake	1830	1	
47.	Păpuşa II Lake	1855	1	
48.	Bolboroşi Spring	1880	1	

RESULTS AND DISCUSSIONS

Table 2 gives a survey of the identified species and their frequency. The maximum species number was found at a small river downstream of Ţapului Lake (Tab. 1).

The most frequent species, recorded at more then 20 sampling sites are *Lebertia tuberosa* and *Sperchon brevirostris*, followed by *Sperchon thienemanni, Arrenurus zachariasi* and *Panisus michaeli*. Nine species were found only in one sampling site. Fourteen species were present only in running water, four species exclusively in standing waters; six in both ecosystem types (Tab. 2).

Table 2: Distribution of water mite species from the Retezat National Park (R - lotic ecosystem, L - lentic ecosystem), indicating new records for the Romanian fauna (*) and for the Carpathian fauna (**). "CP" and "CB" marks species which in other areas of Europe are found as crenophiles respectively crenobionts.

No	Species	Author, date	Ecology	No. of sampling sites	
				Standing waters	Running waters
1.*	*Thyas palustris*	Koenike, 1912	L, CP	1	0
2.	*Panisus michaeli*	Koenike, 1896	L, R, CB	5	4
3.**	*Zschokkea oblonga*	Koenike, 1892	R, CP	0	2
4.	*Sperchonopsis verrucosa*	Protz, 1896	R	0	1
5.	*Sperchon brevirostris*	Koenike, 1895	R	0	23
6.	*Sperchon mutilus*	Koenike, 1895	R, CB	0	3
7.	*Sperchon squamosus*	Kramer, 1879	R, CP	0	1
8.	*Sperchon thienemanni*	Koenike, 1907	R, CB	0	18
9.	*Lebertia tuberosa*	Thor, 1914	L, R, CB	3	24
10.	*Lebertia glabra*	Thor, 1897	R, CB	0	1
11.*	*Lebertia dubia*	Thor, 1899	L, R	2	3
12.	*Limnesia koenikei*	Piersig , 1894	L	1	0
13.	*Hygrobates foreli*	Lebert, 1874	L, R	5	3
14.	*Hygrobates norvegicus*	Thor, 1897	L, R, CB	1	5
15.	*Atractides gibberipalpis*	Piersig, 1898	R	0	7
16.	*Atractides loricatus*	Piersig, 1898	R, CP	0	1
17.	*Feltria armata*	Koenike, 1902	R	0	1
18.	*Feltria minuta*	Koenike, 1892	R, CP	0	3
19.	*Feltria setigera*	Koenike, 1896	R, CP	0	1
20.	*Feltria zschokkei*	Koenike, 1896	R, CP	0	5
21.	*Feltria rubra*	Piersig, 1898	R	0	4
22.*	*Pionacercus leuckarti*	Piersig, 1894	L, CP	1	0
23.**	*Arrenurus zachariasi*	Koenike, 1886	L, R, CP	4	6
24.	*Arrenurus* sp.		L	2	0

Of the species recorded for the first time in Romania, two were found only once (*Thyas palustris* in lake Tăul dintre brazi, and *Pionacercus leuckarti* in Lia Lake). *Lebertia dubia* was present in the samples taken from lakes Lia and Gemenele, as well as from three brooks. *Zschokkea oblonga* was collected from two stream pools, *Arrenurus zachariasi* from ten sampling sites (six running water sites and four alpine lakes).

More than a half of the water mite species from Retezat National Park derive from running water, a quarter were found in both lotic and lentic waters and only 17% were restricted to standing water (Fig. 2).

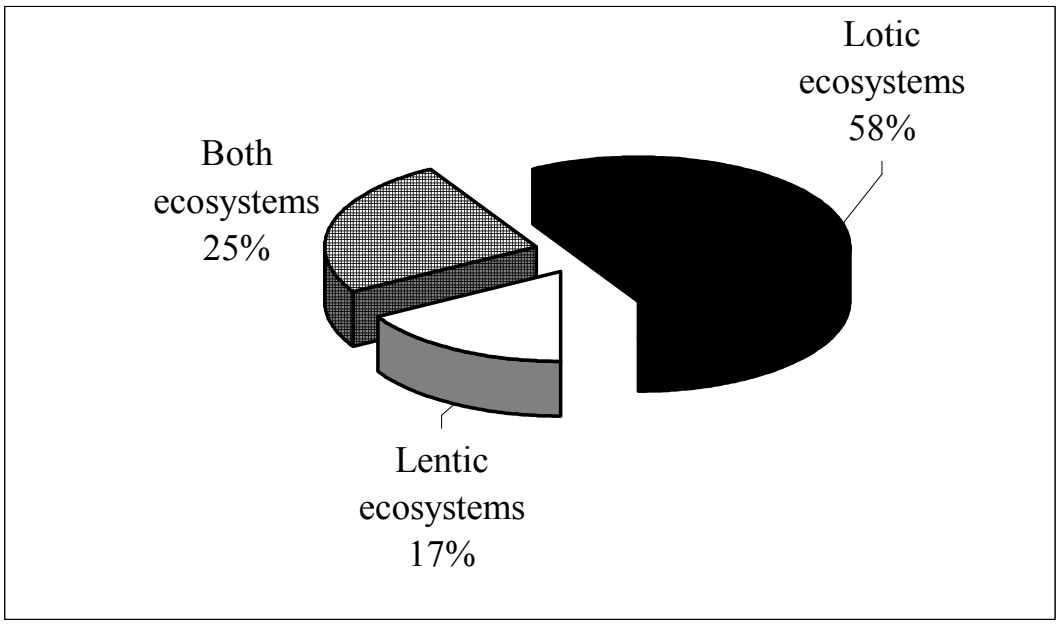

Fig. 2: Percentage of water mite species in running and/or standing water habitats.

Only two species, *Sperchon thienemanni* and *Lebertia tuberosa*, were found at all altitudinal levels. The largest number of species was recorded at high altitude: 15 species at 1900 - 2000 m and 16 at 2000 - 2100 m - most probably reflecting the fact that the highest number of sampling sites was located at these altitudes (Fig. 3). No water mite species could be detected in samples collected at altitudes above 2200 m.

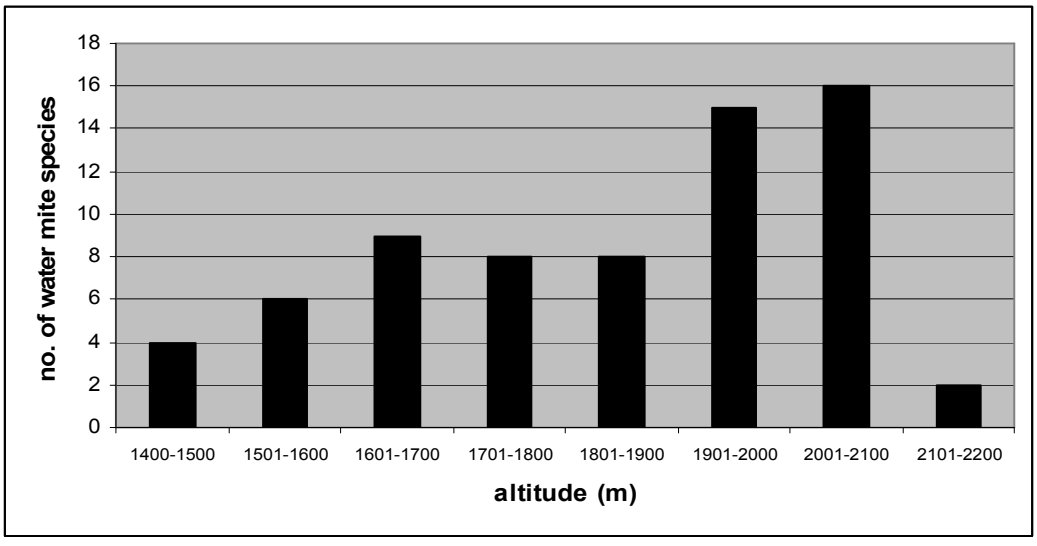

Fig. 3: Altitudinal distribution of number of water mite species from Retezat National Park.

Of the 251 species recorded for the Romanian fauna (Cîmpean, unpubl.), only about 10% (24) were found in Retezat National Park. However, among these species, five are new records for the Romanian fauna, and two were recorded for the first time in the Carpathians. The record of *Zschokkea oblonga* is of particular interest as it extends the known distribution area of this rare species notably in a south-eastern direction.

The composition of the water mite fauna of the Retezat Mountains deserves particular attention with regard to habitat preferences of many species. On the basis of data from limnological studies in Central Europe (Gerecke and Martin, 2006; and bibliography cited there), more than fifty percent of the species recorded here are from Retezat, and are generally considered as crenophiles (nine species) or crenobionts (six species). Most of them are found in running water, but *Panisus michaeli, Lebertia tuberosa, Hygrobates norvegicus* and *Arrenurus zachariasi* are present both in streams and lakes, and *Thyas palustris* and *Pionacercus leuckarti* are present exclusively in lakes. Crenobiont species are in general restricted to the source/spring area and are found only rarely and generally at low individual numbers in spring streams. Further downstream, in alpine spring habitats they are replaced by other, rithrobiontic species. The presence of large populations of crenobiont species in middle order mountain streams is uncommon and confronts us with a problem. Results of morphological studies of selected specimens from Retezat in comparison with Central European material (including detailed measurements) did not reveal any remarkable differences that would indicate genetic differentiation. Thus we have obviously to deal with a geographical within-species differentiation of habitat preference patterns. A similar phenomenon was observed by Gerecke and Di Sabatino (1997) who observed an enlarged ecological valence of island-dwelling water mites when compared with continental populations. Also in particular mountain ranges, some kind of historical isolation could have contributed to the development of situations of decreased concurrence that allowed selected species to extend their habitats downstream. We could also imagine that specific geomorphological conditions may contribute to a blurring of the border between the spring proper (crenal) and its outflow (rhithral). In general, such a decreased differentiation between spring- and stream-fauna is observed in strong flowing rheocrenes in little inclined valleys where typical spring species are rare while the fauna is dominated by immigrating rheobionts. In Retezat Mountains, the contrary situation is apparently realized.

At present we can only propose hypothetical explanations which should be verified or falsified in future studies. Investigations directed to this question should include studies of differential host preference of local populations in selected water mite species, and studies on habitat preference and longitudinal zonation of water mite species in mountain areas surrounding Retezat Mountains.

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ANNEX 1: The sampling sites (altitude and the prelevation data), the list of water mite species and number of male/ female/deutonympha

1 - Ştirbu River, upstream Gemenele Lake, 2000 asl, 11.07.2002
Sperchon brevirostris, 1/0/0; *Sperchon thienemanni*, 2/2/0; *Lebertia (Pseudolebertia) tuberosa*, 6/8/1; *Feltria (Feltriella) rubra*, 0/1/0; Hydrachinia larvae, 1.

2 - Gemenele Lake, 1920 asl, 11.07.2002
Panisus michaeli, 0/1/1; *Lebertia (Pseudolebertia) tuberosa*, 1/0/0; *Lebertia (Hexalebertia) dubia*, 2/0/0; *Hygrobates* sp., 0/0/13; Hydrachnidia larvae, 2.

3 - Ştirbu River, next to Casa Laborator (Laboratory House), 1760 asl, 11.07.2002
Sperchon brevirostris, 1/2/2; *Lebertia (Pseudolebertia) tuberosa*, 6/4/0.

4 - Stânişoara Lake and tributaries, 1990 asl, 18. 08. 2001
Panisus michaeli, 3/1/1; *Lebertia(Pseudolebertia) tuberosa*, 1/2/0; *Arrenurus* sp. 0/1/0.

5 - Stânişoara River (*Juniperus* zone), 1800 asl, 18.08. 2001
Sperchon brevirostris, 1/0/3; *Sperchon thienemanni*, 1/0/0; *Lebertia (Pseudolebertia) tuberosa*, 7/11/0.

6 - Stânişoara River (*Picea* zone), 1600 asl, 18. 08. 2001
Sperchon brevirostris, 10/8/8; *Lebertia(Pseudolebertia) tuberosa*, 0/1/0; *Feltria (Feltriella) rubra*, 0/2/0.

7 - Stânişoara River next to Pietrele Chalet, 1480 asl,
18.08.2001; *Sperchon brevirostris*, 3/1/7; *Sperchon mutilus*, 0/1/0; *Lebertia (Pseudolebertia) tuberosa*, 4/3/0; 10.07.2002; *Sperchon brevirostris*, 1/1/0; *Sperchon thienemanni*, 1/0/0.

8 - Tributaries of the first Lake Pietricelele, 2075 asl, 10.07.2002
Panisus michaeli, 1/0/0; *Sperchon brevirostris*, 0/0/4; *Sperchon thienemanni*, 4/11/0; *Lebertia (Pseudolebertia) tuberosa*, 3/0/1; *Lebertia (Hexalebertia) dubia*, 1/0/0; *Hygrobates (Rivobates) norvegicus*, 0/1/0.

9 - The first Pietricelele Lake (from upstream to downstream), 2080 asl, 10.07.2002
Panisus michaeli, 1/1/1; *Lebertia* sp.; *Hydrachnidia larvae* 19.

10 - Pietrele River downstream of Pietrele Lake, 1990 asl, 15. 08. 2001
Lebertia (Pseudolebertia) tuberosa, 2/9/0; *Feltria minuta*, 1/0/0.

11 - Pietrele River next to Bordul Tomii, 1900 asl, 15. 08. 2001
Panisus michaeli, 0/1/1; *Sperchon brevirostris*, 0/4/2; *Sperchon mutilus,* 1/0/0; *Lebertia (Pseudolebertia) tuberosa*, 2/0/0.

12 - Pietrele River next to Gențiana Chalet, 1680 asl, 15. 08. 2001
Sperchon brevirostris, 4/1/1; *Sperchon thienemanni*, 1/0/0; *Lebertia (Pseudolebertia) tuberosa*, 9/9/1; *Feltria (Feltriella) rubra*, 3/5/0

13 - Valea Rea River (*Juniperus* zone), 1950 asl, 16. 08. 2001
Sperchon brevirostris, 1/1/1; *Lebertia (Pseudolebertia) tuberosa*, 9/9/0; *Feltria minuta*, 1/0/0; *Feltria (Feltriella) rubra*, 2/5/0

14 - Valea Rea River (*Picea* zone), 1600 asl, 16. 08. 2001
Sperchon brevirostris, 1/1/0; *Lebertia (Pseudolebertia) tuberosa*, 3/9/0; *Feltria armata*, 0/1/0; *Feltria zschokkei*, 0/2/0

15 - Galeş River downstream of Galeş Lake, 1980 asl, 17. 08. 2001
Sperchon brevirostris, 1/1/1; *Sperchon thienemanni,* 1/2/0; *Lebertia (Pseudolebertia) tuberosa*, 3/5/2; *Feltria zschokkei*, 2/5/0; *Thyas palustris*, 0/1/1; *Limnesia koenikei*, 0/1/0; *Arrenurus(Megaluracarus) zachariasi*, 4/10/2.

17 - Galeş River downstream of junction with Valea Rea River, 1550 asl, 17. 08. 2001
Sperchon brevirostris, 2/1/0; *Lebertia (Pseudolebertia) tuberosa*, 2/2/0.

18 - Spring bellow of Custura Pass, 2070 asl, 17.07.2002
Lebertia (Pseudolebertia) tuberosa, 3/2/1.

19 - River downstream of Țapului Lake, 2050 asl, 17.07.2002
Panisus michaeli, 2/1/0; *Zschokkea oblonga*, 2/0/0; *Sperchon mutilus*, 1/0/0; *Sperchon thienemanni*, 1/0/0; *Lebertia (Pseudolebertia) tuberosa*, 0/1/1; *Lebertia glabra*, 0/1/0; *Lebertia (Hexalebertia) dubia*, 1/1/0; *Hygrobates (Rivobates) norvegicus*, 1/3/0; *Arrenurus (Megaluracarus) zachariasi*, 1/0/5.

20 - Ciomfu Mare River, 1800 asl, 18.07.2002
Sperchon brevirostris, 2/3/0; *Lebertia (Pseudolebertia) tuberosa*, 0/1/0.

21 - Barbat River, 1550 asl, 18.07 2002
Sperchon brevirostris, 0/1/0; *Feltria minuta*, 1/0/0.

22 - Peleguța River downstream of Peleguța Lake, 2050 asl, 06.07. 2002
Sperchon thienemanni, 0/1/0; *Lebertia (Pseudolebertia) tuberosa*, 1/0/0.

23 - Peleguța River, 1750 asl, 06.07.2002
Sperchon brevirostris, 1/1/1; *Lebertia (Pseudolebertia) tuberosa*, 1/0/0; *Feltria zschokkei*, 0/2/1; *Feltria (Feltriella) rubra*, 2/4/0.

24 - Peleaga River (*Juniperus* zone), 1700 asl, 06.07.2002
Sperchon brevirostris, 3/3/2; *Sperchon squamosus*, 0/2/1; *Sperchon thienemanni*, 1/7/0; *Lebertia (Pseudolebertia) tuberosa*, 3/1/0; *Hygrobates (Rivobates) norvegicus*, 0/1/0.

25 - Peleaga River (*Picea* zone), 1620 asl, 14. 08. 2001
Sperchon brevirostris, 0/1/0; *Hygrobates (Hygrobates) foreli*, 2/0/0; *Atractides gibberipalpis*, 1/1/0; *Feltria* sp., 0/1/0.

26 - Tributaries of Florica Lake, 2100 asl, 13.07.2002
Sperchon thienemanni, 0/1/1; *Lebertia (Pseudolebertia) tuberosa*, 0/2/3.

27 - Florica Lake, 2090 asl,
13.07.2002; *Hygrobates (Hygrobates) foreli*, 15/3/0.
21.08.2001; *Hygrobates(Hygrobates) foreli*, 0/7/0

28 - Water fall between Florica and Viorica lakes, 2080 asl
13.07.2002; *Lebertia (Pseudolebertia) tuberosa,* 3/7/2;
21. 08. 2001; *Lebertia(Pseudolebertia) tuberosa*, 2/2/1; *Hygrobates(Hygrobates) foreli,* 0/1/0.

29 - Viorica Lake, 2070 asl,
13.07.2002; *Lebertia (Pseudolebertia) tuberosa,* 2/0/0.
21.08.2001; *Hygrobates (Hygrobates) foreli*, 2/1/5.

30 - Ana Lake, 1990 asl, 13.07.2002
Panisus michaeli, 0/1/0; Hygrobates (Hygrobates) foreli, 6/0/0.

31 - Ana River upstream Lia Lake, 1915 asl
16.07.2002; *Sperchon thienemanni,* 1/1/1;
22. 08. 2001; *Sperchon brevirostris*, 4/0/1; *Sperchon thienemanni*, 14/16/2; *Atractides gibberipalpis,* 1/0/0; *Hygrobates (Rivobates) norvegicus*, 1/0/0; *Atractides loricatus*, 0/2/0.

32 - Lia Lake, 1910 asl,
16.07.2002; *Hygrobates (Hygrobates) foreli,* 2/4/0; *Arrenurus (Megaluracarus) zachariasi,* 0/1/0.
22. 08. 2001; *Lebertia(Hexalebertia) dubia cirrata*, 0/1/0; *Hygrobates(Rivobates) norvegicus,* 4/2/0; *Pionocercus leuckarti*, 1/15/1; *Arrenurus(Megaluracarus) zachariasi*, 8/1/1.

33 - Tributaries of Bucura Lake, 2060 asl, 10.07.2002
Sperchon brevirostris, 1/0/1; *Sperchon thienemanni,* 0/1/1; *Hygrobates (Rivobates) norvegicus,* 0/1/0; *Atractides gibberipalpis,* 0/1/0; *Feltria (Feltriella) rubra,* 0/3/0.

34 - Berbecilor Vally, 400 m upstream of Bucura Lake, 2100 asl, 12.07.2002
Sperchon thienemanni, 8/11/2; *Lebertia (Pseudolebertia) tuberosa*, 3/5/0; *Atractides gibberipalpis*, 1/0/0.

35 - Berbecilor Vally, 100 m upstream of Bucura Lake, 2050 asl, 12.07.2002
Sperchon brevirostris, 0/0/1; *Lebertia (Pseudolebertia) tuberosa*, 1/1/1; *Atractides gibberipalpis*, 0/1/0; *Feltria setigera*, 0/1/0; *Feltria zschokkei*, 1/1/0; *Feltria (Feltriella) rubra*, 0/3/0.

36 - Lake near Refuge Bucura, 2080 asl, 14.07.2002
Arrenurus (Megaluracarus) zachariasi, 0/1/0.

37 - Bucura River downstream of Bucura Lake, 2000 asl,
13.07.2002; *Sperchon thienemanni*, 13/4/2.
14. 08. 2001; *Sperchon thienemanni* 1907 27/ 9/ 1.

38 - Left tributarie (1) of Bucura Lake, 1800 asl, 08.07.2002
Sperchon thienemanni, 0/2/0; *Lebertia (Pseudolebertia) tuberosa*, 1/1/1; *Feltria (Feltriella) rubra*, 0/1/0.

39 - Left tributarie (2) of Bucura Lake, 1650 asl, 14. 08. 2001
Sperchon brevirostris, 6/1/1; *Sperchon thienemanni*, 5/3/0; *Lebertia (Hexalebertia) dubia*, 1/1/0; *Atractides gibberipalpis*, 1/3/0; *Feltria (Feltriella) rubra*, 0/3/0.

40 - Bucura River upstream of junction with Peleaga Riv**er**, 1620 asl,
05.07.2002; *Sperchon brevirostris*, 3/0/1; *Lebertia* sp., 0/1/0; *Atractides* sp., 0/0/1; *Feltria zschokkei*, 0/1/0.
14.08.2001; *Sperchon brevirostris*, 3/4/1; *Lebertia(Pseudolebertia) tuberosa*, 1/0/0; *Atractides gibberipalpis*, 1/0/0; *Feltria (Feltriella) rubra*, 0/1/0.

41 - Tributarie of Tăul Ascuns Lake, 2180 asl, 09.07.2002
Sperchon thienemanni, 1/2/8; *Lebertia (Pseudolebertia) tuberosa*, 0/2/1.

42 - Puddle near Tăul Urât Lake, 2080 asl, 09.07.2002
Panisus michaeli, 0/0/1.

43 - Brook between Tăul Urât and Tăul Răsucit Lakes, 2090 asl, 09.07.2002
Panisus michaeli; *Zschokkea oblonga*; *Sperchonopsis verrucosa*; *Lebertia (Pseudolebertia) tuberosa*, 1/4/1.

44 - River Zănoaga downstream of Zănoaga Lake, 1990 asl, 21. 08. 2001
Sperchon thienemanni, 3/9/1.

45 - Lăpuşnicul Mare River upstream of the old dam, 1600 asl,
05.07. 2002; *Sperchon brevirostris*, 0/1/0; *Atractides* sp., 0/0/1.
14. 08. 2001; *Sperchon brevirostris*, 1/3/5.

46 - Păpuşa I Lake, 1830 asl, 07.07.2002
Arrenurus sp., 10/5/1

47 - Păpuşa II Lake, 1855 asl, 07.07.2002
Arrenurus sp., 0/1/1

48 - Bolboroşi Spring, 1880 asl, 07.07. 2002
Hydrachnidia larvae

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ARACHNOLOGICAL STUDIES IN THE RETEZAT NATIONAL PARK (ROMANIA)

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, Biosphere Reserve, Araneae, new records, faunistics, taxonomy.

ABSTRACT

The present paper deals with the spider-fauna of the Retezat National Park - Biosphere Reserve (Retezat Mountains, Romania). Until now 144 species from 88 genera were recorded, belonging to 20 families. Out of these, 26 species are new records in Retezat Mountains. The list of species is presented. The arachnofauna of this area is characterized by the presence of a considerable number of rare species. *Bolyphantes index* (Thorell, 1856) and *Ceratinella wideri* (Thorell, 1871) from the family Linyphiidae were recorded for the first time in Romania from this area. Three genera *Agnyphantes* Hull, 1932, *Palliduphantes* Saaristo and Tanasevitch, 2001 and *Parazygiella* Wunderlich, 2004 were also mentioned for the first time in the Romanian fauna from this area.

ZUSAMMENFASSUNG: Arachnologische Untersuchungen im Nationalpark Retezat (Rumänien).

Unser Artikel beschäftigt sich mit der Spinnenfauna des Nationalparks Retezat - Biosphere Reservats (Retezat Gebirge, Rumänien). Bislang wurden 144 Spezies aus 88 Genera erforscht,die in 20 Familien geordnet werden können. 26 Spezies von den 144 sind faunistisch neue Niederschriften. Die Liste der Spezies ist beiliegend. Die Spinnenfauna dieses Gebietes ist für die Anwesenheit mehrerer seltener Spezies charakteristisch. *Bolyphantes index* (Thorell, 1856) und *Ceratinella wideri* (Thorell, 1871) der Familie Linyphiidae wurden in Rumänien zum ersten mal gefunden und niedergeschrieben. Drei Genera, nämlich *Agnyphantes* Hull, 1932, *Palliduphantes* Saaristo und Tanasevitch, 2001 und *Parazygiella* Wunderlich, 2004 wurden ebenso zum ersten mal in der rumänischen Fauna erwähnt.

REZUMAT: Studii arachnologice în Parcul Național Retezat (România).

În lucrarea de față sunt prezentate rezultatele studiilor referitoare la fauna de aranee din Parcul Național Retezat - Rezervația Biosferei (Munții Retezat, România). Până în prezent au fost identificate 144 specii din 88 genuri, reprezentând 20 de familii. Dintre aceste specii 26 sunt semnalate pentru prima dată în Munții Retezat. Lista de specii este prezentată în lucrare. Fauna de aranee din această zonă cuprinde un număr mare de specii rare care apar pe listele roşii ale mai multor țări din Europa. *Bolyphantes index* (Thorell, 1856) şi *Ceratinella wideri* (Thorell, 1871), ambele din familia Linyphiidae sunt specii noi pentru fauna României. Genurile *Agnyphantes* Hull, 1932, *Palliduphantes* Saaristo şi Tanasevitch, 2001 şi *Parazygiella* Wunderlich, 2004 sunt menționate pentru prima oară în fauna țării.

INTRODUCTION

Descriptive faunistical studies are essential to obtain satisfactory information on the biodiversity of different regions, especially in natural reserves.

The history of arachnological survey in Retezat Mountains has shown a slow but steady progress. In the first paper published by Gebhardt (1932) only nine species from seven families were mentioned. Five years later, in 1937, Kolozsvári identified 28 species from 15 families. In 1967, Fuhn published a short description of the spider fauna of the Retezat Mountains. Fuhn found 12 species from five families. A total number of 42 species were mentioned in these three papers.

Recent taxonomical and faunistical publications have contributed significantly to the knowledge of the distribution of spider species in the Retezat Mountains (Urák, 2001; Fetykó and Urák, 2004). In these papers 97 species were mentioned from 18 families. *Pardosa oreophila*, *Gongylidiellum vivum*, *Helophora insignis* and *Midia midas* were new records for Romanian spider fauna. The genus *Midia* was mentioned for the first time.

MATERIALS AND METHODS

The sampling was carried out between 3 and 7 September 2002. The study area was the South-Eastern part of the Retezat Mountains, around the refuges Buta and Păpuşii Lakes.

Spiders were sampled by hand (ground and plant search, turning rocks and leaf litter shifting), using a sweep net, and by using beating tray for grass and low shrubs. All materials were preserved in 70^{o} ethylic alcohol and identified under stereoscopic microscope.

The species were identified using various keys (Loksa, 1969 and 1972; Fuhn and Niculescu-Burlacu, 1985; Sterghiu, 1985; Roberts, 1985 and 1987; Heimer and Nentwig, 1991; Fuhn and Gherasim, 1995) and were ranged taxonomically according to world spider catalogue of Platnick (2006).

RESULTS AND DISCUSSIONS

Altogether 631 spider specimens were collected, 301 adults (112 males and 189 females) and 330 juveniles, belonging to 63 species of 14 families (Tab. 1). Out of these 26 species were new records for Retezat National Park, and two species were new records for Romania. Previously 118 species were recorded from the Retezat National Park, thus the total number of species increased to 144 on the basis of the present study.

The richest families in species are Linyphiidae, represented by 29 species (48.33%) followed by Lycosidae, with six species (10%). The rest of the families are represented by less than five species. The majority of specimens belong also to the family Linyphiidae, 358 specimens (56.74%), followed by Salticidae with 55 specimens (8.72%) and Lycosidae with 42 specimens (6.66%). The rest of the families are represented by fewer specimens (Fig. 1).

The most frequent species was *Diplocephalus latifrons* represented by 51 specimens (23 males and 28 females) and *Bolyphantes alticeps* represented by 41 specimens (11 males and 30 females) both from the family Linyphiidae, and *Sitticus rupicola* represented by 51 specimens (13 males, 20 females and 18 juveniles) from family Salticidae.

Two species were mentioned for the first time in Romanian arachnofauna: *Bolyphantes index* and *Ceratinella wideri*, both from the family Lyniphiidae.

Bolyphantes index is a very rare species, in sub alpine semi-humid open or semi-open habitats, on steep rocky slopes and in grasslands (Buchar and Ruzicka, 2002). We found nine specimens of this species, three males and six females. It is a winter-active spider, which can maintain normal activity down to - 5°C. However, at - 9.3°C it becomes comatized (chill coma) and below the super-cooling point of - 15.3°C will freeze solid (Hågvar, 1973).

Table 1: The checklist of spiders from Retezat National Park - Biosphere Reserve.

No.	Taxon	m	f	j	s	G	K	F	U	FU
I	Pholcidae									
1	*Pholcus opilionoides* (Schrank, 1781)									+
II	Segestriidae	1		8	9					
2	*Segestrina senoculata* (Linnaeus, 1758)	1		8	9		+		+	+
III	Dysderidae									
3	*Dysdera crocata* C. L. Koch, 1838					+				
IV	Theridiidae	1	3	20	24					
4	*Achaearanea lunata* (Clerck, 1757)									+
5	*Robertus truncorum* (L. Koch, 1872)	1	1	0	2					
6	*Steathoda phalerata* (Panzer, 1801)			4	4					
7	*Theridion impressum* (L. Koch, 1881)		1	0	1				+	
8	*Theridion sisyphium* (Clerck, 1757)		1	0	1		+			
V	Linyphiidae	84	134	140	358					
9	*Agnyphates expunctus* (O.P. Cambridge, 1875)								+	
10	*Agyneta subtilis* (O.P. Cambridge, 1863)									+
11	*Araeoncus anguineus* (L. Koch, 1869)								+	
12	*Bathyphantes approximates* (O.P. Cambridge, 1871)		2	0	2					
13	*Bolyphantes alticeps* (Sundevall, 1833)	11	30	0	41					+
14	*Bolyphantes index* (Thorell, 1856)	3	6	0	9					
15	*Bolyphantes luteolus* (Blackwall, 1833)								+	
16	*Centromerus incilium* (L. Koch, 1881)	4	5	0	9					
17	*Centromerus pabulator* (O.P. Cambridge, 1875)								+	
18	*Centromerus sylvaticus* (Blackwall, 1841)	2		0	2				+	
19	*Ceratinella brevipes* (Westring, 1851)	1	4	0	5					
20	*Ceratinella scabrosa* (O.P. Cambridge, 1871)	1	2	0	3					
21	*Ceratinella wideri* (Thorell, 1871)	1		0	1					
22	*Dicymbium tibiale* (Blackwall, 1836)	3	4	0	7					
23	*Diplocephalus latifrons* (O.P. Cambridge, 1863)	23	28	0	51		+		+	+
24	*Diplostyla concolor* (Wider, 1834)	4	2	0	6					+
25	*Draspestica socialis* (Sundevall, 1833)		1	0	1					
26	*Erigone dentipalpis* (Wider, 1834)		1	0	1				+	+
27	*Gonatium rubellum* (Blackwall, 1841)									+

28	*Gongylidiellum vivum* (O.P. Cambridge, 1885)									+
29	*Helophora insignis* (Blackwall, 1841)									+
30	*Incestophantes annulatus* (Kulczynski, 1881)		1	0	1				+	
31	*Lepthyphantes leprosus* (Ohlert, 1865)									+
32	*Linyphia triangularis* (Clerck, 1757)							+		+
33	*Macrargus rufus* (Wider, 1834)	1	1	0	2					+
34	*Mansuphantes arciger* (Kulczynski, 1882)	2	3	0	5					
35	*Mansuphantes mansuetus* (Thorell,1875)		6	0	6					
36	*Maso sundevalli* (Westring, 1851)									+
37	*Meioneta milleri* Thaler, 1997	8	7	0	15				+	+
38	*Meioneta rurestris* (C.L. Koch, 1836)	1	2	0	3					+
39	*Micrargus georgescue* (Millidge, 1975)	5	4	0	9					
40	*Micrargus herbigradus* (Blackwall, 1854)	1		0	1					+
41	*Microlinyphia pusilla* (Sundevall, 1830)	1		0	1		+		+	+
42	*Midia midas* Simon, 1884									+
43	*Mughiphantes mughi* (Fickert, 1875)	6	9	2	17				+	+
44	*Neriene clathrata* (Sundevall, 1830)									+
45	*Neriene emphana* (Walckenaer, 1842)		2	0	2					+
46	*Neriene peltata* (Wider, 1834)									+
47	*Oedothorax agrestis* (Blackwall, 1853)									+
48	*Oedothorax apicatus* (Blackwall, 1850)									+
49	*Oedothorax fuscus* (Blackwall, 1834)								+	
50	*Oedothorax gibbifer* (Kulczynski, 1882)									+
51	*Palliduphantes insignis* (O.P. Cambridge, 1913)		1	0	1					
52	*Porrhomma convexum* (Westring, 1851)								+	+
53	*Porrhomma errans* (Blackwall, 1841)									+
54	*Stemonyphantes lineatus* (Linnaeus, 1758)									+
55	*Tapinocyba affinis* (Lessert, 1907)		1	0	1					
56	*Tenuiphantes alacris* (Blackwall, 1853)								+	
57	*Tenuiphantes jacksoni* (Schenkel, 1925)		1	0	1					
58	*Tenuiphantes mengei* (Kulczynski, 1887)		1	0	1					+
59	*Tenuiphantes tenebricola* (Wider, 1834)	1	1	0	2				+	+
60	*Tenuiphantes tenuis* (Blackwall, 1852)								+	+
61	*Thyreostenius parasiticus* (Westring, 1851)	5	1	0	6					

62	*Tiso vegans* (Blackwall, 1834)									+
63	*Troxochrus scabriculus* (Westring, 1851)		8	0	8					
VI	Tetragnathidae	1		3	4					
64	*Metellina segmentata* (Clerck, 1757)	1		3	4					+
65	*Pachygnatha degeeri* Sundevall, 1830									+
66	*Tetragnatha extensa* (Linnaeus, 1758)						+			+
67	*Tetragnatha nigrita* Lendl, 1886									+
68	*Tetragnatha obtusa* C. L. Koch, 1837						+			
69	*Tetragnatha pinicola* L. Koch, 1870						+			
VII	Araneidae	4	2	13	19					
70	*Aculepeira ceropegia* (Walckenaer, 1802)		1	0	1		+		+	+
71	*Araneus diadematus* (Clerck, 1757)	2	1	2	5				+	+
72	*Araneus saevus* (L. Koch, 1836)	1		0	1					
73	*Araneus triguttatus* (Fabricius, 1775)									+
74	*Araniella alpica* (L. Koch, 1869)								+	
75	*Araniella cucurbitina* (Clerck, 1757)									+
76	*Cyclosa conica* (Pallas, 1772)									+
77	*Larinioides patagiatus* (Clerck, 1757)								+	
78	*Mangora acalypha* (Walckenaer, 1802)	1		0	1					+
79	*Nuctenea umbratica* (Clerck, 1757)									+
80	*Parazygiella montana* (C. L. Koch, 1834)								+	+
VIII	Lycosidae	1	16	25	42					
81	*Alopecosa aculeata* (Clerck, 1757)						+	+		
82	*Alopecosa pulverulenta* (Clerck, 1757)		1	0	1			+		
83	*Arctosa leopardus* (Sundevall, 1833)								+	
84	*Aulonia albimana* (Walckenaer, 1805)									+
85	*Pardosa agrestis* (Westring, 1861)	1		0	1	+				+
86	*Pardosa agricola* (Thorell, 1856)						+			
87	*Pardosa albatula* (Roewer, 1951)		1	0	1					+
88	*Pardosa amentata* (Clerck, 1757)							+		+
89	*Pardosa ferruginea* (L. Koch, 1870)									+
90	*Pardosa monticola* (Clerck, 1757)		10	0	10	+		+	+	+
91	*Pardosa nigra* (C.L. Koch, 1834)							+	+	
92	*Pardosa oreophila* Simon, 1937								+	+

93	*Pardosa palustris* (Linnaeus, 1758)		3	0	3			+	+	
94	*Pardosa prativaga* (L. Koch, 1870*)*		1	0	1				+	+
95	*Pardosa riparia* (C.L. Koch, 1833)									+
96	*Pardosa saltuaria* (L. Koch, 1870)							+		
97	*Pardosa sordidata* (Thorell, 1875)						+			
98	*Trochosa terricola* Thorell, 1856							+		+
99	*Xerolycosa miniata* (C. L. Koch, 1834)						+			
IX	Pisauridae									
100	*Pisaura mirabilis* (Clerck, 1757)						+			+
X	Agalenidae	1	1	1	3					
101	*Chryphoeca sylvicola* (L. Koch, 1834)	1	1	1	3					
102	*Tegenaria ferruginea* (Panzer, 1804)									+
103	*Tegenaria silvestris* L. Koch, 1872								+	+
XI	Cybaeidae									
104	*Cybaeus angustiarum* L. Koch, 1868					+	+		+	+
XII	Hahniidae									
105	*Cryphoeca carpathica* (Herman, 1879)						+			
106	*Cryphoeca silvicola* (C.L. Koch, 1834)						+		+	
XIII	Amaurobiidae	1	4	18	23					
107	*Amaurobius fenestralis* (Stroem, 1768)						+			+
108	*Callobius claustrarius* (Hahn, 1833)					+	+			+
109	*Coelotes atropos* (Walckenaer, 1830)					+	+			
110	*Coelotes inermis* (L. Koch, 1855)	1	1	0	2					
111	*Coelotes terrestris* (Wider,1834)		3	0	3			+	+	+
XIV	Clubionidae	1	1	12	14					
112	*Clubiona alpicola* (Kulczynski, 1881)		1	0	1				+	+
113	*Clubiona diversa* (O.P. Cambridge, 1871)	1		0	1					
114	*Clubiona lutescens* Westring, 1851									+
115	*Clubiona neglecta* O.P. Cambridge, 1862							+		
116	*Clubiona reclusa* O. P. Cambridge, 1863									+
117	*Clubiona similis* L. Koch, 1867						+			
118	*Clubiona trivialis* C.L. Koch, 1841									+
XV	Corinnidae									
119	*Phrurolithus festivus* (C.L. Koch, 1835)									+
XV	Gnaphosidae	3	4	14	21					

120	*Drassodes cupreus* (Blackwall, 1834)		1	0	1					
121	*Drassodes lapidosus* (Walckenaer, 1802)						+	+	+	
122	*Gnaphosa leporine* (L. Koch, 1866)						+		+	
123	*Haplodrassus signifier* (L. Koch, 1855)		1	0	1	+			+	
124	*Micaria pullicaria* (Sundevall, 1832)	2	1	0	3					+
125	*Zelotes aeneus* (Simon, 1878)	1	1	0	2					
126	*Zelotes apricorum* (L. Koch, 1876)								+	
127	*Zelotes subterraneus* (C.L. Koch, 1833)								+	
XVII	Philodromidae		1	34	35					
128	*Philodromus aureolus* (Clerck, 1757)		1	0	1	+	+			
129	*Philodromus cespitum* (Walckenaer, 1802)									+
130	*Philodromus vagulus* Simon, 1875								+	
131	*Tibellus oblongus* (Walckenaer, 1802)						+			
XVIII	Dictynidae			6	9					
132	*Mastigusa macrophtalma* (Kulczynski, 1897)	1	2	4	7					
XIX	Thomisidae			15	15					
133	*Diaea dorsata* (Fabricius, 1777)						+			
134	*Misumena vatia* (Clerck, 1757)								+	+
135	*Misumenops tricuspidatus* (Fabricius, 1775)						+			
136	*Thomisus onustus* Walckenaer, 1806						+			
137	*Xysticus cristatus* (Clerck, 1757)									+
138	*Xysticus viduus* Kulczynski, 1898					1				
XX	Saltacidae	13	21	21	55					
139	*Dendryphantes hastatus* (Clerck, 1757)						+			
140	*Evarcha arcuata* (Clerck, 1757)									+
141	*Evarcha falcate* (Clerck, 1757)		1	2	3					+
142	*Heliophanus cupreus* (Walckenaer, 1802)									+
143	*Salticus scenicus* (Clerck, 1757)			1	1					
144	*Sitticus rupicola* (L. Koch, 1855)	13	20	18	51				+	
Total		112	189	330	631	9	28	12	42	75

Abbreviation: m - number of male specimens, f - number of female specimens, j - number of subadult and juvenile specimens, s - total number of species, G - species mentioned by Gebhardt (1932), K - species mentioned by Kolozsvári (1937), F - species mentioned by Fuhn (1967), U - species mentioned by Urák (2001), FU - species mentioned by Fetykó and Urák (2004).

