TAXONOMIC STRUCTURE OF INVERTEBRATE FAUNA AS A PARAMETER FOR SOME AQUATIC ECOSYSTEMS FROM PIATRA CRAIULUI NATIONAL PARK MONITORING

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Abstract. The taxonomical researches on aquatic invertebrate fauna concretized with establishing the species inventory, with the estimation and analysis of some structural parameters, permitted the evaluation of diversity level on spatial-temporal scale, support for the monitoring of the selected ecosystems and, implicitly the optimization of the protection strategy for this reserve. In this context, a special attention was paid to reophilous species, indicator species and dominant species. From the 27 analyzed aquatic ecosystems, the following were selected: Bârsa Tămaşului River, Bârsa Mare River, Bârsa Mare Pond, Râul Mare al Zărneştilor, Vlăduşca River, Curmătura River, Dâmbovicioara River, Dâmbovița River, placed inside all the five core sites – Valea Bârsei, Prăpăstiile Zărneştilor, Cheile Brusturetului, Cheile Dâmbovicioarei, Cheile Mari ale Dâmboviței, of the Piatra Craiului National Parck.

Key words: aquatic invertebrates; taxonomical research; Piatra Craiului National Park; monitoring activity.

Rezumat. StructurA taxonomică a Faunei de nevertebrate ca parametru de monitorizare a unor ecosisteme acvatice din Parcul Național Piatra Craiului. Cercetările taxonomice asupra faunei de nevertebrate acvatice soldate cu stabilirea inventarelor de specii, cu calcularea şi analiza unor parametri structurali permit estimarea nivelului de diversitate la scară spațio-temporală, susținerea activității de monitoring a ecosistemelor selectate şi implicit optimizarea strategiei de protejare a ariei respective. În acest context, s-a acordat o atenție deosebită speciilor reofile, speciilor indicatoare şi speciilor dominante. Din cele 27 ecosisteme acvatice analizate au fost selectate următoarele: râul Bârsa Tămaşului, râul Bârsa Mare, balta Bârsa Mare, Râul Mare al Zărneştilor, râul Vlăduşca, râul Curmătura, râul Dâmbovicioara, râul Dâmbovița, amplasate în toate cele cinci core sites – Valea Bârsei, Prăpăstiile Zărneştilor, Cheile Brusturetului, Cheile Dâmbovicioarei, Cheile Mari ale Dâboviței, ale Parcului Național Piatra Craiului, şi totodată componentă a Rețelei Naționale NATURA 2000.

Cuvinte cheie: nevertebrate acvatice; cercetări taxonomice; Parcul Național Piatra Craiului; monitoring.

INTRODUCTION

In the process of declaring the Piatra Craiului Massif as a protected area, only the flora and vegetation information and the geomorphologic and speologic particularities were used like scientific proofs; the fauna diversity of the area being almost unknown. This huge lack of information has been addressed after the declaration the PCNP, when the management staff launched, in 2000, a program for biodiversity assessment, implicitly of the terrestrial, aquatic and ecotonal fauna. The MNINGA experts were invited to participate at this project, in which the researches on aquatic ecosystems occupied an important place. We investigated 27 different types of aquatic ecosystems (rivers, brooks, springs, ponds), obtaining original data referring to the aquatic invertebrates. Parts of them are already published (V. Tatole, 2004).

In the same time we developed during 2003 – 2005, the Grant named *Evaluation of Piatra Craiului taxonomical dynamics*, financed by the National Council of Scientific Research and High Education (CNCSIS). This paper includes some data resulted in the frame of the grant researchers.

MATERIAL AND METHODS

The biological material was sampled from the following nine aquatic ecosystems of the Piatra Craiului Massif:

1 – Bârsa Tămaşului River springs at the foot of the north-western mountainside of Piatra Craiului and is a tributary of Bârsa Mare River. Its valley is about 15 m wide, but non-unitary, the water flowing in many threads, three of them being more important. The river bed is graveled and rarely rugged, the stones reaching 30-40cm in diameter. The water flow is rapid.

