Biharean Biologist (2010)
P-ISSN: 1843-5637, E-ISSN: 2065-1155

Vol. 4, No.2, Pp.: 109-119
Article No.: 041114

Using macrozoobenthic invertebrates to asses the quality of some aquatic habitats from Jiului Gorge National Park (Gorj County, Romania)

Diana CUPŞA[1,*], Severus Daniel COVACIU-MARCOV[1], Felicia SUCEA[2] and Ramona HERCUŢ[1]

1. University of Oradea, Faculty of Sciences, Department of Biology, Universitatii str.1, Oradea 410087, Romania.
2. "Jiului Gorge National Park", Lt. Col. Dumitru Petrescu, Târgu-Jiu, Romania
* Corresponding author, D. Cupsa, E-mail: dcupsa@uoradea.ro

Abstract. In the present paper our aim was to investigate community structure of macrozoobenthic invertebrates from the main rivers on the territory of Jiu Gorge National Park. The investigated watercourses are direct tributaries of Jiu River, and a sample site was located on the Jiu River. The number of investigated stations was 11. Biological samples were collected from each site, were sorted, the component taxa and densities were determined, abundance of each taxa, and diversity and evenness in each sample site. The water quality was determined using as an indicator the macrozoobenthic community by calculating IBGN (the Global Normalised Biotic Index). It was noted that some investigated habitats have a well shaped and diverse macrozoobenthic community, while others were subjected to human impact. These have especially a low diversity and are low in number of species and even individuals. In terms of water quality, it is good at two sites, average at seven sites, weak in one sample site and also very weak in one sample site.

Key words: macrozoobentic invertebrates, aquatic habitats, quality, diversity, IBGN, protected area, Romania.

Introduction

Macrozoobenthic invertebrates are constant elements present in natural waters, their specific composition is an important element in assessing the quality of water (Andriev et al. 2008). Benthic community taxa components suffer variations depending on the geographic elevation, substrate type, oxygen content, organic load, chemical pollution, etc. Macrozoobenthic species react to changes in water quality and their analysis is one of the most important methods for monitoring changes in water quality parameters.

Studies on the composition of the macrozoobenthic invertebrates are numerous in different rivers of Transylvania (Cupşa 1997, Cupşa et al. 2002, 2003a,b, 2009, Cupşa & Vaida 2005, Cupşa & Banyai 2006, Curtean-Bănăduc 2005, Popescu-Marinescu & Elian-Tălău 1980, Robert & Curtean-Bănăduc 2005, Rogoz 1969, Szito 1995, Szito & Mozes 1997, 1999), but the territory of Jiu Gorge National Park were not made until now.

In the park were conducted ground surveys of flora and fauna both before its designation as a protected area (Petrescu et al. 2004, Tudor et al. 2004, Stoiculescu et al. 2005, Iftimie 2005) as well as after (Dobre et al. 2007, Covaciu-Marcov et al. 2009).

The aim of this study is to make an inventory of species belonging to macrozoobenthic invertebrates from main rivers of Jiu Gorge National Park and to assess the quality of water based on invertebrate biomarkers group, considering that the study area, although protected suffers from a significant human impact.

Materials and methods

The research was conducted in June of 2009, when we investigated a total of 11 habitats located on direct tributaries or even the Jiu River, from Jiu Gorge National Park territory.

The samples were collected with a Surber net and fixed on the field with 4% formalin. The organisms were selected in a laboratory under a 40X stereo microscope, submerged in 70% ethylic alcohol, followed by their identification and taxonomic classification (Petrescu 2002, Aubert 1959, Ujvarosi 2002 Waringer & Graf 1997) and by the statistic interpretation of the results, after measuring: the abundance, the Margalef index (D_1), the Simpson index (I), the Shannon-Wiener index (H), the evenness index (E) (Burcă 2004, Sârbu & Benedek 2004). To establish the water quality IBGN index was used. In order to establish the conclusions, corresponding graphic representations were made.

The study area

The Jiu Gorge National Park is located in South-Western Romania, in the Southern Carpathians. It has a surface about

©Biharean Biologist, Oradea, Romania, 2010

11.127 Ha. The Jiu River flows through the centre of the park from North to the South. West to the park are the Vâlcan Mountains and to the East the Parâng Massif (Posea & Badea, 1984). The lenght of the Jiu Gorge is about 30 km. The altitude in the park varies between 300 m, in the southern area near the town of Bumbeşti Jiu (300m a.s.l.) and the maximum altitude is around 1400-1500 m a.s.l. Along the Jiu River is present the 66 National Road and parallel to this the 202 railroad, a simple electrified line, with 4 train stations within the park boundaries. In the park there are several tributaries of the Jiu River, the most important are the Chitul and the Bratcu.