Ceratinella wideri is a rare, vulnerable species, living in the sparse vegetation of dry and open habitats (Buchar and Ruzicka, 2002). We found only one male specimen. It is included in the Red List of Austrian spiders (Kreuels and Platen, 1999).

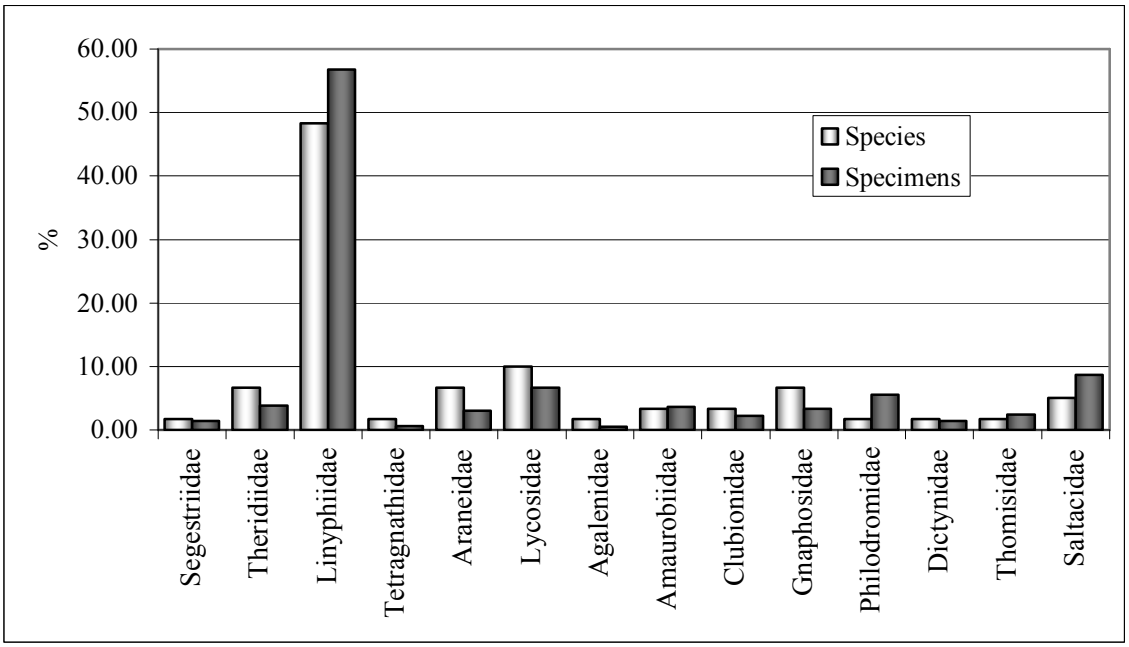

Fig. 1: The percentage representation of the spider families.

The occurrences of *Araneus saevus* were confirmed in the Romanian arachnofauna. This species was included in the lists by Weiss and Petrişor (1999), Weiss and Urák (2000) based on bibliographical data (Fuhn and Oltean, 1970). Those data could not be confirmed yet, because of the absence of specimens in collections from Romania. We found only one male specimen on the spruce beside the Buta refuge. It is a rare species, which is included in the Red List of Swedish species (Gärdenfors, 2000).

The occurrence of *Xysticus viduus* in the Romanian fauna, mentioned by Gebhardt (1932) is questionable, because of the absence of specimens from collections.

It is five years since the last checklist of Romanian spiders was published (Weiss and Urák, 2000). Within this time important changes occurred in the taxonomy and nomenclature of this group (Platnick, 2006). Some species were placed in new genera, and thus new names appeared in the checklist of Romanian arachnofauna.

The changes are following: *Lepthyphantes expunctus* from family Linyphiidae was moved in the newly created genus *Agnyphates*, and *Lepthyphantes insignis* from family Linyphiidae was moved in the newly created genus *Palliduphantes*, whereas *Zygiella montana* from the family Tetragnathidae was moved in the newly created genus *Parazygiella*, from family Araneidae. Genera *Agnyphantes* Hull, 1932, *Palliduphantes* Saaristo and Tanasevitch, 2001 and *Parazygiella* Wunderlich, 2004 were mentioned for the first time in the Romanian fauna.

CONCLUSIONS

In the Retezat Mountains a total number of 144 spider species were identified, from 88 genera, belonging to 20 families. 26 species were new records from this area, two species are new records from Romania and three genera were mentioned for the first time in Romanian fauna. The high number of species, especially the high number of new records is remarkable. Nevertheless these new records mostly occurred due to the sporadic, desultory character of previous studies.

These latest studies (Urák, 2001; Fetykó and Urák, 2004) of the Retezat National Park's arachnofauna filled gaps. Long-term researches based on systematic and methodologically accurate collection of biological materials will be important for obtaining satisfactory information on the biodiversity of spiders in Retezat National Park.

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CADYSFLY (INSECTA, TRICHOPTERA) LARVAE COMMUNITIES OF BĂRBAT RIVER BASIN (RETEZAT MOUNTAINS, ROMANIA)

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, benthic macroinvertebrates, Trichoptera larvae communities.

ABSTRACT

This paper presents a description of the Trichoptera larvae communities of Bărbat River Basin and its main tributaries.

In the studied area 29 species were identified belonging to 16 genera and seven families. In this study 16 trichopterans species are new records for the Retezat Mountains area.

The trichopteran present the highest species diversity (nine species) in Tulişa Brook, 500 m upstream of the confluence with the Bărbat River, and the lowest species diversity (two species) in the streams Ciumfu Mare, Ciumfu Mic, Curmăturii and Uric.

The studied trichopteran larvae communities reveal the fact that the aquatic habitats of the higher Bărbat River basin are in a good state and the anthropogenical impact is insignificant in this sector. In the lower basin of the river is revealed the anthropogenic impact - especially waste water polltion.

RÉSUMÉ: Communautés des larves de trichoptères (Insecta, Trichoptera) du basin de la rivière Bărbat (Les Montagnes Retezat, Roumanie).

Lè papier fait une description de la structure des communautés des larves de trichoptères de la rivière Bărbat et ses principaux affluents.

On a identifié 29 espèces qui appartiennent à 16 genres et sept familles dans la zone de référence. A l'occasion de cet étude ont été collectées 16 espèces non signalées jusqu'à présent dans les montagnes Retezat.

Les trichoptères présentent la diversité spécifique la plus importante (neuf espèces) dans le ruisseau Tulişa, à une distance de 500 m en amont par rapport à la confluence avec la rivière Bărbat, et une diversité spécifique minimale (deux espèces) dans les ruisseaux à caractère torrenticole: Ciumfu Mare, Ciumfu Mic, Curmăturii et Uric.

La structure des communautés de larves de trichoptères étudiées relève le fait que les habitats aquatiques du basin supérieur de la rivière Bărbat présente un bon état, l'impact anthropique dans cette région est insignifiant, dans le basin inférieur il y a des influences anthropiques, en particulier une pollution avec de l'eau résiduel ménager.

REZUMAT: Comunităţi ale larvelor de trichoptere (Insecta, Trichoptera) din bazinul râului Bărbat (Munţii Retezat, România)

Lucrarea prezintă o descriere a structurii comunităţilor larvelor de trichoptere din râul Bărbat şi principalii săi afluenţi.

În zona de referinţă au fost identificate 29 specii aparţinând la 16 genuri şi şapte familii. Cu prilejul acestui studiu a fost colectate 16 specii care nu au fost semnalate până în prezent în Munţii Retezat.

Trichopterele prezintă diversitatea specifică cea mai mare (nouă specii) în pârâul Tulişa, la 500 m amonte de confluenţa cu râul Bărbat, iar cea mai mică diversitate specifică (două specii) în pârâurile cu caracter torenticol: Ciumfu Mare, Ciumfu Mic, Curmăturii şi Uric.

Structura comunităţilor larvelor de trichoptere studiate evidenţiază faptul că habitatele acvatice din bazinul superior al râului Bărbat prezintă o stare bună, impactul antropic în această regiune fiind nesemnificativ, în bazinul inferior se resimt influenţele antropice - în special poluarea cu ape reziduale menajere.

INTRODUCTION

This study presents a description of the trichopteran larvae communities of Bărbat River Basin in the Retezat Mountains. These mountains are situated in the western part of the Romanian Meridional Carpathians (Fig. 1), a massif with a complex glacial relief and with altitudes higher then 2000 m (Peleaga Peak, 2509 m; Retezat Peak 2482 m; etc.).

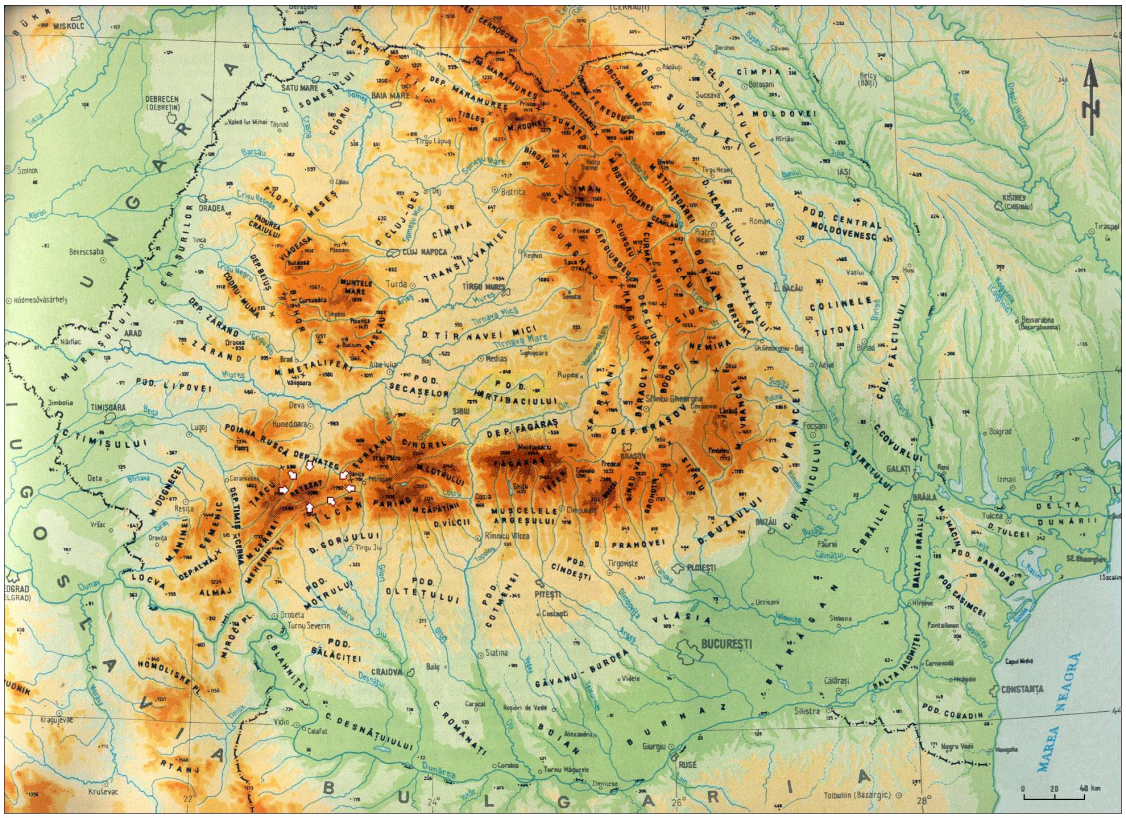

Fig. 1: The Retezat Mountains study unit (⇨) location (Badea et al., 1983 - modified).

The surface of the Retezat Mountains is about 466 km^2 and covers the Hunedoara County. The Bărbat River is placed in the eastern area of Retezat Mountains (Fig. 2).

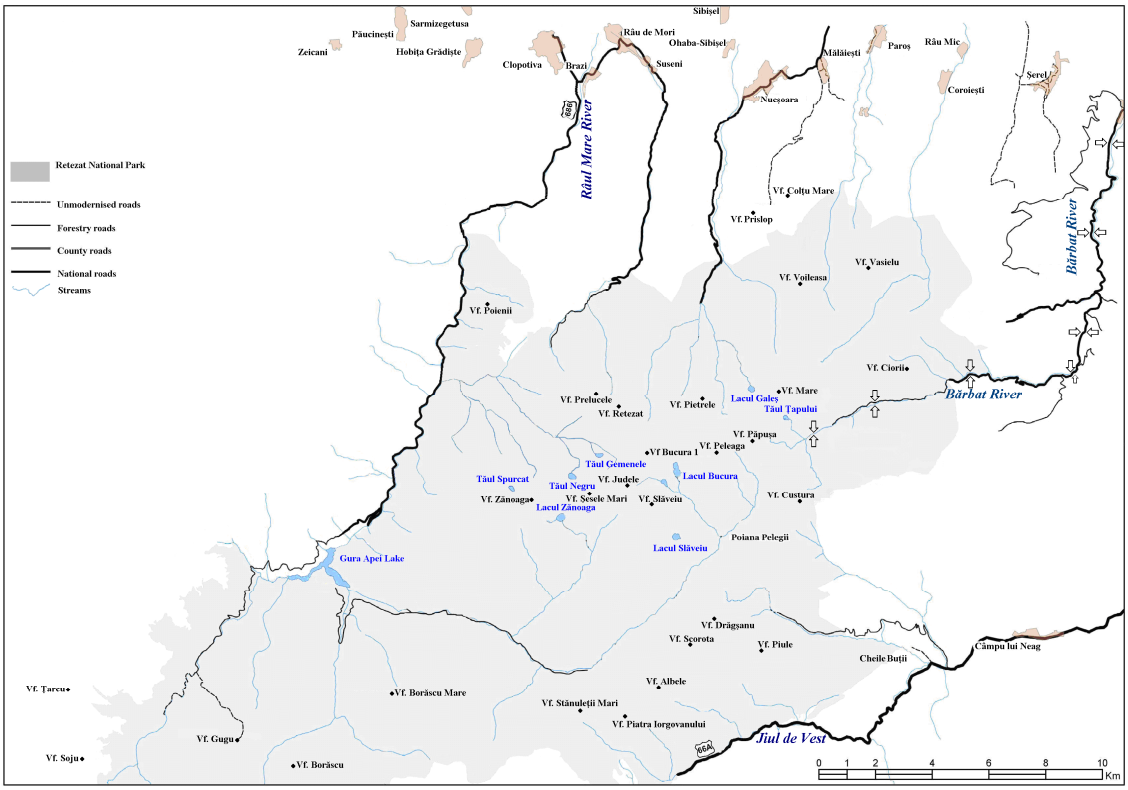

Fig. 2: Bărbat River localisation (⇨) in Retezat Mountains area (*** - modified).

With a watershed surface of 96 km^2 and a length of 28 km, the Bărbat River is one of the main tributaries of the Strei River (Mureş River Basin), and the confluence is in the proximity of the Pui locality. The Bărbat River has its springs in the glacial circles of Custura Mare and Ciumfu Mare (Posea et al., 1983; Roşu 1980.).

Studies regarding the Retezat Mountains trichopterans were carried out by Klapalek (1899), Mocsary (1908), Botoşănenu (1955, 1957, 1959, 1961, 1967, 1975), Murgoci (1953, 1954). These studies looked at aspects of systematic, faunistic, chorology, zoogeography and biology of the species.

Faunistical and chorological data concerning the trichopterans in the studied area appear in the synthesis works of Botoşănenu and Schneider (1978), Ciubuc (1993) and Ujvarosi (1997).

Until the present, cenological studies regarding the trichopteran larvae of the Bărbat River basin were not made.

MATERIAL AND METHODS

The data are based on quantitative benthic macroinvertebrates and trichopterans qualitative samples, sampled in 2000 - 2003, in four field summer sampling campaigns, each with 23 sampling stations. Seven of them were placed along the Bărbat River (S_4 - 200 m downstream of the confluence with the Țapului Brook; S_6 - 50 m downstream of the confluence with the Ciumfulete Brook; S_7 - 30 m downstream of the confluence with the Ciumfu Mare Brook; S_{14} - 50 m downstream of the confluence with the Corea Brook; S_{17} - 150 m downstream of the confluence with the Murguşa Brook; S_{20} - 400 m downstream of the confluence with the Sohodol Brook; S_{23} - 200 m downstream of the Uric Brook) and 17 placed along the main tributaries of them (S_1 - 2 m downstream of the Tăul Custurii; S_2 - 2 m downstream of the Ciumfu Mare Lake; S_3 - 2 m downstream of the Tăul Țapului Lake; S_5 - 2 m downstream of the Ciumfu Mic Lake; S_8 - on Lănciţa Brook at 500 m upstream of the confluence with Bărbat River; S_9 - on Izvorul Mare Brook at 500 m upstream of the confluence with Bărbat River; S_{10} - on Pârâul cu Târle Brook at 500 m upstream of the confluence with Bărbat River; S_{11} - on Curmăturii Brook at 500 m upstream of the confluence with Bărbat River; S_{12} - on the Făgeţel Brook at 500 m upstream of the confluence with the Bărbat River; S_{13} - on Corea Brook at 500 m upstream of the confluence with Bărbat River, S_{15} - on Tulişa at 500 m upstream of the confluence with Bărbat River; S_{16} - on Murguşa Brook at 500 m upstream of the confluence with the Bărbat River; S_{18} - on Arpadia Brook at 500 m upstream of the confluence with Bărbat River; S_{19} - on Sohodol Brook at 500 m upstream of the confluence with Bărbat River; S_{21} - on Corbului Brook at 500 m upstream of the confluence with Bărbat River; S_{22} - on Uric Brook at 300 m upstream of the confluence with the Bărbat River).

The sampling stations were chosen according to the valley morphology, the type of the river substratum, the confluence with the main tributaries and the human impact types and degrees on the river sectors, in order to highlight the trichopteran species diversity, and also the variation of the benthic macroinvertebrate communities.

In each sampling station many samples were taken, in order to highlight the specific habitat diversity. In the study period 288 quantitative benthic macroinvertebrates samples were sampled and analyzed. The benthic macroinvertebrates quantitative samples were carried out with an 887 cm^2 surface Surber Sampler, with a 250 µ mesh net. The sampled biological material was fixed in 4% formaldehyde solution at which $NaHCO_3$ was added.

The biological material was sorted and analyzed in the laboratory, preserved in 70% alcohol and included in the "Lucian Blaga" University of Sibiu, Department of Ecology and Environment Protection, Hydrobiology Laboratory collection.

The analyzed biological material included 1932 trichopterans larvae in their last larvae stages.

For the quantitative structure description of the trichopteran larvae communities we have used the relative abundance (A%) and the statistical density (Ds).

To analyze and quantify the association degree among species, the average square contingency coefficient (CCM) values and the Cole interspecific association coefficient were determined; to test which of the species are statistically significantly associated the χ^2 test was used for the probability level of 5% ($\chi^2 > 3,89$) (Krebs, 1989).

RESULTS AND DISCUSSIONS

In the reference zone 29 trichopteran species were identified, belonging to 16 genera and seven families.

The identified trichopteran species list of the Bărbat River basin, with the specific sampling sites (S_1 - S_{23} - sampling stations):

Fam. Rhyacophilidae

Rhyacophila tristis Pictet, 1834 (S_2, S_4, S_7, S_9, S_{10}, S_{12}, S_{15}, S_{18}, S_{19}, S_{21}, S_{22}, S_{23})
R. septentrionis Mc. Lachlan, 1867 (S_4, S_{11}, S_{13}, S_{14}, S_{16})
R. fasciata Hagen, 1859 (S_8, S_{11}, S_{15}, S_{17})
R. nubila (Zetterstedt, 1840) (S_7, S_{20}, S_{23})
R. glareosa Mc.Lachlan, 1867 (S_{20})

Fam. Philopotamidae

Philopotamus montanus (Donovan, 1813) (S_4, S_6, S_{12}, S_{13}, S_{15}, S_{16}, S_{18}, S_{19})

Fam. Hydropsychidae

Diplectona atra Mc. Lachlan, 1878 (S_{17})
Hydropsyche angustipennis (Curtis, 1834) (S_9, S_{12}, S_{13}, S_{16})
H. fulvipes (Curtis, 1834) (S_{21})
H. instabilis (Curtis, 1834) (S_7)
Cheumatopsyche lepida (Pictet, 1834) (S_{21})

Fam. Limnephilidae

Drusus discolor (Rambur, 1842) (S_6, S_{22})
D. romanicus Murgoci & Botoşăneanu, 1954 (S_{15}, S_{16})
D. trifidus Mc. Lachlan, 1868 (S_1, S_2, S_6, S_7, S_8, S_9, S_{17}, S_{18})
Ecclisopteryx guttulata (Pictet, 1834) (S_{10}, S_{15})
Limnephilus lunatus Curtis, 1834 (S_1, S_9)
L. vittatus (Fabricius, 1798) (S_{15})
Anabolia nervosa (Curtis, 1834) (S_4, S_6)
Potamophylax latipennis (Curtis, 1834) (S_3)
P. nigricornis (Pictet, 1834) (S_5, S_{15}, S_{21}, S_{23})
P. cingulatus (Stephens, 1837) (S_4)
P. rotundipennis (Brauer, 1857) (S_3, S_6)
Halesus digitatus (Schrank, 1781) (S_1, S_{13}, S_{19})
Melampophylax mucoreus (Hagen, 1861) (S_3, S_4, S_6, S_{15}, S_{23})

Fam. Goeridae

Goera pilosa (Fabricius, 1775) (S_3)
Silo nigricornis (Pictet, 1834) (S_8)
S. pallipes (Fabricius, 1781) (S_3, S_6, S_{10}, S_{15})

Fam. Leptoceridae

Setodes hungaricus Ulmer, 1908 (S_{19}, S_{23})

Fam. Sericostomatidae

Sericostoma personatum (Kirby and Spence, 1862) (S_7, S_{14}, S_{19}, S_{21})

Also, in the Arpadia Brook, 0.5 km upstream of the confluence with Bărbat River in the qualitative samples, individuals belonging to the *Policentropus* genera were found.

We mention that the presence of the species *Hydropsyche fulvipes*, *Drusus discolor*, *Potamophilax latipennis*, *Halesus digitatus* and *Melampophylax mucoreus* were confirmed through adult sampling; the adult sampling was necesary due to the problems related to their identification in larval stage.

In the study period 16 species are new records for the Retezat Mountains: *Rhyacophila septentrionis, Rhyacophila nubila, Rhyacophila vulgaris, Rhyacophila glareosa, Diplectona atra, Hydropsiche angustipennis, Hydropsiche fulvipes, Hydropsiche instabilis, Cheumatopyiche lepida, Limnephilus lunatus, Anabolia nervosa, Potamophylax rotundipenni, Melampophylax mucoreus, Silo nigricornis, Setodes hungaricus* and *Sericostoma personatum.*

In the Bărbat River Basin, the trichopterans had the highest species diversity (nine species) in the Tulişa Brook (S_{15}) (Tab. 1, Fig. 3).

The trichopterans present the lowest species diversity (two species) and the lowest density in the streams Ciumfu Mare (S_2), Ciumfu Mic (S_5), Curmăturii (S_{11}), Uric S($_{22}$), and in the Bărbat River, at 50 m downstream of the confluence with the Corea Brook (S_{14}) (Fig. 3, Tab. 1).

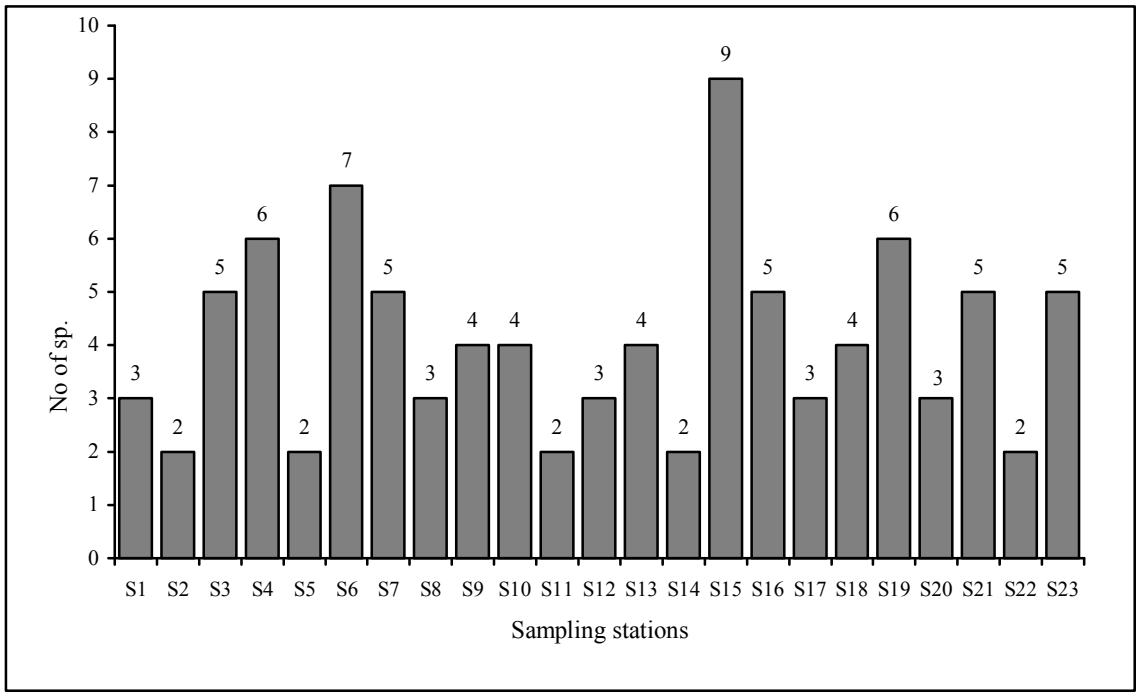

Fig. 3. The trichopteran species number variation in Bărbat River Basin.

Table 1: The structure of trichopteran larvae communities present in the Bărbat River basin 23 lotic sectors and the numerical weight of this systematic group in the benthic macroinvertebrate communities (Ds - average density, P - trichopteran numerical weight in the benthic macroinvertebrate community structure, A% - relative abundance of each species).

Sampling station	P (%)	The specific structure of the trichopteran larvae community	Ds (Number of individuals/m^2)	A (%)
S_1	3.23	*Drusus trifidus*	3	5.00
		Limnephilus lunatus	3	5.00
		Halesus digitatus	38	90.00
S_2	5.32	*Rhyacophila tristis*	10	25.00
		Drusus trifidus	29	75.00
S_3	4.20	*Potamophylax latipennis*	5	5.40
		Potamophylax rotundipennis	14	15.70
		Melampophylax mucoreus	32	36.80
		Goera pilosa	27	31.60
		Sillo pallipes	9	10.50
S_4	2.97	*Rhyacophila tristis*	19	13.94
		Rhyacophila septentrionis	14	10.70
		Philopotamus montanus	10	7.16
		Anabolia nervosa	48	35.80
		Potamophylax cingulatus	34	25.00
		Melampophylax mucoreus	10	7.40
S_5	4.17	*Limnephilus lunatus*	16	33.87
		Potamophylax nigricornis	31	66.13
S_6	15.63	*Philopotamus montanus*	17	9.50
		Drusus discolor	16	8.80
		Drusus trifidus	43	23.80
		Anabolia nervosa	78	42.80
		Potamophylax rotundipennis	9	4.80
		Melampophylax mucoreus	10	5.50
		Silo pallipes	9	4.80
S_7	64.28	*Rhyacophila tristis*	35	18.26
		Rhyacophila nubila	84	44.28
		Hydropsyche instabilis	20	10.28
		Drusus trifidus	34	18.18
		Sericostoma personatum	17	9.00
S_8	7.40	*Rhyacophila fasciata*	27	33.33
		Drusus trifidus	27	33.33
		Silo nigricornis	27	33.33
S_9	8.79	*Rhyacophila tristis*	8	7.10
		Hydropsyche angustipennis	8	7.10
		Drusus trifidus	87	78.70
		Limnephilus lunatus	8	7.10
S_{10}	3.18	*Rhyacophila tristis*	25	18.18
		Rhyacophila vulgaris	12	9.10
		Ecclisopteryx guttulata	49	36.36
		Silo pallipes	49	36.36
S_{11}	2.86	*Rhyacophila septentrionis*	38	66.67
		Rhyacophila fasciata	19	33.33

S_{12}	22.22	*Rhyacophila tristis*	41	46.33
		Philopotamus montanus	18	20.34
		Hydropsyche angustipennis	30	33.33
S_{13}	19.70	*Rhyacophila septentrionis*	16	10.00
		Philopotamus montanus	16	10.00
		Hydropsyche angustipennis	16	10.00
		Halesus digitatus	109	70.00
S_{14}	24.73	*Rhyacophila septentrionis*	61	66.67
		Sericostoma personatum	31	33.33
S_{15}	16.02	*Rhyacophila tristis*	26	15.40
		R. fasciata	8	4.60
		Philopotamus montanus	54	30.70
		Drusus romanicus	5	2.60
		Ecclisopteryx guttulata	5	2.60
		Limnephilus vittatus	40	23.00
		Potamophylax nigricornis	5	2.60
		Melampophylax mucoreus	10	5.70
		Silo pallipes	22	12.80
S_{16}	22.93	*Rhyacophila septentrionis*	28	23.32
		Rhyacophila vulgaris	11	9.30
		Philopotamus montanus	6	4.65
		Hydropsyche angustipennis	73	60.53
		Drusus romanicus	3	2.30
S_{17}	8.97	*Rhyacophila fasciata*	13	15.57
		Diplectona atra	56	66.67
		Drusus trifidus	15	17.76
S_{18}	16.26	*Rhyacophila tristis*	3	26.80
		Philopotamus montanus	75	66.80
		Drusus trifidus	7	5.80
		Policentropus sp.	1	0.60
S_{19}	10.49	*Rhyacophila tristis*	7	5.50
		Rhyacophila vulgaris	16	12.20
		Philopotamus montanus	73	54.50
		Halesus digitatus	12	9.50
		Setodes hungaricus	6	4.70
		Sericostoma personatum	18	13.60
S_{20}	19.83	*Rhyacophila nubila*	72	56.60
		Rhyacophila glareosa	34	26.62
		Hydropsyche fulvipes	21	16.78
S_{21}	9.40	*Rhyacophila tristis*	15	13.00
		Hydropsyche fulvipes	25	21.70
		Cheumatopsyche lepida	51	43.40
		Potamophylax nigricornis	5	4.30
		Sericostoma personatum	21	17.60
S_{22}	6.55	*Rhyacophila tristis*	5	8.40
		Drusus discolor	58	91.60
S_{23}	18.54	*Rhyacophila tristis*	44	23.10
		Rhyacophila nubila	15	7.70
		Potamophylax nigricornis	103	53.80
		Melampophylax mucoreus	15	7.70
		Setodes hungaricus	15	7.70

The trichopteran species with the widest distribution in the Bărbat River basin is *Rhyacophila tristis* present in 12 of the 23 studied lotic sectors. The species with the most restricted distributions are *Diplectona atra* sampled only in the Bărbat River downstream of the confluence with Murguşa Brook, *Rhyacophila glareosa* sampled only in the Bărbat River downstream of the confluence with the Sohodol Brook, *Hydropsyche fulvipes* sampled only in the Corbului Brook, *Hydropsyche instabilis* sampled only in the Bărbat River downstream of the confluence with Ciumfu Mare Brook, *Cheumatopsyche lepida* sampled only in the Corbului Brook.

The numerical weight of the trichopteran larvae in the benthic macroinvertebrate comunities vary, between the reference area with 64.28% in the Bărbat River 30 m downstream of the cnfluence with the Ciumfu Mare Brook (S_7) and 2.86% in Curmăturii Brook at 500 m upstream of the confluence with the Bărbat River (S_{11}) (Tab. 1).

Analysing the structure of the trichopteran larvae communities of the Bărbat River basin (Tab. 1) it can be seen that in streams (S_1, S_8, S_{10}, S_{11}, S_{12}, S_{13}, S_{15}, S_{18}, S_{19}, S_{22}) the species with the highest relative abundance of these communities are lithophilous, rheophilous and oxyphilous species, and the communities of the middle and lower course of the Bărbat River (S_7, S_{14}, S_{20}, S_{23}) are based on eurivalent species.

The analysis of the contingency tables in the cases of the 29 trichopteran species identified in the Bărbat River basin, taken as pairs, based on the Cole interspecific association coefficient (C) and on the average square contingency coefficient (CCM), indicate significant positive associations, for a significance level of 5%, among the species: *Rhyacophila tristis* and *Sericostoma personatum* (χ^2 = 3.856, CCM = 0.361, C = 0.581 ± 0.259), *Rhyacophila tristis* and *Philopotamus montanus* (χ^2 = 5.690, CCM = 0.430, C = 0.540 ± 0.192), *Melampophylax mucoreus* and *Silo pallipes* (χ^2 = 4.859, CCM = 0.412, C = 1 ± 0.345).

Analysing the similarity of the trichopteran larvae communities in the 23 sampled lotic sectors, on the basis of the present species relative abundance (Tab. 1), allows these communities to be grouped in 14 classes (Fig. 4): I. communities where the species *Halesus digitatus* (S_1 and S_{13}) is numericaly dominant; II. communities where the species *Rhyacophila septentrionis* (S_{11} and S_{14}) is numericaly dominant; III. communities where the species *Diplectona atra* (S_{17}) is numericaly dominant; IV. communities where the species *Potamophylax nigricornis* (S_5 and S_{23}) is numericaly dominant; V. communities where the species *Philopotamus montanus* (S_{12}, S_{15}, S_{18}, and S_{19}) is numericaly dominant; VI. communities where the species *Ecclisopteryx guttulata* and *Silo pallipes* (S_{10}) are numericaly codominant; VII. communities where the species *Cheumatopsyche lepida* (S_{21}) is numericaly dominant; VIII. communities where the species *Drusus trifidus*, *Rhyacophila fasciata* and *Silo nigricornis* (S_8) are numericaly codominant; IX. communities where the species *Melampophylax mucoreus* si *Goera pilosa* (S_3) are numericaly codominant; X. communities where the species *Anabolia nervosa* (S_4 and S_6) is numericaly dominant; XI. communities where the species *Rhyacophila nubila* - S_7 and S_{20} is numericaly dominant; XII. communities where the species *Hydropyche angustipennis* (S_{16}) is numericaly dominant; XIII. communities where the species *Drusus trifidus* (S_2 and S_9) is numericaly dominant; XIV. communities where the species *Drusus discolor* (S_{22}) is numericaly dominant.

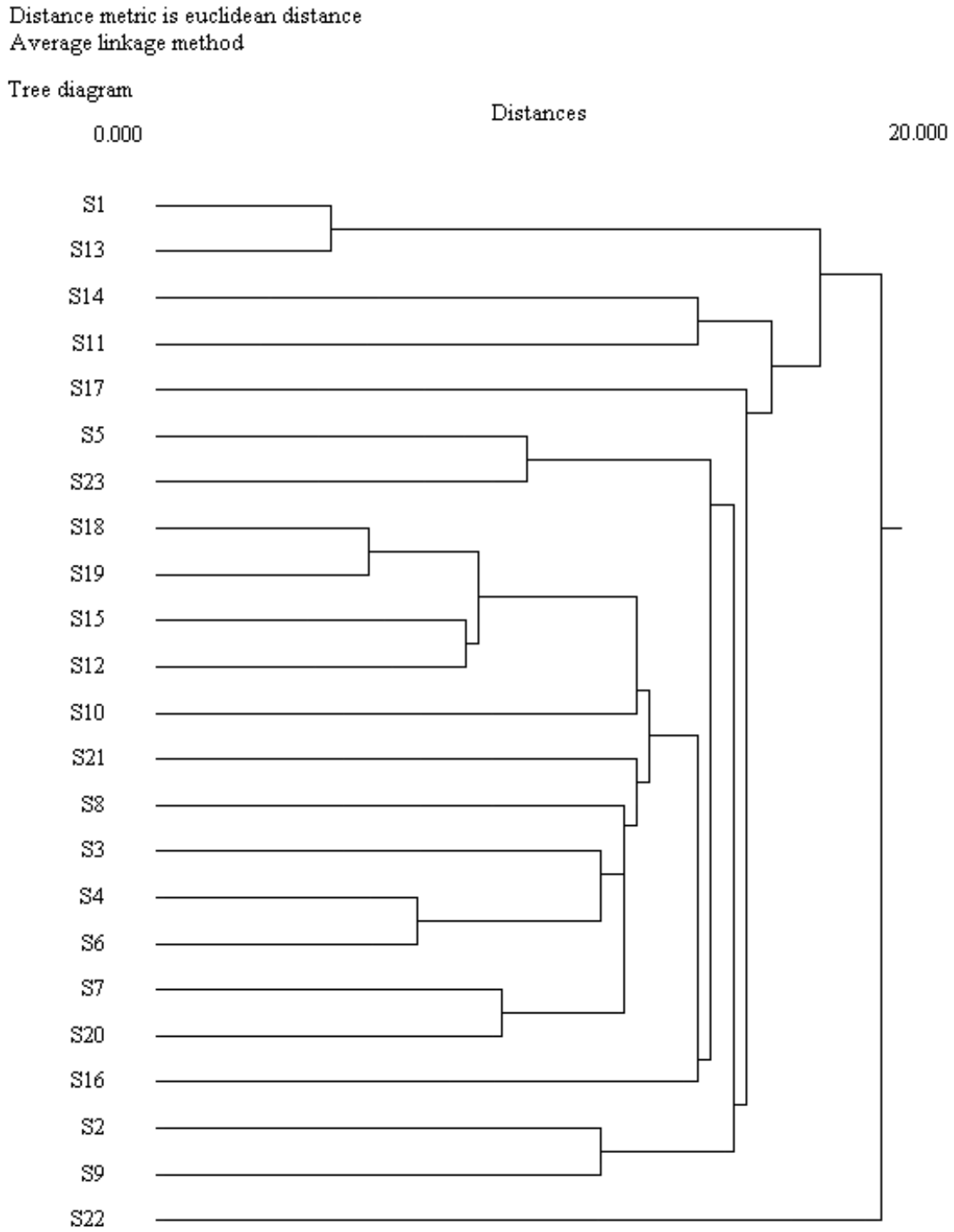

Fig: 4. Tree diagram drawn on the basis of the trichopteran species relative abundence (A%), species present in the 23 analyzed lotic sectors.

CONCLUSIONS

The trichopteran fauna of the Bărbat River basin presents a high species diversity. In the studied area 29 trichopteran species belonging to 16 genera and to seven families were identified, representing 10.86% of the Romanian trichopteran fauna (Ciubuc, 1993).

The trichopteran larvae communities study reveals the fact that the aquatic habitats of the upper Bărbat River basin is in a good state, and that the anthropogenic impact in this area is insignificant. In the lower Bărbat River basin anthropogenic influences are present -especially waste water pollution.

For the conservation of the natural habitats, characteristic for the Carpathians rivers and of the rare species present in the Bărbat River basin, protection measures are needed and also the implementation in time of an ecological management programe. These actions are needed especially due to the fact that a series of hydrological constructions are planned and there is rapidly growing tourism in the area.

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CONTRIBUTIONS ON THE STUDY OF THE MACROZOOBENTHIC INVERTEBRATES FROM THE GLACIAL LAKES OF THE LĂPUŞNICU MARE RIVER BASIN (RETEZAT MOUNTAINS, ROMANIA)

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, glacial lakes, macrozoobenthic invertebrates, dominant species.