2 – Bârsa Mare River is formed by the confluence of Bârsa Groşetului, Bârsa Tămaşului and Vlăduşca rivers that spring at the foot of the Făgăraş Mountains, with Bârsa lui Bucur and Bârsa Fierului, that spring from Țagla Mountains. The valley is wide, the flow is slow, the river bed is covered by stones of 5-40cm, rounded, without heavy stones emerging from the water;

3 – Bârsa Mare Pond is placed near the road, at 2km from Gura Bârsei. It's a permanent pond, being supplied by limnocrenous springs. It is formed by a system of puddles and channels. It has a rich aquatic and palustrian vegetation, developing the optimal condition for a high biotope diversity;

4 – Râul Mare al Zărneştilor is a tributary of Bârsa Mare River, that springs at the foot of the eastern mountainside of Piatra Craiului, constituted from a few aquatic sources;

5 – Vlăduşca River's valley is about 1m wide, the flow is slow, the river bed is covered with small stones and gravel;

6 – Curmătura River is a tributary of Râul Mare al Zărneştilor, its valley is about 1-1.5m wide, the flow is very low, especially in summer and autumn, the river bed is covered by stones;

7 – Dâmbovicioara River (at Brusturet Gorges) flowing in the south of Piatra Craiului Massif, the valley is very savage, being marked by the high water flow and speed, the river bed is preponderantly formed by stones, covered in algae and mosses;

8 – Dâmbovicioara River (at Dâmbovicioara Gorges); the sampling station was placed at the entrance in the gorges, the valley is 4-6m wide, the flow is fast, the river bed is covered by large stones, but the gravel is present, too, some stones are covered by bioderma**;**
9 – Dâmbovița River (Dâmbovița Large Gorges), the valley is about 15-20 m wide; the water flow is moderately, the river bed is formed by large rounded stones covered by bioderma.
The samples were taken with a hydrobiological net (Haveneau type), with a square area of 0.500 m^2. We have considered the biotope zoning: substratum nature (stones, bioderm, sand, mud), flow rapidity (stream, slow waters), river bed topography (center, bank, sunny areas, afforested areas). For each station the relative abundance of the aquatic invertebrate groups was calculated, and where the sampling was done on 100m transects, numeric abundance gradient of dominant taxa was also estimated.

RESULTS AND DISCUSSIONS

Remarks on the structure of aquatic invertebrate fauna from the selected ecosystems

As a result of sample processing we identified the organisms, the following list of taxa being established: Turbelariata, Nematoda, Oligochaeta, Hirudinea, Gastropoda, Amphipoda, Copepoda, Ostracoda, Arachnida, Colembolla, Ephemeroptera, Plecoptera, Heteroptera, Trichoptera, Coleoptera and some families of the order Diptera: Culicidae, Tipulidae, Simuliidae, Psychodidae, Chironomidae, Tabanidae, Rhagionidae.

In Fig. no. 1, the values of the relative abundances are shown, which permitted the assessment of the taxonomical dynamics level of aquatic invertebrates.

In decreasing order we can signal the presence of 18 macrotaxa in Bârsa Tămaşului River, 11 in Dâmbovița and Bârsa Mare River, 10 in Bârsa Mare pond, 7 in Vlăduşca and Dâmbovicioara River (Cheile Brusturetului), 6 in Dâmbovicioara River (Cheile Dâmbovicioarei) and finally, 5 in Râul Mare al Zărneştilor and Curmătura River.
In taxonomical order, we can observe that the dominant groups are the following:

- Gastropods (18.40%) in Bârsa Mare Pond;
- Amphipods in Dâmbovicioara River, with 38.61% at Brusturet Gorges and 54.22 % at Dâmbovicioara Gorges;
- Ephemeroperans in Curmătura River (11.27%), in Dâmbovița River (19.00%), in Bârsa Tămaşului River (20.50%), in Dâmbovicioara River–Cheile Dâmbovicioarei (33.73%), in Bârsa Mare River (42.49%) and 54.05% in Dâmbovicioara River–Cheile Brusturetului;
- Plecoprans in Bârsa Tămaşului River (29.35%), trichopterans, also in Bârsa Tămaşului (15.74%);
- Chironomids in Bârsa Mare (20.33%), in Bârsa Tămaşului River (21.58), in Bârsa Mare Pond (59.05%), in Curmătura River (66.20%), in Dâmbovița River (68.78%), in Râul Mare al Zărneştilor (83.4%), in Vlăduşca River (90.00%).