Biological samples were collected from 11 sampling stations located in the Jiu and its main tributaries of the park territory as follows:

1. Gambrinus Alt = 654 m, 45^{0}21'07'' N, 23^{0}22'37'' E. A creek right side tributary of the Jiu located in the northern area of the park. In the sample region it passes through a deciduous forest, so the riverbed is almost permanently and totally overshadowed. The riverbed is very shallow, covered with rocks and very rich in allochthonous plant debris, leaves from surrounding trees. The water depth is very small about 10 cm, flow undergoing large variations depending on precipitation.

2. Strâmbuţa Alt = 558 m, 45^0 20'43'' N, 23^{0}22'56'' E. is a left hand tributary of the Jiu River in the northern region of the park. The creek crosses a forest area, which overshadows the riverbed. The banks are high, the riverbed is covered with boulders and large slabs of stone. The riverbed width is up to 4-5 m, the depth is generally low, and there are over one meter deep whirlwinds. The water flow is turbulent.

3. Polătişte Alt = 614 m, 45^{0}20'11'' N, 23^{0}23'12''E. River is a left side tributary of the Jiu in the northern part of the park, crossing a forest area in the Parang Mountains. The riverbed is 5-7 m wide, water depth of 50 cm. Riverbed is covered with rocks and boulders.

4. Valea Porcului Alt = 556 m, 45^{0}17'43'' N, 23^{0}23'10'' E. It is a stream that constantly flows across a beech forest. The riverbed depth is about 30 cm, covered with stones. The banks have an abundant grassy vegetation.

5. Chitu Alt = 512 m, 45^{0}15'51'' N, 23^{0}24'11'' E. Is a left side tributary of the Jiu River in the central portion of the park. The creek crosses a forest area, has deep sides and turbulent flow. The banks are high, the riverbed is about 3 m wide and 20-30 cm deep. Substrate is covered with boulders and stones.

6. Valea Ursului Alt = 406 m, 45^{0}15'29'' N, 23^{0}23'26'' E. The creek is a tributary to the left side of Jiu in the central portion of the park. Around the flowing in Jiu the riverbed is covered with rocks and boulders. The creek passes through an open area, much of the day being exposed to solar radiation. Along the brook, in the sampling area is a hydrotechnics construction for the sluice of torrents. The riverbed is about 3 m wide and 10-20 cm deep.

7. Bratcu – at quarry Alt = 412 m, 45^{0}13'17'' N, 23^{0}22'06''E. The creek is a right side tributary of the Jiu located in the southern part of the park. The riverbed is narrow, about 4 m of 20-30 cm deep, rocky shores are very high, steep. Substrate is covered with rocks and stones, water is always turbid, because of the suspension from quarry.

8. Bratcu at 1100 m Alt = 1100 m, 45^0 16'22'' N, 23^{0}19'36'' E. It is situated in the mountain area of the brook Bratcu, the substrate is composed of boulders, the flow is rapid, turbulent. The riverbed width is approximately 1 m, the water is clear, the banks are made from sand and gravel. The river passes through a beech forest, which contain patches of planted coniferous trees. Banks have varying heights in the different portions of the creek.

9. Meri ponds Alt = 376 m, 45^{0}13'07'' N, 23^{0}22'25'' E. The sampling station is located on a stream, near the ponds of limestone quarry at Meri. The brook forms small ponds devoid of vegetation, with maximum depth of about 1 m, and with an area of about 30-40 m^2. The stream receives water from the mine with white suspension, but not chemically polluted, as proof that there are stable populations of *Bombina* here. Because of the suspension, the water is constantly turbid.

10. Jiu at Meri Alt = 352 m, 45^{0}12'97'' N, 23^{0}22'42'' E. The station is located in the southern region of the park, on the Jiu River. The banks are covered by trees which overshadow the water. The riverbed width is about 15 m by 1 m water depth in the middle of the bed. Substrate is covered with rocks and boulders, in some places the sides with sand and gravel.

11. Trântoru Alt = 312 m, 45^{0}11'20'' N, 23^{0}23'28'' E. Is a left tributary of the Jiu located in the southernmost part of the park. Sampling station is located in a former lake bed across a deciduous forest. The riverbed is sinuous, with the appearance of a torrent without a very accurate route. Substrate is covered with mud, from place to place, in areas where the water is very low and has an intermittent flow, grows grass land vegetation. The water depth is very small (about 10cm), and the flow is highly variable, consistent with the rainfall.