ABSTRACT

The paper contains the results of the research upon the macrozoobenthic invertebrates from the lakes situated in the Lăpuşnicu Mare River basin. We have studied 14 lakes from which we collected benthic samples and we determined the structure of the benthos. The number of taxa is relatively small, because the water in the lakes is cold all year long, and even in the summer months they not reach more than 15^0C at the surface. So only cold water species can live here, and those which are adapted to the high oxygen content. The benthic invertebrates from the lake feed mainly on the abundant debris washed into the lake from the slopes. Sometimes we noticed significant differences between the benthic fauna in lakes from the same glacial circle, situated very close to each other. The structure of the benthic macroinvertebrate fauna in the glacial lakes is determined most frequently by chance, because the environmental conditions are very alike and do not justify the faunistical differences.

RÉSUMÉ: Contribution sur l'etude des nevertebres macrozoobentiques dans les lacs glaciers des basin de Lăpuşnicu Mare riviere (Les Montagnes Retezat, Romania).

Ce travail contient les résultants de recherches au sujet de faune macrozoobenthique du lacs glacier, situent dans le Bazin du Rivier Lăpuşul Mare. Ont été étudie un nombre de 14 lacs, du quel sont collecte essais benthonique e sont poursuite la composition du benthos. Le nombre des groupes, est relativement petit, avoir en vu le fait que, les au des lacs glacier sont froid presque tout le temps des année, elle ne depasont 15^0C a la surface, pas même dans les mois d'été. Par conséquence ils pouvant s'installer seulement les espèces criofile, oxifile et qui se nourrissent prépondérant avec détritus, celui-ci seront abundant dans les lacs glacier au cause d'apport de matériel alohton antrene de la pente avec les précipitation. S'ave observe qu'il existe parfois de grands différences entre la faune de quelqu'un lacs situant dans le même circ. glacier, situe un près de l'autre. La composition de la faune benthonique dans les lacs glacier est détermine le plus souvent d'enveniment avoir vu les conditions très semblable de midi et la structure benthonique différente.

REZUMAT: Contribuţii la studierea nevertebratelor macrozoobentonice din lacurile glaciare ale bazinului Lăpuşnicul Mare (Munţii Retezat, România).

Lucrarea cuprinde rezultatele studiului faunei macrozoobentice din lacurile glaciare din bazinul râului Lăpuşnicu Mare. Au fost studiate 14 lacuri din care s-au colectat probe bentonice şi s-a urmărit compoziţia bentosului. Numărul de grupe faunistice este relativ mic, având în vedere faptul că apele lacurilor glaciare sunt reci aproape tot timpul anului, ele nu depăşesc 15^0C la suprafaţă nici vara. Ca urmare se pot instala doar specii criofile, oxifile şi care se hrănesc preponderent cu detritus, acesta fiind abundent în lacurile glaciare, datorită aportului de material alohton antrenat de pe pante de precipitaţii. S-a observat că există uneori mari diferenţe între fauna unor lacuri situate în acelaşi circ glaciar, situate aproape una de alta. Compoziţia faunei bentonice în lacurile glaciare este determinată cel mai adesea de întâmplare, având în vedere condiţiile asemănătoare de mediu şi structura bentică diferită.

INTRODUCTION

The Retezat National Park is situated in the western part of the Romanian Meridional Carpathians and it is delimited to the north by the Haţeg depression, to the east by the Tulişa Mountains, to the south by the Jiu Valley and to the west by the Ţarcu Mountains. The total surface area of the Retezat Mountains is about 466 km^2 and stretches into the Hunedoara County territory.

These mountains are characterized by the highest humidity of the Carpathians, and we found the highest number of glacial lakes from the Carpathians (37.8 %). These glacial lakes are usually part of the limnologic complexes which drain the water from the slopes.

The glacial lakes were formed by the melting of the snow which acted together with the glacial erosion and created two main types of lakes: glacial circle lakes and glacial valley lakes.

The glacial circle lakes are the most characteristic for the glacial erosion. They are usually round in shape and have many tributaries which drain water in the lake. They usually have also an emissary which is the origin of a stream or a river (for example lake Bucura).

The glacial valley lakes are small in number because the great quantity of water from the glacial circles washed the substrate away and drained the streams from above. A typical example of glacial valley lakes is those from the Bucurii Valley formed by 19 lakes.

The studied region is situated in the southern part of the mountains in the hydrographic basin of the Lăpuşnicu Mare River which includes the following lake complexes: Bucura complex with lakes Bucura, Florica, Ana, Lia, Tăul Porţii; Slăveiului complex with lakes Slăveiului and Turcel; Peleaga complex with lakes Peleaga and Peleguţa; Zănoaga complex with lakes Zănoaga, Judele, Ascuns, Urât, Răsucit. (Gîştescu, 1963)

The geomorphologic, faunistic and floristic diversity attracted the scientist to this part of the country. The first research was carried out in the XVIII-th century and was followed by numerous and diverse others.

The first faunistic researches were made in terrestrial ecosystems by Bielz (1888), followed by the study of crustaceans (Daday, 1879, 1883; Szilady, 1900), entomofauna (Szilady, 1900, 1906; Dioszeghy, 1917) and avifauna (Danford and Brown, 1875; Buda, 1882; Congreve, 1929).

After the establishment of the National Park in 1935, the faunistic studies were made by applying the modern scientific methods and concepts. The first hydrobiological studies were made by Prunescu-Arion and Toniuc (1967), Godeanu (1972, 1974, 1981), Bănărescu and Ehran-Dinca (1975 - 1976). The terrestrial lumbricidae were studied by Pop (1972), the entomofauna by several scientists (Konig, 1959, 1969; Fuhn, 1967, 1974; Brădescu, 1971 - 1985; Damian-Georgescu, 1975-1976; Pârvu, 1980, 1985; Gheorghiu, 1983; Burnaz and

Konig, 1984). The oribatida were mentioned for the first time by Feider et al. (1972). Some avifaunistical studies were made by Gîrlea (1977), Salmen (1980) and some mammological studies by Iacob (1965, 1972) and Almăşan (1984).

Between 1980 - 1990 numerous ecological studies were performed in the park concerning the structure, biomass and productivity of the consumers found in the soil (Popovici, 1984; Popovici et al., 1985, 1987) faunistic and ecological studies on the different groups of pedofauna: protozoans (Tomescu, 1984) nematoda (Popoviciu, 1984, 1987), lumbricida (Pop, 1972, 1984), colembola (Weisner, 1984), acarina (Georgescu, 1984), coleoptera (Teodoreanu, 1984). Other fauna groups miriapoda (Ceuca, 1984; Matic 1985), entomofauna (Kiss, 1984; Botoc, 1984; Bechet, 1985), amphibia and reptilia (Stugren and Ghira, 1987; Ghira and Stugren, 1988), avifauna (Munteanu, 1985, 1986, 1987).

The studies of the benthic macroinvertebrates from the national park are lacking due to the difficult access to the majority of the lakes and the difficulty of sampling these habitats. This study is one of the first investigations of the benthic fauna from the Retezat Mountains (Cupşa et al., 2003 a, b).

MATERIALS AND METHODS

A total number of 14 lakes were investigated during June to August 2000. One series of samples was collected due to the difficulties in reaching the sample sites both because the weather conditions (a lot of days with fog or rain and the long period when snow covers the peaks and access is dangerous even for alpinists because the high risk of avalanches) and because of the position of the lakes (many of them are situated in the glacial circles below the touristic paths in unmarked areas, edged by very steep slopes, sometimes almost impossible to descend or climb).

The collected samples were qualitative and quantitative. The quantitative samples were collected with a bodengreifer. The samples were preserved in 4% formalin in the field and sorted in the laboratory under a 40 X magnifying stereomicroscope and transfered in 80% alchool solution.

The taxa were determined under stereomicroscope or even 100 X microscope.

The sample sites were the following:

1. Lake Peleaga
2. Lake Peleguța

} from Peleaga complex

3. Lake Bucura
4. Lake Ana
5. Lake Lia
6. Lake Florica
7. Tăul Porții

} from Bucura complex

8. Lake Zănoaga
9. Lake Judele
10. Lake Ascuns
11. Lake Urât
12. Lake Răsucit

} from Zănoaga complex

13. Lake Turcelul
14. Lake Slăveiul

} from Slăveiu complex

RESULTS

From the 14 studied lakes we have identified 15 invertebrate taxa (Tab. 1). The most frequent groups are the Chironomida larvae found in all 14 lakes (F = 100 %), followed by the Oligochaeta and Plecoptera larvae, found in 11 lakes (F = 78.57 %), Trichoptera larvae found in eight lakes (F = 57.14 %) (Tab. 2).

The most abundant group is the Chironomida due to their high adaptability and detrivorous feeding. They are followed in abundance by the Oligochaeta. These groups feed specifically on debris. The content of the debris in the glacial lakes is important because the soil and other organic materials are washed by the rain from the slopes nearby into the glacial lakes. The Cladocera are also abundant, but they are not benthic invertebrates so we do not discuss them. They occur in the samples accidentally; they live in the upper layers of the lake water and in the summer period are very abundant because this is when they reproduce.

The less abundant groups are the Nematode, Gasteropoda, Ephemeroptera larvae and larvae of other Diptera groups than Chironomida (Fig. 1). We found only one species of Gasteropoda *Ancylus fluviatilis* in only one lake, Zănoaga.

Table 1: The benthic macroinvertebrate groups density (N/m^2) in the studied lakes.

Lake	Nematoda	Oligochaeta	Gastropoda	Bivalva	Acarina	Copepoda	Cladocera	Ostracoda	Colembola	Ephemerop.*	Plecoptera*	Trichoptera*	Coleoptera*	Chironomida*	Diptera**	Total
Peleaga	-	-	-	-	-	3	-	-	1	-	1	-	-	300	-	306
Peleguța	-	20	-	3	-	6	86	2	-	-	36	2	-	107	-	262
Bucura	-	-	-	-	2	3	25	-	-	-	-	-	-	120	-	150
Ana	-	20	-	1	-	-	-	-	1	-	7	7	5	125	-	166

Lia	-	25	-	15	-	-	100	-	-	2	13	4	-	50	-	209
Florica	-	77	-	-	-	-	160	-	-	-	5	-	1	82	-	325
Porții	-	8	-	-	1	-	-	-	-	1	1	-	-	28	-	39
Zănoaga	-	9	7	-	-	-	-	-	-	-	-	3	-	5	-	24
Judele	3	50	-	2	-	5	-	-	-	-	-	-	-	2	-	62
Ascuns	-	-	-	-	-	-	-	-	-	-	2	3	-	84	-	89
Urât	-	6	-	-	-	2	3	-	-	-	5	3	3	22	-	44
Răsucit	-	15	-	-	-	-	-	-	-	-	8	1	-	39	1	64
Turcel	-	15	-	38	-	-	-	1	-	-	5	4	-	80	-	143
Slăveiul	-	32	-	28	-	-	139	-	-	-	3	-	-	164	-	366

* larvae; ** other than Chironomida.

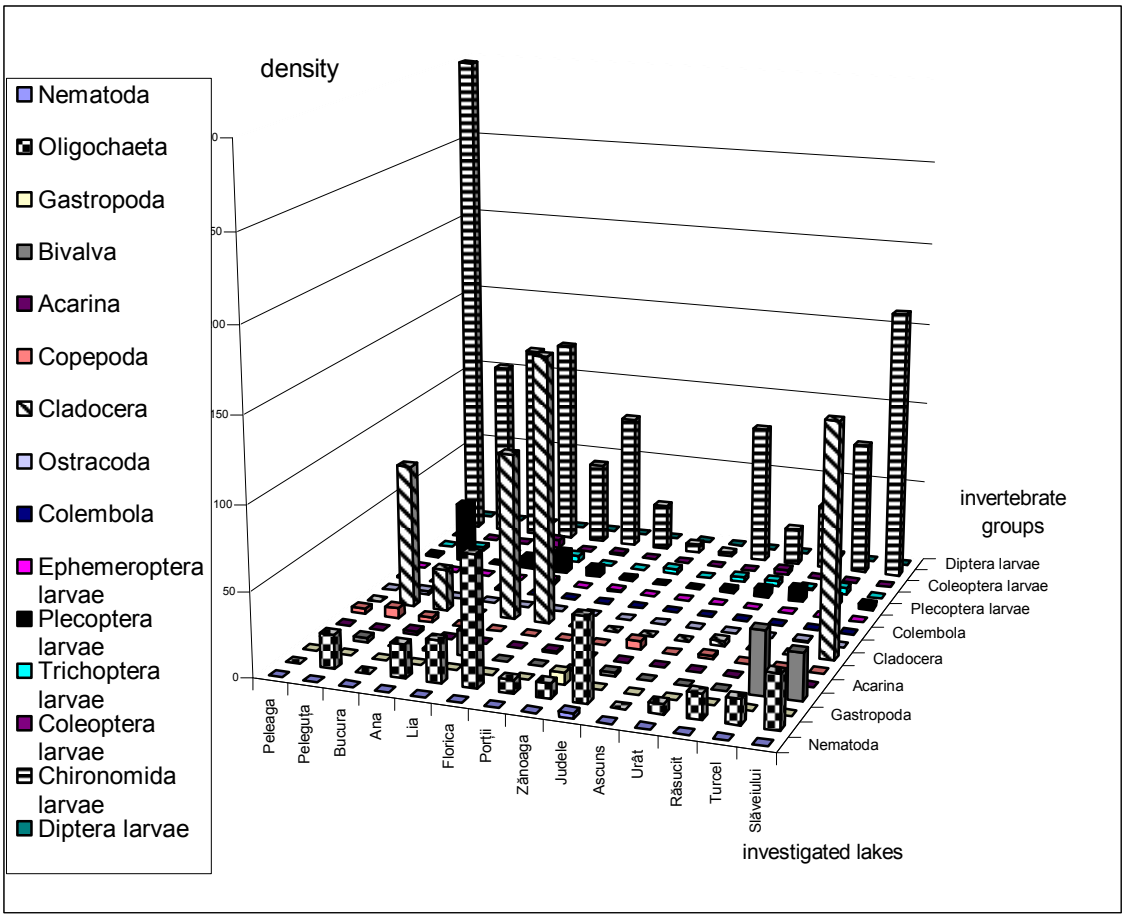


Fig. 1: The density of the macrozoobenthic invertebrata groups from the investigated lakes.

The high altitude Peleaga Lake is situated at 2509 m high.

In this lake we found only four invertebrate groups. The highest abundance was encountered by Chironomida larvae with 98.36 % (Fig. 2 a), followed by Plecoptera larvae 0.32 %. The other down invertebrate groups (Copepoda and Colembola) are not benthic groups and occur accidentally in samples.

Table 2: The relative abundance of the benthic macroinvertebrate groups in the studied lakes.

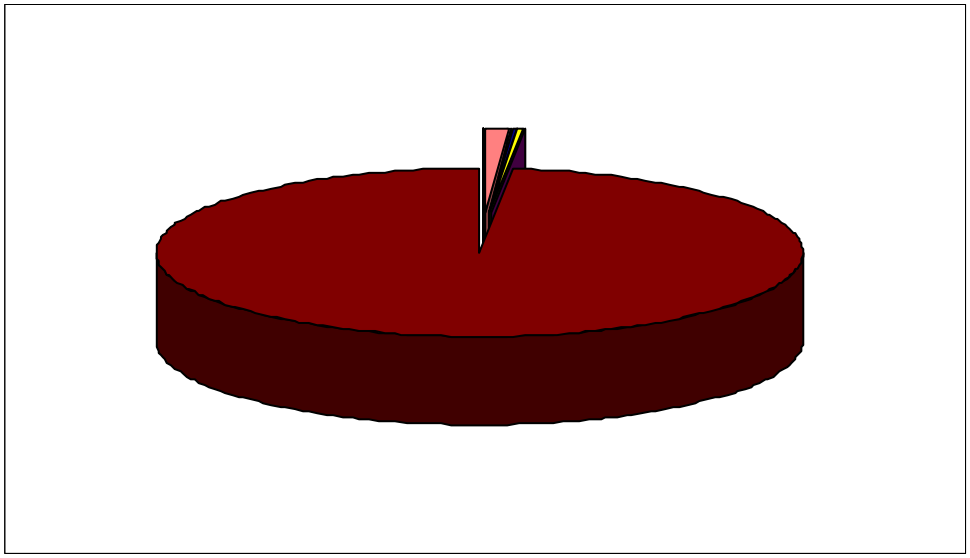
Lake	Nematoda	Oligochaeta	Gastropoda	Bivalva	Acarina	Copepoda	Cladocera	Ostracoda	Colembola	Ephemeroptera*	Plecoptera*	Trichoptera*	Coleoptera *	Chironomida*	Diptera **
Peleaga	-	-	-	-	-	0.98	-	-	0.33	-	0.33	-	-	98.36	-
Pelegușa	-	7.63	-	1.14	-	2.29	32.82	0.76	-	-	13.74	0.76	-	40.84	-
Bucura	-	-	-	-	1.33	2	16.66	-	-	-	-	-	-	80	-
Ana	-	12.04	-	0.60	-	-	-	-	0.60	-	4.21	4.21	0.60	75.30	-
Lia	-	8.09	-	4.85	-	-	32.36	-	-	0.65	4.20	1.29	-	48.54	-
Florica	-	23.69	-	-	-	-	49.23	-	-	-	1.53	-	0.31	25.23	-
Porții	-	20.51	-	-	2.56	-	-	-	-	2.56	2.56	-	-	71.79	-
Zănoaga	-	3.5	29.16	-	-	-	-	-	-	-	-	12.5	-	20.83	-
Judele	4.83	80.65	-	3.22	-	8.06	-	-	-	-	-	-	-	3.22	-

Ascuns	-	-	-	-	-	-	-	-	-	-	2.25	3.37	-	94.43	-
Urât	-	13.63	-	-	-	4.54	6.81	-	-	-	11.36	6.81	6.81	50	-
Răsucit	-	23.43	-	-	-	-	-	-	-	-	12.5	1.56	-	60.93	1.56
Turcel	-	10.49	-	26.57	-	-	-	0.69	-	-	3.49	0.79	-	55.94	-
Slăveiului	-	8.74	-	7.65	-	-	37.98	-	-	-	0.82	-	-	44.81	-
Frequency	7.14	78.57	7.14	42.85	14.28	35.71	42.85	14.28	14.28	14.28	78.57	57.14	21.42	100	7.14

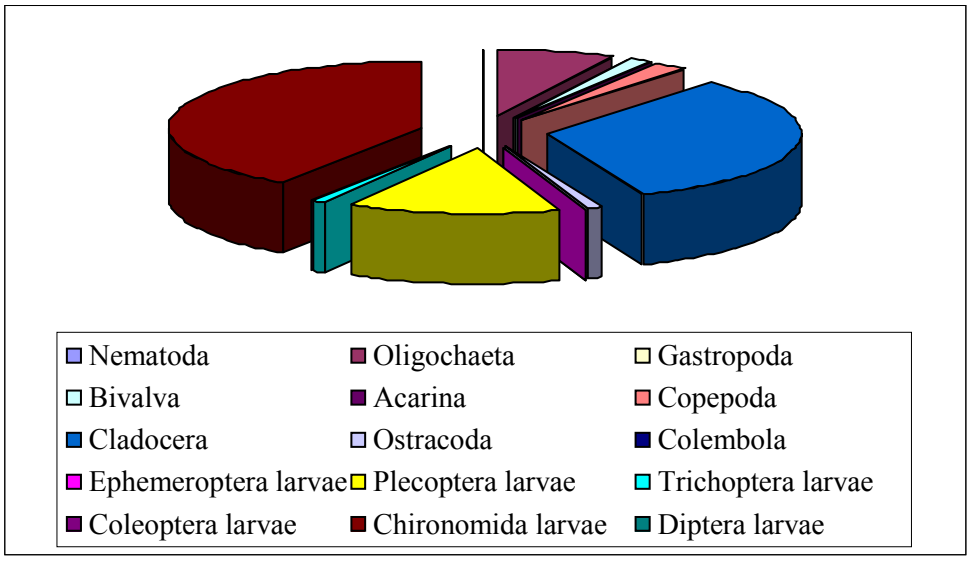
* larvae; ** other than Chironomida.

In lake Peleguţa we found a higher variety of benthic macoinvertebrates. We found eight groups of which the most abundant are the Chironomida larvae, followed by benthic groups the Plecoptera larvae and Oligochaeta. (Fig. 2 b)

Peleaga and Peleguţa are part of the same glacial circle, but Peleaga is situated higher. The fauna of the two lakes is very different despite the small distance between them. The benthic fauna of Peleguţa is more diverse that the fauna of Peleaga lake.



a



b

Fig. 2: The abundance of the benthic macroinvertebrates from lakes Peleaga (a) and Peleguța (b).

In Bucura we found only four groups of invertebrates, the most abundant are the Chironomida larvae, two of the groups are not typically benthic groups (Copepoda and Cladocera). (Fig. 3 a)

In lake Ana we found seven groups, and the most abundant are the Chironomida larvae, and Oligochaeta. Here we found some bivalve and Plecoptera and Ephemeroptera larvae. So the benthic structure in this lake is more diverse than in lake Bucura. (Fig. 3 b)

In lake Lia the situation is very similar to lake Ana, the benthic structure is well represented, the dominating group is Chironomida larvae, the rest of the benthic groups have small abundances. (Fig. 3 c)

In lake Florica the bivalves are lacking, also the Trichoptera larvae. The most abundant group is the Cladocera but they are not benthic so we exclude them from the discussion. From the benthic groups the Chironomida larvae and the Oligochaeta have almost the same abundance. (Fig 3 d)

In Tăul Porții the benthic structure is also dominated by the Chironomida larvae, followed by Oligochaeta. Here we didn't find the zooplanktonic species found in the other lakes from the Bucura glacial circle (Copepoda and Cladocera). (Fig 3 e)

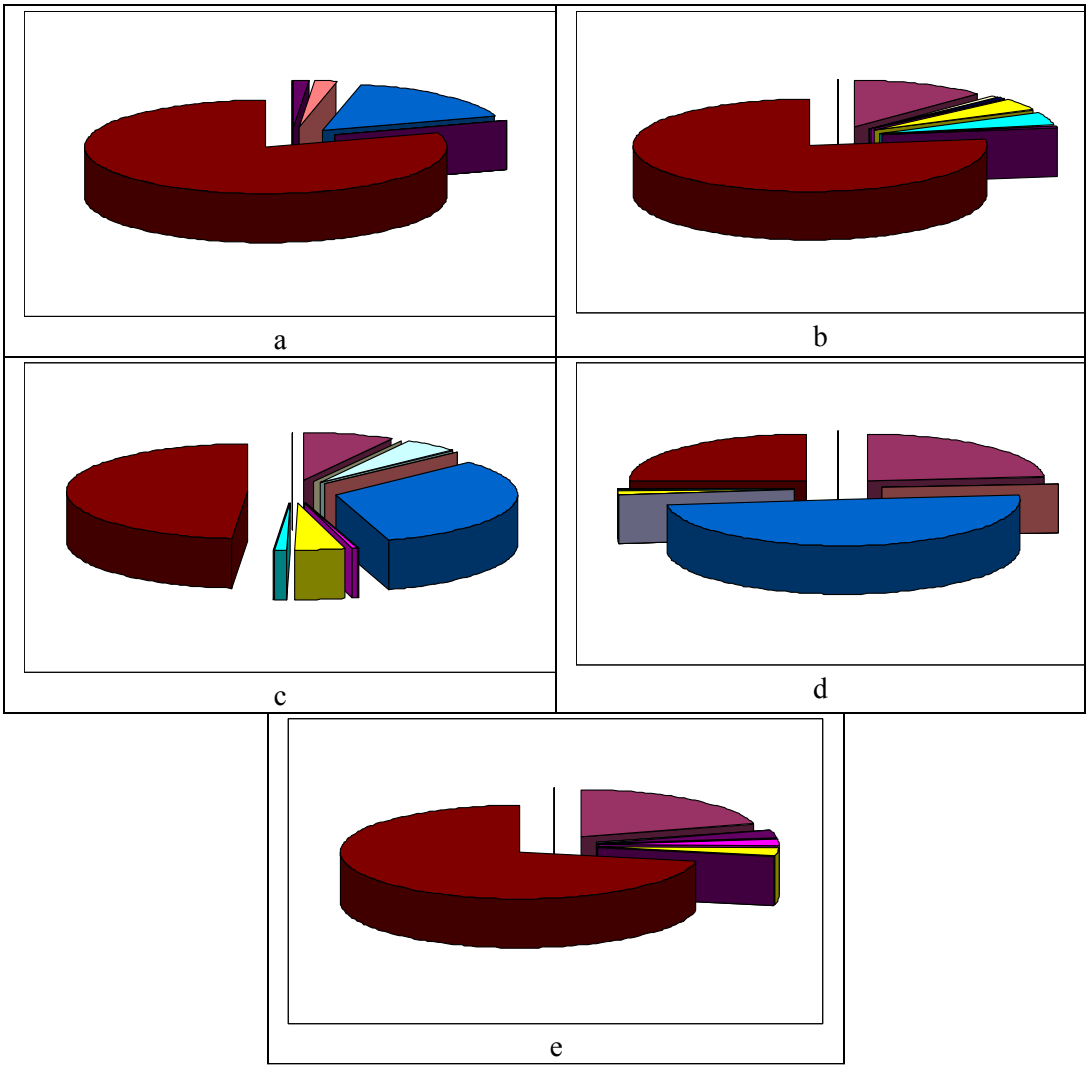


Fig. 3: The abundance of the benthic macroinvertebrates from lakes Bucura (a), Ana (b), Lia (c), Florica (d) and Tăul Porții (e).

In lake Zănoaga we found only four groups of invertebrates. It is the only lake in the whole park where we found Gasteropoda (*Ancylus fluviatilis*) (Cupşa et al., 2002; Cupşa et al., 2003 a, b). The most abundant group is the Oligochaeta followed by Gasteropoda and Chironomida larvae (Fig 4 a).

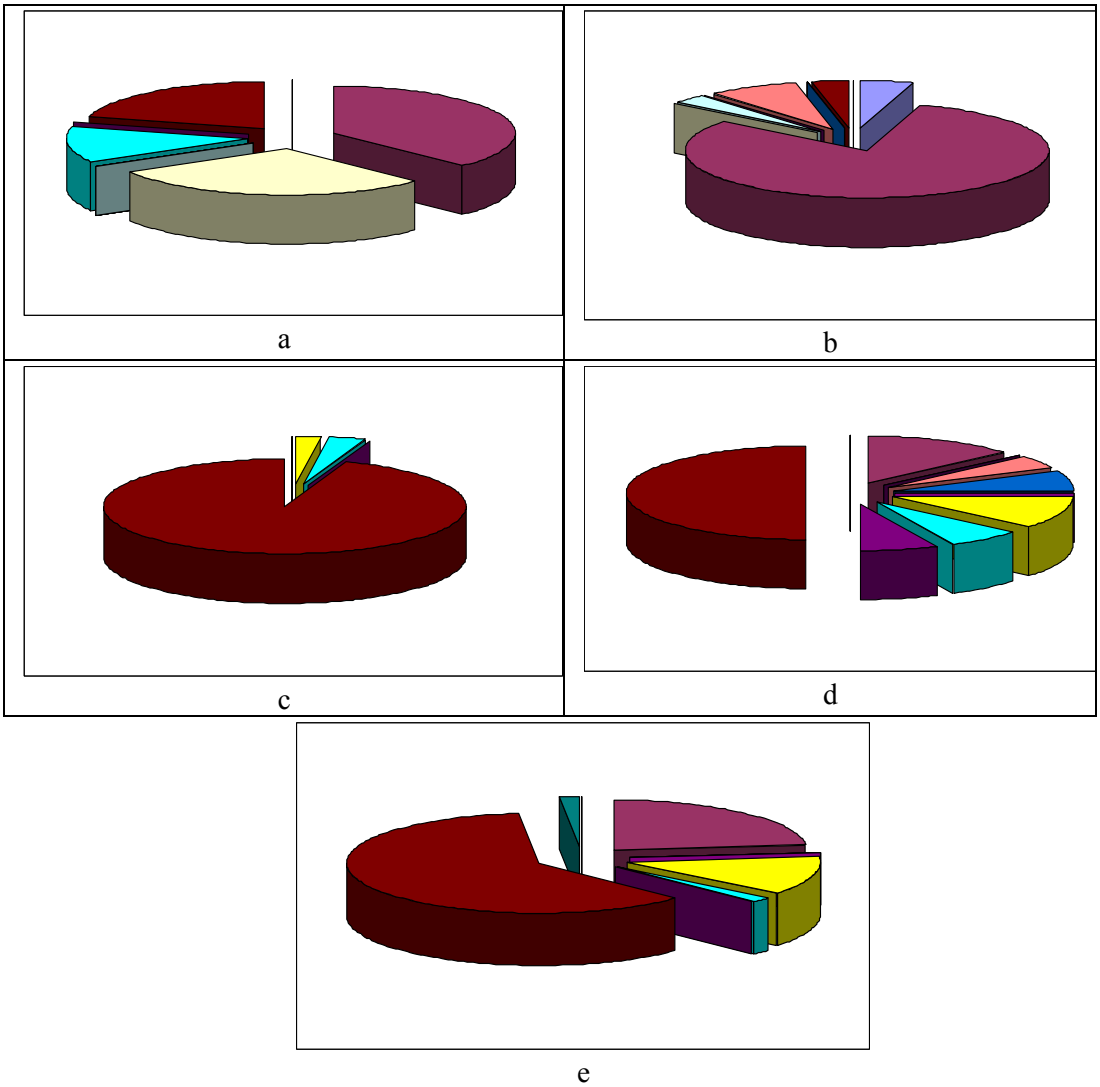


Fig. 4: The abundance of the benthic macroinvertebrates
from lakes Zănoaga (a), Judele (b), Ascuns (c), Urât (d), Răsucit (e).

In Judele Lake the Oligochaeta is also the most abundant group with 80.64 %. Here we also have found nematodes. It is the only lake in the Lăpuşnicu Mare River basin which has nematodes in the benthos fauna. We have found nematodes in lakes from Nucşorul river basin (Cupşa et al., 2002; 2003 a, b). The Chironomida larvae and the bivalve have very low abundances. (Fig. 4 b)

In the Ascuns Lake we found only three invertebrate groups, the most abundant of which are the Chironomida larvae, with Plecoptera and Trichoptera larvae having very low abundances (Fig. 4 c).

Lake Urât has the highest number of benthic invertebrate groups in the Zănoaga glacial circle. The community is dominated by the Chironomida larvae which have an abundance of 50 %, followed by Oligochaeta and Plecoptera larvae. (Fig. 4 d)

In lake Răsucit the most abundant are also the Chironomida larvae followed by the Oligochaeta, here there are no zooplanctonic species. (Fig. 4 e)

In lake Turcel we found seven invertebrate groups of which six are benthic. The most abundant group is the Chironomida larvae followed by the Bivalva. (Fig. 5 a)

In lake Slăveiu the benthic structure looks very alike, but the Trichoptera larvae are absent and the Chironomida larvae are the most abundant followed by the Oligochaeta. (Fig. 5 b).

Of the all invertebrate groups the Chironomida are the most frequent (100 %) (Tab. 2), followed by the Oligochaeta and Plecoptera (78.57 %) and the Trichoptera (57.14 %). These are the base of the benthic community in the studied lakes. The high abundance of the Oligochaeta and the Chironomida in the most lakes shows that the most important trophic base in the lakes is the debris from the substrate. The high zooplanktonic species density of the in some lakes (Cladocera and Copepoda) shows that in the summer period the phytoplankton is well developed offering a good trophic base for the zooplankton.

The highest density of fauna was found in Slăveiu Lake (Tab. 1), followed by Porții and Peleaga, and the lowest density in Zănoaga. The similarity index Sörensen (Tab. 3) both for the lakes from the same glacial circle and from all lakes taken two by two was calculated. We have found that in the lakes from the same glacial circle the index shows significant differences in the case of Peleaga and Peleguța lakes from Peleaga glacial complex, Bucura with the other lakes from the Bucura complex (Ana, Lia, Florica and Porții) and Zănoaga with Judele from the Zănoaga complex.

Comparing the lakes from the different lake complexes we have found that the index shows significant differences for more than half of the studied lakes in the case of Peleaga, Bucura and Judele. These lakes are situated at the highest altitudes in the Park and at the longest distance from the river Lăpuşnicu Mare and its major tributaries. So the invertebrates which are found in this lake get there by chance, or by active flying in the case of insects with aquatic larvae (Ephemeroptera, Plecoptera, Trichoptera and Chironomida). The most successful in this process were the Chironomida which are found in all lakes and the least successful Ephemeroptera which are the least frequent. The Chironomida success is due also probably to the fact that they are feeding on debris so they always have enough food to complete their life cycles. The other groups are mainly carnivorous so they maybe do not always find enough food to develop in high densities.

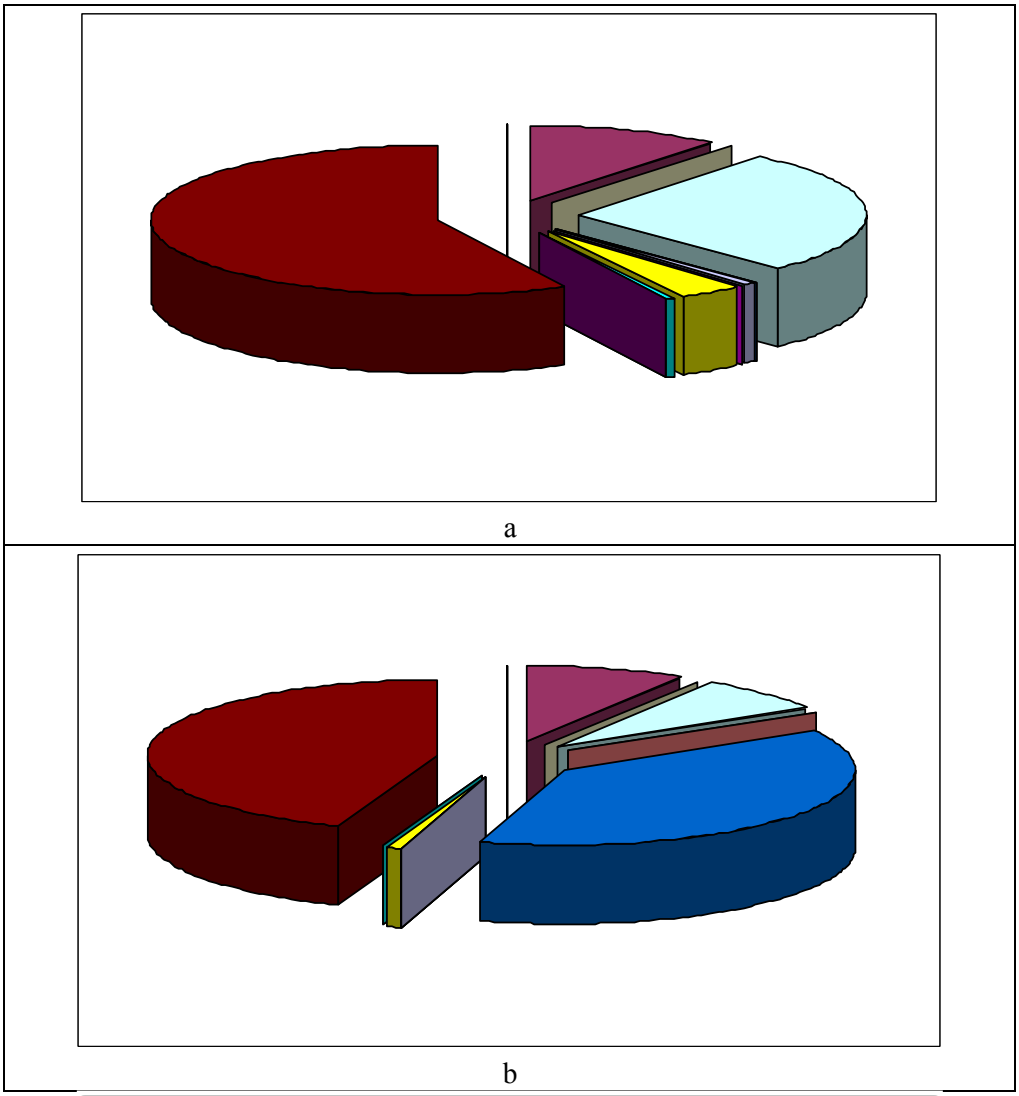


Fig. 5: The abundance of the benthic macroinvertebrates from lakes Turcel (a) and Slăveiu (b).

The exclusively aquatic organisms (Oligochaeta, bivalves, etc.) probably reached the lakes in a vegetative form carried by the wind or by the birds, or some of them carried by the fish which swam upstream. The glacial lakes from the Lăpuşnicu Mare River basin benthic fauna is not diverse, due to the water low temperature, a poor trophic base and the difficulty of reaching lakes situated at high altitude (almost all over 2000 m). This situation was observed also in other glacial lakes from the Retezat National Park (Cupşa et al., 2002; 2003 a, b).

Table 3: The values of Sorensen index between the studied lakes.

Peleguța	Bucura	Ana	Lia	Florica	Porții	Zănoaga	Judele	Ascuns	Urât	Răsucit	Turcel	Slăvei	lake
18.18	50	55.55	36.36	44.44	44.44	25	44.44	57.14	60	44.44	40	44.44	Peleaga
	50	53.33	80	61.53	46.15	50	61.53	54.54	85.71	61.53	85.77	76.92	Peleguța
		18.18	36.36	44.44	44.44	25	44.44	28.57	60	22.22	20	44.44	Bucura
			78.57	50	50	54.54	50	60	71.42	66.66	76.92	66.66	Ana
				66.66	66.66	54.54	50	60	71.42	66.66	76.92	83.33	Lia
					60	44.44	40	25	66.66	60	54.54	80	Florica
						44.44	40	50	50	60	54.54	40	Porții
							44.44	57.14	60	74.44	60	44.44	Zănoaga
								25	54.54	40	54.54	60	Judele
									74.44	75	66.66	50	Ascuns
										72.72	61.53	66.66	Urât
											54.54	60	Răsucit
												72.72	Turcel
													Slăvei

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THE RÂUL MARE RIVER (RETEZAT MOUNTAINS, ROMANIA) FISH FAUNA

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, lotic system, fish associations, fish zonation, human impact.

ABSTRACT

This paper work summarizes a fish survey of the Râul Mare and relates these results to the natural and human factors affecting the ichthyofauna diversity of this lotic system.

This study is interesting due to the fact that this river flows through the oldest national park in Romania, The Retezat National Park established in 1935. The river has both pristine remote lotic sectors but also sectors under important anthropogenic impact.

Mapping out the ichthyologic component as an element of the lotic system allows assertions concerning fish assemblages structure variation along the river to be made and cause - effect relationships to be identified, important informational elements needed for the local/regional ecological management plan.

RÉSUMÉ: L'ichtyofaune de Râul Mare (Les Montagnes Retezat, Roumanie).

L'oeuvre présente les résultats d'une étude ichtyologique en lien avec des facteurs naturels anthropiques qui influence la diversité de l'icthyiofaune de Râul Mare.

Par l'intermédiaire de ses résultats, cet étude est intéressant aussi de point de vue écologique parce que la rivière Râul Mare traverse le plus ancien parc national de Roumanie - „Parcul Național Retezat", crée en1935 et aussi parce qu'il présente des zones avec des spécificités naturelles ainsi que des zones soumises à un impact anthropique important.

Prenant en considération l'ichtyofaune comme élément important du sisteme lotic, le livre fait l'analyse de la diversité structurelle des communautés de poissons et des relations cause effet ont été identifiées comme des éléments fournisseurs d'informations de base pour les besoins locaux/régionaux de gestion écologique.

REZUMAT: Ihtiofauna Râului Mare (Munții Retezat, România).

Lucrarea prezintă rezultatele unui studiu ihtiologic, relaționate cu factori naturali şi antropici care afectează diversitatea ihtiofaunei Râului Mare.

Prin intermediul rezultatelor sale, acest studiu este interesant din punct de vedere ecologic datorită faptului că Râul Mare curge prin cel mai vechi parc național din România - „Parcul Național Retezat" (înființat în anul 1935) şi pentru că prezintă atât sectoare cu caracteristici naturale cât şi sectoare supuse unui impact antropic semnificativ.