All the other groups, although, are much more poor represented in the studied ecosystems, their presence guaranteeing the species richness and some of them having a major ecological importance.

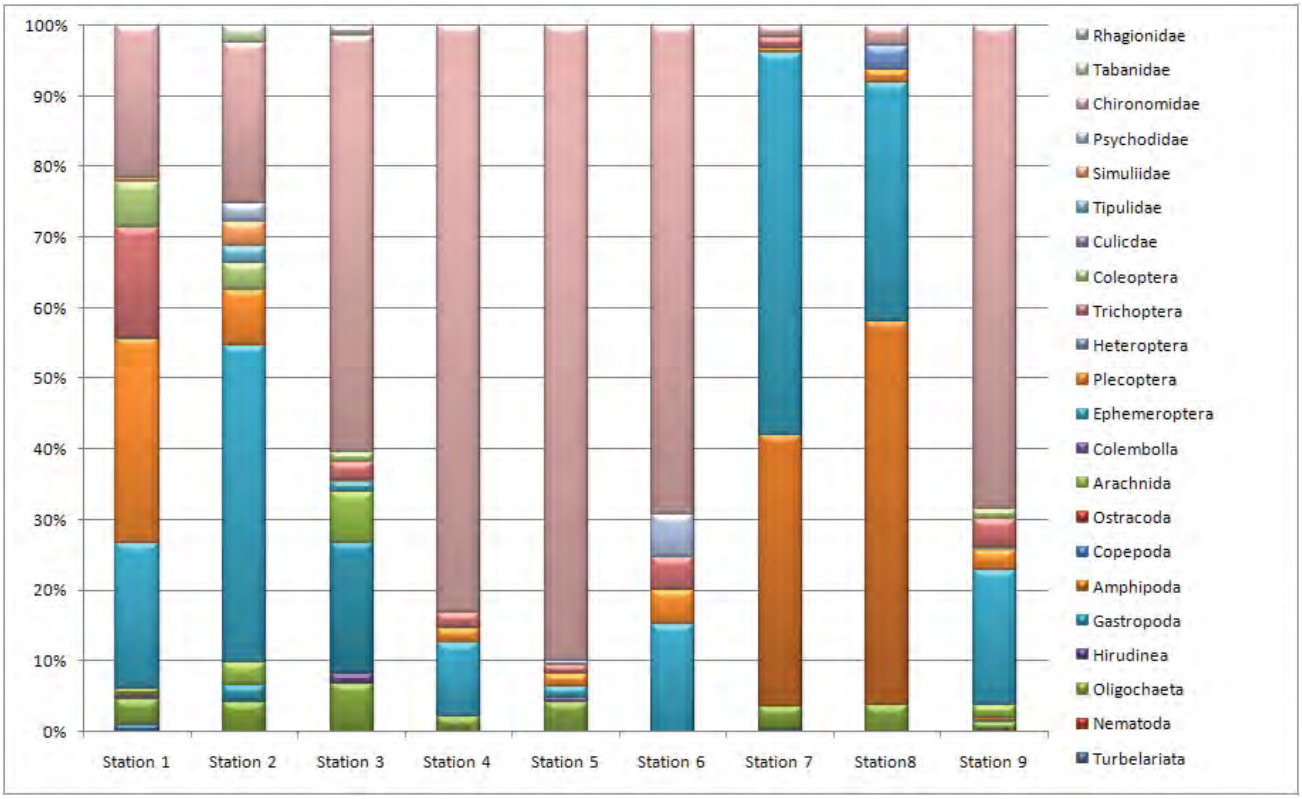

Figure 1. The level of representativeness of the invertebrate groups from the 9 studied ecosystems (according to relative abundance values).
Figura 1. Nivelul de representativitate al grupelor de nevertebrate în cele 9 ecosisteme (după valorile abundenței relative).