Results

After collecting samples from the field we identified in the 11 sample sites, a total number of 44 benthic invertebrate taxa most of which are represented by insect larvae. These taxa totalised a number of 2,165 individuals (Table 1).

Considering each sampling site we observed that the highest number of individuals was reported at Chitu, with 390 individuals. Large numbers of individuals have also been reported at the Valea Ursului, Jiu at Meri, Valea Porcului sample sites, Bratcu at quarry and Trântoru where benthic invertebrate density is over 200 (Table 1). Lower densities, less than 100 specimens/m^2, were reported at Polătişte (82), Strâmbuţa (76), Meri Ponds (68) and Gambrinus (57).

The number of taxa varies between 6 and 25 in the sampling sites. The largest number of taxa has been reported at Chitu, followed by Trântoru 19 species, Bratcu at 1100 m 18 species, 17 species at Polătişte and Strâmbuţa and at Valea Ursului 15 species. The lowest numbers of species were six at Meri ponds, Bratcu at quarry 10 species and Gambrinus with eight species (Table 1).

In terms of species abundance at Gambrinus we could see that the Ephemeroptera larvae predominate, constituting almost half the community in terms of abundance, followed by Chironomidae larvae with

Table 1. Abundance, number of taxa and of the individuals in the sample sites.

	Gambrinus	Strambuta	Polatiste	Valea Porcului	Valea Ursului	Chitu	Bratcu at quarry	Bratcu at 1100 m	Meri ponds	Jiu at Meri	Trantoru
Turbelariata											
Dugesia sp.	-	1.32	1.22	1.73	0.93	5.64	-	0.7	-	1.94	3.5
Oligochaeta	7.02	2.63	13.41	0.35	39.51	4.1	2.64	6.34	-	2.9	1.5
Hirudineea	5.26	-	-	-	-	-	-	-	-	0.32	-
Gastropoda											
Ancylus sp.	-	-	-	-	-	-	-	-	-	0.32	-
Radix sp.	-	-	-	-	-	-	-	0.7	80.88	-	-
Bivalvia											
Pisidium sp.	-	-	-	-	-	-	-	-	8.82	-	-
Gamarida	-	-	2.44	60.55	35.8	9.23	-	0.7	-	70.65	19
Ephemeroptera											
Ephemera danica	-	-	-	-	-	0.51	-	-	-	-	-
Epeorus sp.	1.75	1.32	3.66	-	-	2.31	0.88	8.45	-	-	-
Rhithrogena sp.	-	2.63	1.22	-	-	0.26	0.44	1.41	-	-	-
Ecdyonurus sp.	-	3.95	4.88	2.42	1.54	10	-	0.7	-	1.29	5.5
Heptagenia sp.	-	-	-	1.73	-	1.28	-	5.63	-	-	-
Cloeon sp	-	-	-	-	0.31	-	-	-	-	-	-
Baetis sp.	47.37	7.89	12.2	16.96	5.25	25.9	30.84	26.76	-	6.45	3.5
Leptophlebia sp.	-	1.32	-	-	-	-	-	-	1.47	-	1
Ephemerella sp.	-	1.32	-	-	-	0.26	-	-	-	-	0.5
unidentifed Ephemeroptera	-	2.63	1.22	-	-	-	-	-	-	-	-
Ephemeroptera (Total)	49.12	21.05	23.17	21.11	7.1	40.51	32.16	42.96	1.47	7.74	10.5
Odonata											
Aeschnna sp.	-	-	-	-	-	-	-	-	5.88	-	-
Libelula sp.	-	-	-	-	-	-	-	-	1.47	-	-
Plecoptera											
Nemoura sp.	-	-	-	0.69	-	-	-	0.7	-	-	-
Perla marginata	-	17.11	14.63	-	-	0.51	-	-	-	-	5
Perla sp.	-	-	1.22	-	0.93	0.51	-	10.56	-	-	0.5
Perlodes sp.	5.26	-	-	5.54	-	-	-	13.38	-	-	-

Table 1. (Continued)