Subliniind ihtiofauna ca element important al sistemului lotic a fost analizată variația structurii comunităților de peşti de-a lungul râului şi au fost identificate relațiile cauză - efect ca elemente informaționale de bază pentru necesarul plan local/regional de management ecologic.

INTRODUCTION

In the past 50 - 60 years, many economic development pressures have changed lotic systems throughout the Romanian territory. Unfortunately in the last half of century the "traditional" engineering concepts have been applied to problems of flood control, electric energy production, irrigation and road construction. This kind of approach has not incorporated the natural lotic systems structure and function, the riparian functions, and the associated aesthetic and financial value. Almost all over the country the lotic systems alterations have resulted in adverse habitat changes with impact on numerous fish associations/populations (Bănăduc, 1999, 2005; Battes et al., 2003; Davideanu et al. 2005; Crăciun et al., 2004; Fulga and Kiseliova, 2005; Moşu et al., 2005; Ureche et al., 2006) and structural and functional related biota (Curtean-Bănăduc 2005 a, b; Staicu et al. 1998; Benedek and Curtean - Bănăduc, 2001; Curtean, Sîrbu, Drăgulescu and Bănăduc, 1999; Curtean, Morariu, Făcălău, Lazăr and Chişu, 1999; Curtean-Bănăduc, Bănăduc and Sîrbu, 2001) and have contributed to important declines in native fish populations.

Streams or stream sectors in good natural condition are rare and mostly localized in not easy accessible areas. The upper and middle Râul Mare River course is situated in such a relatively inaccessible area and an important length is in the oldest national park in Romania, The Retezat National Park established in 1935, with a total surface of 38.047 ha. The UNESCO Programme Man and Biosphere highlighted the universal value of this park in 1979, through its selection in the international network of biosphere reserves.

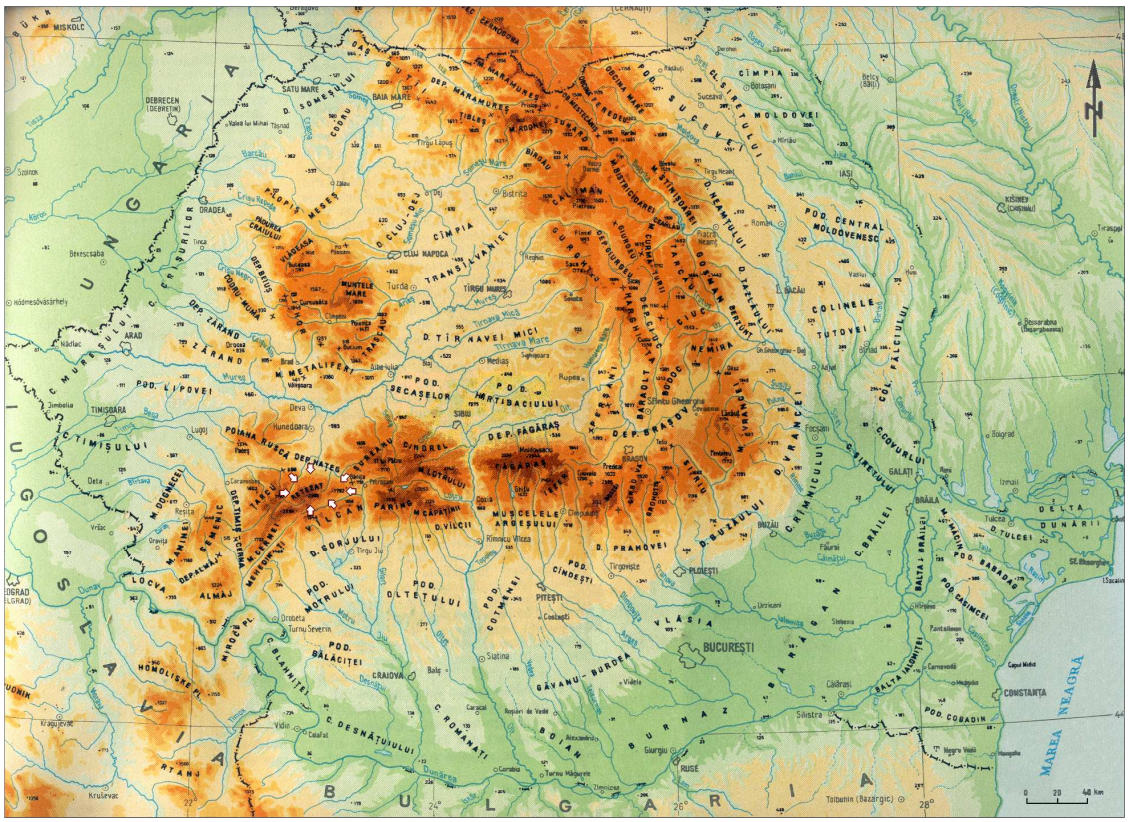

Fig. 1: The Retezat Mountains study unit (⇨) location (Badea et al., 1983 - modified).

The Retezat Mountains are situated in the western part of the Romanian Meridional Carpathians (Fig. 1), massif with a complex glacial relief and with many altitudes higher then

2000 m (Peleaga Peak, 2509 m, Retezat Peak 2482 m, etc.). The surface of the Retezat Mountains is about 466 km^2 and lies in the Hunedoara County territory.

The main aim of this study is to reveal, based on the lotic system fish fauna assessment, the impact of the economic development pressures on one of the (at least theoretically) most protected rivers in Romania. This assessment intends to go beyond the fish fauna description and provide some prediction of the stream conditions, potential and reference points for Carpathians first order streams.

Although the fish associations can have an important degree of natural variability, they can be useful indicators of the lotic systems status/health (Karr, 1981; Moyle and Herbold, 1987; Kleynhans, 1999). Also, it is highly recommended that fish are given consideration in biological water-quality surveys of lotic systems because they are seen by the general public to be ecologically relevant, and they are important in relation to the legislative mandates because of the health of human populations, and the endangered wildlife species concerns.

All the biotic information is related to water and habitat quality and human activities, to provide a picture of the lotic system quality across the whole river, and used for the mapping of the ichthyologic elements of the river which allow assertions concerning fish assemblages structure and cause - effect relations identification as a part of a needed integrated management plan for the Râul Mare River watershed.

MATERIALS AND METHODS

The presented fish assemblages survey, through time (one hour) on effort unit quantitative and qualitative samplings were made with a hand - net, in a total of 11 sites in July 2006, in Râul Mare River (Fig. 2; Tab. 1).

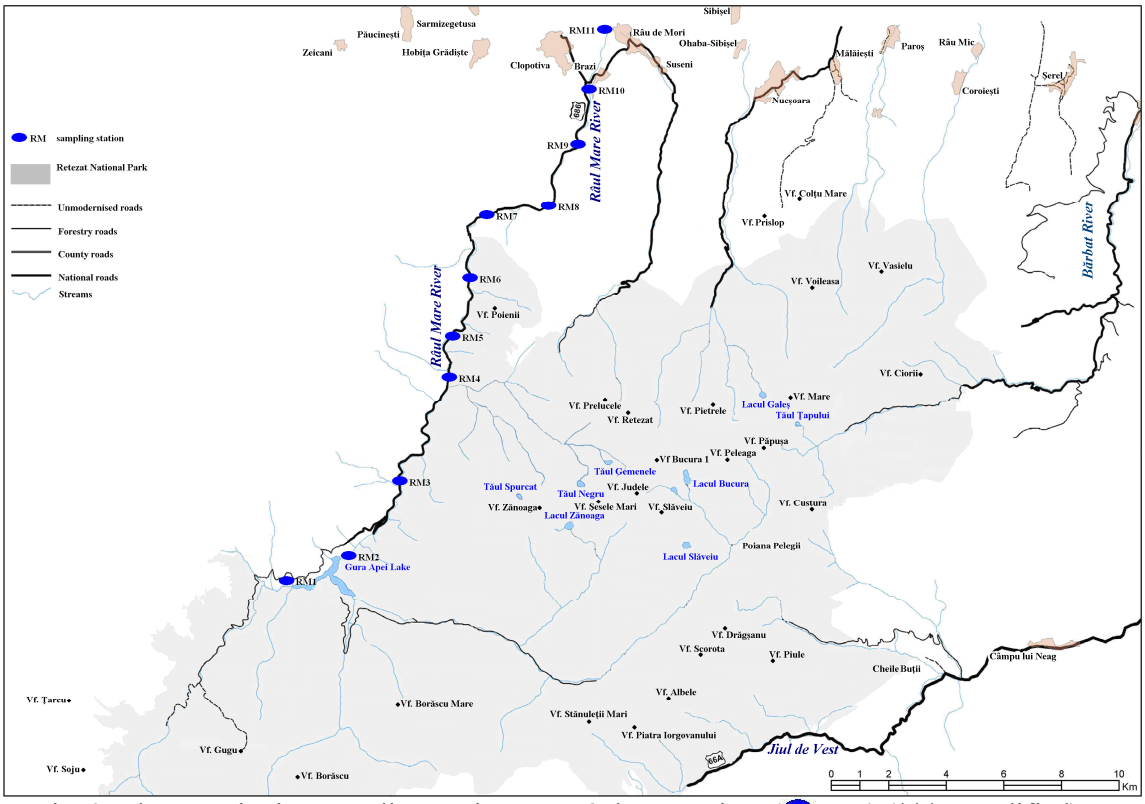

Fig. 2: The quantitative sampling stations on Râul Mare River (● RM) (*** - modified).

The 11 studied sampling stations were chosen according to: the valley morphology, the type of river substratum, the confluence with the main tributaries, and to the human impact presence bias (hydro technical works, pollution sources). Only the remote site (RM_1) represents background conditions and are unaffected by human activities.

The fish were identified, counted, some were released back to the stream and others were fixed in a 4% formaldehyde solution, then preserved in 70% alcohol and included in the collections of the Natural History Museum of Sibiu and of the Aquatic Biology Laboratory within the Department of Ecology and Environmental Protection, of Sciences Faculty of the "Lucian Blaga" University of Sibiu.

The studied biological material (in quantitative samples) is formed of the following seven species: *Salmo fario* Linnaeus, 1758; *Thymallus thymallus* (Linnaeus, 1758), *Barbus petenyi* Heckel, 1852; *Squalius cephalus* (Linnaeus, 1758); *Phoxinus phoxinus* (Linnaeus, 1758); *Orthrias barbatulus* (Linnaeus, 1758) and *Cottus gobio* Linnaeus, 1758 (Tab. 1).

RESULTS AND DISCUSSIONS

In the 101 sampled individuals (Tab. 1) seven species belonging to seven genera and five families were identified.

Table 1: The sampling sites localisation, the sampled (in time/effort unit) fish species in Râul Mare River (RM), their number and their relative abundance (A%).

Sampling station	Species	Specimens	A%
RM_1 (250 m upstream of the Gura Apei Lake/Râu Şes River)	*Salmo fario*	2	100
RM_2 (250 m downstream of the Gura Apei Dam)	*Salmo fario*	2	8.70
	Phoxinus phoxinus	9	39.13
RM_3 (5 km downstream of the Gura Apei Dam)	*Salmo fario*	9	39.13
	Phoxinus phoxinus	3	13.04
RM_4 (10 km downstream of the Gura Apei Dam)	*Salmo fario*	4	100
RM_5 (12.5 km downstream of the Gura Apei Dam)	*Salmo fario*	4	100
RM_6 (15 km downstream of the Gura Apei Dam)	*Salmo fario*	5	71.43
	Cottus gobio	2	28.57
RM_7 (17.5 km downstream of the Gura Apei Dam)	*Salmo fario*	7	87.50
	Cottus gobio	1	12.50
RM_8 (20 km downstream of the Gura Apei Dam)	*Salmo fario*	3	42.86
	Thymallus thymallus	1	14.28
	Cottus gobio	3	42.86

Sampling station	Species	Specimens	A%
RM_9 (22.5 km downstream of the Gura Apei Dam)	*Salmo fario*	2	20.00
	Phoxinus phoxinus	2	20.00
	Orthrias barbatulus	3	30.00
	Cottus gobio	3	30.00
RM_{10} (25 km downstream of the Gura Apei Dam)	*Salmo fario*	2	5.55
	Barbus petenyi	1	2.78
	Squalius cephalus	1	2.78
	Phoxinus phoxinus	29	80.56
	Orthrias barbatulus	1	2.78
	Cottus gobio	2	5.55
RM_{11} (250 m upstream of the Ostrov Dam Lake)	-	-	-

The Râul Mare River ecological status is assessed in terms of the following analysis elements: the fish associations structure in terms of relative abundances, indicator species, in terms of their life stages and ecological preferences, the dominance of some species on particular habitat types; and based on the Carpathian Fish - Index of Biotic Integrity (Bănăduc and Curtean-Bănăduc, 2002). This index score represents a nine metric sum and the scores can be interpreted with the following intervals comparison: 45-43 excellent; 42-36 very good; 35-31 good; 30-24 fair; 23-17 fairly poor; 16-10 poor and 9-1 very poor.

Based on all these items, the general river quality conditions were identified, and also the areas of concern were flagged.

The presence in the Râul Mare River top length of flow/Şaeş River in the **RM_1** river sector of only typically intolerant native coldwater species *Salmo fario*, even if the Gura Râului Lake (which can act like a non native fish species "nursery" (Bănăduc, 2005) for *Phoxinus phoxinus*) is close, clearly highlights the presence of the upper sector of the trout zone (Bănărescu, 1964). This fact points out some biotope characteristics: the river passes through a very uneven relief with many rapids and stony riverbed, water with a high concentration of dissolved oxygen, low and relatively invariable water temperature, very high current velocity.

The species belonging to the Salmonidae Family are associated with high quality river habitat. The presence of *Salmo fario* species reveal a river sector with an excellent ecological status, with no environmental stress, characterized by a high biotic integrity, and an undisturbed lotic sector of the studied river with pristine conditions. The lack of permanent human settlements favours this situation in this area.

The maximum 45 Carpathian Fish - Index of Biotic Integrity score reflects an excellent, pristine conditions and exceptional assemblage of species.

The small number and dimensions of *Salmo fario* individuals sampled in **RM_2** can be explained mainly by the Gura Apei Dam management, which is characterised by a high water discharge variation and long periods of no water on the river bed. The presence of *Phoxinus phoxinus* individuals is unnatural for this river sector. They came accidentally from the Gura Apei Lake and show an important biotic influence of the dam lake downstream the river.

The fairly poor score of 23 in the Carpathian Fish - Index of Biotic Integrity shows the tolerant species dominance in an accentuated degraded habitat.

In sector **RM_3** the river starts again to recover (partially) its habitat quality. The water flow is still low in comparison with the natural potential regime, the springs downstream the dam can not replace the whole needed water supply retained by the Gura Râului Dam. The *Salmo fario* species is dominant and the number of individuals is higher than anywhere else in this river. It may be the upstream moving instinct of this species which keeps them here in such a high abundance. The presence of *Phoxinus phoxinus* individuals is unnatural for this river sector. Like in the upstream sector they came accidentally from the Gura Apei Lake and show an important biotic influence of the dam lake on the river.

The good 32 Carpathian Fish - Index of Biotic Integrity score describes a better intolerant/tolerant fish species report.

After an anthropogenic induced appearance of some species characteristic for more downstream sectors (*Phoxinus phoxinus*), in river sector **RM_4 - RM_5** the constant number of *Salmo fario* individuals and the lack of *Phoxinus phoxinus* reveals a clear trout zone, for the first time downstream of the Gura Râului Lake. The habitat quality is strongly recovered due to the protection of Retezat National Park watersheds. Unfortunately there are large economic pressures upon the park administration to accept new watershed engineering modifications! These modifications will have a negative impact on this unspoiled river sector ichthyofauna.

The very good 42 Carpathian Fish - Index of Biotic Integrity score underlines the presence of intolerant species.

In river sector **RM_6 - RM_7** the *Cottus gobio* species appearance, in lower abundance compared with the *Salmo fario* species individuals, indicates where the superior trout sub zone with the inferior trout sub zone interlink and a good habitat quality. The very good 42 Carpathian Fish - Index of Biotic Integrity score is still present here and underlines the presence of intolerant species.

An inferior trout sub zone interlinked with grayling and Balkan barbel zones was identified in river sector **RM_8**, an ecologically valuable river sector, due to the reducing number and quality of grayling zones all over the country in the last few decades. *Thymallus thymallus* species requires habitat and biocoenosis conditions characteristic for a relatively short sector on the rivers so any small habitat loss of these specific sectors unbalances the local populations and can induce the grayling disappearance there. The excellent 43 Carpathian Fish - Index of Biotic Integrity score reflects an exceptional fish species assemblage.

Another interface area from one fish zone to another was identified in the river sector **RM_9 - RM_{10}**, a passage with well balanced interlinkage of trout zone species and grayling and Balkan barbel zones species. The maximum fish diversity was recorded in the study peirod in **RM_{10}** river sector, a normal situation due to the maximum river microhabitats diversity existent here. In this river sector a good 33 Carpathian Fish - Index of Biotic Integrity score was calculated.

The absence of any kind of fish species, when the river microhabitat conditions and water quality are still good, in river sector **RM_{11}** may be due to the proximity of the Ostrov Lake, which can induce such an effect. Further studies are needed to reveal such lakes-rivers proximity effects.

Downstream this river sector follows three power plants with dams and lakes (Ostrovu Mic, Păclişa and Haşeg) and seven with derivation channels (Clopotiva, Ostrovul Mare, Cîrneşti I, Cîrneşti II, Toteşti I, Toteşti II and Sântămărie Orlea). In fact here the Râul Mare River simply disappears.

CONCLUSIONS

After the Râul Mare River fish fauna assessment the existence of pristine or almost pristine river sectors, of river sectors which support a very stressing human impact in the last 30 years of hydrotechnical works and their exploitation, and intermediate as ecological status river sectors are obvious.

It is also obvious that a proper management plan, at least for the liquid and solid flows, and for the riverine human activities is highly necessary for this river biota and associated natural values and this area good ecological status.

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CONTRIBUTIONS TO THE STUDY OF RODENTS IN THE RETEZAT NATIONAL PARK (ROMANIA)

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, rodent population, stocktaking, habitat, transect, relative abundance, capture index, sex-ratio, Stănuleți, Câmpuşel.

ABSTRACT

This study contains the results obtained after stocktaking the rodent populations from the Retezat National Park, which was performed in the summer of 2004, in two locations. We tried an ecological assessment of the target habitats according to the data gathered from the field and considering the natural potential and antropic influence in the area.

We obtained data on the structure of rodent populations, like the report structured on age or sex, abundance and so on. We also observed the presence of rare and endangered species. The obtained results were also given to the Administration of the Retezat National Park, so that the management plans for the areas were the observations took place could be ellaborated.

RÉSUMÉ: Contribution a l'etude des rongeurs du Parc National Retezat (Roumanie).

Ce travail comprend les resultats de l'inventaire des populations des rongeurs dans le Parc National Retezat, Roumanie, efectué - pendant l'été de l'année 2004 en deux endroits. On a essayé de faire une évaluation écologique des habitats investigués en corelation avec le potentiel naturel et l'intervention antropique.

On a obtenu un set de dates sur la structure des communautés de rongeurs, comme les cathégories d'age et de sexe, l'abondance, etc. En plus, on a documenté la présence des especes rares ou en danger dans le parc. Les resultats obtenus on été mis à la disposition de l'Administration du Parc National Retezat pour être utilisés en vue de l'élaboration du plan de management

REZUMAT: Contribuții la studiul rozătoarelor din Parcul Național Retezat (România).

Lucrarea de față cuprinde rezultatele inventarierii populațiilor de rozătoare din Parcul Național Retezat, care s-a realizat în vara anului 2004, în două locații. S-a încercat evaluarea ecologică a habitatelor investigate în funcție de datele culese pe teren, în corelație cu potențialul natural şi influența antropică.

S-au obținut date legate de structura comunităților de rozătoare, cum ar fi raportul pe categorii de vârstă şi de sexe, abundența ş.a. S-a urmărit, de asemenea, prezența speciilor rare sau amenințate. Rezultatele obținute au fost puse la dispoziția Administrației Parcului Național Retezat în vederea construirii planurilor de management pentru zonele studiate.

INTRODUCTION

In the summer of 2004 we performed two sessions of rodent populations stocktaking in the Retezat National Park.

The first one took place at Stănuleți (1400 m altitude) at the limit between the Retezat Crystalline Massif, also known as Retezatul Mare and the limestone massif of Retezatul Mic, on the Lapuşnicul Mare River valley. From a geological point of view, the area contains crystalline shale which, towards the southern limits, are crossed by limestone which have been modelled by wurmian glaciers. Vegetation consists mainly of coniferous and mixed coniferous and deciduous forests, shrubs (hazel and alder) and, in the open, plenty of grass. The anthropic factor is very low: there is one forest narrow track which is used by tourists, but there were very few of them during our observations.

The second investigation took place at Câmpuşel (1130 m), in the southern area of the Retezatul Mic Mountains, at the limit between the park and the buffer area, on the bank of the Valea Iarului river. It is an area where forest habitats, with mixed and confireous forests prevail, but also glades and grasslands. Compared to the first zone, the anthropic factor is higher, as this one is the starting point for some tourist routes and also a hunting area.

MATERIALS AND METHODS

In order to investigate the rodent fauna in these habitats we used the capture-mark-recapture method, using wooden traps, as these one allow for the capture of living individuals.

The first stocktaking was performed during the interval 20.07 - 25.07.2004, at Stănuleți, which is situated at 1400 m. We installed three transects of fifteen traps each in different habitats and another two transects of fifteen traps each in other habitats during the interval 24.07 - 27.07.2004. We chose to arrange them in a line, with a 15 m distance between them. The captured individuals were determined, measured, weighted, marked by shearing a little fur of their back and then released at the same spot. We also determined their sex, breeding capability and age (adult or juvenile). All the data was put down in the observation list. Yet, for some of the individuals, data is missing, as they managed to escape while we were handling them. In order to avoid death by hypothermia or starvation, the traps were sheathed with vegetation and there was plenty of bait. The individuals which died while in the traps or the ones for which determination was not possible in the field were collected and determined afterwards, in the laboratory, by examing their theeth.

The second stocktaking took place between 28.08 and 1.09.2004 at Câmpuşel, at 1130m. There were installed three transects of ten traps each, in line, with a ten m distance between them. They were placed in different habitats. The same method was employed. The traps were checked for four days, once a day, in the morning.

The installing and checking were performed in different weather conditions: shining sun and medium temperatures, wind, rain and low temperatures.

We processed afterwards the data gathered, in order to interpret the results.

HABITAT CHARACTERIZATION

Stănuleți

- Transect 1: Glade close to the outskirts of the spruce fir forest, with high grass (*Urtica dioica*, *Rumex alpinus*, *Hyeracium* sp.) and rare trees. The transect was placed close to an abandoned anthropic area, crossed by a narrow forest road and the other part was in the dry riverbed, in an area with boulders.

- Transect 2: Spruce fir forest; the transect was placed at aproximately 100 m from the forest road, parallel with it.

- Transect 3: Riparian habitat, along the left bank of the Lăpuşnicul Mare Creek, where flood areas alternate with areas covered with boulders and exposed to the sun, where the bank is steep.

- Transect 4: Pioneer vegetation area, with pine, hazel, willow, alder and shrub areas; area covered with boulders and wood, with an approximately 30° ramp. The number 13, 14 and 15 traps were placed near the Paltina river course.

- Transect 5: The Paltina river bank, in the flood area, which is covered with boulders and tree trunks; prevailing vegetation consists of hazel and alder shrubs.

Câmpuşel

- Transect 1: The first six traps were placed in a low grass vegetation glade, occasionaly used for grazing; traps number seven to ten were placed in the spruce fir forest, in an approximately 60º ramp.

- Transect 2: High grass glade, at the outskirts of a deciduous sapling forest.

- Transect 3: Riparian habitat, flooding area on the bank of the Valea Iarului creek.

RESULTS AND DISCUSSIONS

During the stocktaking at Stănuleți there were captured and marked 62 *Apodemus sylvaticus* individuals, 27 *Apodemus flavicollis*, 39 *Clethriomys glareolus*, six *Microtus arvalis*, three *Microtus agrestis*, four *Muscardinus avellanarius* and one *Glis glis*, while the capture at Câmpuşel was much poorer, with only 24 individuals of *Apodemus flavicollis*, five *Apodemus sylvaticus*, three *Clethrionomys glareolus* and one *Microtus arvalis*. The low number of captures is probably due to the much higher antropic presence in this area, compared to the first one.

The processing and interpretations of the results was performed considering the following criteria:

1. Relative abundance (Tab. 1):

$$A\% = n_i/N * 100$$

where: A = relative abundance;

n_i = number of the i species individuals;

N = total number of captured individuals;

2. Standardized capture index (Fig. 1 a, b, c, d, e and Fig. 2 a, b, c, d, e)

This index deals with the number of captured individuals of each species, compared to the number of functioning traps:

$$Isc = 2*n_i/(c-c_n)*100$$

where: Isc = standardized capture index;

n_i = number of the i species captured individuals;

c = total number of performed captures;

c_n = number of traps not working (escapes, overthrown traps, opened traps etc.)

Other processing of data referred to the sex-ratio and placement of dominant populations depending on their age.

Table 1: Relative abundance for each habitat.

Sp.	Stănuleți										Câmpușel					
	T1		T2		T3		T4		T5		T1		T2		T3	
	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%	Nr	%
Apodemus flavicollis	5	10	3	10	4	13	8	25	7	21	5	62.5	10	59	9	50
Apodemus sylvaticus	11	23	6	21	19	59	9	28	17	50	1	12.5	3	17.6	1	5.5
Apodemus sp.	0	0	0	0	2	6	3	9	2	6	1	12.5	0	0	1	5.5
Microtus agrestis	3	6	0	0	0	0	0	0	1	3	0	0	0	0	0	0
Microtus arvalis	5	10	1	3	0	0	0	0	0	0	0	0	0	0	1	5.5
Microtus sp.	6	13	0	0	0	0	1	3	0	0	0	0	0	0	2	11
Clethrio-nomys glareolus	11	23	13	45	5	16	6	19	4	12	1	12.5	0	0	2	11
Muscardi-nus avellanarius	1	2	1	3	0	0	2	6	0	0	0	0	0	0	0	0
Glis glis	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0
Insectivore	6	13	5	17	1	3	3	9	3	9	0	0	4	23.5	2	11
Total	48	27.4	29	17	32	18.3	32	18.3	34	19.4	8	18.6	17	39.5	18	41.8

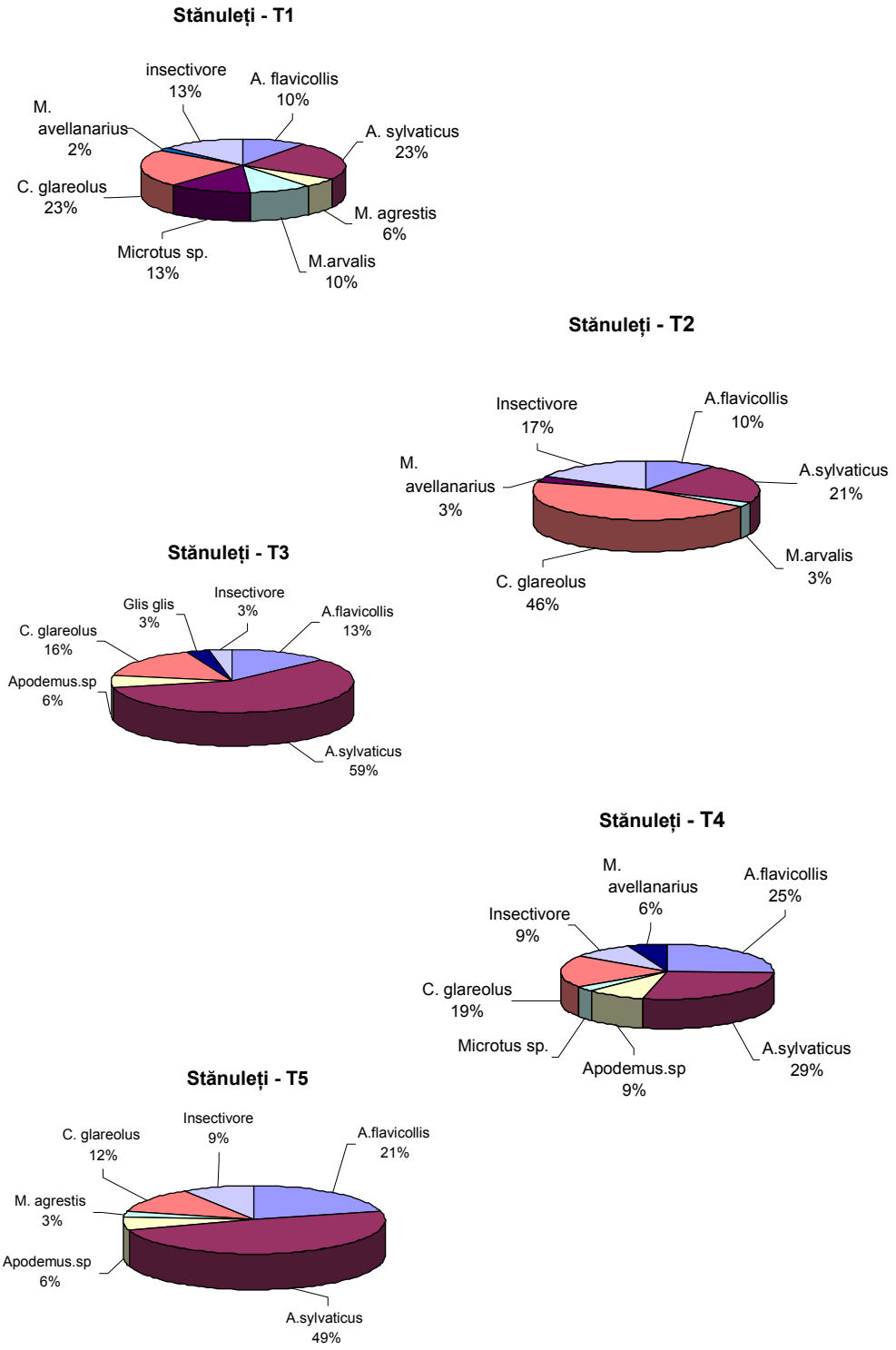

Fig. 1 a, b c d: Graphic of relative abundance for the five transects at Stănuleți.

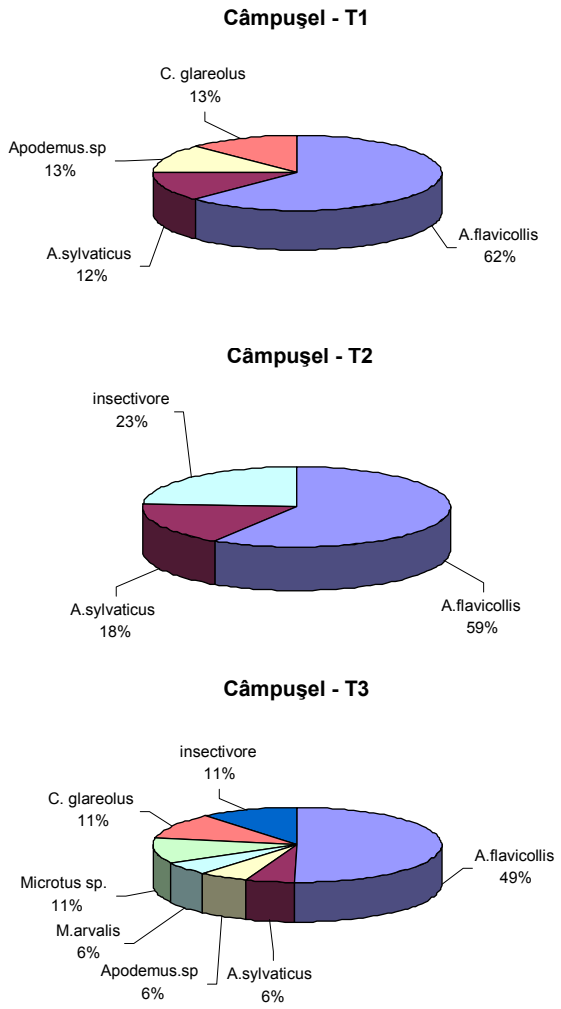

Fig. 2 a, b, c: Graphic of relative abundance for the three transects at Câmpuşel.

The investigated habitats were mainly forest ones, respectively glades or open fields inside the forest and also wetlands: banks of rivers or creeks, flooding areas. In the forest habitats, rodent populations consist mainly of silvicolous species: *Apodemus flavicollis* şi *Clethrionomys glareolus,* which codominate only in habitat one. In most cases, *Apodemus flavicollis* dominates, except for the spruce fir from Stănuleți, on transect two, *Clethrionomys glareolus* prevails. In the glades with lots of grass and in the flooding areas of creeks, we also captured *Microtus agrestis* and *Microtus arvalis* individuals. Also, in the open fields, boulders and bush and shrub areas, *Apodemus sylvaticus* was mainly captured.

A surprise was the capture of a *Glis glis* individual and that of four *Muscardinus avellanarius* individuals, arboreal species that rarely descend on ground. In all cases, the traps were placed at the base of a spruce fir tree or near more trees.

As far as the spreading according to age, during both investigations we observed that adult individuals prevailed, when compared to juveniles (Tab. 2 and Tab. 3, Fig. 3 and Fig. 4), which proves that in both cases we dealt with adult populations. The cause of there proportions could be the climate, considering the fact that 2004 was a rainy year, with low temperatures, that could have prevented a high breeding rate.

Table 2: Spreading structured on age groups for the rodent populations at Stănuleți.

Sp.			*Apodemus flavicollis*	*Apodemus sylvaticus*	*Apodemus* sp.	*Microtus agrestis*	*Microtus arvalis*	*Microtus* sp.	*Clethrionomys glareolus*	*Muscardinius avellanarius*	*Glis glis*	Insectivors	Total
No. specimens			27	62	7	4	6	7	39	4	1	18	175
Adults		No.	24	44	7	4	5	5	30	4	1	18	142
		%	89	71	100	100	83	71	77	100	100	100	81
Juvenils		No.	3	18	0	0	10	2	9	0	0	0	33
		%	11	29	0	0	17	29	23	0	0	0	19
Transect 1	Adults	No.	4	7	0	3	4	4	8	1	0	6	37
		%	80	64	0	100	80	67	73	100	0	100	77
	Juvenils	No.	1	4	0	0	1	2	3	0	0	0	11
		%	20	36	0	0	20	33	27	0	0	0	23
Transect 2	Adults	No.	2	5	0	0	1	0	9	1	0	5	23
		%	67	83	0	0	100	0	69	100	0	100	79
	Juvenils	No.	1	1	0	0	0	0	4	0	0	0	6
		%	33	17	0	0	0	0	31	0	0	0	21
Transect 3	Adults	No.	4	16	2	0	0	0	4	0	1	1	28
		%	100	84	100	0	0	0	80	0	100	100	88
	Juvenils	No.	0	3	0	0	0	0	1	0	0	0	4
		%	0	16	0	0	0	0	20	0	0	0	13
Transect 4	Adults	No.	8	5	1	0	0	1	5	2	0	3	25
		%	100	56	33	0	0	100	83	100	0	100	78
	Juvenils	No.	0	4	2	0	0	0	1	0	0	0	7
		%	0	44	67	0	0	0	17	0	0	0	22
Transect 5	Adults	No.	6	11	2	1	0	0	4	0	0	3	27
		%	86	65	100	100	0	0	100	0	0	100	79
	Juvenils	No.	1	6	0	0	0	0	0	0	0	0	7
		%	14	35	0	0	0	0	0	0	0	0	21

Table 3: Spreading structured on age groups for the rodent populations at Câmpuşel.

Sp.			*Apodemus flavicollis*	*Apodemus sylvaticus*	*Apodemus* sp.	*Microtus arvalis*	*Microtus* sp.	*Clethrionomys glareolus*	Insectivors	Total
No. specimens			25	5	2	1	2	3	6	43
Adults		No.	23	5	2	1	1	3	6	41
		%	96	100	100	100	50	100	100	95
Juveniles		No.	1	0	0	0	1	0	0	2
		%	4	0	0	0	50	0	0	5
Transect 1	Adults	No.	5	1	1	0	0	1	0	8
		%	100	100	100	0	0	100	0	100
	Juveniles	No.	0	0	0	0	0	0	0	0
		%	0	0	0	0	0	0	0	0
Transect 2	Adults	No.	9	3	0	0	0	0	4	16
		%	90	100	0	0	0	0	100	94
	Juveniles	No.	1	0	0	0	0	0	0	1
		%	10	0	0	0	0	0	0	6
Transect 3	Adults	No.	9	1	1	1	1	2	2	17
		%	100	100	100	100	50	100	100	94
	Juveniles	No.	0	0	0	0	1	0	0	1
		%	0	0	0	0	50	0	0	6

Another investigated aspect was the population structure according to their sex. According to table nr. 4, at Stănuleți there is a relatively balanced male/female ratio (Fig. 5), for dominant species, while in Câmpuşel (Tab. 5) males prevail. And yet this is not relevant, considering the low number of individuals for which sex was determined.

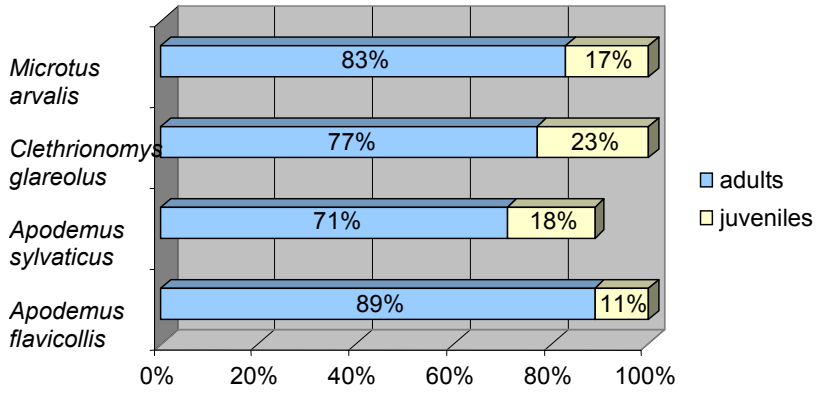

Fig. 3: Spreading structured on age cathegories
for the dominant rodent populations at Stănuleți.

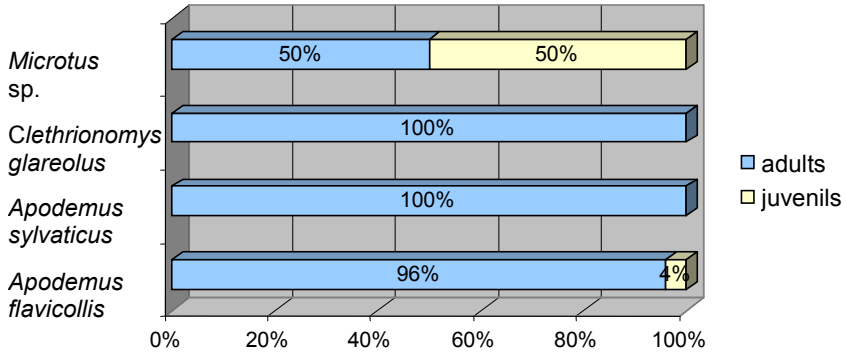

Fig. 4: Spreading structured on age cathegories
for the dominant rodent populations at Câmpuşel.

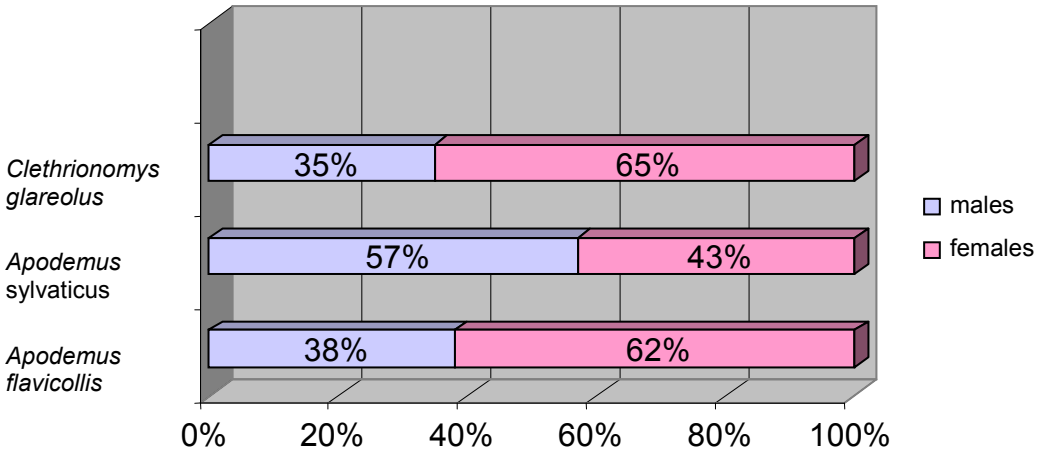

Fig. 5: Structure of dominant populations in Stănuleți according to the sex group.