The estimate of the status conservation of studied ecosystem can be made by the selecting and identifying all the species groups considered important. So, the reophile elements (ephemeropterans, plecopterans, trichopterans), indicator species (Turbelaria, efemeropterans, plecopterans, trichopterans, some dipterans), dominant elements (dipterans – chironomids, efemeropterans, plecopterans) were put in evidence. All these species are presented in next table.

Table 1. The species list of the main invertebrates groups from the studied aquatic ecosystems
Tabel 1. Lista de specii a grupelor de nevertebrate importante din ecosistemele acvatice studiate

TAXA	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
TURBELARIATA *Planaria torva* MÜLLER, 1784	+						+		
HIRUDINEA *Glossiphonia complanata* L., 1758	+		+						
CRUSTACAEA AMPHIPODA *Gammarus balcanicus* SCHÄFERNA, 1922	+						+	+	+
OSTRACODA *Candona* sp.	+								
COLEMBOLLA *Podura aquatica* L. ,1758	+								
Sminthurides aquaticus (BOURLET, 1843)					+				
EPHEMEROPTERA POTAMANTIDAE *Potamanthus luteus* (L., 1767)	+								
EPHEMERIDAE ***Ephemera danica* MÜLLER, 1764**		+							
***Ephemera lutea* LINNÉ, 1767**			+						
EPHEMERELLIDAE *Ephemerella ignita* (PODA, 1761)	+	+		+	+	+	+	+	
CAENIDAE *Caenis macrura* STEPHENS, 1836				+				+	+
BAËTIDAE *Baëtis carpaticus* MORTON, 1910	+								
***Baëtis rhodani* (PICTET, 1843-45)**		+	+						+
Baëtis melanonix (PICTET, 1845)		+							
Baëtis scambus EATON, 1870									+
Baëtis vernuus CURTIS, 1834									+
Centroptilum luteolum (MÜLLER, 1776)		+	+						
Centroptilum pennulatum EATON, 1870	+								
Cloëon dipterum (L., 1761)			+						
OLIGONEURIIDAE *Oligoneuriella rhenana* (IMHOFF, 1852)		+				+	+	+	+
ECDYONURIIDAE *Heptagenia flavipennis* (DUFOUR, 1841)	+	+					+		
Ecdyionurus fluminum EATON, 1887	+								
Ecdyionurus insignis (EATON, 1870)	+								
Ecdyionurus venosus (FABRICIUS, 1775)	+								
Epeorus assimilis EATON, 1885	+						+	+	
Rhithrogena diaphana NAVÁS, 1917									+
Rhithrogena semicolorata (CURTIS, 1834)	+						+	+	
PLECOPTERA TAENIOPTERYGIDAE *Brachiptera risi* (MORTON,1896)								+	
Brachyptera seticornis (KLAPÁLEK, 1902)	+								
Rhabdiopteryx alpina KUEHTREIBER, 1934	+								
Taeniopterix sp	+								
LEUCTRIDAE *Leuctra carpathica* KIS, *1966*	+								
Leuctra fusca LINNAEUS, *1758*	+	+	+	+	+	+		+	+
Leuctra inermis KEMPNEY, *1899*		+							
Leuctra mortoni KEMPNEY, 1899	+								
Nemoura cinerea RETZIUS, *1783*	+	+							
CAPNIDAE *Capnia vidua (KLAPÁLEK, 1904)*	+								
CHLOROPERLIDAE *Chloroperla kisi* KIS, *1966*	+								
TRICHOPTERA Hydropsychidae *Hydropsyhe* sp.	+								
HYDROPTILLIDAE *Hydroptilla* sp.			+						
RHYACOPHILIDAE *Rhyacophila laevis* PICTECTETI 1834									+
Rhyacophila obliterata MCLACHLAN, 1865	+	+							