Table 4: Structure of rodent populations in Stănuleţi according to the sex group.

Sp.			*Apodemus flavicollis*	*Apodemus sylvaticus*	*Apodemus agrestis*	*Microtus arvalis*	*Clethrionomys glareolus*	Total
No. specimens			24	42	3	4	20	93
♂♂		No.	9	24	2	2	7	44
		%	38	57	67	50	35	47
♀♀		No.	15	18	1	2	13	49
		%	62	43	33	50	65	53
T1	♂♂	No.	1	3	2	1	2	8
		%	25	13	67	33	28	35
	♀♀	No.	3	4	1	2	5	15
		%	75	57	33	67	71	65
T2	♂♂	No.	1	3	0	0	2	6
		%	50	60	0	0	50	55
	♀♀	No.	1	2	0	0	2	5
		%	50	40	0	0	50	45
T3	♂♂	Nr.	2	9	0	0	1	12
		%	50	60	0	0	33	55
	♀♀	No.	2	6	0	0	2	10
		%	50	40	0	0	67	45
T4	♂♂	No.	4	3	0	0	2	9
		%	50	75	0	0	40	53
	♀♀	No.	4	1	0	0	3	8
		%	50	25	0	0	0	47
T5	♂♂	1	6	0	1	0	8	1
		17	55	0	100	0	42	17
	♀♀	5	5	0	0	1	11	5
		83	45	0	0	100	58	83

Tabel 5: Structure of dominant populations in Câmpuşel according to the sex group.

Sp.			*Apodemus flavicollis*	*Apodemus sylvaticus*	*Microtus arvalis*	*Clethrionomys glareolus*	Total
No. specimens			19	5	1	3	28
♂♂		10	4	1	2	17	34
		53	80	100	7	61	301
♀♀		No.	9	1	0	1	11
		%	47	20	0	33	39
T1	♂♂	No.	2	1	0	1	4
		%	67	100	0	100	80
	♀♀	No.	1	0	0	0	1
		%	33	0	0	0	20
T2	♂♂	No.	3	2	0	0	5
		%	33	67	0	0	42
	♀♀	No.	6	1	0	0	7
		%	67	33	0	0	58
T3	♂♂	No.	5	1	1	1	8
		%	71	100	100	50	73
	♀♀	No.	2	0	0	1	3
		%	29	0	0	50	27

Field measurements, when compared to those available in literature (Murariu, 2001 and Pucek, 1981) (Tab. 6 and 7) are generally situated within the quoted limits, but the body dimensions of the *Apodemus flavicollis* individuals captured in Câmpuşel area are smaller than the normal.

It must also be considered that between the dominant populations of *Apodemus flavicollis* and *Apodemus sylvaticus* can occur hybridizations, the two species being related. The hybrids bear the genes of both *Apodemus flavicollis* species (the legtht of their tails is greater than or equal to the legth of the head plus that of their body) and *Apodemus sylvaticus* species (small body dimensions). This aspect must be studied deeper in the future.

It is also possible that a subadult population of *Apodemus flavicollis* was dealt with here, these being the young ones born among the first generations for that year. Some of them were in their breeding period, which is quite normal, the young ones reaching their sexual maturity within three months from their birth.

Table 6: Body measurements (min and max) of captured individuals, compared to those in literature (Murariu, 2001 and Pucek, 1981) - Stănuleți.

Sp.		*Apodemus sylvaticus*		*Apodemus flavicollis*		*Clethrio-nomys glareolus*		*Microtus arvalis*		*Microtus agrestis*	
value		min	max	min	max	min	max	min	max	min	max
Head+ Body lenght (mm)	original	70.6	108.3	84.8	112.7	62	102	65	90.5	108.5	116.6
	Pucek	73	105	90	120	80	110	83	122	85	133
	Murariu	75.8	106.9	95	120	66	115	90	117	92	135
Tail lenght (mm)	original	73.6	112	82.8	113.7	32	49.7	34	37.5	34.6	47.5
	Pucek	70	100	86	125	38	69	23	40	25	46
	Murariu	63	93.9	95	132	22	51	30	44	25	42
Ear lenght (mm)	original	15	24.6	14.1	22.9	11.5	16	9.3	14.7	12.6	14.6
	Pucek	14	17.2	15	20	12	15	14	15	13.5	14.5
	Murariu	14.1	17.7	15	20	10	15	10	14	9.5	16
Leg lenght (mm)	original	13.4	16.2	19.6	24.3	16.3	18.7	11.6	15.7	19	20
	Pucek	18.5	23.8	21.5	25.4	16	18	16	18.5	17	22
	Murariu	19	24	23	27	14.6	18	15	19.1	16	19
Weight (g)	original	18	36	20	34	14	24	19	19	31	44
	Pucek	17	38	20	55	15	36	14	51	20	47.6
	Murariu	11.5	28.5	20	56	16.1	32.7	19.8	37.4	23.3	48.3

Standardized capture index (Fig. 6 and Fig. 7), characterizes capture effort for each habitat.

Table 7: Body measurements (min and max) of captured idividuals, compared to those in literature (Murariu, 2001 and Pucek, 1981) - Câmpuşel.

Sp.		*Apodemus sylvaticus*		*Apodemus flavicollis*	
value		min	max	min	max
Head+ Body length (mm)	original	67.6	83.5	62.5	86.1
	Pucek	73	105	90	120
	Murariu	75.8	106.9	95	120
Tail length (mm)	original	69.4	93	64.6	98.2
	Pucek	70	100	86	125
	Murariu	63	93.9	95	132
Ear length (mm)	original	8.1	16.2	11.3	18.9
	Pucek	14	17.2	15	20
	Murariu	14.1	17.7	15	20
Leg length (mm)	original	20.5	27	21.4	25.6
	Pucek	18.5	23.8	21.5	25.4
	Murariu	19	24	23	27
Weight (g)	original	16	29	13	36
	Pucek	17	38	20	55
	Murariu	11.5	28.5	20	56

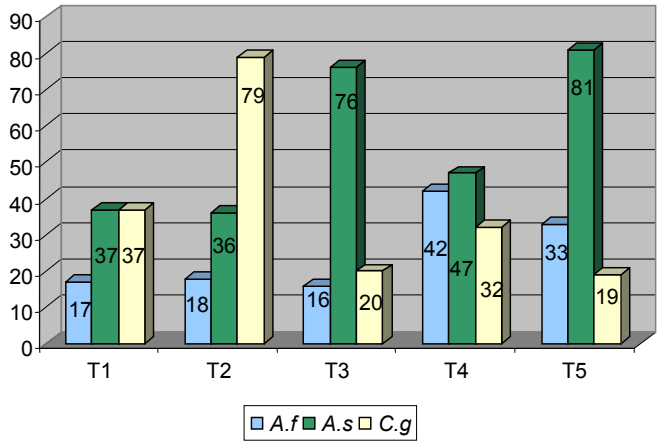

Fig. 6: Standardized capture index for dominant populations (*A. f.* - *Apodemus flavicolis, A. s.* - *Apodemus sylvaticus* and *C. g.* - *Clethrionomys glareolus*) in Stănuleți.

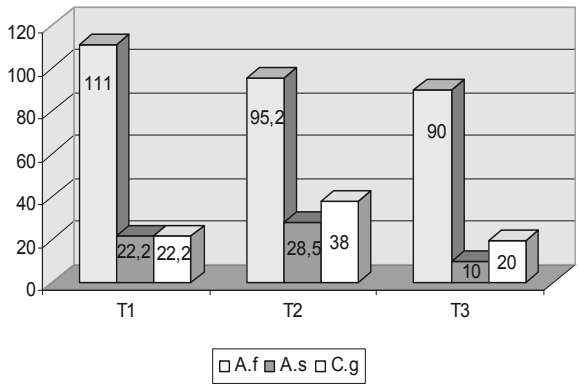

Fig. 7: Standardized capture index for dominant populations populations (*A. f.* - *Apodemus flavicolis, A. s.* - *Apodemus sylvaticus* and *C. g.* - *Clethrionomys glareolus*) in Câmpuşel.

CONCLUSIONS

In the biocenosis of natural ecosystems from the Retezat National Park, where we performed two sessions of stocktaking in the summer of 2004, in the first location, at Stănuleți (1400 m) we identified seven rodent species and in the second location, at Câmpuşel (1130 m) we identified only four species.

The analysis of the fauna specter for each studied habitat shows that in the majority of cases the dominant species are the same for both: *Apodemus flavicollis, Apodemus sylvaticus, Clethrionomys glareolus*. At Câmpuşel, where *Apodemus flavicollis* clearly dominates all the other species, it is possible that it elliminated the other species through competition.

The species biodiversity was high especially in the first location, where antropic influence is very low, but the fact that the stocktaking was performed in July, before the drastic change in the weather conditions caould also be an explanation for the high capture rate. The second stocktaking was performed in August, after a rainy, low-temperature period, which could have prevented a more eterogeneous capture. Here *Apodemus .flavicollis*, a humidity tolerant species, dominated other silvicolous species, that like dryer habitats. On the transect placed in the glade that is occasionally used for grazing, T1, in traps one - six there was one single capture within a four - day period (one *Apodemus flavicollis* individual), which proves the sensitivity of micromammals to this factor.

Spreading of individuals depending on their sex in the first location varied around a 1:1 ratio and adults prevailed, while in the second location, the low number of individuals for which sex was determined does not allow to jump any conclusion. Here, the rather small body dimensions of the *Apodemus flavicollis* individuals, compared to those in literature can be caused by hibridization betwenn *Apodemus flavicollis* şi *Apodemus sylvaticus*, which is a smaller species. It is either that, or we dealt with subadult individuals.

The capture frequency at Stănuleți is greater for *Apodemus sylvaticus*, with the exception of the transect placed in the spruce fir forest, where the capture of *Clethrionomys glareolus* was greater. Thus we came to the conclusion that silvicolous species, respectively *Apodemus flavicolis* and *Clethrionomys glareolus* are not codominant. *Apodemus sylvaticus* prefers more opened and warmer areas, like the T4 habitat (with boulders and pioneer vegetation) or the boulders on the banks of the rivers (T3 and T5).

The capture of a *Glis glis* individual and of four *Muscardinus avellanarius* individuals in traps placed on the ground is the proof that arboricolous species, like dormouse, occasionally come down to the ground to feed. In all situations, the traps were placed at the base of the trees or very close to them.

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SMALL MAMMALS FROM RETEZAT NATIONAL PARK (ROMANIA)

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, insectivores, rodents, chorology, community structure, altitudinal distribution.

ABSTRACT

The Retezat National Park shelters a rich fauna of small mammals. Up to the present 22 species are known from here, nine insectivores (all the species from Romania) and 13 rodents. Between 2000 and 2005 a series of investigations using live trapping were carried out. The research aimed to draw up a detailed chorological list for the small mammal species and to characterize the community's structure in different habitat types. The diversity and abundance of small mammal communities decrease with altitude, however, a relativly high diversity was recorded in humid spruce forests with a rich herbaceous layer. *Sorex alpinus* was only found in this habitat. In most of the habitats dominant species are *Clethrionomys glareolus* and *Apodemus flavicollis*, and in years with low densities of the latter, *Sorex araneus*. In 2003 and 2005 *Apodemus flavicollis* was found only in the beech forests.

RÉSUMÉ: Petits mammifères du Parc National Retezat (Roumanie).

Le Parc National Retezat abrit une riche faune des petits mammifères. Jusqu'au présent 22 espèces sont connues d'ici, neuf insectivores (toutes les espèces de Roumanie) et 13 rongeurs. Entre les années 2000 et 2005 nous avons entrepris une série des investigations visant l'élaboration une liste chorologique détaillée pour les espèces de petits mammifères, leur distribution altitudinale et en divers types de habitats. La diversité et abondance de ces communautés baissent á l'hauté. Elles sont dominées dans la plupart des habitats par *Clethrionomys glareolus* et *Apodemus flavicollis*, et durant ses années de déclin, par *Sorex araneus*. En 2003 et 2005 *Apodemus flavicollis* a été capturé seulement dans les forêts de hêtre.

REZUMAT: Mamifere mici din Parcul Național Retezat (România).

Parcul Național Retezat adăpostește o faună bogată de mamifere mici, până în prezent fiind cunoscute 22 de specii, nouă insectivore (toate speciile din România) şi 13 rozătoare. Între anii 2000 şi 2005 am întreprins o serie de investigații pe baza capturării animalelor vii, urmărind obținerea unei liste corologice detaliate pentru aceste specii, distribuția lor pe altitudine şi diverse tipuri de habitate. Diversitatea şi abundența comunităților scad pe altitudine, o diversitate relativ ridicată fiind însă întâlnită în molidişurile cu umditate ridicată şi strat ierbos abundent. Numai în acest habitat a fost capturat *Sorex alpinus*. Comunitățile de mamifere mici sunt dominate în majoritatea habitatelor de *Clethrionomys glareolus* şi *Apodemus flavicollis*, iar în anii cu densități scăzute ale acestuia, de *Sorex araneus*. În anii 2003 şi 2005 *Apodemus flavicollis* a fost găsit doar la altitudini mici, în pădurile de fag.

INTRODUCTION

Like in any mountain region from Romania, only a few studies have been carried out in the Retezat Mountains on the small mammal communities. The first study on the flora and fauna of the Retezat Mountains was published by Csató (1866). These data were taken over by Bielz (1888) and Călinescu (1931). This paper also contains the data published by Miller (1912), regarding the mammals collected by Danford and Dodson from the Retezat Mountains area. Unfortunately, the only toponym used is "Hațeg - Hunedoara", even for the mountain species. Other original data were published by Hamar (1957), regarding the rodents, by Vasiliu (1961), Wagner (1974) and Simionescu and Munteanu (1988). The latter published also, in 1993, a synthesis on the bird and mammal communities from the Retezat National Park.

The present study, carried on during 2000 - 2005, aimed to draw up a detailed chorological list for the small mammal species and to characterize the communities' structure in different habitat types.

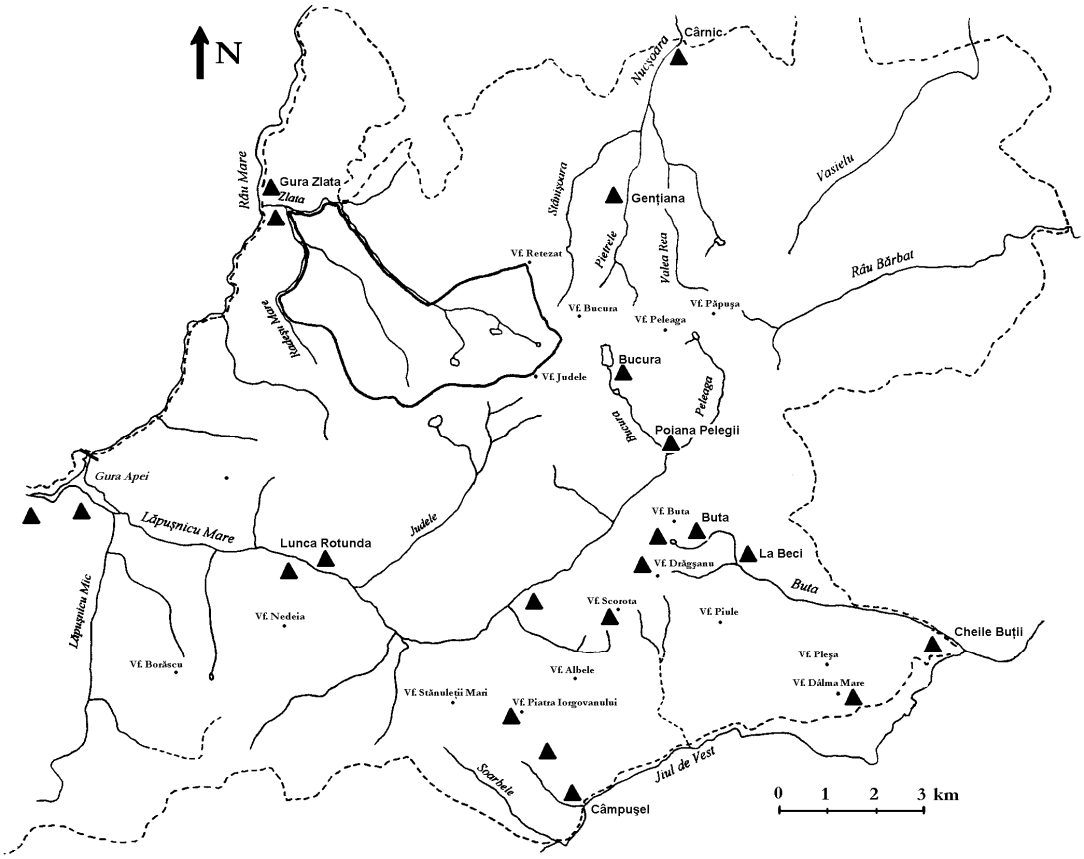

Fig. 1: Position of the 21 research stations (▲).

MATERIALS AND METHODS

The investigations were carried out by live-trapping of small mammals using Sherman-like wood box traps.

21 stations were researched at different heights, in several areas of the park (Fig. 1), especially in the southern part (Retezatul Mic). The research area stretches between the following extreme points: in North - Cârnic Chalet (45˚25'49.90" N; 22˚53'42.40" E), in South Cheile Buții (45˚18'08.56" N; 22˚58'18.65" E), in East Câmpușel Forest Range (45˚15'43.25" N; 22˚52'14.49" E) and on the West Gura Apei Lake shore (45°18'56.86" N; 22° 40'25.60" E).

Studies were accomplished during nine field campaigns between 2000 and 2005. The traps were set either in a rectangular net (in forests) or in transect (along river banks), ten m distance one from another. They were baited using oil soaked bread and meat. Traps were checked twice a day, in the night and at dawn. Captured animals were determined according to Murariu (2000) and Popescu and Murariu (2001) based on morphological external features. Their age and sex (in rodents case) was noted. Individuals were measured, weighed and marked by cutting their fur on different parts of the body, and then released.

RESULTS

Up to the present 22 species of small mammals are known from the Retezat Mountains, nine insectivores (all the species that live in Romania) and 13 rodents. For a few species there are only vague spatial references in the literature, thus we can not know if they were found within the present park's borders, or beyond them.

Order **Insectivora** Bowdich, 1821

Fam. **Erinaceidae** Bonaparte, 1838

1. *Erinaceus concolor* Martin, 1838

It was cited in the Retezat National Park, in the beech forests (Munteanu, 1993).

Fam. **Talpidae** Gray, 1825

2. *Talpa europaea* Linnaeus, 1758

Was encountered in the beech and spruce forests as well as in the alpine areas (Munteanu, 1993).

During our investigations one individual was found dead beneath the Albele Peak, at 1950 m height and another in Godeanu Mountains, near the Gura Apei dam lake shore.

Fam. **Soricidae** Gray, 1821

3. *Sorex araneus* Linnaeus, 1758

Wagner (1974) considers this species as an abundant one, the number of captured individuals (31) being almost as high as that of the dominant species (*Clethrionomys glareolus* - 32 individuals). Munteanu (1993) mentions it at high altitudes, in spruce forests, *Pinus mugo* shrubs and alpine zones. It is the most frequent and abundant species among insectivores, being captured in most of the investigated stations, both at low and high altitudes. It was more abundant on the Lăpuşnic Valley (Drăgşanu camping place and Poiana Pelegii).

During our research, the population density of this species was very variable.

4. *Sorex minutus* Linnaeus, 1766

Was mentioned in the Retezat National Park, in the beech forests (one individual collected by Wagner, 1974), the spruce forests and the subalpine shrubs (Munteanu, 1993).

During the 2000 - 2005 studies it was more seldom captured than the previous species. One individual was found in 2002 at Scorota Peak, in 2003 the species was encountered only at low altitudes, at Cheile Buții and Cârnic, while in 2004 and 2005 it was found in spruce forests (Buta, Lăpuşnic Valley and Poiana Pelegii).

5. *Sorex alpinus* Schinz, 1837

This is considered a rare species, characteristic for mountain areas, especially humid spruce forests. In the literature only one individual is mentioned, captured by Miller (1912) from this area (Hațeg in original), this being also the first recording of the species in Romania (Călinescu, 1931).

In 2003 two specimens were captured in the humid forest at Buta and the next year three individuals in the same habitat type, namely humid spruce forests.

6. *Neomys fodiens* (Pennant, 1771)

It is an aquatic insectivore, found almost exclusively on the river banks in forested areas. Călinescu (1931) cites the species in the area, near the waters, up to 1500 m, whereas Wagner (1974) mentions it up to 1800 m.

In 2002 one individual was found dead on the road to Câmpuşel, while in 2003 two specimens were captured, at Cheile Buţii and Poiana Pelegii. The latter was also recaptured.

7. *Neomys anomalus* Cabrera, 1907

Vasiliu (1961) found this species in the Râul Mare Valley.

In 2005 an individual was captured at Cheile Buţii, in the broadleaf forest, about 50 m distance from the river bank.

8. *Crocidura leucodon* (Hermann, 1780)

Was mentioned only from the outskirts of Retezat Mountains. One specimen was captured in September 2004 on the Bucura Lake shore.

9. *Crocidura suaveolens* (Pallas, 1811)

Wagner (1974) found it in the Retezat Mountains, in the beech forests (beneath 800 m altitude).

Order **Rodentia** Gray, 1821

Fam. **Sciuridae** Gray, 1821

10. *Sciurus vulgaris* Linnaeus, 1758

It was recorded by Hamar (1957) on the Valea Rea and Pietrele Valley and by Munteanu (1993) in the beech and spruce forests.

Several individuals were spotted at Lunca Berhina, below Genţiana Chalet, above Gura Bucurei and around Buta Chalet.

11. *Marmota marmota* Linnaeus, 1758

According to Bielz (1888) this species disappeared from Romania during the second half of the XIXth century. In 1866 Csató mentioned it already as a rare species, being observed on the Vasielu Peak and near Zănoaga Lake. After some unsuccessful attempts to reintroduce this species, in 1972 the repopulation succeeded in the Retezat, Făgăraş and Călimani mountains. Is present in the alpine meadows in the central part of Retezat Mountains.

In August 2000, one adult was spotted near the Viorica Lake and four juveniles near the Florica Lake, while in September 2005 five specimens were observed in Valea Rea and Galeşu Valley.

Fam. **Gliridae** Thomas, 1897

12. *Eliomys quercinus* (Linnaeus, 1758)

Was trapped in the Valea Rea and Pietrele Valleys (Hamar, 1957).

13. *Myoxus glis* (Linnaeus, 1766)

Was mentioned from Gura Apei and Pietrele Valley, beneath 700 m (Hamar, 1957).

During our researches one individual was captured at the upper limit of the spruce forest, above Câmpuşel. According to the shepherds, this species lives in the vicinity of Buta Chalet, being found sometimes in the sheepfold.

14. *Muscardinus avellanarius* (Linnaeus, 1758)

Hamar (1957) found it in Valea Rea, Pietrele Valley and at Zănoaga. Although it is considered the most largely distributed dormouse species in Romania, being cited at different altitudes, up to the subalpine shrubs.

We encountered it only in 2003, when a juvenile individual was captured at Beci, another was found dead on the road in the same area and a six member family (two adults and four juveniles) were observed in a hazelnut shrub at Gura Zlata.

Fam. **Arvicolidae** Gray, 1821

15. *Clethrionomys glareolus* (Schreber, 1780)

This species was first cited in the XIXth century in the Retezat Mountains (Bielz, 1888). The specimens collected from this area by Miller were described as a new subspecies *Evotomys glareolus istericus* Miller, 1900 (Călinescu, 1931), not recognized at present. The quantitative data found in the references indicate it as the dominant species in the forested areas of the Retezat Mountains, more abundant in the coniferous forests, descending to 700 m (Hamar, 1957). Wagner (1974) also records this species dominance.

During our researches this species was captured in most of the investigated habitats, both at low and high altitudes, during every trapping period.

16. *Pitymys subterraneus* (de Sélys - Longchamps, 1836)

The presence of this species in Retezat Mountians was recorded by Miller in 1912 (ap. Călinescu, 1931). It is found mostly at high altitudes, in the subalpine shrubs (Munteanu, 1993), prevailing in the alpine tundra. Hamar (1957) found it also lower, beginning with 700 - 800 m height, but most of the specimens were collected in the subalpine area, near the Galeşu, Zănoaga and Bucura Lakes.

During our investigations in 2002, one individual was captured in the mixed forest on the Buta Valley and another one was found dead beneath the Piatra Iorgovanului Peak, in a subalpine pasture at the base of the rocks. In 2005 a specimen was captured in Poiana Pelegii, in a swampy area.

17. *Microtus agrestis* (Linnaeus, 1761)

This species was first recorded in the Retezat Mountains by Wagner (1974) in the subalpine area (1800 - 2100 m).

During our research, several specimens were captured. In 2002, below Buta Lake and Piatra Iorgovanului Peak, in the *Pinus mugo* shrubs, in 2003 on the Buta bank at Beci, and in 2005 two specimens (one adult female and a juvenile - probably a family) in the humid spruce forest at Buta and one at Cheile Buții.

18. *Chionomys nivalis* Martins, 1842

Miller made the first record of this species in 1912 from the area. He described the specimens collected from here as *Microtus ulpius* Miller, 1908 (Călinescu, 1931). Hamar (1957) mentions the same species between 1800 - 2200 m, in areas with *Pinus mugo* shrubs.

33 specimens were captured near Bucura, Galeşu, Lia and Zănoaga lakes. This species descends to the forested area to 900 m altitude (Wagner, 1974). In August 2000 it was spotted in Retezatul Mic, above Scocul Drăgşanu, at the entrance of the Kis Vertical Cave. In 2002, it was captured on rocky ground, near the Scorota Peak (2021 m), in June 2004 below Drăgşanu Peak (an adult male and an adult female), while in September 2004 and June 2005 it was found in the humid spruce forest at Buta Chalet (one adult female recaptured in June). In September 2005 *Chionomys nivalis* was encountered below Peleaga Peak (2509 m) and in 2004 was captured also on Lăpuşnicu Mare Valley, at Drăgşanu camping place.

Fam. **Muridae** Gray, 1821

19. *Apodemus sylvaticus* (Linnaeus, 1758)

Was cited by Csató in the Retezat Mountains (Bielz, 1888) and collected by Miller (Călinescu, 1931). The data regarding its vertical distribution are contradictory: Hamar (1957) mentions it only up to 700 - 750 m altitude, outside the compact forests, where it competes with *Apodemus flavicollis*, while Wagner (1974) captured 14 individuals between 800 - 1750 m height.

During our investigations no specimen belonging to this species was captured. This fact suggests that Wagner could have mis-identified some *Apodemus flavicollis* individuals.

20. *Apodemus flavicollis* (Melchior, 1834)

The first recording of the species in the area was made by Miller in 1912 (Călinescu, 1931). It inhabits the entire forested area, from the lower limit of the forest to the subalpine area (Hamar, 1957; Wagner, 1974). *Apodemus flavicollis* represented the species with the highest range of the multiannual dynamics during the research period in Retezat Mountains but also in some other mountain areas. In some years (2000, 2002 and partially 2004) it was largely spread, being captured in most of the investigated habitats, being also the dominant species in many of them. In other years (2003 and 2005) however, it was not encountered at high altitudes.

21. *Apodemus agrarius* (Pallas, 1771)

It was spotted at Pietrele Chalet in 2005 (Călin Hodor, in verbis). Hamar (1957) mentions it only up to 650 m (outside the park's borders).

22. *Mus musculus* Linnaeus, 1766

It is spread in low areas, up to 900 m (Wagner, 1974). Hamar (1957) found it in every investigated human settlement, while Munteanu (1993) mentioned it in beech forests.

DISCUSSION

The specific diversity and abundance of small mammal communities decrease with altitude. A similar situation was recorded also by Simionescu (1968). The highest number of species (captured or cited in the literature), 15, is found in the lower areas, in the beech forests zone, while in the alpine areas, above the upper limit of the subalpine shrubs, only five species were recorded. The impoverishment of small mammal communities at higher altitudes is recorded both in years with low and high populational densities.

The small mammals communities from the forested habitats are dominated by two typical forest rodents, namely *C. glareolus* and *A. flavicollis*, and the insectivore *S. araneus* in years with low population densities of the latter. However, several charactersitic features can be observed in the different major habitat types.

In the beech forests (Gura Zlata, Cheile Buții, Cârnic) the communities are dominated by the two mentioned rodent species, *A. flavicollis* being usually more abundant, even in years with low populational densities (2003, 2005), when it was encountered only in these stations. The mixed forests (Corciova, La Beci, Câmpuşel, Rotunda Chalet) shelter similar small mammals communities, but *A. flavicollis* was absent in 2003 and 2005, when the highest abundance was recorded by *C. glareolus*. Spruce forests can be easily divided into two categories. Moist forests with rich herbaceous layer, dead tree trunks and large rocks (Lunca Rotunda, Buta, Poiana Pelegii, Lăpuşnicul Mare Valley) record a high small mammals' diversity. Besides *A. flavicollis* and *C. glareolus*, dominant in the rodent peak years, some other rodent species were found: *M. agrestis, P. subterraneus* and, at the beginning of summer and in autumn, *Ch. nivalis* (captured at Buta and on Lăpuşnic Valley). Insectivores are also well represented, being more abundant in the upper sector of Lăpuşnicul Mare Valley, compared to other areas. Among the species of this group *S. araneus* is prevailing, while *S. minutus* is seldom captured. The presence of *S. Alpinus* captured only in this habitat type, during rodent decline years is notable. The spruce forests with scarce herbaceous layer, dry, excesively acid or strongly influenced by different human activities, shelter a poor small mammal fauna comprising at most the three most common species (*C. glareolus, A. flavicollis* and *S. araneus*).

The subalpine shrubs (mostly *Pinus mugo* shrubs - Buta Lake, Drăgşanu Ridge and Piatra Iorgovanului) are dominated in the peak years by *A. flavicollis*, accompanied by *C. glareolus* and *M. agrestis*, at lower densities. In decline years only a few captures are recorded, *C. glareolus, M. agrestis, S. minutus,* and mostly *S. araneus*. Subalpine rocky areas (Drăgşanu, and Scorota Peaks, Bucura Lake) are characterized by the presence of *Ch. nivalis*. In peak years *A. flavicollis* was also encountered, but was less abundant than in the neighbouring shrubs, and in decline years, *S. araneus*. The alpine zone that was not investigated by trapping, only by visual observations, shelters a small mammals fauna formed of a few species. Among them one is found only here (*Marmota marmota*), some are charactersitic for high altitudes (*Ch. nivalis, P. subterraneus*), while the other are highly euribiotic (*S. araneus, T. europaea*). *Ch. nivalis* inhabits the alpine area up to the highest altitudes, being observed below Peleaga Peak (2508 m).

In open areas with no woody vegetation (secondary mountain and subalpine meadows, forest clearings - Poiana Pelegii, Drăgşanu Ridge) a very low number of animals was found, belonging to one species, namely *S. araneus*.

Riverbanks represent a distinct habitat type, characterised by the presence of *N. fodiens*, found along most of the mountain rivers or streams in forested areas at different altitudes, but in low densities, thus it is only seldom captured. *N. anomalus* is even more rare and the only specimen was captured in Cheile Buţii, in the mixed broadleaf forest, about 60 m from the riverbank. From the quantitative point of view some characteristics of this habitat type can be also be remarked. The density of *A. flavicollis* populations during peak years are usually lower than in the neighbouring forests, while in decline years it is higher, the river banks representing probably a path for the recolonization of habitats from higher altitudes. *C. glareolus* and *S. araneus* do not seem to present any preferences for this habitat, being captured along the river banks less frequently than in the neighbouring forests.

CONCLUSIONS

From the Retezat National Park 22 species of small mammals are known up to the present, nine insectivores (all the species from Romania) and 13 rodents. Among them *Crocidura leucodon* is mentioned for the first time from this area. The diversity and abundance of small mammals' communities decrease on altitude, being highest in the broad leaf forests. In most of the forested habitats dominants are *Clethrionnomys glareolus* and *Apodemus flavicollis*, and in years with low densities of the latter, *Sorex araneus*. In 2003 and 2005 *Apodemus flavicollis* was found only in the beech forests. A relative high diversity is recorded in humid spruce forests with rich herbaceous layer. *Sorex alpinus* was only found in this habitat. It appeared against the background of *Apodemus flavicollis*'s absence, but it was found only two years (in 2003 and in 2004). River banks are characterised by the presence of *Neomys* species.

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FOREST MANAGEMENT AND CONSERVATION IN RETEZAT NATIONAL PARK (ROMANIA)

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, forest management, conservation, forest ownership and administration.

ABSTRACT

The paper is assessing the features of the forest vegetation, the main impact of the forest ownership and administration and the opportunities and challenges for the sustainable management and conservation of the forests included in the Retezat National Park. Forest habitats cover about half of the park area (18,608 ha) and are represented by 46 different types of forest. Norway spruce and common beech are the dominant species and the vast majority of the forests are included in the protection forest functional group, with 34% of them strictly protected. In spite of some human interventions during the last centuries the core area of the park includes forests which still maintain their natural status and processes. Forest land ownership and administration have influenced the sustainable management and conservation of the Retezat's forests and presently only a small percentage of the forest land included in the park is in non-state ownership. The adaptation of the forest management plans to the requirements of the park management plan (e.g. the internal zoning, the extension of the core area, the reduction of clear cuts in the buffer area etc.) is a significant challenge for the future.

RÉSUMÉ: Le management et la conservation des forêts dans le Parc National Retezat (Roumanie).

L'ouvrage présente les caractéristiques de la végétation forestière, l'impact des formes de propriété et des modalités d'administration ainsi que les opportunités et les provocations en ce qui concerne le management et la conservation des forêts du Parc National Retezat. La végétation forestière couvre environ la moitié de la superficie du parc national (18.608 hectares) et elle est représentée par 46 types de forêts. Les espèces les plus répandues sont l'épicéa et l'hêtre et la plus grande partie des forêts est inclue dans le groupe fonctionnel des forêts de protection, 34% étant strictement protégées. Même si dans les derniers siècles les forêts ont été affectées par les quelques interventions anthropiques, les forêts de surface strictement protégées du parc présentent structures et procès spécifiques aux forêts naturelles. La propriété et la façon d'administrer ces forêts ont influencées au cours des années le management et la conservation des forêts de Retezat et à présent seulement une petite partie des forêts du parc ne constitue pas la propriété de l'état. Une provocation importante pour l'avenir est donnée par le besoin d'adapter les aménagements forestiers aux besoins du plan de management du parc (par ex. la division interne par surfaces, l'extension de la surface strictement protégée, la diminution des surfaces de coupe rasées dans la surface tamponne, etc.).

REZUMAT: Managementul şi conservarea pădurilor în Parcul Naţional Retezat.

Lucrarea prezintă caracteristicile vegetaţiei forestiere, impactul formelor de proprietate şi a modului de administrare precum şi oportunităţile şi provocările în ceea ce priveşte managementul şi conservarea pădurilor din Parcul Naţional Retezat.

Vegetaţia forestieră acoperă circa jumătate din suprafaţa parcului naţional (18.608 ha) şi este reprezentată de 46 de tipuri de pădure. Cele mai răspândite specii sunt molidul şi fagul iar marea majoritate a pădurilor sunt incluse în grupa funcţională a pădurilor de protecţie, 34% fiind strict protejate. Cu toate că în ultimele secole au fost afectate de unele intervenţii antropice, pădurile din zona strict protejată a parcului prezintă structuri şi procese specifice pădurilor naturale. Proprietatea şi modul de administrare a pădurilor au influenţat în timp managementul şi conservarea pădurilor din Retezat, iar în prezent doar o mică parte a pădurilor din parc nu sunt în proprietatea statului. O provocare importantă pentru viitor o reprezintă adaptarea amenajamentelor silvice la cerinţele planului de management al parcului (ex. zonarea internă, extinderea zonei strict protejate, reducerea tăierilor rase în zona tampon etc.).

INTRODUCTION

The Retezat Mountains are located in the Southern Romanian Carpathians, with an area of about 800 km^2. Retezat is separated from the other massifs by large valleys (Jiu with its tributary Bănița, and Râul Mare), and a large depression (Țara Hațegului).

The Retezat National Park was established in 1935 with an area of 10,000 ha, as the first national park of Romania, and currently the park covers 38,138 ha. The forests within the 10,000 ha of the initially established national park were set aside as a special conservation area in 1986. Even before this year, most of these forests were not managed for economic purposes, mainly due to the lack of access. The extension of the park area in the year 2000 (Low nr. 5/2000) to an area almost four times bigger than the initial area, raised several issues related to the management of the forests according to the objectives stipulated by the park management plan. The first management plan of the Retezat National Park was approved in 2003 (MAPDR), after a participatory planning process. The internal zoning of the park reflects the park management objectives and requires some adjustments of the forest management measures recommended by the forest management plans. At the same time, changes in the forest ownership will continue to raise new issues for forest management in this national park.

Based on the analysis of the forest management plans, the park management plan and the existing literature on the forest vegetation within the national park, this paper is assessing the features of the forest vegetation, the main impact of the forest ownership and administration and the opportunities and challenges for the sustainable management and conservation of the forests included in the Retezat National Park.

RESULTS AND DISCUSSIONS

The main features of forest vegetation The vegetation of the Retezat Mountains is very rich due to its location at a crossing point of several vegetation provinces. Three main ecosystem complexes can be distinguished along the altitudinal gradient: forests, meadows and/or pastures and alpine area. The vegetation communities of Retezat National Park are well documented in a number of publications (Boşcaiu, 1993; Burduşel et al., 1996; Cernelea and Simtea, 1985; Coldea et al., 1993; Csürös et al., 1964; Radu, 1994; 2005; etc.).

Forests from the Retezat Mountains can be subdivided by altitudinal gradient into 46 different types belonging to three forest zones: deciduous, mixed and conifers (Boşcaiu, 1993; Botnariuc et al., 1997; Cernelea and Simtea, 1985; Coldea and Preda, 1993; Stoiculescu and Badea, 1997) - see figure 1. Cernelea and Simtea (1985) described the forest types found in Retezat as follows: 15 types of beech forests, 13 types of mixed beech-conifer forests, 15 types of spruce forests and three extra-zonal mountain floodplain forests.

Deciduous Forests - The lower altitudinal parts of Retezat Mountains (550 - 800 m) and their main valleys (Râul Mare, Râu-Bărbat, Jiul Românesc, Nucşoara, etc.) are characterized by hardwood forests.

Sessile oak (*Quercus petraea*) is found in Râul Mare and Jurii Valley up to an altitude of 1000 m, and in Râul Barbat up to 800 m. Manna ash (*Fraxinus ornus*) occurs on sunny slopes and European beech (*Fagus sylvatica*) and hornbeam (*Carpinus betulus*) are found on shaded slopes in the lower altitudinal strip of Retezat Mountains. It should be mentioned that oak and ash occupy a very small area within the national park borders.

Beech forests occupy large areas between 700 m and 1200 m altitude ascending in some places up to 1250 m. Cernelea and Simtea (1985) indicate that *Agrostis tenuis* is a common species in the herbaceous layer of beech forests. Other species found in the composition of deciduous forests are: Turkey oak (*Quercus cerris*), Norway maple (*Acer platanoides*), European birch (*Betula pendula*), alder (*Alnus incana*), sycamore (*Acer pseudoplatanus*) and hazelnut (*Corylus avellana*).