TAXA	1	2	3	4	5	6	7	8	9
Rhyacophila tristis PICTET, 1834					+	+	+	+	+
Agapetus sp.	+								
Drusus sp.		+							
POLYCENTROPIDAE *Polycentropus sp.*	+								
GOËRIDAE *Goera* sp.	+		+						
Silo sp.			+						
LIMNEPHILIDAE *Chaetopteryx polonica* DZIĘDZIELEWICZ, 1889	+	+							
Limnephilus decipiens (KOLENATI, 1848)									+
Limnephilus sp.	+		+	+					
SERICOSTOMATIDAE *Sericostoma* sp.	+								
LEPTOCERIDAE *Mystacides* sp.	+								
DIPTERA CULICDAE Culex sp	+								
SIMULIIDAE *Simulium reptans* (LINNAEUS, 1758)	+	+							
PSYCHODIDAE *Pericoma canescens* (MEIGEN, 1804)	+	+							
CHIRONOMIDAE *Ablabesmyia longistyla* FITTKAU, 1962			+	+		+			
Ablabesmyia monilis (LINNAEUS, 1758)	+		+	+		+		+	
Ablabesmyia phatta **(**EGGER**,**1863)						+			
Brillia bifida (KIEFFER, 1909)	+		+						
Brillia longifurca KIEFFER, 1921	+								
Cladotanytarsus mancus (WALKER, 1856)	+	+	+			+		+	
Conchapelopia pallidula **(**MEIGEN, 1818)		+	+			+			
Corynoneura celeripes WINNERTZ, 1852	+					+			
Corynoneura scutelata WINNERTZ, 1846	+		+			+			
Cricotopus algarum **(**KIEFFER**,** 1911)	+		+					+	
Cricotopus curtus Hirvenoja, 1973		+							
Cricotopus flavocinctus (KIEFFER, 1924)		+							
Cricotopus fuscus (KIEFFER**,** 1909)	+	+				+			
Cricotopus tibialis (MEIGEN, 1804)	+		+						
Cricotopus tremulus (LINNAEUS**,** 1758)	+					+			
Cricotopus triannulatus MACQUART**,** 1826		+				+			
Cricotopus ***vierriensis*** GOETGHEBUER**,**1935		+	+			+			
Diamesa insignipes *Kieffer in Kieffer and* THIENEMANN*, 1906*					+	+			
Diamesa tonsa (WALKER,1856)	+					+			
Dicrotendipes nervosus (STAEGER**,** 1839)						+			
Epoicladius flavens (MALLOCH**,** 1915)	+								
Eukiefferiella brevicalcar (KIEFFER**,** 1911)	+	+				+			
Eukiefferiella clypeata (KIEFFER**,** 1923)	+	+			+	+			
Eukiefferiella gracei (EDWARDS, 1929)	+		+			+			
Heleniella ornaticollis (EDWARDS, 1929)						+			
Lauterborniella agrayloides (KIEFFER, 1911)				+					
Limnophyes minimus (MEIGEN, 1818)	+	+				+			
Limnophyes prolongatus (KIEFFER IN THIENEMANN, 1921)			+						
Macropelopia nebulosa (MEIGEN, 1804)					+				
Mesosmittia flexuella (EDWARDS, 1929)									+
Metriocnemus fuscipes (MEIGEN, 1818)									+
Metriocnemus hygropetricus KIEFFER, 1912		+			+				
Micropsectra curvicornis CHERNOVSCKI, 1949		+	+						
Micropsectra junci (MEIGEN, 1818)	+	+	+			+	+		
Micropsectra lobatifrons BOTNARIUC ET CURE, 1956			+						
Microtendipes tarsalis (WALKER, 1856)		+		+					
Nanocladius bicolor (ZETTERSTEDT, 1838)		+							
Neozavrelia luteola (GOETGH. *in* GOETGH. & THIENEM, 1941)		+		+					
Nilotanypus dubius (MEIGEN, 1804)	+	+			+				
Orthocladius rivicola KIEFFER, 1921	+	+							
Orthocladius saxicola KIEFFER, 1911		+	+						
Paracladius alpicola (ZETTERSTEDT, 1850)				+					+
Paraorthocladius rufiventris (MEIGEN, 1830)					+				
Paraphaenocladius impensus (WALKER, 1856)									+
Paratanytarsus bituberculatus (EDWARDS, 1929)									+
Paratanytarsus austriacus (KIEFFER in ALBRECHT,1924)		+							
Paratanytarsus penicillatus (GOETGHEBUER, 1928)									+
PolypedilumTripodura aegiptium KIEFFER, 1925									+