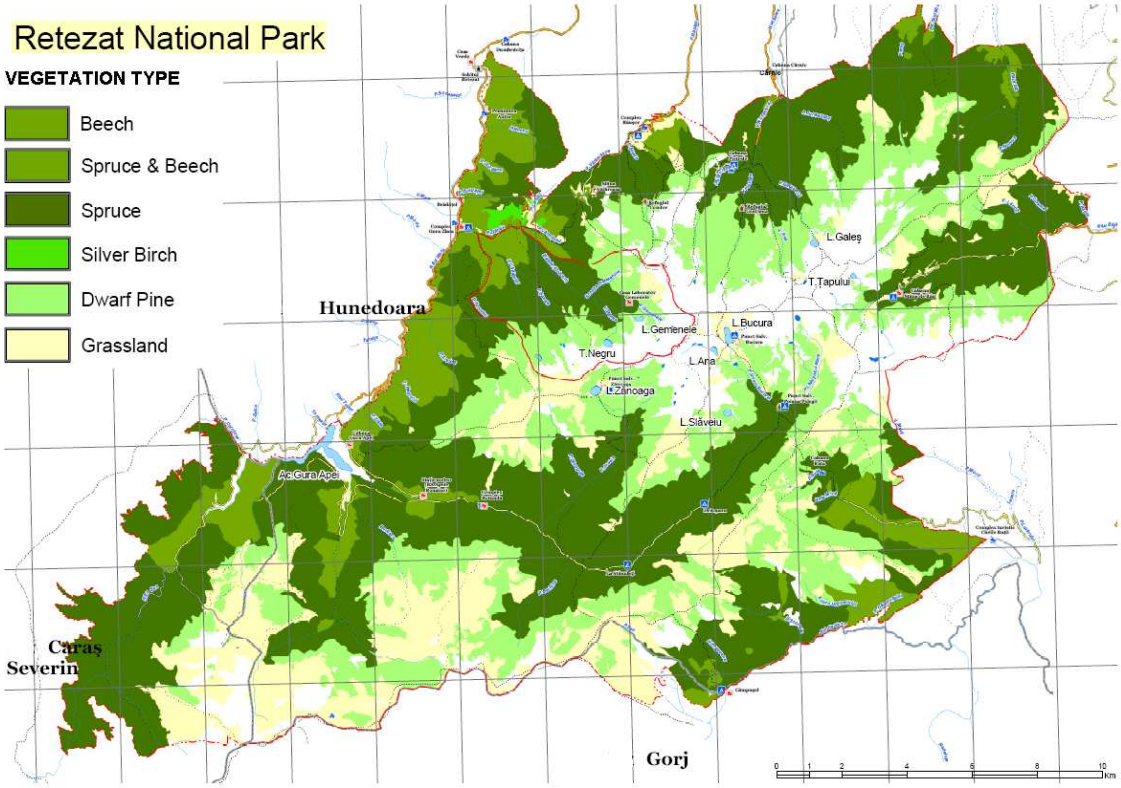


Fig. 1: Distribution of the main vegetation types in the Retezat National Park (Retezat National Park Administration, 2005 - modified).

Mixed Forests - Beech - conifer mixtures occur between altitudes of 1250 m and 1450 m. These forests are composed predominantly of European beech, Norway spruce (*Picea abies*) and silver fir (*Abies alba*) with a sporadic presence of European birch, Norway maple, hazelnut, mountain ash (*Sorbus aucuparia*) and goat willow (*Salix caprea*).

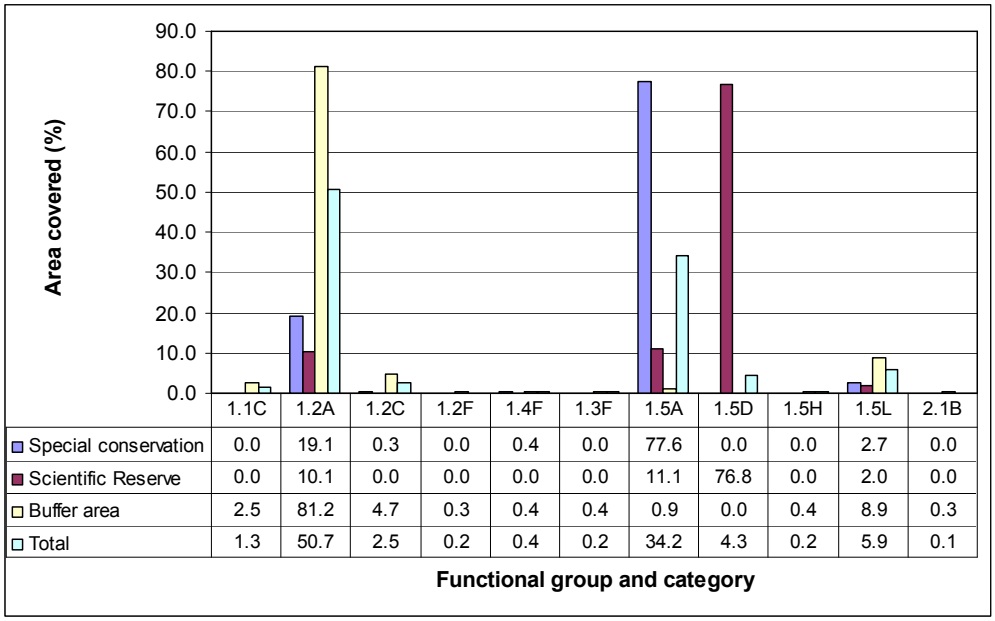
Coniferous Forests - Spruce forests are found between altitudes of 1000 m and 1750 m, sometimes reaching 1850 m (e.g. Zănoaga and Mare peaks). The main shrub species which are present in the conifer forest ecosystems are: mountain ash, goat willow, juniper (*Juniperus*

communis ssp. *alpina*), and red raspberry (*Rubus idaeus*) together with the wide-spread *Vaccinium vitis-idaea* and *Vaccinium myrtillus* in temporarily open spaces.

In the upper part of this conifer forest zone, individual trees of dwarf pine (*Pinus mugo*) or Arolla pine (*Pinus cembra*) are found in the lower density spruce forests. The herbaceous layer of spruce forest is composed of Festuca rubra, *Festuca rubra* with *Agrostis tenuis* or *Nardus stricta* associations (Cernelea and Simtea, 1985). Scots pine (*Pinus sylvestris*) is present on steep slopes and frequently on rocks (Cernelea and Simtea, 1985).

The forests of the park cover about 49% of the total park area (18,608 ha), at an altitude ranging from 690 m to 1,900 m. The timber line here is at its highest altitude in Romania.

The vast majority of the forest from the Retezat National Park (99.9%) is included in the first functional group - protected forests, according to the Romanian forest management planning norms. Forest distribution by functional categories is presented in figure 2.

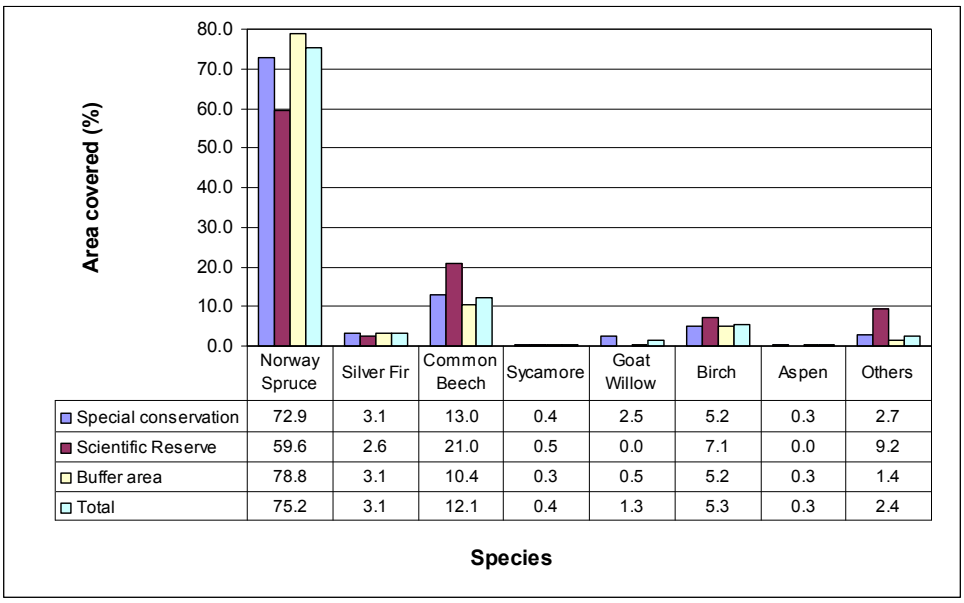


	1.1C	1.2A	1.2C	1.2F	1.4F	1.3F	1.5A	1.5D	1.5H	1.5L	2.1B
Special conservation	0.0	19.1	0.3	0.0	0.4	0.0	77.6	0.0	0.0	2.7	0.0
Scientific Reserve	0.0	10.1	0.0	0.0	0.0	0.0	11.1	76.8	0.0	2.0	0.0
Buffer area	2.5	81.2	4.7	0.3	0.4	0.4	0.9	0.0	0.4	8.9	0.3
Total	1.3	50.7	2.5	0.2	0.4	0.2	34.2	4.3	0.2	5.9	0.1

Fig. 2: Distribution of forests by functional group and category in the Retezat National Park: 1. 1. A) forests in well and water source protection areas, mapped based on relevant studies and approved by the Ministry of Silviculture (TII); 1. 1. C) forests on slopes in mountain and hilly regions up to 15 - 30 km away from the lakes/reservoirs and in their collection watershed (TIV); 1. 2. A) forests on stony slopes, debris with slopes steeper than 40^o, flisch with slopes steeper than 35^o, sandy soils with slopes steeper than 30^o, and any steep slope with high erosion (T II); 1. 2. C) forests surrounding alpine meadows, in strips 100 - 300 m wide (width according to the site conditions and structure of stands) (TII); 1. 2. F) forests in areas where avalanches are originating or run-off (TII); 1. 3. F) forests at high altitudes with difficult regeneration conditions (TII); 1. 4. F) forest strips around hotels, camping sites etc., at a radius of up to one km; 1. 5. A) core areas of the national parks established by law (TI); 1. 5. D) scientific reserves (TI); 1. 5. H) seed reserves (TII); 1. 5. L) forests from the national parks which are not included in categories 1.5 A, C, D, E (buffer zones); TI - No felling; TII - Conservation felling (sanitation or safety); TIII - Selection or group selection system felling; TIV - Selecion or group selection system felling and restricted shelterwood.

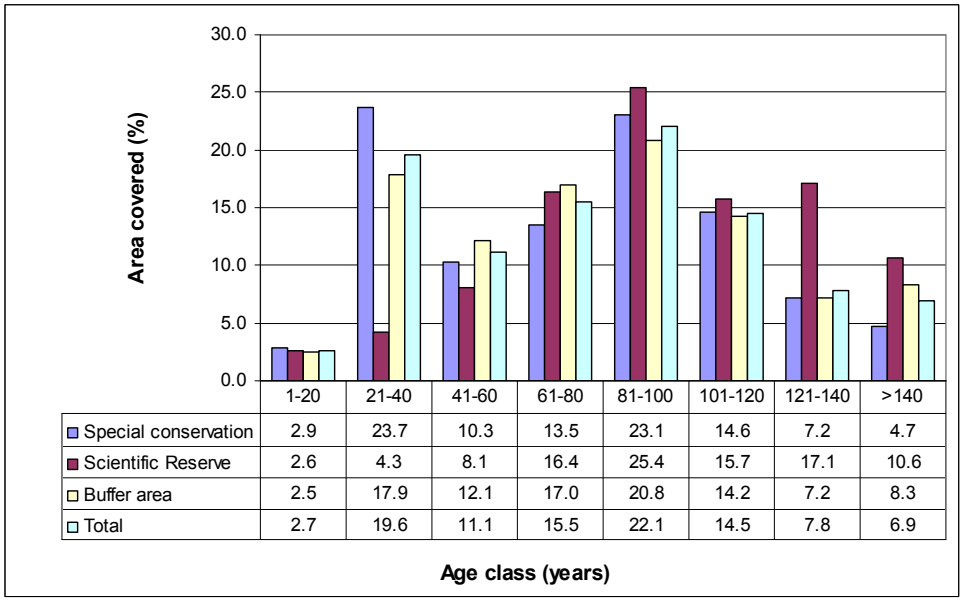
It can be noticed (Fig. 2) that over 90% of the forest compartments are included in three categories (1.2.A, 1.5.A and 1.5.L). The management plans for the forests included in the park require a strict protection for 34% of the forests (for special conservation), with no active management. An additional 51% of the total forest area is under special management measures for slope protection, only with sanitary cuttings allowed if feasible.

The dominant species in the park is Norway spruce, which covers 75.2% of the forest area (Fig. 3), followed by common beech about 12%, whilst birch 5.3% and silver fir 3,1%. Almost 15% of the forests are older than 120 years, with 28% of the forests from the scientific reserve over 120 years (Fig. 4), whilst 89% of the forests are naturally regenerated.



	Norway Spruce	Silver Fir	Common Beech	Sycamore	Goat Willow	Birch	Aspen	Others
Special conservation	72.9	3.1	13.0	0.4	2.5	5.2	0.3	2.7
Scientific Reserve	59.6	2.6	21.0	0.5	0.0	7.1	0.0	9.2
Buffer area	78.8	3.1	10.4	0.3	0.5	5.2	0.3	1.4
Total	75.2	3.1	12.1	0.4	1.3	5.3	0.3	2.4

Fig. 3: The forest species composition in the Retezat National Park.



	1-20	21-40	41-60	61-80	81-100	101-120	121-140	>140
Special conservation	2.9	23.7	10.3	13.5	23.1	14.6	7.2	4.7
Scientific Reserve	2.6	4.3	8.1	16.4	25.4	15.7	17.1	10.6
Buffer area	2.5	17.9	12.1	17.0	20.8	14.2	7.2	8.3
Total	2.7	19.6	11.1	15.5	22.1	14.5	7.8	6.9

Fig. 4: Age class distribution of forests from the Retezat National Park.

The impact of forest ownership and administration on the conservation and sustainable management of forests There is written evidence (Radu, 2005) that in the second part of the XIXth century massive forest harvesting was undertaken in the forests owned by Kendeffy family, who employed the Italian entrepreneur PECAL to harvest the wood in the Râul Mare lower watershed. Significant harvesting is also documented for the period 1913 - 1914 in the Judele and Lapuşnicul Mare watersheds, but it seems that these major impacts did not affect the core forest area of Retezat, where later the national park was established.

Despite the fact that Retezat was the first national park in Romania (1935), the management objectives were established only after 1999, when the park administration was established. Thus, the forest ownership, i.e. having the forest areas in state ownership and state administration between 1948 and 1999, has played a crucial role in the conservation and sustainable management of forests included in the park after its establishment.

Before nationalisation in 1948, the forests situated in the initially established national park (around 10,000 ha located mainly in the Dobrun - Zlata watershed) belonged to Kendeffy family and the state (although, part of the alpine pastures were given to the local communities after the expropriation of Kendeffy family, according to the 1923 Land Reform (Radu, 2005). Part of the forests were well preserved due to the fact that the owners had good rules to protect the area, especially due to their main objective to preserve the wildlife for hunting purposes, so neither grazing nor wood harvesting were allowed in the forest. After Retezat was declared a national park in 1935, the harvesting was restricted and the forest administration had to enforce this rule in the park area covered by forests. However, forest fires and some illegal logging were reported in the area in the period 1943 - 1947 due to the war and the dry summer of 1946.

After 1948, when all Romanian forests were nationalised, management planning and the functional zoning of the forest according to the forest management planning norms became the main tool for conservation of forest ecosystems within the park borders.

The first forest management plan for the Retezat and Haţeg forest districts was finalized in 1951, covering 36,915 ha of forests and in 1955 the different protection zones of Retezat National Park were delineated via the establishment of Gemenele Scientific Reserve (1,840 ha) and a buffer area around it of 11,160 ha (Radu, 2005). During the revision of the forest management plans in 1964, the extension of the park area to 20,000 ha (out of which 9,026 ha of forest) was proposed.

Wood harvesting was allowed in the park area in the 1968 - 1969 as part of the high selection forest system applied in some of the forests and 450 ha of forest was cut in the period 1976 - 1980 with the purpose of establishing the Tomeasa dam and reservoir (Radu, 2005).

The area of the national park was enlarged, according to the Ministerial Order 7/27.01.1990, to a total area of 54,541.8 ha, including a core area of six reserves (18,429 ha) and two buffer areas totalling 36,112.8 ha.

Sixty-four years after the legal establishment of the park, the Administration of Retezat National Park was established, based on the Ministerial Order 289/1999. However, the forest area within the park continues to be managed by the state via the local forest districts of the National Forest Administration - Romsilva.

Law 5/2000 specifies in its annex that the total area of Retezat National Park is 38,047 ha and the Park Management Plan developed for the period 2002 - 2006 by the park administration corrected the total area through GIS mapping to 38,138 ha, forests covering 49% of the park area (18,608 ha).

According to Law 1/2000, 1,044 ha of forest lands were restituted to the communities which owned the forest in the north-eastern buffer area of the national park (Fig. 5). Despite this restitution, the state remained the major forest owner in the park area (17,564 ha).

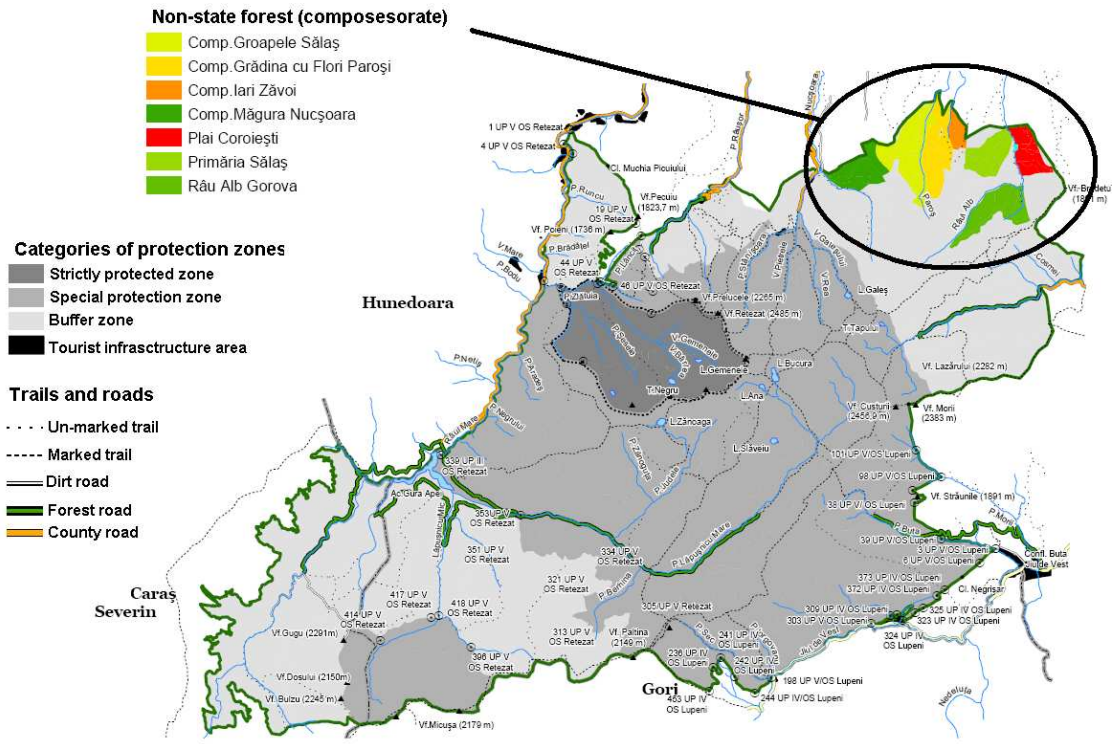


Fig. 5: Location of the non-state forest
after the implementation of Law 1/2000 (APNR 2005 - modified).

The Ministerial Order 552/2003 defines the internal zoning for all large protected areas in Romania, including Retezat National Park. The forests included in the core area (special conservation zones) cover 5,495 ha of the Retezat National Park and its adminsitrative situation is presented in table 1.

Table 1: The administrative location of the core area including forest habitats in the Retezat National Park.

Forest District	Working Unit	Forest Compartment*
Lupeni	IV Câmpuşel	157 - 159
	V Buta-Bilugu	3 - 18, 43
Pui	V Râu Bărbat	101,102
	VI Râu Alb	149 - 159
Retezat	V Retezat-Lăpuşnic	23 - 170, 189 - 193

*including the open spaces within each compartment group.

Opportunities and challenges for forest management and conservation The composition and dynamics of the forests have not been influenced through an active management on large areas in the Retezat National Park. Therefore, the main opportunity for forest management practices is given by the presence of forests that have now a relatively long period since natural processes have been allowed by excluding any active management, both in the scientific reserve (strictly protected area) and in the core area (special conservation area). These areas can be monitored and the lessons learned from the natural processes can help forest management planning, mainly in the following locations: a) areas naturally regenerated after the harvesting from the beginning of the 20th century (Lapuşnicul Mare Valley); b) areas naturally regenerated after the windfalls that occurred in the 1940s (especially in the Gemenele Scientific Reserve); c) areas naturally regenerated after avalanches; d) areas naturally regenerated after the major flood from 1999, that generated changes even in the geomorphology of some of the slopes and valley floors (e.g. Lapuşnicul Mare Valley); e) areas naturally regenerated in the vicinity of the timber line, in the former grazing areas.

The park also hosts significant areas of old-growth forests, with a very rich biodiversity (Radu, 2005).

In order to address some of the challenges for forest management in the national park according to the park objectives there will be a need to: a) adapt entirely the forest management plans to the internal zoning of the national park and to adopt appropriate management measures. An analysis of the functional groups and categories in the main internal zones of the park area shows that some of the forests from the scientific reserve and from the core area are still in categories that allow some felling; b) ensure that the forests owned by the local communities and those which will be restituted to former owners will have an appropriate management, in full compliance with the park management plan, with special conservation measures implemented in areas with high biodiversity; c) reduce or better eliminate clearcuts in spruce forests even in the buffer zones, as an important objective of the park for the conservation of landscape; d) extend in the future the surface of the core area of the park, as the aim of the park is the "protection and conservation of representative samples for this biogeographically area of the country, with its natural assets of special values".

The possibility of addressing these challenges is closely linked to the possibility of allocating financial incentives to the forest owners and administrators in order to compensate the economic short term losses derived from the conservation measures.

CONCLUSIONS

In spite of some human influences during the last centuries a significant part of the forests from the Retezat National Park still maintain their natural status and processes. Almost all forests from the park are included in the protection forest group and are preserved or managed for protection purposes.

The changes in forest ownership now only affects a relatively small part of the forests (about 1,000 ha) situated in the buffer area, but the recent legislative developments in forest ownership and administration might affect the conservation of park forests. An important challenge for the near future will be the adaptation of the forest management plans to the internal zoning and management objectives of the national park.

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AN APPROACH TO SURVEYING AND MAPPING THE BIODIVERSITY OF NATIONAL PARKS (ROMANIA)

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KEYWORDS: Romanian Carpathians; Retezat, Piatra Craiului and Vânători-Neamț parks.

ABSTRACT

The national parks of the Romanian Carpathians have long been the focus of intense scientific study, producing a wealth of learned articles. Their biodiversity value was also recognised internationally and in 1999, the World Bank and the Romanian Government together commissioned a Biodiversity Conservation Management Project (BCMP) for three parks: Retezat, Piatra Craiului and Vânători-Neamț. The objectives of this project included development of model approaches to conservation management for a range of park types. A pre-requisite for this objective was the presence of rigorous and comprehensive baseline data on the biota present, their abundance and distribution, and the composition of communities. Komex and the Centre for Ecology and Hydrology were asked to design methods for surveying the biodiversity of the parks. The methods had to be a) applicable by surveyors with a wide range of expertise; and b) consistent both across the three parks and all habitats, allowing for ready comparison and producing a standard baseline for subsequent monitoring. This paper outlines approaches that were developed for use from 2000 onward, discussing practical problems and solutions as well as the benefits of providing a consistent framework within which more focussed, detailed studies by Romanian experts could contribute further.

ZUSAMMENFASSUNG: Ervorschung und Kartierung der Nationalpärke Biodiversität.

Die Nationalparks der Rumänischen Karpaten sind schon lange Zeit im Brennpunkt intensiver wissenschaftlicher Untersuchungen, was sich in zahlreichen Zeitschriftenbeiträgen niedergeschlagen hat. Ihr Biodiversitätswert ist international anerkannt. 1999 haben die Weltbank und die rumänische Regierung gemeinsam ein Biodiversitäts-, Naturschutz- und Landnutzungsprojekt für drei Parks ins Leben gerufen: Retezat, Piatra Craiului und Vânători-Neamț. Die Zielsetzung dieses Projektes ist die Entwicklung von Modellansätzen für Naturschutzmanagement in verschiedenen Park-Typen. Eine Voraussetzung für dieses Ziel was die Verfügbarkeit von umfangreichen, detaillierten Daten bezüglich der vorhandenen Biota, ihrer Häufigkeit und räumlichen Verteilung, und der Artenzusammensetzung von Pflanzen- und Tiergemeinschaften. Komex und Zentrum für Ökologie und Hydrologie, UK, wurden beauftragt, Methoden zur Biodiversitätskartierung der Parks zu entwickeln. Diese mussten a) durch Kartierer mit unterschiedli- chem Erfahrungshorizont anwendbar sein; und b) übertragbar und konsistent für alle Parks und alle Habitate sein, sodaß Vergleiche möglich sind und die Daten als Grundlage für späteres Monitoring geeignet sind. Dieser Beitrag beschreibt die Ansätze, die für die praktische Anwendung seit 2000 entwickelt wurden, diskutiert Lösungen zu praktischen Probleme und die Vorteile eines konsistenten methodischen Vorgehens, in dem detailliertere Studien von rumänischen Experten wissenschaftlich integriert werden könnten.

REZUMAT: O abordare asupra studierii şi cartării biodiversităţii parcurilor naţionale.

Parcurile naţionale din Carpaţii Româneşti au fost pentru o perioadă îndelungată de timp centre de intense studii ştiinţifice, care au ca rezultat o bogăţie de articole. Valoarea acestor parcuri, din punct de vedere al biodiversităţii a fost de asemenea recunoscută internaţional şi în 1999, Banca Mondială împreună cu Guvernul României au realizat Proiectul de Management pentru Conservara Biodiversităţii (BCMP) pentru trei parcuri: Retezat, Piatra Craiului şi Vânători-Neamţ. Obiectivele acestui proiect au inclus dezvoltarea unui model de abordare a managementului conservativ pentru o serie de tipuri de parcuri. Un lucru necesar pentru acest obiectiv a fost existenţa unor riguroase şi cuprinzătoare date referitoare la biota prezentă, abundenţa şi distribuţia acesteia şi compoziţia comunităţilor. Komex şi Centrul pentru Ecologie şi Hidrologie au fost solicitate să creeze metode pentru cercetarea biodiversităţii parcurilor. Metodele trebuiau să fie a) fie aplicabile de către cercetători dintr-o varietate largă de domenii de expertiză; şi b) consecvente pentru toate trei parcurile şi toate habitatele, permiţând o comparare facilă şi producând repere standard pentru monitoringul ulterior. Această lucrare schiţează abordările dezvoltate pentru utilizare din 2000, discutând probleme practice şi soluţii ca şi beneficiile oferirii unei reţele consecvente în cadrul căreia experţii români pot contribui mai departe prin studii mai concentrate şi detaliate.

INTRODUCTION

Over a quarter of the land area of Romania supports forest ecosystems including amongst the last relatively undisturbed, virgin forest remaining in Europe and indeed some of the most ecologically important temperate forests in the world (Phare, 1999). The Carpathian Mountains include not only forest, but also important grassland, wetland and alpine ecosystems. Romania has a long and distinguished history in both conservative forest management and ecological study of these wilderness areas (e.g. Popovici, 1993). However, until very recently, there was neither a fully functioning system of protected areas, nor the necessary institutional capacity to support such a system (Stanciu, 1999).

The Romanian Biodiversity Conservation Management Project (BCMP)

During the 1990s, Romania first ratified a series of international biodiversity conventions, the Paris in 1990, the Bern in 1993 (Lyster, 1985) and that on Biological Diversity in 1994 (Convention on Biological Diversity, 1992), and secondly drafted a national Biodiversity Conservation Strategy and Action Plan (1995-6). In order to meet the priorities identified by this plan, the Romanian government (aided by the Global Environmental Facility of the World Bank) commissioned a Biodiversity Conservation Management Project, to be implemented from 1999 by the then Ministry of Waters Forests and Environmental Protection (MWFEP) and the National Forest Authority (NFA). sustainable conservation management at three, largely forested, areas of the Carpathians, with mechanisms to help replicate practice at other priority conservation sites throughout România (MWFEP, 1999).

These three areas were chosen to allow opportunities to develop different management strategies i.e. a national park (Retezat), a natural park (protected landscape of Piatra Craiului), and biodiversity-friendly forest management (Vânători-Neamţ Forest Park). Retezat National Park Biosphere Reserve (ca 38.000 ha or 60.000 ha with buffer zones) included pristine mountain forest and alpine ecosystems, with 42 endemic plant species and designation as an "Important Bird Area" under the Bonn Convention (Lyster, 1985). The proposed Piatra Craiului-Bucegi Natural Park (ca 100,000 ha) had ca 3,400 ha of pristine ecosystems, with a hinterland of productive forestry and agriculture. The proposed Vânători-Neamţ Forest Park, with natural mixed hill-forest and meadows, provided an opportunity to establish biodiversity protection through sustainable forest management.

The development of the BCMP required rigorous approaches. To that end MWFEP asked Komex International and the UK Centre for Ecology and Hydrology (CEH) to develop an approach for undertaking baseline biodiversity and ecological surveys of all three *BCMP* park sites. As well as identifying park conservation priorities and guiding conservation planning and management, this strategy and action plan had to design monitoring systems that would provide periodic feedback on the status of critical ecosystems and their biodiversity within the three parks. Such an approach had to pay special attention to known threats e.g. over-grazing, tourism impacts, hunting and other forms of resource use. A major report was presented to the MWFEP and NFA, giving a full description of survey and analytical methods, together with background appendices and species reference tables (Patriquin et al., 2000). This report also included recommendations on evaluating social impacts and described the training and resource needs, but discussion of these aspects is omitted here. Instead, the present paper confines its attention to the principles behind the biodiversity survey approach, outlining some of the methods recommended, discussing practical problems and some suggested solutions.

RATIONALE

Much was already known about the ecology and biodiversity of the three parks (e.g. Popovici, 1993). For the Retezat, there were recent published accounts of vascular plants, lichens, *Mycophyta*, soil algae, birds, mammals, reptiles, amphibians, *Nematoda, Oligochaeta, Acarina, Chilopoda* and a wide range of insect groups (Popovici, 1993). Piatra Craiului had not been so intensively studied, and still less was known about Vânători-Neamț. More importantly, these thorough, erudite accounts were largely focussed on restricted study areas within the parks, or it was almost impossible to relate the information spatially to the different compartments of the parks in any manner that could usefully influence the future management planning for nature protection. Consequently, as well as this existing scientific research, there needed to be broad-scale and complete coverage of the parks at a less-detailed level, enabling the different parts of each park to be objectively assessed and the three parks compared.

Thus, the key aim was creation of a rigorous and geographically comprehensive baseline for those present biota, their abundance and distribution, and the composition of communities. From such a baseline, any change due to management or other factors could be quantified, and biodiversity protection targeted on those areas where it was most needed. Furthermore, this broad-scale survey would provide a consistent framework within which more focussed, problem-related studies by Romanian experts could further contribute to the successful protection of the remarkable natural richest of the Carpathian mountains.

EXISTING INFORMATION

The published literature referring to the Carpathian national parks was reviewed and a series of species lists were derived (Tab. 1). One aim of these lists was to identify those taxa with some designated status in Romania or internationally i.e. endemic, protected or exploited economically through hunting, harvesting etc (e.g. Government of Romania, 2000). At the same time, an attempt was made to distinguish species that were ecologically important in the parks e.g. dominant or constant species of communities (Coldea, 1993), or keystones within particular habitats (Hunter and Price, 1992). As well as thus deriving a basic checklist for the parks, information on the habitat requirements of these species was marshalled from local experts and from literature review (e.g. Ellenberg, 1988). The park biologists and research team also compiled a catalogue of the known variety of habitats in each park. These were related to the EUNIS habitat classification (Davies and Moss, 1999), which provided a consistent international system within which the Romanian examples could be evaluated.

Table 1: Information available for Retezat (R), Piatra Craiului (PC) and Vânători-Neamț (VN) parks.

Available Data	R	PC	VN	Comments
Endemics	✔	✔	?	Some endemics are also rare Not all suitable as indicators National endemic and rare plant list available Similar lists are available for birds and mammals Need to select "Red List" plants that it would be practical to monitor
Economic species	✔	✔	✔	Identify from hunting regulations and knowledge of park biologists, foresters etc
Protected species	✔	✔	✔	"Red Lists" for plants, mammals and birds
Keystone species				Difficult to provide comprehensive list as yet
Key species: each park	?	?		Preliminary suggestions, including plant community lists for R and PC with constant and faithful spp.
Specific habitat needs (home range size etc)				Hunting Authority had data for wintering areas etc

Construction of base maps

In addition to compilation of biological information, extant maps for the study areas were obtained including a) Forest Cover Maps used in forest management (scale 1:20000); b) land use maps (1:50000); and c) topographic maps (scales 1:5000 to 1:50000). Reliable detailed base-maps were necessary at all stages of the project for i) planning the sampling strategy; ii) the survey teams to locate sites, and upon which to make records; and iii) development of a Geographical Information System (GIS). It was suggested that the base-maps be constructed at the 1:20000 scale by combining aerial photograph interpretation with Forest Cover Maps, allowing non-forested areas (meadows, *Pinus mugo* and other scrub, water-bodies, bare rock, scree etc) to be delineated and access points and routes to be marked.

SAMPLING DESIGN AND STRATEGY

Two different approaches were considered desirable. Obviously a comprehensive survey covering all parts would be the ideal, but even with several volunteer survey teams, the sheer size of the three parks and difficult terrain made this impractical within the time available. Alternatively, a stratified random sampling approach might be used to ensure that all key habitats in the study areas were included and received appropriate survey effort. However, the absence of existing, accurate habitat maps made this also impossible. Therefore a non-stratified random approach was adopted, with inbuilt safeguards.

Combination on the base-maps of data on forest cover and non-forested land allowed a provisional habitat map to be constructed on which to plan the strategy. As survey results accrued, the estimates for the location and extent of each habitat would be checked against these base-maps, to ensure that the baseline survey had captured the full range of habitat variation effectively and was not biased in relation to accessibility, altitude, aspect or soil type. Should bias be detected, additional survey effort could be targeted in underrepresented habitats and areas of the parks. Such classification of habitats in relation to altitude, aspect, soil type and other physical characteristics could also later play a key role in deriving habitat suitability maps for important species, and even defining potential areas for re-introductions.

Selecting sample plots: a pragmatic random approach

It was recommended that sample plots for both vegetation and fauna be selected randomly, by overlaying the 1:20000 base-maps with a regular grid of 1 km x 1 km cells, each further divided into four 25 ha square sub-cells. The horizontal and vertical gridlines were given alphanumeric labels allowing each cell to be coded, and the sub-cells given an alphabetical reference letter. The number of 25 ha sub-cells within the entire survey area of the three parks could be summed, and following random number/letter generation, a set of cell codes selected for sampling in Year 1 (given constraints on time and manpower).

The initial selection was screened, and those cells that would require substantial time to reach (i.e. > 1 day's return walk from camps), or that posed a marked safety risk (e.g. mountain cliffs) were removed from the initial list of survey-cells. New codes were generated to replace any cells thus eliminated. Habitats that were disproportionately represented in the rejected cells would be the subject of later targeted survey. The centre points of selected survey-cells were marked with latitudinal and longitudinal co-ordinates, and survey locations linked to form logistically feasible walking routes requiring 1 - 2 days of survey time each, using the knowledge of park staff. It was realised that apparently accessible cells might on arrival prove dangerous to record, and thus a series of "reserve" cells was also chosen. Finally, the original selection could be checked against the provisional habitat map to assess whether there appeared to be any obvious sampling bias. This process could be repeated after each year's survey to ensure that the coverage of the plant communities was adequate. In study's subsequent years, a subset of the cells sampled in Year 1 would be selected for longer-term monitoring, on the basis that they supported representative habitats, high diversity, protected and indicator species or were believed sensitive to change.

Main Survey Plot Location and Establishment

The survey-cell was intended to serve as a broad sampling unit, within which the ecological surveys would be conducted. A preliminary campaign to establish these plots would save effort from the full survey team, and enable unsuitable survey-cells to be identified as early as possible. Square plots would be established within the survey-cell such that the bottom and top sides run east to west. Using latitudinal and longitudinal co-ordinates derived from the base-maps, the team would use global positioning systems (GPS) to find the centre-point of the selected survey-cell, and from that point, lay out the sides of the survey square. Using a hip-chain and compass, the team would mark off 300 m from the centre point of the plot to the north, south, west and east, thus forming a cross pattern of four positions that would represent the mid-points of the sides of the sample square. From each mid-point on the square sides the surveyors would then move out 300 m along the appropriate compass lines to establish the northwest, northeast, southeast and southwest corners of the main plot, and these locations recorded by GPS, allowing plot locations to be immediately transferred to the GIS.

Markers would be placed at 100 m intervals along each edge of the main plot, allowing grid lines (east-west and north-south) to be established within the plot. Similarly, following a compass bearing and using a hip-chain to mark distances, markers would be paced at 100 m along each grid line to create 100 m x 100 m (1 ha) grid cells. The intersection points of the grid lines could form standard sampling locations for some zoological surveys.

Selecting survey components

All elements of biodiversity have some value in the designation of a protected area. However, the scarcity of resources (time, money and surveyors) means that some priorities have to be made. The best criterion for choosing what to survey was that the data collected

could be applied directly to decision-making and management of biodiversity resources. Hence the Komex-CEH team advocated an approach based on a general inventory of ecosystems and habitats together with a) a sample-based survey of associated species, and b) more detailed surveys of habitats, communities and species considered to be "important/valued". Such "valued ecosystem components" (Treweek, 1999) must be chosen using criteria for evaluating importance that are consistent and transparent, and that can be reviewed as acquisition of survey data provides evidence of "importance". Certain general criteria for evaluating importance appeared applicable here: a) biota designated as of international or national conservation importance; b) especially characteristic of the park or the Carpathians; c) highly restricted distribution; d) declining status; e) ecological importance (keystones etc); f) monitoring/ scientific value e.g. indicators of disturbance, already the subject of research, presence of earlier comparative data or amenable to long-term monitoring; and g) economic or social importance.

Survey Schedule

Limited resources required that the surveys be pragmatically scheduled, with emphasis in Year 1 on revising Forest Cover Maps, making an inventory of selected wildlife species as a baseline for monitoring; and identification of areas, habitats, plant communities and species requiring more detailed study. Year 1 provides an improved habitat map and classification that could later be used to identify biodiversity 'hot-spots' or relate concentrations of particular species to habitat suitability and availability. Subsequent years should include monitoring of key groups surveyed in Year 1, and also focus on valued ecosystem components and studies of management-related issues. For example, ecotones might be identified where altered extent of habitats and position of the ecotone would be a measure of change within the park. Similarly a rigorous study comparing vegetation of meadows grazed only by wild herbivores with those that are and/or have been sheep-grazed could provide valuable data on to what extent and where pastoralism can occur within the protected area. It was also vital that the efforts of other institutions studying the parks be integrated with the baseline survey. Thus BCMP-related work might contribute useful contextual information to other research programmes e.g. the University of Bucharest (mountain lakes; 1993), the Romanian Ornithological Society (diurnal raptors and waterfowl) and the NFA itself (insect pests). The results of these associated studies could be marshalled within the BCMP survey structure.

SUGGESTED SURVEY METHODS: EXAMPLES

Some 16 complementary surveys were proposed within the original report to the BCMP project (Patriquin et al., 2000), including in Year 1 coverage of birds, vegetation, ungulate browse and pellet counts, small mammals, winter mammal tracking, invertebrates (*Coleoptera*, *Opiliones* and *Formifera*), reptiles and amphibians, watercourses, and snow accumulation and melting. This paper outlines methods covering only a selection of major biota, with particular attention on birds and vegetation, since these best illustrate the survey framework. The methods suggested use standard approaches (Mueller-Dombois and Ellenberg, 1974; Sutherland, 1996), as well as those derived from more focussed research (Davis and Whitehead, 1980; Gurnell and Flowerdew, 1990; Pollard and Yates, 1993). However, the particular needs of the BCMP work, coupled to the constraints of landscape and resources, meant that some approaches had to be adapted prior to application.