TAXA	1	2	3	4	5	6	7	8	9
Potthastia longimana(KIEFFER, 1922)		+							
Prodiamesa olivacea (MEIGEN, 1818)		+			+	+	+		
Psectrocladius calcaratus (EDWARDS, 1929)	+			+					
Psectrocladius octomaculatus WÜLKER, 1956	+			+					
Psectrocladius psilopterus KIEFFER IN KIEFF. &THIENEN, 1906	+								
Psectrotanypus varius (FABRICIUS,1787)			+	+					
Pseudodiamesa branickii (NOWICKI, 1873)	+								
Pseudodiamesa nivosa (GOETGHEBUER, 1928)	+	+				+			
Rheosmittia spinicornis (BRUNDIN, 1956)				+					
Rheotanytarsus nigricauda FITTKAU, 1960						+			
Stempellina bausei (KIEFFER, 1911)									+
Stempelinella brevis (EDWARDS, 1929)				+		+			
Tanytarsus curticornis KIEFFER, 1911						+			
Tanipus punctipennis MEIGEN, 1818	+			+					
Tanypus vilipennis (KIEFFER, 1918)									+
Thienemanniella clavicornis (KIEFFER, 1911)	+			+					
Tienemannimyia lentiginosa (FRIES, 1823)		+			+	+			
Tienemannimyia geijeskesi (GOERTGHEBUER, 1934)				+					
Tvetenia bavarica (GOETGHEBUER, 1934)	+					+			
Tvetenia verralli (EDWARDS, 1929)	+					+			
Zavrelemyia melanura (MEIGEN, 1804)			+	+		+			
TABANIDAE *Tabanus* sp.		+							
RHAGIONIDAE *Atherix variegata*			+						

Referring to the level of representation of the significant species for the conservation status, we listed in decreasing order the following data records: 64 species in Bârsa Tămaşului River, 40 in Bârsa Mare River, 33 species in Curmătura River, 28 species in Bârsa Mare Pond, 20 species in Dâmbovița River, 19 species in Râul Mare al Zărneştilor, 12 species in Vlăduşca and Dâmbovicioara River, at Dâmbovicioarei Gorges, and finally, only 10 species species in Dâmbovicioara River, at Brusturet Gorges.

It can be observed from table no. 1, that the first three stations have the highest diversity.

We consider that all the 9 analyzed aquatic ecosystems are:

- representative by the invertebrates taxonomical structure;
- permanently or almost permanently in aquatic status, a most important quality in the context of geological condition from the Piatra Craiului Massif, where the limestone substrate are preponderantly;
- easy accessible, implicitly representing a large opportunity for monitoring activity.

Consideration on some aquatic ecosystem monitoring from Piatra Craiului National Park

The Directive of the Parliament and European Council and the *Law no 310/06.28.2004 for the modification and completion of the Law of waters no 107/1996* are important elements in establishing the legislative framework for considering water "*a natural patrimony which has to be preserved, treated and protected as such*".

Also these documents include the *benthic invertebrates' fauna* as one of the four estimation criteria for the ecological state of the rivers, alongside phytoplankton, macrophytes and phytobenthos, and ichthyofauna.