Optional Techniques for Bird Survey and Inventory

A plot-based point count method would be used where birds could be surveyed from observation points located systematically in a grid. The approach is meant to ensure sampling of the full range of habitats in a manner repeatable in all three parks. Point counts are made from a fixed location for a fixed time period and can be undertaken at any time of year. Two approaches were suggested. The first surveys 500 m x 500 m (25 ha) plot using a line transect

along which twenty observation points would be recorded. The transect winds through most of the plot area, with the aim of capturing the full range of habitats (though experience may be required to ensure such coverage). Any birds observed within 50 m of the observation point in forest or 150 m in grassland would be identified to species.

The second approach uses a fixed radius point count method along a pre-established grid in which birds can be inventoried. This grid-based approach might be preferred if most available surveyors lack the experience required to set up the line transects. This approach requires the establishment of 600 m x 600 m plots (Fig. 1), with markers placed each 100 m along all sides of the plot, dividing it into a grid of 100 m x 100 m (1 ha) cell size (Fig. 1).

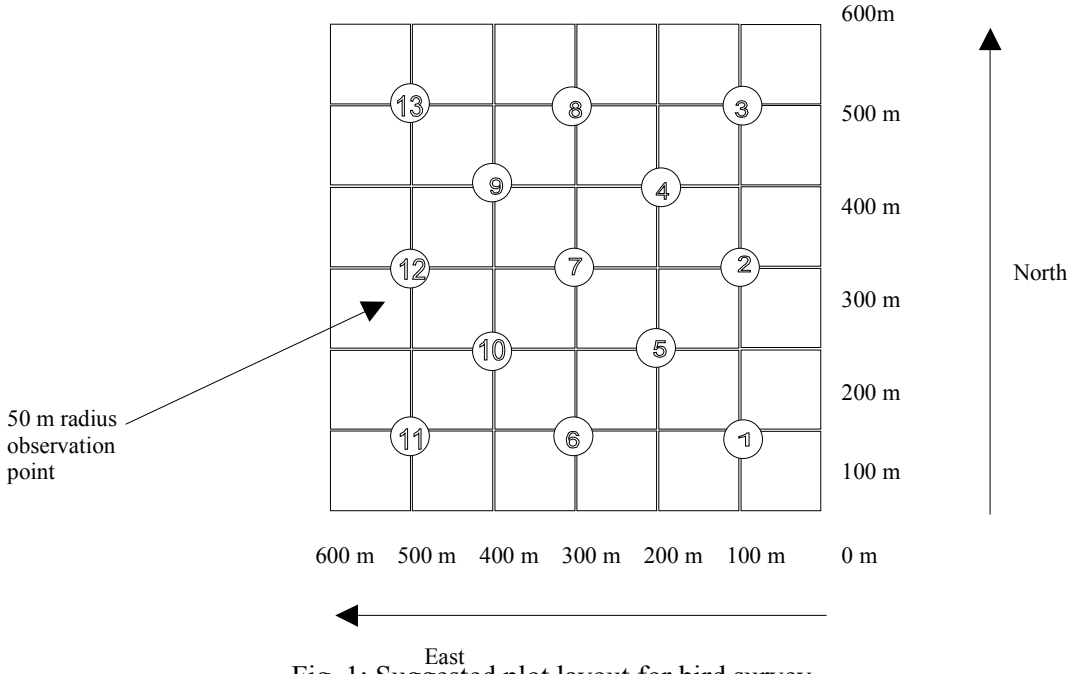

Fig. 1: Suggested plot layout for bird survey.

Following a similar hip-chain and compass approach to that outlined for location of the main plots, the surveyor would begin at the 100mE grid line (i.e. 100 m east of the south-east corner of the plot) and mark out observation points at 200 m intervals moving north (Fig. 1). Upon reaching the end of the grid, the next set of observation points will be at 200 m intervals moving south along the 200mE grid line. The pattern would then be repeated on the 300mE, 400mE and 500mE grid lines, resulting in thirteen numbered points distributed over the grid from which records would be gathered. Independence of the sample points is achieved by having each one ≥ 141 m (diagonal) from the closest other point, helping to avoid double-counting of species, and compensating for observer error in distance estimation.

Guidelines proposed that teams of two surveyors would sample each plot - one person conducting bird survey whilst the other recorded ungulate browse and pellet counts. Surveys should commence around sunrise and cease at 10 a.m., and would not take place in heavy rain, thick fog or when wind speeds are > 13 km/hr. Having waited at each observation point for a few minutes to allow the birds time to resume normal activity, the surveyor would count for a fixed amount of time i.e. not too short so as to risk missing birds, and not too long to avoid double-counting. Five minutes may prove a good compromise (Fuller and Langslow, 1984). At each numbered observation point, data on birds observed within 50 m (forest) or 150 m

(grassland) should be supplemented with records of starting time, GPS location, weather conditions (including wind speed) and habitat characteristics i.e. the EUNIS habitat type (Davies and Moss, 1999), percentage cover of trees and shrubs, and vegetation structure (e.g. open forest, shrubby grassland). Incidental notes on other birds observed within the plot should be made in order to develop a complete species occurrence list for the park.

Analysis of bird data

Such point counts could be used to provide estimates of the relative abundance of each species in the park, or, when coupled with distance estimation to yield measures of absolute density (Buckland, 1987). The number of birds of each species observed could be summed for each point and converted to a density estimate (birds/ha). Thence, replicate points of the same habitat types within the 25 ha plot would be averaged to allow estimation of, for example, breeding males present for each habitat. Analysis would be conducted using replicates from each habitat type, and the number of species observed totalled, with densities of breeding individuals estimated for each. Subsequently species richness data can be used to test for changes in richness at each plot over successive years, and the Shannon-Weiner index (1949) calculated to quantify the evenness of species diversity within each habitat. Large changes in species richness or diversity might indicate a change in the community structure. Comparison of the densities of species within each habitat type over successive years would give an indication of population stability. For the purposes of the park management, densities could be compared for identified "indicator species".

Vegetation survey

Setting out the bird plots can be readily integrated with creation of the main survey plots, but it is the vegetation recording that provides the fundamental characterisation of habitat types. Within each habitat type recognised at the preliminary visit, a 30 m vegetation transect would be established, forming the centre-line along the middle and length of a rectangular macroplot (20 m x 30 m) (Fig. 2) that would be used to survey tree density, cover, and species composition, as well as moss and lichen cover.

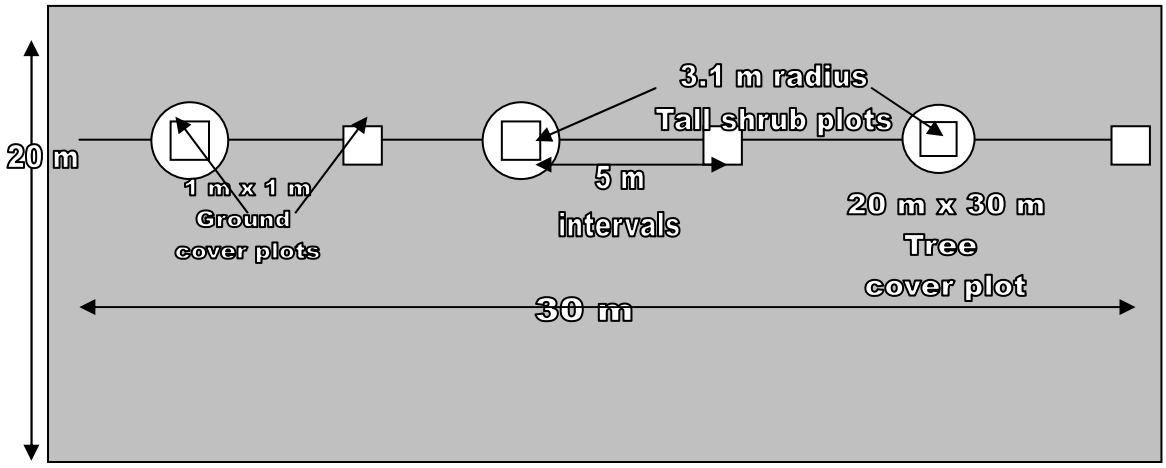

Fig. 2: Design of vegetation transects in macroplot 20 m x 30 m.

As shown in the figure, five $1m^2$ quadrats would be placed at 5 m intervals along the transect, and within each quadrat, all plant species < 1 m tall (short shrubs, grasses, forbs, bryophytes and lichens) would be identified and their cover estimated. Species in the 1 - 3 m (tall shrub) stratum would be recorded in three plots of 3.1 m radius located at the 5 m, 15 m, and 25 m points on the transect. The cover of tree species would be estimated for the entire

macroplot (20 m x 30 m), as well as the numbers of individual of each species in the tree layer, allowing tree density to be estimated. To facilitate the use of a fuller range of statistical methods, percentage cover (rather than cover classes as Domin) would be used, with cover values < 15% estimated to the nearest 1% and those > 15% estimated to the nearest 5%. In habitats such as grassland that lack one or more strata (tree and/or tall shrub), the relevant plots would not be recorded i.e. the minimum requirement would be five 1 m^2 quadrats on a transect.

The resultant sizes of recording unit would therefore be 600 m^2 for plants > 3 m tall, 90 m^2 for plants 1 - 3 m tall and 5 m^2 for plants < 1m tall. The design corresponds reasonably well with the recommendations of Mueller-Dombois and Ellenberg (1974) who advocate 200 - 500 m^2 plot to adequately estimate tree cover, a 50 - 200 m^2 plot for understorey vegetation, a 5 - 25 m^2 plot for shrub and herb vegetation and a 1 - 4 m^2 plot for moss/lichen vegetation.

Analysis of vegetation data

Analysis would begin by averaging the replicated samples within each individual transect, and the averaged data treated as a single relevé summary that would be used in all subsequent analysis. The large volume of data produced by the three park surveys would require initial exploration in order to establish broad patterns, for which an ordination (e.g. CANOCO - ter Braak, 1996) was deemed most appropriate. The data matrices constructed might consist of ground flora, scrub, canopy and zoological data. Ordination allows examination of links e.g. between ground flora and canopy, or scrub and birds. Environmental data gathered (e.g. altitude) might also be used as explanatory variables, to assess how much of the variation may be accounted by such measures. Such exploratory work would suggest patterns or relationships for more detailed investigation, which might then be tested using ANOVA or regression techniques. If density estimates can be linked to habitat, estimates of the whole park can be determined through standard stratified sampling techniques.

The use of indicator values for soil reaction (R) and fertility (N) was suggested as a means of providing an assessment of vegetation change during later monitoring (Ellenberg, 1988). If the mean indicator values (mR and mN) of the species in a plot showed a consistent change over time, this might, for example, provide a warning of acidification or fertilisation.

Survey of selected invertebrate groups

It was acknowledged that invertebrates are generally under-recorded in surveys and that expertise was likely to be in shorter supply than for birds and vegetation. However, the value of many invertebrate groups as indicators of change meant that some limited preliminary survey was deemed essential, with the intention that other groups be covered in the future as time and resources allowed. In the first instance the survey would focus on *Coleoptera* (beetles), *Formifera* (ants) and *Opiliones* (harvestmen), since these groups are relatively well known and are all responsive to management changes or disturbance in terms of population response, making them potentially useful indicator-groups even if limited taxonomic expertise did not allow identification to species-level. In later years, a Butterfly Monitoring Scheme should be introduced (Pollard and Yates, 1993) and possible transect routes for such Schemes should also be identified in Year 1.

Suggested preliminary survey methods for invertebrates

Recording the contents of pitfall traps is a time-consuming activity, and it was thought that no more than 400 traps could be adequately recorded for each park. Since there might be up to 40 EUNIS habitat types, as few as ten pitfall traps might be recorded in each type. To provide a reasonably accurate assessment of a given example of a habitat, a 20 m-long invertebrate sampling transect (ten pitfall traps) should be set up in the same location as a

vegetation transect, staying within the same habitat, but oriented at 90° to the vegetation transect. The pitfall traps would be installed at 2m intervals and marked for relocation. With the resources available, only one invertebrate transect might be possible within each of the 40 EUNIS habitats, without any within-habitat replication. To avoid this weakness, it was recommended that, in the reconnaissance survey, a more limited coverage of EUNIS types be attempted but with four replicates (transects) in the ten most extensive EUNIS habitats.

The locations selected should be relatively accessible, to facilitate periodic checking. The frequency of checks would depend on the preservative used in the traps. Advantages and disadvantages were assessed for ethylene glycol, alcohol, formaldehyde and brine (salted water). Traps baited with raw meat, cheese or fermenting fruit might be used for *Coleoptera*, but in that case no preservative should be used and the traps would need to be checked daily. Composition of catches will vary depending on the design and size of traps, the choice of preservative and whether or not traps are covered. Hence, all these factors would need to be standardised if catches are to be compared between sites or at the same site over time.

Analysis of invertebrate data

Samples should be sorted at least to family level and where possible to species, with numbers of individuals of each type counted. Any flying insects caught in the pitfall traps would also be identified and recorded. However, no analysis of the numbers of flying insects should be made, since their capture is very strongly influenced by the colour and visibility of traps and it is known that it is extremely difficult to standardise these features. Assuming that the reconnaissance would indeed take a replicated approach that focussed on a limited number of key habitats, then some basic statistical testing (ANOVA etc) will be possible within each park. For the whole dataset within each park, some classification of invertebrate communities can be achieved using multivariate approaches comparable to those referred to for the vegetation.

LIMITATIONS of the APPROACH

There remained potential limitations to the methodologies that would have to be borne in mind, with possible refinement required. These were discussed with the BCMP staff to prevent potential misinterpretation of the monitoring data. Retrospective habitat classification would be needed to ensure that all variation in habitat type and distribution had been captured. Although habitat classification should be conducted in terms of EUNIS types, these would be subsequently cross-referenced to forestry types, phytosociological associations etc. Problems of using birdsong as a census-tool were discussed, and the possible underestimation of the non-breeding population (Sutherland, 1996). Vegetation survey problems included a) the inability to stratify sampling from the outset to ensure full coverage of habitats; and b) the relative inaccessibility of some vegetation types. A more subjective procedure that took account of safety, and potential differences at the base and top of cliffs, as well as adjacent scree, was advocated.

CONCLUSIONS

Biodiversity survey is an essential requirement to underpin effective management of protected areas - the manager has to know what biota the area holds, where they occur and what their environmental needs are. The long history of biological study in the Carpathians has gone a significant way toward providing information on the needs of species and communities. However, with such extensive wild habitats, good coverage of the distribution of biota is much harder to achieve. This project set out to provide a pragmatic approach to gathering sufficient information that would: characterise the habitats across three parks, be robust to survey teams with relatively limited taxonomic and field skills, be consistent between parks, allowing managers to compare the efficacy of their management, and provide a consistent baseline against which change due to management or external factors could be gauged and quantified.

The approaches advocated in the Komex-CEH report to the BCMP (Patriquin et al., 2000) benefited hugely from earlier detailed studies (e.g. Popovici, 1993), and also through application and adaptation of methods that have proved successful in similar habitats elsewhere e.g. within Canadian forests. The project set as a central goal the incorporation of mapped and surveyed information into a GIS that could function as a management-support tool for the future. Within the three parks, the BCMP attempted to include staff with GIS and other information technology skills into their management teams to provide this support.

The methods recommended used a sampling system that was pragmatic, with scope for change, but still providing the basis for a rigorous quantitative assessment of the biodiversity and ecology through standard statistical approaches and tests. The approach provided scope for new elements of survey to be incorporated at a later stage, and suggested techniques (e.g. identification of ecotone transects and use of Ellenberg indicator values) that would be sensitive to detecting any change that might influence management practices.

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RETEZAT NATIONAL PARK (ROMANIA) BIODIVERSITY MONITORING PLAN

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KEYWORDS: Romanian Carpathians, Retezat Mountains, Retezat National Park, Biosphere Reserve, biodiversity monitoring, raptors, *Rupicapra rupicapra*, *Marmota marmota*, *Pinus mugo, Rhododendron myrtifolia, Pinus cembra,* butterflies, amphibians, *Lutra lutra*, carnivores.

ABSTRACT

This monitoring plan has been developed in close correspondence with the management plan for Retezat National Park.

Nine protocols from the Retezat National Park Biodiversity Monitoring Plan are presented in the article. Every protocol contain a monitoring question/s addressed and data about indicators, justification, attributes, number of plots/sites for monitoring, distribution and selection of plots/sites for monitoring, size and location of plots/sites for monitoring.

Data collection section of the protocols contain detailed information on what data is collected, and how, data collection formats, quality assurance and standardisation mechanisms, frequency and timing of repeat monitoring, data management and analysis protocols, data storage and management information, data analysis procedures and details of statistical methods to be used. Report format and process for communicating results to management, resource allocation protocols, resources/equipment required, and maintenance or calibration requirements for equipment are also presented in the protocols.

RÉSUMÉ: Plan de monitorisation de la biodiversité du Parc National Retezat (I).

Le plan de monitorisation de la biodiversité du Parc National Retezat a été conçu en étroite concordance avec le plan de management du parc.

L'article présente protocoles de monitorisation décrivant les questions auquelles la monitorisation va apporter une réponse, les indicateurs, la justification, le nombre, la distribution et la grandeur des places, points ou transectes qui seront utilisés. L'article présente également des informations détaillées concernant la nature des données recueillies sur le terrain, leur format et mode de standardisation, la fréquence de la mise en place du protocole ainsi que des informations concernant le stockage et traitement des données recueillies et la présentation des résultats. Dernièrement, il s'agit des informations concernant les ressources temps et matériel alloués ainsi que les responsabilités du maintien et calibrage de l'équipment utilisé."

REZUMAT: Planul de monitorizare a biodiversității Parcului Național Retezat (I).

Planul de monitorizare a biodiversității Parcului Național Retezat a fost conceput în strânsă concordanță cu planul de management al parcului.

În articol sunt prezentate nouă protocoale de monitorizare care cuprind întrebarea la care monitorizarea va da un răspuns, indicatorii, justificarea, numărul, distribuția şi mărimea pieţelor, punctelor sau transectelor ce vor fi utilizate. Se mai prezintă informații detaliate asupra categoriilor de informații care se culeg din teren, formatul şi modul de standardizare al datelor, frecvența cu care trebuie implementat protocolul, precum şi informații privind modul de stocare şi prelucrare a datelor culese şi modul de raportare al rezultatelor. Nu sunt omise informații privind resursele timp şi materiale alocate precum şi informații privind responsabilități în menținerea şi calibrarea echipamentelor folosite.

INTRODUCTION

Background

This monitoring plan has been developed in correspondence with the management plan for Retezat National Park (RNP). It is developed to provide a basis for long-term assessment of the status of the biodiversity in RNP and the effectiveness of management activity in protecting the park's biodiversity and landscapes. A series of monitoring questions were derived from the management plan, and from broader discussions, reflecting the need to determine whether the biodiversity of RNP is being effectively maintained.

The monitoring questions included assessments of both the background condition of biodiversity in the park, and of the impacts of management actions prescribed in the management plan, and of other forms of resource use. As well as assessing the status of biodiversity resources over time, the monitoring plan also assesses pressures and threats (including levels of resource use). Parallel monitoring processes within the management plan and associated workplans will consider the level of response by the involved staff and others to identified threats (i.e. implementation). However, the feedback on the status of biodiversity from the monitoring questions within the present plan will determine whether management has been effective in maintaining key populations and habitats.

Monitoring questions were assessed based on relative priority, and a set of potential indicators were developed for each monitoring question. Protocols were developed for each key indicator, including detailed assessment of likely time, personnel and resource needs to implement these over the long-term. The monitoring plan has been developed within the current, and likely future, context of the park system in Romania. Thus the protocols have been developed to rely upon minimal equipment and resource inputs, and to take account of the constraints on staff time, and limited future funding to pay for outside specialist assistance after the end of the Biodiversity Conservation Management Project (BCMP) funding. The protocols have been developed to be pragmatic and adaptable and yet rigorous and repeatable. They should not rely on high levels of technical specialism (that may not be available within future staffing scenarios). In order to maximise information generation certain protocols have been designed to involve rangers and volunteers (with only basic identification skills) and to collect incidental information from local forest users. The necessary approaches for data analysis have been considered within the protocols, and this has fed back into the design of sampling approaches within the protocols.

RESULTS AND DISCUSSIONS

Explanation of the Monitoring Plan

The management plan was structured based on the answers of the priority monitoring questions: Is the general biodiversity of the park being maintained? Are key (important and endangered species) being maintained? Are populations of key and introduced species under control? Are populations and distribution of amphibians being maintained? Is the otter population modifying? Is the alpine marmot population modifying? Are the populations of large carnivores and pray species maintained or increasing? Are bat populations being maintained? Are Edelweiss and other flower populations reducing as a result of over-collection? Are the areas and regimes of hay and high patch meadows being maintained? Have impacts of grazing within the park been reduced? Is the impact on the vegetation from grazing increasing? Is the number of sheep recorded in field similar with the number of sheep from mayoral lists? Is the quality of rivers being maintained or improved? Are the surfaces of the forest being maintained? Are the areas of the dwarf pine (*Pinus mugo*) being maintained? Are cuttings or other natural factors affecting dwarf pine shrubs in the park? Are levels of NTFP (non timber forest products - fruits, mushrooms and medicinal plants)/use or poaching increasing? Is the availability of NTFPs being maintained? Are there indications of other changes in biodiversity? Are forest quality and processes being maintained? Is dead wood being left in place for wildlife? Are levels of illegal activities and NTFP use changing in the park? Is the forest cover in the park being maintained? Is the landscape of the park being maintained within acceptable limits? Are the affects of tourism on biodiversity or landscape decreasing? Is the quantity of litter collected from different area of the park being reduced? Is there an increasing of scientific interest regarding the park, expressed by increased number of studies and projects on park territory? Has the biologist been successful in encouraging applied ecological research within the park? These have been broken down as to what will be monitored (target species or indicator), what aspect of the species or area will be monitored, the limits of acceptable change, and how it will be monitored. The monitoring protocols associated with each major monitoring question are identified by a number (some may be used to provide information to answer more than one question). Monitoring questions have been prioritised by their relationship to the management plan and to the fundamental reasons for which the park has been set up. In addition, some estimate of the time and personnel requirements to complete each protocol has been listed. It is assumed that access to transport and appropriate equipment (purchased under the BCMP) will be available for future years. It is important that as far as possible monitoring is conducted on the same general dates each year.

The body of the plan is the list of monitoring protocols written to expand the process of monitoring for each identified monitoring question, target species or area and indicator. It is acknowledged that time and personnel constraints may restrict the completion of all protocols listed, and thus some protocols may be left aside until opportunities to initiate them arise at a later stage (e.g. through volunteer assistance or increasing park income). Prioritisation of protocols should be based upon the relative importance of information for management (Tab. 1) and necessary time commitment. All priority I protocols must be completed, as should most of priority II protocols.

Table 1: Outline of monitoring plan for Retezat National Park, organised by key monitoring questions from the management plan (PN - protocol number, P - priority, PB - park biologist, ROS - Romanian Ornithological Society, RLS - Romanian Lepidopterological Society, Rs - rangers).

Target species or indicator	Attribute measured	Targets or limits to change	How measured	PN	P	Notes
Raptor population	Focus on breeding raptors. Attributes measured to include relative abundance and number of nests of eight species.	Increase the population or maintained at 2003 levels.	Collect data over seven separate days/ one week/three times/year. Seven different routes will be defined each approximate one day (approximate eight km) walk.	1	I	PB and ROS volunteer. 7 - 10 days between 10th April and 10th of May and three days analysis; once every year.
Chamois (*Rupicapra rupicapra*) population	Attributes measured to include relative abundance of adults and proportion of juveniles present in the population.	Increase the population or maintained at 2003 levels.	Observation and count of chamois on the transects.	2	I	PB and rangers max. - 14 days in June - July; one day analysis; annually.
Carpercaillie *Tetrao urogallus*	Relative abundance and relative density.	Increase the population or maintained at 2003 levels.	Surveys of the lekking sites.	23	I	PB and rangers - ten days in April.
Marmots and chamois populations	Distribution and relative abundance.	Increase the population or maintained at 2003 levels for chamois and decrease the population or maintained 2003 levels for marmots.	Observation and count of marmots and chamois on the tourist paths.	3	I	PB - five days for analysis every year in November.
Pinus mugo, Rhododendron myrtifolia, Pinus cembra	Relative abundance/ density.	Maintained at an optimal level.	Survey in plots.	4	III	PB - five days in the field and two days analysis; every three years.

Target species or indicator	Attribute measured	Targets or limits to change	How measured	PN	P	Notes
Pinus mugo, Rhododendron myrtifolia, Pinus cembra	Change in Dwarf pine and rhododendron cover area and number of *Pinus cembra* individuals.	Maintained at an optimal level.	Fix point photography.	4B	I	PB five days on the field in June and two days analysis in the autumn every three years
Rare or endemic butterflies	Relative abundance, presence/ absence.	Increase the population or maintained at 2003 levels.	Transect survey with RLS volunteers.	5	II	RLS volunteer seven days, in May PB two days analysis; annually.
Amphibians species	Species composition, relative abundance.	Increase the population or maintained at 2002 levels.	Survey of breeding ponds.	6	I	PB - seven days March - April for valleys and seven days in June for lakes; three days data analysis every year.
Lutra lutra	Presence/ absence.	Increase the population or maintained at 2003 levels.	River side transects.	7	I	PB and rangers five days in June and five days in winter. PB four days for registration data and analysis.
Marmota marmota	Estimated abundance of marmot's burrows, estimated abundance of marmots, burrows density.	Maintained at 2002 levels.	Monitoring marmot colonies.	8	I	PB - five days in summer and three days analysis annually.
Ursus arctos, Lynx lynx, Canis lupus	Presence/ absence.	Increase the population or maintained at 2003 levels.	Transects survey.	9	I	PB and Rs seven - ten days in the winter.

Target species or indicator	Attribute measured	Targets or limits to change	How measured	PN	P	Notes
Bat species	Number of bat species, overall activity.	Increase the population or maintained at 2003 levels.	Transects survey.	10	II	At least twenty nights for the PB and the rangers every year. (five days in April - May, five days in June - July, five days in August and five in October.)
Bat species	Number of bat species, overall activity.	Increase the population or maintained at 2003 levels.	Caves winter survey.	10 B	II	PB and Rs, volunteers five - ten days in February and five -ten days in July.
Leontopodium alpinum, Nigritella nigra, Nigritella rubra, Trollius europaeus, Orchidaceae species.	Relative abundance. Number of flowers/flower stems present.	Increase the population or maintained at 2003 levels.	Monitoring plots in meadows.	11	II	PB and the rangers seven days in July PB - five days (data entry/ analysis) in March every two years.
Vegetation composition and identified indicator species (*Nardus stricta, Rumex alpinus, Urtica dioica* etc.)	Species richness % cover. Relative abundance.	Decrease in vegetation cover.	Monitoring plots in meadows.	12	I	PB - ten days (field work) PB - five days (data entry/ analysis) annually.
Sheep	Number of sheep.	Number of sheep not higher than the carrying capacity.	Any modification.	13	I	Rangers/PM - fifteen days (field and local mayories and councils) annually.

Target species or indicator	Attribute measured	Targets or limits to change	How measured	PN	P	Notes
Ephemeroptera Plecoptera, Tricoptera, Visible algal growth, PH.	Presence/ absence Relative abundance PH.	Maintained at 2003 or improve the level of water quality.	Transects. Point sampling along rivers.	14	II	PB - ten days, volunteers/ rangers; PB seven days for the identification of specimens and three days for analysis every year.
Forest cover, area of forest cut	Area of forest retained and lost. Level of illegal activity.	<10% forest loss. Any sign of illegal activities.	Forest management plans and records. Incidental records.	15	III	Rangers six days every year for collecting the data and PB three days for analysis every five years.
Dwarf pine	The size of areas where dwarf pine was cut (destroyed).	Maintained at 2003 level or increase the cover area.	Incidental survey, built into the workload of all personal and rangers working within the park.	16	III	Rs - 10 days every year for collecting the data and three day for analysis every five years.
NTFP (fruits, mushrooms, and medicinal plants)	Level of off-take Relative abundance.	Maintained at 2003 level.	Observations Interviews Monitoring plots in forests.	17	III	Volunteers - ten - twenty days and PB three days once at every three years.
Tree growth/ density; regeneration; dead wood; invertebrate fauna	Changes in forest structure; changes in cover/species richness of ground cover; seedling density; leaf litter depth; ground invertebrate richness and abundance.	Maintained at 2003 level.	Monitoring plots in forest areas.	18	III	PB, Rs and some volunteers five - ten days per autumn three days kept free for analysis once every three years in winter.

Target species or indicator	Attribute measured	Targets or limits to change	How measured	PN	P	Notes
Official and incidental records of use and infractions	Records of observed impacts and activities.	Maintained at 2003 level.	Incidental survey, built into the workload of all foresters working within the park. Official records.	19	I	All staff for collecting the data. PB three days every year for analysis.
Visual landscape values and *Pinus mugo* development.	Changes in the shape/ distribution of forests and meadows; evidence of intrusive or inappropriate constructions.	Maintained at 2003 level.	A series of camera shots side by side will be taken to form a panorama.	20	I	PB or Rs three days in summer and three days in winter, once every three years. One day will be required for analysis
Litter	Number of standard litterbags collected, volume of collected litter.	Decrease of litter quantity.	Litter collected at campsites and picnic areas.	21	III	Park rangers two days per year to organise. Volunteers will be responsible for reporting back on data collection, head ranger analyse the data, with help from the park biologist (one day work).
Scientific outputs	Number of scientific articles, books and projects regarding park (e.g. Biodiversity, geography, geology, tourism, forestry).	Increasing number of scientific articles, books and projects regarding the park.	A database will be developed, with codes for the type of activity (study excursion, field research, scientific article, scientific book, etc), the leader and the number of persons involved, the article/book author's name, the utility of activity for park (high/medium/low) A bibliography of published material will be developed.	22	I	PB/ ten days over the whole year.

Retezat National Park - Monitoring protocol 1

Raptors survey

Priority 1.

Monitoring question/s addressed:

Is the general biodiversity of the park being maintained?

Are key (important and endangered species) being maintained?

*Indicato*r: Raptor population

Justification: A number of raptor species recorded from the park are classified as threatened, and the golden eagle is the park emblem. Raptors continue to be targeted by hunter, shepherds and egg collectors throughout Romania. As predators, raptors provide an indication of changes in prey abundance in the park resulting from ecosystem changes.

Attributes: Focus on breeding raptors (*Pernis apivorus, Accipiter gentilis, Accipiter nisus, Buteo buteo, Aqulia chrysaetos, Aquila pomarina, Falco tinnunculus, Falco peregrinus*). Attributes measured to include relative abundance and number of nests of 8 species.

Sampling protocols

Number of plots/sites for monitoring

Collect data over seven separate days/ one week. Seven different routes will be defined each approximate one day (approximate eight km) walk.

Distribution and selection of plots/sites for monitoring

Independent (unrelated) routes (transects) will be distributed across the key zones and habitats of the park. Randomisation approaches will be used, to determine start points of the walk, but existing paths will then be followed.

Size of plots/sites for monitoring

Routes will be circular (or else raptors only counted in one direction). Routes will be around eight km (with abundance estimated per km walked). Birds will be observed within 250 m of observation points.

Location/marking of specific plots

Routes will be marked on a map. The same set of routes will be walked each year. A description of the routes, and of the vantage point sites for observations, will be written.

Data collection protocols

Detailed information on what data is collected, and how

Observers will walk the route indicated at a slow walking pace. Birds encountered on the walk will not be considered part of the survey. Point counts will be taken at fixed observation points marked on the map at approx. one km (approx. 40 minutes) intervals. Observers can reposition themselves to the nearest vantage point to make observations, but must stay at that point for duration of point count. Observers will note visibility at each site (360, 180 or 90º). All individual raptors observed while scanning with binoculars will be recorded. Observer judgement will be used to determine number of birds seen at any observation point. Point counts will be taken over a period of ten minutes from the time when the observation point is reached. Birds sighted beyond approx. 250 m away (where identification becomes less accurate) will not be included in the survey. At each site information will be entered into the appropriate data collection sheet. Anecdotal records of non-target raptors (vagrant or non-breeding species) will also be recorded, as will incidental records on other key species (such as chamois).

*Data collection format*s

See below.

Quality assurance and standardisation mechanisms

All personnel involved must be able to demonstrate basic raptor identification skills through an initial trial. At least two personnel will be involved on each transect to ensure safety and confirm identifications. Where possible the same personnel will be involved in subsequent annual surveys. Map reading skills must be demonstrated in observers used (also fitness of observers must be considered). If new staff engaged, the observation points and protocols will be demonstrated. Unusual or unpredicted observations will be challenged as soon as possible. Observers will be tested with regard to their estimation of distance (and ability to determine between birds < 250 m away, and those beyond that distance).

Frequency and timing of repeat monitoring

All surveys will be conducted between 10th April and 10th May. Transects will not be walked on consecutive days. Surveys to be conducted annually (once every year).

Data management and analysis protocols

Data storage and management information

A raptor sightings database will be designed in Excel to include 'total individuals per km^2' for each target species, on each transect walked in each year of survey (based on an observational area (km^2) defined from each point count made). The park biologist will be in charge of data management, but areas of high raptor density will be integrated into the GIS system. Data will remain property of the National Park Retezat, but observers and the ROS (Romanian Ornithological Sciety) will have open access to data they have helped to collect. In addition, data will be shared with national data bases/ROS. Back up copies of the data will be kept at an alternative location. Original datasheets will be retained.

Data analysis procedures and details of statistical methods to be used

The 'individuals per unit search effort or km^2' variables for each species will be compared over the years of monitoring (with each route walked per year considered as a separate variable, therefore an ideal number of seven routes has been considered - but could be reduced to four if necessary). In addition' total raptors per unit search effort' will be considered. Conversion of numbers to densities can be done using the total area surveyed (km^2) to enable density estimates to be made for the park. The data will be entered into a statistical programme (such as Minitab) for analysis of regression over at least four years of data collection. In addition, the average of individuals per km per year (over all transects) will be used to plot data in a readily accessible manner. A significant relationship over time will be accepted at levels of $p < 0.05$.

Report format and process for communicating results to management

The raptor survey will be briefly summarised in the annual report on monitoring progress to the park manager. Where no significant change has been noted, this will be stated. Any problems regarding the survey accuracy will also be noted. Where significant change has been recorded, the data will be presented in bullet points or graphically. Where statistical significance has been achieved in the results, the statistics will be quoted and interpreted. The implications of these results will be highlighted in bullet points, as will recommendations for management action and/or further research. Declines in raptor populations would also be reported to forestry departments and hunting associations. ROS would also be informed.

Resource allocation protocols

The survey will be lead by the park biologist and a ROS volunteer. This will require seven field days for the park biologist every year. He will process the data; this will take three days per year. The park biologist will be responsible for planning and implementing this survey. Some basic statistical training will be necessary to enable effective analysis.

Resources/equipment required

The ROS volunteer will not be paid. The park needs to provide binoculars for the park biologist (and possibly the ROS volunteer) - however observers will generally use their own binoculars. Field guides, maps, compasses, tents and sleeping bags will be needed.

Maintenance or calibration requirements for equipment

Equipment will be the responsibility of the park biologist. Availability of tents and other field gear must be negotiated in advance with other users (such as park rangers). Repairs needed to equipment will be reported to the Head Ranger.

Appendix

Data collection protocol

Observers will walk the route indicated at a slow walking pace. Birds encountered on the walk will not be considered part of the survey. Point counts approx. every half km of the route, where these can be marked on map (approx. 20 minutes intervals). Observers can reposition themselves to the nearest vantage point to make observations, but must stay at that point for duration of point count. All individual raptors observed while scanning with binoculars will be recorded. Observer judgement will be used to determine number of birds seen at any observation point. Point counts will be taken over a period of ten minutes from the time when the observation point is reached. Birds sighted beyond approx. half a km away (where identification becomes less accurate) will not be included in the survey. At each site information will be entered into the appropriate data collection sheet. Anecdotal records of non-target raptors (vagrant or non-breeding species) will also be recorded, as will incidental records on other key species (such as chamois).

On the map of your route please mark the site of all observation points (numbered one - sixteen) if these differ from the points marked for observation.

Name of recorder and members of the survey team:

Route number walked (one - seven):

Date: Approx. temp. (ºC):

Weather conditions: Wind speed (0 - 5):

Point	Time:
1, 2, 3	Habitat/cover (to confirm marked point)
View	Number of individuals seen: Juveniles Subadults Adults Males Females Total.
	Pernis apivorus
	Accipiter gentilis
360º	*Accipiter nisus*
	Buteo buteo
	Aqulia chrysaetos
180º	*Aquila pomarina*
	Falco tinnunculus
	Falco peregrinus
90º	Other
	Behaviour

Other information:

Birds seen beyond half km radius?

Other (non-target) raptors observed?

Any notable changes in habitat since previous years?

Any other key species encountered?

Retezat National Park - Monitoring protocol 2
Chamois (*Rupicapra rupicapra*) population monitoring

Priority 1.

Monitoring question/s addressed:

Is the general biodiversity of the park being maintained?

Are key (important and endangered species) being maintained?

Indicator: Chamois (*Rupicapra rupicapra*) population

Justification: Chamois are a flagship species for the park, and are hunted outside of the park. Chamoix have been identified as a priority species in the management plan, and may be affected by interference/disturbance by sheep and tourists.

Attributes: Attributes measured to include relative abundance of adults and proportion of juveniles present in the population.

Sampling protocols

Number of plots/sites for monitoring

Seven long transects to be walked at each of (four) areas known to hold reasonable chamois populations.

Distribution and selection of plots/sites for monitoring

Routes (transects) will be defined across the main chamois areas, with record kept of effort at each transect (time taken and distance walked). It may be necessary to use flexible transects (can go down side paths when exploring chamois habitat), however where obvious paths and main route can be used each year this would be preferable. Chamois routes may be compatible with raptor monitoring in some cases.

Size of plots/sites for monitoring

Routes will take around one day to walk. The start and finish points of recording will be defined, based on know areas of suitable chamois habitat.

Location/marking of specific plots

Routes will be marked on a map. The same set of routes will be walked each year. A description of the routes, and of key vantage point sites for observations, will be written.

Data collection protocols

Detailed information on what data is collected and how

Observers will walk the route indicated at a slow walking pace, scanning for chamois as they go. Side paths can be explored to increase chamois records, as long as this is taken into account in search effort (time or distance). The number of chamois seen will be recorded on a data sheet/notebook (giving location, number of adults, number of juveniles, distance from path, behaviour, time, weather).

Data collection formats

To be developed. See below.

Quality assurance and standardisation mechanisms

All personnel must be able to identify a chamois. At least two personnel will be involved on each transect to ensure safety and increase chance of observation. Where possible the same personnel will be involved in subsequent annual surveys. Map reading skills must be demonstrated in observers used (also fitness of observers must be considered). If new staff engaged, the observation points and protocols will be demonstrated. Unusual or unpredicted observations will be challenged as soon as possible. Distance estimation skills will be assessed.

Frequency and timing of repeat monitoring

Surveys will be conducted over the summer (June - July). Where possible surveys will be distributed within a ten - fourteen days. Surveys to be conducted annually.

Data management and analysis protocols

Data storage and management information

A chamois database will be designed in Excel to include 'total individuals per unit effort (time or distance)' for each transect walked in each year of survey. In addition, the proportion of juveniles in the population will be assessed each year. The park biologist will be in charge of data management, but areas of high chamois density will be integrated into the GIS system. Data will remain property of the Retezat National Park, but will be made available for national monitoring programmes and to scientific community at park biologists discretion. Back up copies of the data will be kept at an alternative location. Original datasheets will be retained.

Data analysis procedures and details of statistical methods to be used

The variables of 'individuals per unit of search effort ' will be compared over the years of monitoring (with each route walked per year considered as a separate variable, therefore sample site of transects walked needs to be considered). In addition' proportion of juveniles in population' will be considered across all samples per year, and plotted over time. The precision of the data could be improved by delineating the distance over which chamois are recorded (e.g. within 250 m). This would also enable density estimates to be made for the areas. The average of individuals per unit effort per year (over all transects) will be used to plot data in a readily accessible manner. In addition, data will be entered into a statistical programme (such as Minitab) for analysis of regression over at least four years of data collection (if indicated necessary by the data). A significant relationship over time will be accepted at levels of $p < 0.05$.