The using of biological indexes has to follow some complex studies, developed along several years, and which can present a real evaluation, usable in establishing the management and integrated monitoring plan.

The many taxa of invertebrate fauna offer an important source for monitoring testing in the ecosystem quality evaluation. So, the benthonic invertebrates represent correct and adequate criteria in establishing the global quality of the aquatic surface ecosystem, being in the same time, easy to use.

From the European Biological Index applied by the European Community we selected the one, which is best fitted with the biotic component of aquatic ecosystems from Romania, being in the same time very accessible.

The one selected is the Biological Monitoring Working Party Score (BMWP*)*. This biotic index is created and was initially standardized for the evaluation of the quality of the national network of flowing waters from the United Kingdom (Armitage, P.D., D. Moss, J.F. Wright & M.T. Furse, 1983, Wright, J.F., D. Moss, P.D. Armitage, M.T. Furse 1984). Later this index was adapted and standardized in Spain (Alba-Tercedor 1992 – cited by Alba-Tercedor, 2000).

For each taxon of "family" level a score between 1 and 10 is given (according to the sensibility of the respective taxon to pollution). Plecopterans, some ephemeropterans, trichopterans, dipterans, known to be the most sensitive to pollution (especially to the organic one) get the highest score (10). The more tolerant organisms to pollution, as the oligochaetes and chironomids, culicids, thaumaleids get the lowest score (1, respectively 2).

The score of each identified family is summed up and according to the total value of the BMWP' biotic index the quality class is established.

Briefly, we can observe, after summarizing the value of the taxa, the following:

- the three ecosystems, Bârsa Tămaşului River, Bârsa Mare River and Bârsa Mare Pond are corresponding, after BMWP, to the Ist class of quality, scoring 270, 151 and 106 points;

- three ecosystems, Curmătura River, Dâmbovicioara River – Brusturet Gorges and Dâmbovița River are corresponding, after BMWP, to the II[nd] class of quality, scoring 87, 81 and 65 points;
- the three ecosystems, Râul Mare al Zărneştilor, Vlăduşca River and Dâmbovicioara River –Dâmbovicioara Gorges are corresponding, after BMWP, to the III[rd] class of quality, scoring 58, 49 and respectively 40 points.

Sampling station	Râul Bârsa Tămaşului	Râul Bârsa Mare	Balta Bârsa Mare	Râul Mare al Zărneştilor	Râul Vlăduşca	Râul Curmătura	Râul Dâmbovicioara – Cheile Brusturetului	Râul Dâmbovicioara – Cheile Dâmbovicioarei	Râul Dâmbovița
	1	2	3	4	5	6	7	8	9
Score	270	151	106	58	40	87	49	65	81

The same observation is true for some dipteran families, different evaluated.

It must be mentioned that this system can not reflect the real situation entirely, for example, it is known that in the chironomids case many very sensitive species exist, which can be used as indicators for oligotrophic ecosystems, but by applying the BMWP, the whole family is evaluated at only 2 points. But, the ecological plasticity of the majority of species in this family, and the great difficulty of species identification, can lead to the confirmation of BMWP.

The monitoring activity must be based on efficient and accessible methodology. However, we consider that it is appropriate to be developed only by expert teams. Aquatic ecosystems are influenced by anthropic pressure, like the forestry activities, uncontrolled tourism.

Recommendations

Biological indexes represent indispensable tools for the integrated monitoring.

The using of biological indexes is useful during the monitoring of the quality of all the aquatic ecosystems.

The using of biological indexes has to follow some complex studies, developed along several years, and which can present a real evaluation, usable in the establishing of the management and integrated monitoring plan.

More specific:

- benthic invertebrates are generally abundant, sedentary and have a relative long life cycle; therefore they can be used as indicators for a longer period of time;
- being heterogeneous, zoobenthic communities offer the chance that at least one or several groups of organisms to be sensitive to the changes of the aquatic environment;
- excepting large rivers, biological samples can be taken without difficulties.

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*** International Laws and Resolutions Romanian Environmental Laws

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