Report format and process for communicating results to management

The chamois survey will be briefly summarised within the annual report on monitoring progress to the park manager. Where no significant change has been noted, this will be simply stated. Any problems regarding the accuracy of the survey will also be noted. Where significant change has been recorded, the data will be presented in bullet points or graphically as appropriate. Where statistical significance has been achieved in the results, the statistics will be quoted and interpreted. The implications of these results will be highlighted in bullet points, as will recommendations for management action and/or further research. If declines are noted in the park, hunting associations and forestry departments would be informed.

Resource allocation protocols

Number of staff involved, roles and training requirements

The survey will be conducted by the park biologist and the head ranger. Maximum 14 days for park biologist and head ranger every year. The park biologist will process the data, this will take less than one day per year. The park biologist will be responsible for planning and implementing this survey. Some basic statistical training will be necessary to enable effective analysis.

Resources/equipment required

Binoculars, maps, compasses, tents and sleeping bags will be needed.

Maintenance or calibration requirements for equipment

Equipment will be the responsibility of the park biologist. Availability of tents and other field gear must be negotiated in advance with other users (such as park rangers). Repairs needed to equipment will be reported to the Head Ranger.

Chamois observation sheet

Observers will walk the route indicated at a slow walking pace, scanning for chamois as they go. Side paths can be explored to increase chamois records, as long as this is taken into account in search effort (time or distance). The number of chamois seen will be recorded on a data sheet/notebook (giving location, number of adults, number of juveniles, distance from path, behaviour, time and weather).

Area/transect number:

Name of observer:

Date:

Weather conditions and approx. temperature:

For each independent observation, complete a separate row of this table. If no chamois are seen, keep records of evidence of chamois use (droppings).

Location of observation	Details of animals seen	Other information
Code of site: (mark code on map) Habitat type: Average % cover stone: Average % cover grass: Time of observation:	Number of chamois: Adults Juveniles Distance from observer: Behaviour: Feeding Alert Running Other	Recent chamois droppings observed; No Yes If yes, indicate where pellets seen and approx. estimated density (number/m^2) in a randomly placed quadrat ………… /m^2
Code of site: (mark code on map) Habitat type: Average % cover stone: Average % cover grass: Time of observation:	Number of chamois: Adults Juveniles Distance from observer: Behaviour: Feeding Alert Running Other	Recent chamois droppings observed; No Yes If yes, indicate where pellets seen and approx. estimated density (number/m^2) in a randomly placed quadrat ………… /m^2
Code of site: (mark code on map) Habitat type: Average % cover stone: Average % cover grass: Time of observation:	Number of chamois: Adults Juveniles Distance from observer: Behaviour: Feeding Alert Running Other	Recent chamois droppings observed; No Yes If yes, indicate where pellets seen and approx. estimated density (number/m^2) in a randomly placed quadrat ………… /m^2

Retezat National Park - Monitoring protocol 3
Monitoring of chamois and marmots with the tourists.

Priority 1.

Monitoring question/s addressed:

Is the general biodiversity of the park being maintained?

Are populations of introduced species under control?

Are key (important and endangered species) being maintained?

Indicator: incidental recording by tourists and park rangers of chamois and marmots.

Justification: Information on chamois and marmots across the park is patchy, and not all areas will be captured in the monitoring protocols. Collection of incidental records is a quick and cheap way to improve information available to park management, on the distribution (and relative abundance) of these species.

Attributes: Distribution and relative abundance (where possible)

Sampling protocols

All park rangers will be made aware of the need to record observations of these species (through regular communication, training and attendance at rangers/Salvamont meetings). Tourists will be informed of the Park's interest in observations of these two species, through posters at entrance points and a notice on the ticket. The need for reports will also be advertised in the park newsletter. Data sheets will be available from all manned park information points (and will be handed out with the entrance ticket), and will also be sent out from park headquarters on request. School and university trips will be made aware of the need for this information. Post boxes for completed data sheets will be left at major park departure points. A return address will also be included on the form. Data sheets will be collected regularly from post boxes.

Data collection protocols

Data will be entered into data collection forms by observers. These forms will ask questions about the observations, which not only collect the relevant details, but also indicate the likely accuracy and quality of the data reported.

It is difficult to assess the quality of information received from the forms, but the park biologist will review the answers given and assess the likely accuracy of reports based on this information, and the consistency of reports with other information available. Questionable reports will be validated in the field or discarded. Trusted informants or multiple reports will have higher credibility than one off reports.

The survey will be advertised and data sheets made available throughout the summer.

Data management and analysis protocols

Records will be computerised, and records will be marked onto a map to identify possible patterns for activity. Judgement can be used to determine likely distribution of the two species, and the possible group sizes or territories involved. It is possible to estimate average encounter rates with the two species when search effort is a known quantity. Average number seen per data sheet submitted can be interpreted over different years for monitoring purposes. The proportion of visits on which the two different species were observed can be calculated for Park rangers/Salvamont observations (when total numbers of visits or days in the field is known, and reporting rate is high). The reactions of chamois to tourists (proportion recorded running vs. continuing to graze) will provide some indication of relative impact of tourists on this species. This can be plotted against variables such as number of people in group, distance from normal tourism routes, time of year (young present) and time of day.

Report format and process for communicating results to management

This incidental and imprecise information can be used to guide the development of more detailed surveys and to identify general trends within the park, which may need action or further research. The outcome of this survey should be summarised in the monitoring report to the park manager. In addition, summaries should be published in the newsletter to inform participants of the outcome of their efforts.

Resource allocation protocols

The park biologist will be responsible for designing the data collection sheet. He will liaise with the public awareness officer to ensure wide information dissemination about the survey. The park biologist will oversee the distribution procedures for data sheets, and the condition of posters and post boxes. The park biologist will liaise with the Park rangers/Salvamont to ensure awareness and training. This is likely to take two weeks over the period of the summer. The park biologist will also have to liaise/report on this project (five days/year) and analyse results (five days/year).

This survey requires printing of data sheets, printing and laminating of posters. Post boxes need to be built. However, this survey may have further public awareness/ engagement benefits. Post boxes and posters must be maintained.

Chamois survey data sheet (only on marked touristic traks)

Date:

Observer Name/Adress:

Climate conditions:

% clouds	Wind			Rain			Sleet			Snowfall			Fog		
	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H

L = Low; M = Medium; H = High.

The place of observations, as exactly as is possible.	No. of chamois observed			Behaviour, the chamois are 1. stil grazing 2. watchful 3. scared and start runing 4. walk relaxt
	No. Chamois/ groups	Adults	Juvenils	

Marmots survey data sheet (only on marked touristic traks)

Date:

Observer Name/Adress:

Condiții climatice:

%clouds	Wind			Rain			Sleet			Snowfall			Fog		
	L	M	H	L	M	L	M	H	L	M	L	M	H	L	M

L = Low; M = Medium; H = High.

The place of observations, as exactly as is possible.	No. of marmotes				The number of marmots burrows
	Seen	Heard	Adults	Juveniles	

Retezat National Park - Monitoring protocol 4

Monitoring of *Pinus mugo, Rhododendron myrtifolia* and *Pinus cembra*

Priority 2 - 3.

Monitoring question/s addressed:

Is the general biodiversity of the park being maintained?

Are key (important and endangered species) being maintained?

Indicator: Dwarf pine, Rhododendron myrtifolia, *Pinus cembra*

Justification: These are all considered key species of the park and characteristic of the sub-alpine zone. There has been some evidence of die back in dwarf pine and *Pinus cembra*.

Attributes: relative abundance/density.

Sampling protocols

Number of plots/sites for monitoring

It is suggested that a minimum of ten plots be considered. This should be increased relative to the time/resources available, with a maximum of 25 plots.

Distribution and selection of plots/sites for monitoring

Random plots will be sampled in the sub-alpine zone. Plots used in the baseline survey (containing the key target species) will be the basis for plot selection, and a random sub-sample of these will be used (by random number table). The representativeness of plots will be cross checked. Where the area is difficult or impenetrable, the transect may be adapted to ensure access and safety, as long as the same site is used in consecutive years.

Size of plots/sites for monitoring

Use approaches from baseline survey - 20 x 30 m plot located within a\1 km x 1 km grid square (as previously used).

Location/marking of specific plots

The exact position of the plot will be recorded in description, photographs and grid reference. Where possible the same 30 m transect will be used over subsequent years. Permanent metal markers will be used wherever possible. The direction of transect will be recorded.

Data collection protocols

Detailed information on what data is collected, and how

The protocols outlined in the baseline survey will be continued for continuity.

These use a series of three circular plots each of 3.1 m radius, located at 5 m, 15 m and 25 m along the 30 m transect. In each circular plot the % cover of the three target species will be estimated, along with a note of the number of individual plants (> 10 cm) of each species in the plot. A note will also be made of cover in the rest of the plot (including bare rock).

Data collection formats

Adapt baseline survey sheet.

Quality assurance and standardisation mechanisms

Check identification skills of participants. Double recording of cover could be a useful technique. Discrepancies may be questioned, or where important checked in the field. The park biologist may choose to accompany a random group into the field to observe accuracy of methods used.

Frequency and timing of repeat monitoring

This survey should coincide with rhododendron flowering season (late June - July), with all plots to be completed during this period. Survey to be completed once every three years.

Data management and analysis protocols

Data storage and management information

Data will be held by the park (with copies held by observers involved). Information will be inputted to a database in Excel by the park biologist. Basic calculations of average cover on each transect will be made.

Data analysis procedures and details of statistical methods to be used

Cover will be estimated across replicates in each transect. Each transect will the be considered as a separate sample. Differences year to year across the same set of transects can be identified through calculating differences in cover estimates. Trends in cover of the three different species can be plotted over time. Where change is apparent, the abundance of the species can be compared year-to-year using paired T-tests, and trends verified over time using regression analysis (involving appropriate transformations where necessary).

Report format and process for communicating results to management

Reporting will be intermitent (every three years). A brief note of the completion of this survey, and any indication of change will suffice. This may be illustrated graphically, and implications and recommendations should be bulleted where appropriate.

Resource allocation protocols

Number of staff involved, roles and training requirements

The park biologist will contact silvacultural training coleagues to take part in this survey. He will provide basic training (on methods and safety) to all participants, and may accompany groups into the field for at least three days (every three years), depending on needs to oversee work and help locate plots. The park biologist will enter the data and analysis it over one week. The work should be completed by teams of four students, with a professor/teacher supporting the group.

Resources/equipment required

Student groups will be expected to cover their own costs as part of their courses. It is unlikely that resources will be available to cover expenses in future years. The park will provide the teams with the necessary equipment (on loan). Equipment needs include tents, ponchos, sleeping bags (where necessary), poles, tapemeasure, maps, compass.

Maintenance or calibration requirements for equipment

Use of equipment will need to be arranged in advance. There is a danger of damage to equipment loaned to student groups, and this must be taken into account.

Retezat National Park – Monitoring protocol 4B

Monitoring of *Pinus mugo, Rhododendron myrtifolia* and *Pinus cembra*

Priority 1.

Monitoring question/s addressed:

Is the general biodiversity of the park being maintained?

Are key (important and endangered species) being maintained?

Indicator: Dwarf pine*, Rhododendron myrtifolia, Pinus cembra*

Justification: These are all considered key species of the park and characteristic of the sub-alpine zone. There has been some evidence of die back in dwarf pine and *Pinus cembra.*

Attributes: Change in dwarf pine and rhododendron cover area and number of Pinus cembra individuals.

Sampling protocols

Number of plots/sites for monitoring

It is suggested that a minimum of ten plots be considered. This should be increased relative to the time/resources available, with a maximum of 25 plots.

Distribution and selection of plots/sites for monitoring

Random plots will be sampled in the sub-alpine zone. Plots used in the baseline survey (containing the key target species) will be the basis for plot selection, and a random sub-sample of these will be used (by random number table). The representativeness of plots will be cross checked. Where the area is difficult or impenetrable, the plots may be adapted to ensure access and safety, as long as the same site is used in consecutive years.

Size of plots/sites for monitoring

Fixed point photography will be used, from a marked point on every occasion. A fixture will indicate the exact direction of the photograph, and a previous photo will be used to help orientate the observer.

Location/marking of specific plots

The exact position of the plot and photographic point will be recorded in description, photographs and grid reference. Permanent metal markers will be used wherever possible for the photographic point. A standard hole fixture (metal tube) in the ground will be used, along with a monopod of fixed height.

Data collection protocols

Detailed information on what data is collected and how

Each site will be photographed.

Data collection formats

Pictures will be compared. Date and time will be logged on each photo.

Quality assurance and standardisation mechanisms

Check fixed point for photographs consistent (by comparison in subsequent photographs).

Frequency and timing of repeat monitoring

This survey should coincide with rhododendron flowering season (late June - July), with all plots to be completed during this period. Survey to be completed once every three years.

Data management and analysis protocols

Data storage and management information

Data will be held by the park, with copies of photographs and negatives held in secured locations. The park biologist will be responsible for checking that dates, location and labels for each photograph are accurate prior to storing this data. Electronic (digital) copies of all photographs will be made, and this data will be backed up and held at a second location.

Data analysis procedures and details of statistical methods to be used

Changes in cover will be marked onto photographs

Report format and process for communicating results to management

Reporting will be intermittent (every three years). A brief note of the completion of this survey, and any indication of change will suffice. This may be illustrated schematically, and implications and recommendations should be bulleted where appropriate.

Resource allocation protocols

Number of staff involved, roles and training requirements

The park biologist or rangers will complete the survey over a period of five days in summer every three years.

Resources/equipment required

Maps compasses GPS etc. will be needed, along with the camera, monopod and film. Makers and tubes will be needed in the first year, and recurrent costs will be needed for camera maintenance, film and processing.

Maintenance or calibration requirements for equipment

Use of equipment will need to be arranged in advance. Cameras require regular cleaning.

Retezat National Park Protocol 5
Rare and endemic butterflies monitoring

Priority 2

Monitoring question/s addressed:

Is the general biodiversity of the park being maintained?

Are key (important, endangered and endemic species) being maintained?

Indicator: four species of rare or endemic butterflies.

Justification: A number of butterflies species recorded from the park are classified as threatened and endemic species. Butterflies continue to be targeted by illegal collectors throughout Romania and especially in Retezat Mountains. The butterflies can indicate the presence of a healthy population of food plants.

Attributes: Focus on four species of rare or endemic butterflies (list species here). Attributes measured to include relative abundance, presence/absence.

Sampling protocols

Number of plots/sites for monitoring

Collect data over minimum seven separate days/one week.

Seven different meadows will be defined with a transect of approx. three hours (approx. three km) walk in each. In addition, seven different drinking places along each transect will be used for point counts. Seven plots will be established at regular intervals along the transect to assess populations of food plants. These plots will be established in areas of general occurrence of food plants.

Distribution and selection of plots/sites for monitoring

Independent (unrelated) routes (transects) will be distributed across the key zones. Randomization approaches will be used, to determine start points of the walk. The same transects will be followed each year.

Size of plots/sites for monitoring

Routes will be around three km (with abundance estimated per km walked). Butterflies will be observed within 10 m of transects and observation points.

Location/marking of specific plots

Routes, meadows, drinking places, plots with food plants will be marked on a map. The same set of routes will be walked each year. A description of the routes, and of the vantage point sites for observations, will be written, and GPS records taken.

Data collection protocols

Detailed information on what data is collected and how

Observers will walk the route indicated at a slow walking pace. Transect might have a number of sections (ten) but once the route and sections have been decided upon they should not be changed. The transect walker records all butterflies (only of key target species) in each section within 10 m of each side of the transect. Observers will spend ten minutes at each observation point and record only the different individual butterflies counted in this time. Only butterflies within a radius of ten m will be recorded.

Observers will note visibility at each site (360, 180 or 90º). All individual butterflies observed while scanning with binoculars will be recorded. Incidental records of non-target butterflies will also be recorded, as will incidental records on other key species (such as chamois). At drinking ponds and food plant plots the observer must record every individual butterfly seen (numbers and species). For each food plant plot a (1 x 1 m) quadrat will be placed five m from the observation point (after observations completed) and food plant cover assessed. This will be repeated three times at each observation point.

Data collection formats

To be developed. See below.

Quality assurance and standardisation mechanisms

All personnel involved must be able to demonstrate basic butterflies identification skills through an initial trial. At least two personnel will be involved on each transect to ensure safety and confirm identifications. Where possible the same personnel will be involved in subsequent annual surveys. Map reading skills must be demonstrated in observers used (also fitness of observers must be considered). If new staff are engaged, the observation points and protocols will be demonstrated. Unusual or unpredicted observations will be challenged as soon as possible. Observers will be tested with regard to their estimation of distance.

Frequency and timing of repeat monitoring

Data management and analysis protocols

Data storage and management information

A butterflies sightings database will be designed in Excel to include 'total individuals per km^2' for each target species, on each transect walked in each year of survey (based on an observational area (km^2) defined from each point count made). The park biologist will be in charge of data management, but areas of high butterfly density will be integrated into the GIS system. Data will remain property of the Retezat National Park, but observers and the RLS will have open access to data they have helped to collect. In addition, data will be shared with national data bases/RLS. Back up copies of the data will be kept at an alternative location. Original datasheets will be retained.

Data analysis procedures and details of statistical methods to be used

The variables of 'individuals per unit search effort or km^2' for each species will be compared over the years of monitoring (with each route walked per year considered as a separate variable, therefore an ideal number of seven routes has been considered – but could be reduced to four if absolutely necessary). In addition' total butterfly per unit search effort' will be considered. Conversion of numbers to densities can be done using the total area surveyed to enable density estimates to be made for the park. The data will be entered into a statistical programme (such as Minitab) for analysis of regression over at least four years of data collection. In addition, the average of individuals per km per year (over all transects) will be used to plot data in a readily accessible manner. A significant relationship over time will be accepted at levels of $p < 0.05$.

Report format and process for communicating results to management

The butterfly survey will be briefly summarised within the annual report on monitoring progress to the park manager. Where no significant change has been noted, this will be simply stated. Any problems regarding the accuracy of the survey will also be noted. Where significant change has been recorded, the data will be presented in bullet points or graphically as appropriate. Where statistical significance has been achieved in the results, the statistics will be quoted and interpreted. The implications of these results will be highlighted in bullet points, as will recommendations for management action and/or further research. Declines in butterfly populations would also be reported to RLS.

Resource allocation protocols

Number of staff involved, roles and training requirements

The park biologist and a RLS volunteer will conduct the survey. This will require four field days for the park biologist every year. The park biologist will process the data; this will take - two days per year. The park biologist will be responsible for planning and implementing this survey. Some basic statistical training will be necessary to enable effective analysis.

Resources/equipment required

The RLS volunteer will not be paid a fee, but subsistence and travel costs should be met. The sustainability of this input (given resource restrictions in future) and possibilities of training forest rangers or using students should be considered. The park needs to provide binoculars for the park biologist (and possibly the RLS volunteer) - however observers will generally use their own binoculars. Field guides, maps, compasses, GPS, tents and sleeping bags will be needed. A vehicle and fuel will be necessary.

Maintenance or calibration requirements for equipment

Equipment will be the responsibility of the park biologist. Availability of tents and other field gear must be negotiated in advance with other users (such as park rangers). Repairs needed to equipment will be reported to the Head Ranger.

Buterflies monitoring data sheet

Date: Observer:

Pasture no.: Transect no.:

Climate conditions:

%	Wind			Rain			Sleet			Snowfall			Fog		
clouds	S	M	P	S	M	P	S	M	P	S	M	P	S	M	P

S = slab(ă); M = mediu(e); P = Puternic(ă)

Point no.	Sp. 1 no. exemplaires:
Vizibility %:	
Presence of food plants Yes No	Sp. 2 no. exemplaires:
Presence of drinking place Yes No	
	Sp. 3 no. exemplaires:
	Sp. 4 no. exemplaires:

(Verso): Observations:

Retezat National Park Monitoring Protocol 6
Amphibians monitoring

Priority 1.

Monitoring protocols mnitoring amphibians and lentic habitats

Monitoring question/s addressed: Are populations and distribution of amphibians being maintained?

Measure/Indicator: amphibians species, relative abundance of each species.

Justification: amphibians are sensible to modifications of aquatic and terrestrial habitats. This group is protected at European level. Modification in population size can indicate habitat deterioration.

Attributes: species composition, relative abundance.

Sampling protocols

Number of plots/sites for monitoring

The area of ponds will first be surveyed in the baseline year for monitoring. This will involve mapping all suitable permanent ponds and areas when semi-permanent ponds may form. These sites will be checked during the breeding season to identify which areas are currently used by amphibians species. When the distribution of potential amphibians sites has been identified, up to ten representative ponds will be selected to provide the basis of long term monitoring.

Distribution and selection of plots/sites for monitoring

On the basis of the baseline survey he most representative permanent and semi permanent ponds. Ponds from different areas of the park will be included.

Size of plots/sites for monitoring

All representative ponds and semi-permanent ponds will be searched. A maximum of ten will be used for long-term monitoring.

Location/marking of specific plots

GPS and map records will be made for each permanent and semi-permanent pond to aid relocation in future years. Details directions to reach each site will be recorded.

Data collection protocols

Detailed information on what data is collected and how

During the day the location of each pond / semi-permanent pond will be checked and its location confirmed. The size of the pond will be estimated (diameter and circumference), and surrounding habitat and any signs of disturbance will be noted. Frogs, newts and toads seen during the day will be identified and counted (this is best done during the mating season) Any signs of eggs and the number of egg clusters (frogspawn) will be noted (this will be visible during the mating season, but will peak after the end of mating). Repeat daytime visits to ponds should be considered during different stages of the mating season. The circumference of each pond will be walked searching for adult frogs at the edge of the water, or migrating between ponds. These will be recorded to species.

Data collection formats

Quality assurance and standardization mechanisms

Identification of amphibians species and any confusion will need to be checked through staff training. A suitably slow search rate needs to be standardized. If other newt species are found in the same area, ponds may need to be revisited to confirm identification, and trapping techniques will need to be used (training would be needed for this, along with regular trap inspections to avoid mortality).

Frequency and timing of repeat monitoring

It is usually best to assess newt populations during the breeding season III - IV for valleys and VI for alpine lakes and ponds during each year. The survey will be conducted annually.

Data management and analysis protocols

Data storage and management information

Data on location of amphibians ponds will be kept confidential, except to accredited academic and conservation organizations (in case of risk of collectors gaining interest). The GIS system will be updated to keep track of past and present records of newt distribution. Locations and numbers will be entered into the computer. Computer records will be backed up and original data sheets retained.

Data analysis procedures and details of statistical methods to be used

Where appropriate the density of newts seen at different sites will be calculated based on area surveyed (area visible within torch range). Density at the same ponds can be tracked over time, and trends established. In addition, the total number of amphibians seen and number of ponds occupied over time will be recorded, and any negative trends identified.

For frogs presence/absence data will be used to assess use of ponds. The number of balls of frogspawn seen will be averaged at each site every year, and changes in these will be used to assess possible population change (but note this is considered a poor predictor of population change). Adult frogs seen in a standardized survey will be used to analysis population changes over subsequent years.

Report format and process for communicating results to management

If sudden or significant changes occur in the number of amphibians a further survey would be initiated. If concerns about the newts are confirmed then mitigation actions should be instigated. Reports will be brief with bullet points and graphs to ensure appropriate action can be taken by park management.

Resource allocation protocols

Number of staff involved, roles and training requirements

The park biologist will need to spend up to seven days on this survey (depending on the number of ponds located). Data entry and analysis will take another one day per year.

Resources/equipment required

GPS, torches, vehicle and appropriate field kit. Ongoing costs include torch batteries and petrol.

Maintenance or calibration requirements for equipment

Torches may need regular maintenance, with batteries stored separately.

Buterflies monitoring data sheet:

Date:	Start:	End:	Observer(s):
Locality:	Toponimy:	County:	Geographical coordonates (GPS):

Topographic maps:	Scale:	Latitude:	Longitude:	Altitude:	Anexed sheets:

All the area was researched? Yes No	If not, indicate: m of bank; m^2 of habitat

Amphibiens and reptiles species	Adults		Juveniles		Sounds	Larvae	Frogspawn	Metode utilizate 1.Vizuală 2.Auditivă 3.Ciorpac 4.Capcane 5. Colectare manuală
	♂	♀	♂	♀				
					Yes No			1. 2. 3. 4. 5. Specimen Voucher? Yes No

Other present animals:	Insects:
	Fish:
	Reptiles:
	Birds:
	Mamals:

Phisico-chemical characteristics of the studied area (use the remain free space for the additional measurements):

Weather: No clouds Rain Sleet Fog Snow Clouds (%):				Wind: Low Strong Absent
Air temperature (^oC):	Water temperature (^oC):	% cover with ice	Turbidity: Clear Not clear	
pH:	Conductivity:	Alcalinity:	Water colour:	

Habitat and sorounding area description - only the surface considered relevant for the amphibians populations study.

Ecosystem: Aquatic Terestrial	Origin: Natural Anthropogenic	Habitat: Temporay Permanent	Draining: Permanent Ocasional Absent		
Description: lake pool puddle chanel ditch forest reed plot, bushes, pasture hayfield ecotone swamp pond brook Others:			Substrate/Soil: Clay/Mud Sand Pebels Dead leafs Others:	Exposition: Slope (%): Shadowed (%):	
Length (m):	Breadt (m):	Perimeter (m):	Maximum depth: <1 m 1 - 2 m >2 m		
Vegetation in the pool and in its soroundings:					
% cover with vegetation of the bank: % herbaceous: % ligneous:	% water cover with vegetation: % algae: % macrophites:		% vegetation around the pool, 25 m): % herbaceous: % ligneous:	Under water vegetation % algae % macrophites	
Northern bank characteristics: Areas with low depth: Yes No Emergent vegetation: Yes No					
The soroundings area description: forest bushes reed pasture hayfield clifs roks agricultural land others:					
The main plant species:				The distance to the forest (m):	
Human impact: Human setlements Industry Agricultural plants Fish ponds Zootechny Forestry plantation Roads Chanels Wastes Others:					

Observations regarding the microhabitat (descrption, map, etc.):

Retezat National Park Monitoring Protocol 7
Otter monitoring

Priority 1.

Monitoring questions addressed: Are key elements of biodiversity in the park being maintained? Number of otters in PNR that changes?

Measure/Indicator: *Lutra lutra*

Justification: The otter is an endangered species at European and national level. It can indicate the presence of a healthy population of fish in the rivers.

Attributes: presence/absence otter

Sampling protocols

Number of plots/sites for monitoring

Seven rivers in which the otter has been observed.

Distribution and selection of plots/sites for monitoring

The seven rivers in which the otter has been observed.

Size of plots/sites for monitoring

Ten km transect along river bank.

Location/marking of specific plots

The rivers that will be monitored should be marked on the map, monitoring areas (the ten km transect) will be marked with the GPS (start and finish point), drawn onto the map and marked in the field with paint. Each kilometer will be both painted and marked with the GPS.

Data collection protocols

Detailed information on what data is collected and how

The observer/s will follow the transect with minimum disturbance, using the same path each year, and making the observation in the same time of year. He/she will note in the data collection notebook, each otter observed, the droppings, tracks and slides on every km of the transect. The droppings will be collected to determine the species and the age of the fish prey (this examination will be done by other researchers). The bag with collected droppings will have a label with the name of the observer, the river and km of transect where it has been collected.

Data collection formats

Details of time and date of transect, weather conditions, name of surveyor, details of any otter or otter sign seen (and location on transect) will all be collected in a field notebook. This information will be transcribed at the end of the survey and handed directly to the park biologist.

Quality assurance and standardisation mechanisms

The observer needs to have knowledge about the otter, tracks, spraint, and other signs and to be used to field work.

Frequency and timing of repeat monitoring

The observations will be carried out twice a year, once in the summer and once in winter (June and December). The survey will be conducted annually (or less if necessary).

Data management and analysis protocols

Data storage and management information

The data collected in the field will be stored in an electronic format, each incidental observation of the otters, droppings, tracks will be marked on the digitised map. The data will be backed up and a copy stored separately. Original data sheets and field note will be kept.

Data analysis procedures and details of statistical methods to be used.

Each year, the data found, will be compared with those from the previous ones. It will be established the presence/ absence of the otters on the rivers on different sectors of the transect. If no otter sign is recorded from any river for more than three years, the distribution of otters will be considered to have changed, and further surveys will be initiated to check presence across all other rivers in the park.

Report format and process for communicating results to management

The results will be reported annually to the park manager in a brief report of one page. In case of difficulties occurring (ie poaching) a separate information of the park manager will be made. Every five years a more detailed report will be presented, including maps and graphs.

Resource allocation protocols

Number of staff involved, roles and training requirements

The park biologist will be responsible for the selection of the rivers, marking them, marking the kilometres from transects, collecting, interpreting and reporting the data from observers. As observers, will be mainly used the park rangers and foresters that are responsible for the area on which the rivers that need to be monitored are located. The students in Biology can also be used when the forester is not reliable. In the first year, the biologist needs seven days in order to select and mark the river and the kilometres. In the next years, the biologist will need one day, for collecting the data from foresters and one day for interpreting and reporting them.

Resources/equipment required

GPS, map, car, camping gear, paint, and binoculars will be needed. Fuel, plastic bags for droppings, labels, and data sheets will be recurring requirements.

Maintenance or calibration requirements for equipment

The equipment will be requested from park manager in advance. Any problems with equipment will be reported immediately.

Retezat National Park Monitoring Protocol 8
Marmots monitoring

Priority 1.

Monitoring question: Is the marmot population modifying?

Indicator or target: *Marmota marmota*

Justification: A species artificially introduced that can affect the ecosystem, needs to be monitorized in order to assess the impact.

Attributes measured: Estimated abundance of marmot's burrows, estimated abundance of marmots, burrows density.

Sampling protocols

Number of plots/sites for monitoring

7 - 10 colonies plus a long transect routed amongst all key marmot habitat.

Distribution and selection of plots/sites for monitoring

One or two colonies in all glacier complexes, selected randomly within each galcier complex.

Size of plots/sites for monitoring

All burrows and specimens from one colony (the whole colony for each selected colony) and a 5km long transect.

Location/marking of specific plots

GPS, map, photography of each key colony. The transect to be walked will be marked on the map and a description will be kept.

Data collection protocols

Detailed information on what data is collected and how

The surveyor follows the transect between the glacier complexes, taking all the measures for minimum disturbance and walking on the same route each year.

The observer will note on GPS and the map each colony encountered and will take pictures. The number of colonies visible from the transect will be recorded.

The observer will count and record all the burrows and marmots from each selected colony chosen as plot.

The number of burrows and marmots will be write down in the data sheet notebook, along with number of young marmots seen, signs of habitat degradation, predators and other species seen.

Data collection formats

See annex

Quality assurance and standardisation mechanisms

The same transect each year

Surveyor's skills: knowledge about marmots and other animals.

Counting skills

Frequency and timing of repeat monitoring

The survey will be conducted during summer when the juveniles come out of the burrows (July - August).

The survey will be conducted every year.

Data management and analysis protocols

Data storage and management information

The marmots data basis will designed with the help of the IT specialist in Excel, with a spreadsheet showing 1. Number of colonies recorded each year; 2. Number of burrows each year at each selected colony; 3. Number of marmots (adults and juveniles separately and combined) at each site in each year.

The colonies and burrows will be marked in digitised maps.

The spreadsheet will be backed up and stored separately, and original datasheets and notebooks will be retained.

Information will be shared with scientists and other interested parties.

Data analysis procedures and details of statistical methods to be used

Total number of colonies will be plotted over time. Correlation/regression techniques could be applied.

Number of burrows at each site will be plotted over time. A two way ANOVA could be used to separate effects of time and colony site. Regression approaches are recommended to detect trends in individual colonies, but it will be better to use each colony as a separate data point to detect larger trands across the whole population over time (number of burrows at each site being a separate data point, with the variable being year of study). A similar analysis could be completed for number of marmots seen.

Numbers and changes in the proportion of juveniles among the total number of animals seen can be used to track changes in population composition over time, and to estimate reproductive rate.

Other analysis could be conducted once a large data base has been collected to determine effect of weather and distance from track of the number of marmots seen.

Report format and process for communicating results to management

Will be done by the park biologist, the results of the survey will be reported to the management every year, in case nothing significantly happens.

However, if something important occurs, this will be reported into a detailed report produced by the park biologist.

Resource allocation protocols

Number of staff involved, roles and training requirements

Field responsible is the park biologist; the team includes also the chief ranger and volunteers.

A number of minimum five days is necessary for the field work (park biologist).

The data interpretation will be done by the park biologist and the IT specialist, three days.

Resources/equipment required

Resources or equipment is required? Are there any consumable items that need to be reordered every year? Will the necessary equipment be available when you need it?

Maps, GPS, photo equipment, films, car, fuel, food, tent, sleeping bag, binoculars. Fuel, batteries, and photographic film/development will be recurring costs.

Maintenance or calibration requirements for equipment

The park biologist will check for damage at the end of the field season.

Marmot survey data sheet.

Name of surveyor:	
Date:	Temperature (°C):
Time start of transect:	Cloud cover (1 - 10):
Time finished:	Rain (describe):

Total number of discrete colonies recorded from whole transect:
(Please mark locations of new colonies on map or take GPS reading)

Colony n + 1			
Location (valley, code and GPS reading)	Number of burrows counted	Number of marmots seen	
		Adults	Juveniles
Are there fresh marmot droppings present?		Yes	No
Any sign of predators? (give details):			
Any sign of habitat degradation around the burrows? (describe):			
Any other interesting species seen? (list);			

Retezat National Park Monitoring Protocol 9
Carnivore surveys

Priority 1

Monitoring question/s addressed: Are the populations of large carnivores and pray species maintained or increasing?

Measure/Indicator: *Ursus arctos, Lynx lynx, Canis lupus.*

Justification: Large carnivores are endangered species in Europe. The large carnivores population has suffered a severe decline in Retezat Massif because of human disturbance and hunting. Retezat National Park has a large population of these animals.

Attributes: relative abundance, home range and habitat use.

Sampling protocols

Number of plots/sites for monitoring:

A number of 5 - 10 transects will be chosen inside park boundaries.

Distribution and selection of plots/sites for monitoring

Transects will be defined across the main large carnivores areas. It may be necessary to use flexible transects, however where obvious paths and main route can be used each year this would be preferable. Transects will be linked with a route that can be travelled in one day.

Size of plots/sites for monitoring

Routes will take around one day to walk (around seven km per day). The start and finish points of recording will be defined, based on know areas of suitable large carnivores habitat. Each transect will be walked three times over the winter, at least one week apart and after fresh snow fall.

Location/marking of specific plots

Routes will be marked on a map. The same set of routes will be walked each year. A description of the routes, and of key vantage point sites for observations, will be written.

Data collection protocols

The surveyors will walk in the field in a way that minimizes disturbance along a set route used every year. The surveyors will start to move along predetermined routes until he will observe the first footprint of large carnivores. In each study area transects will be visited following snowfall three times during the survey period to assess use of the area by carnivore and prey species. The best period for survey is after each snowfall. At least two cm of snow must have fallen during the snow event in order for surveying to begin. One designated individual should monitor whether reports for the survey period, and mobilise survey crews as soon as possible following snowfall. The survey should be conducted one full day after snowfall to allow time for wildlife use of the area and track accumulation. All large carnivores trails observed five m to either side of transect centreline will be investigated to determine the originating species. The species should be recorded on the transect data sheet.

Data collection formats

Standard form will be used.

Quality assurance and standardisation mechanisms

The same route will be followed each year, with the same number of surveyors. The identification skills of surveyors will be checked, as will distance estimation skills. If possible the same personnel will be involved in subsequent annual surveys. Map reading skills must be demonstrated in observers used. If new staff engaged, the observation points and protocols will be demonstrated. Unusual or unpredicted observations will be challenged as soon as possible. Very important is the quality of the staff involved in snowtracking. There could appear errors in identification of the prints from wolves, dogs and lynx.

Frequency and timing of repeat monitoring

The survey will be done through the winter time. We have to take into account seasonal activity rhythms of the species. Bears are normally hibernating in January and February they came out at the end of February and beginning of March (deep snow and low temperatures could delay this). If there is deep snow, the ungulates concentrate in the feeding places, usually in the valleys. In these circumstances lynx and wolves could follow them. So there are so called "concentration sites" that could be considered in the survey. From middle February until middle of March, there is the lynx mating season and the lynx use, also, "hot spots". The survey will be conducted once time in each year in wintertime.

All of a transect should be surveyed within one day to avoid statistical complications. Surveys should be continued for four days, until the individual tracks and trails can no be longer distinguished. The interval for continuation of the surveys should be as short as possible.

If possible these surveys will be repeated on the same date each year. Weather condition and snow width are the main factors that influence the timing and period.

Data management and analysis protocols. Data storage and management information.

The park biologist is responsible for storing and analyzing data. Data will be shared with the AGVPS (General Association of Sport Hunting and Fishing) and Forest Directorate. Areas of high large carnivores density will be integrated into the GIS system. Back up copies of the data will be kept at an alternative location. Original datasheets will be retained.

Data analysis procedures and details of statistical methods to be used

A large carnivore and pray species database will be designed in Excel.

Data should be organized by snowfall event and by transect.

Data from similar habitat types can be grouped by individual transect sections to conduct a comparison of use by habitat type. Note that the low number of detections in track data skews the data into a non-normal distribution. Non-parametric statistical procedures are recommended for trend analysis (e.g. Kruskal-Wallis test for variance analysis and Dunn's multiple comparison test). To avoid temporal pseudo-replication for tracking data collected over several snow events, an average of the tracks observed on each transect during the monthly survey should be used.

Report format and process for communicating results to management

The large carnivores and prey survey will be briefly summarized within the annual report on monitoring progress to the park manager. Where no significant change has been noted, this will be stated. Any problems regarding the accuracy of the survey will be noted. Where significant change has been recorded, the data will be presented. Where statistical significance has been achieved in the results, the statistics will be quoted and interpreted. The implications of these results will be highlighted in bullet points, as will recommendations for management action and/or further research. If declines are noted in the park, hunting associations and forestry departments would be informed.

Resource allocation protocols

The survey would take up to 30 days in wintertime. This activity needs four people. All Park staff (seven people) will be involved. The park team will collaborate with people from Forest Directorate, which made this survey every year. Data entry and analysis will take two days of the park biologist time.

Resources/equipment required

The team will need access to binoculars, GPS, and field/safety equipment. Maps and compasses will be needed, as will data sheets.

Maintenance or calibration requirements for equipment

The biologist will report any problems with the equipment.

Winter tracking survey sheet

Date:

Observer:

Transect Code	Snow event	Snowfall event

Snow condition	
Sky condition	

Point no.	Species	Number of tracks	Habitat code	Additional comment

Incidental observations

Species	Number of records	Habitat Code

Data Sheet Completion Notes:

Transect Code:

Enter the transect code (e.g. transect no. six)

Snow Event: Enter the visit number, one of three repeat visits to the transect.

Snowfall Day: The number of days after snowfall that the survey is being conducted.

Snow Conditions/Sky Conditions: Enter snow condition (e.g. wet snow, dry snow, fresh powder) and the sky conditions (e.g. overcast, cloudy, light snow).

Point no.: enter the point number of observation on a map

Species: Enter the species name identified from the observed trail.

Number of individuals: Note the number of tracks encountered for each species

Habitat Code:

The following codes will be used: 1 = young deciduous, 2 = young coniferous, 3 = young mixed, 4 = old deciduous, 5 = old coniferous, 6 = old mixed, 7 = riparian, 8 = meadow, 9 = road/trail.

Additional Comment: Record any observations regarding the activity of the animal or other relevant details of the sighting.

Incidental Observations: Any wildlife including vertebrates or invertebrates, seen on route to the survey square should be noted in this field. Any non-target species observed while on the plot should also be noted in this field. Age, sex and number of individuals as well as the observation location should be noted if possible.

CONCLUSIONS

Biological monitoring is used to gain an understanding of what is changing in the ecosystems and why. By integrating long-term studies of species and habitats trends with the abiotic data and land-use change information from the same area, a more complete profile of an ecosystem can be prepared, and evidence of change and/or condition documented. This integrated information should be useful for the National/Nature park management plan with respect to natural resource management and the conservation of biodiversity.

Until now just two National Parks and one Nature Park have monitoring plans. We hope that those will be used as models for the new established administration of the Romanian National and Nature Parks in order to create a uniform National Biodiversity Monitoring Network. In the future other monitoring sites located in the smaller reserves and Natura 2000 sites will take part of this, increasing the value of the planed network.

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