	Gambrinus	Strambuta	Polatiste	Valea Porcului	Valea Ursului	Chitu	Bratcu at quarry	Bratcu at 1100 m	Meri ponds	Jiu at Meri	Trantoru
Siphonoperla sp.	-	1.32	-	-	1.23	1.28		-	-	-	2.5
Rhabdiopteryx sp.	-	2.63	6.1	-	-	-	-	-	-	-	4.5
Total Plecoptera	5.26	21.05	21.95	6.23	2.16	2.31	0	24.65	0	0	12.5
Coleoptera											
Ditiscidae	-	-	-	-	-	-	-	0.7	-	-	-
Dryops sp.	-	14.47	-	-	-	-	-	-	-	-	-
Dryopidae adults	-	-	-	-	-	0.26	-	-	-	0.32	0.5
Dryopidae larvae	-	-	-	-	-	1.03	0.44	-	-	0.32	0.5
Hydraenidae larvae	-	-	-	-	-	-	-	-	-	-	12
Hygrobiidae	-	-	-	0.35	-	-	-	-	-	-	-
Trichoptera											
Ecnomus sp.	-	-	-	-	-	0.77	-	-	-	-	-
Hydropsiche sp.	3.51	7.89	14.63	2.77	0.62	5.9	5.29	4.93	-	10.32	10
Phylopotamus sp.	-	1.32	3.66	-	-	1.03	-	6.34	-	-	-
Philopotamide	-	-	-	0.35	-	-	-	-	-	-	2
Rhyacophyla sp.	-	-	1.22	-	1.54	2.82	0.88	6.34	-	-	-
Limnephylus sp.	-	-	2.44	-	0.62	4.87	-	2.11	-	0.97	-
unidentified Trichoptera	-	-	-	-	0.31	-	-	-	-	-	-
Total Trichoptera	3.51	9.21	19.51	3.11	3.1	15.38	6.17	19.72	0	11.9	12
Diptera											
Simulidae	-	-	-	-	0.31	-	-	-	-	-	-
Weidemannia onedorum	-	-	-	-	-	0.26	-	-	-	-	-
Brachydentera sp.	-	-	-	-	-	-	-	-	-	-	0.5
Ephydra sp.	-	-	-	-	-	5.9	0.44	-	-	-	-
Ephydridae	5.26	5.26	8.54	1.38	0.31	1.79	0.44	3.52	-	1.94	2
other Brahicerae	-	-	-	-	-	0.51	-	-	-	-	-
Chironomidae	24.56	25	7.32	5.19	10.8	13.08	57.71	-	1.47	2.26	25.5
No. of individuals	57	76	82	289	390	324	227	142	68	310	200
No. of taxa	8	17	17	13	25	15	10	18	6	13	19

24.56%. Very low abundance (less than 10%) has the Trichoptera, Plecoptera larvae and other benthic groups (Table 1).

At Strâmbuța we have recorded the highest abundance of Chironomida (25%), followed by Ephemeroptera (21.05%), Plecoptera (21.05%) and Trichopterans (9.21%) so that these four groups are the most important groups of macrozoobenthic invertebrates at this sample site (Table 1). At Polătişte the greatest abundance was recorded by the Plecoptera (*Perla marginata* 14.63%), and Trichoptera (*Hydropsyche* sp. 14.63%), and the Oligochaeta (13.41%) are also abundant. At Valea Porcului the most abundant group was Gammarida (60.55%), followed by Ephemeroptera, in particular that of the genus *Baëtis* (16.96%).

At Valea Ursului the most abundant were the Oligochaeta (39.51%), followed by Gammarida (35.8%) and Chironomida (10.8%) at the expense of other benthic groups.

At Chitu the greatest was observed for the Ephemeroptera larvae (Leptophlebia 25.9%), followed by Trichopterans (15.38%) and Chironomidae (13.08%). Plecoptera (2.31%) instead have a very small abundance in this station.

For Bratcu at quarry, the community is dominated by the Chironomidae larvae which abundance reached 57.71%, followed by Ephemeroptera (32.16%). Plecoptera are missing in this sampling site and the remaining groups have low abundance.

In the case of Bratcu at 1100 m, located upstream of Bratcu at quarry, the Ephemeroptera are the most abundant, being about half of the total benthic invertebrate groups (42.96%). They are followed by Plecoptera (24.65%) and Trichopterans (19.72%). This station is one where the Chironomidae larvae are missing.

At Meri station, the number of groups is very low, the maximum abundance is reached by the Gastropods (80.88%), followed by Bivalvia (8.82%). The two groups make up about 90% of the benthic community. Plecoptera and Trichoptera are missing from this sampling site.

In Jiu at Meri, the community is dominated by Gammaride constituting 70.65% of the benthic invertebrates, followed by Trichopterans (11.29%) and Ephemeroptera (7.74%). Plecoptera are missing from this station and the rest of the invertebrate groups have low abundance.

The greatest abundance at Trântoru site is reached by Chironomida, 25.5%, followed by Gammarida (19%), Plecoptera (12.5%), Trichopterans (12%) and Ephemeroptera (10.5%).

We have calculated four diversity indices for each of the sampling sites. Shannon-Wiener diversity index ranges between 2.39 and 0.66. Higher values (above 2) have the sites Strâmbuța Polătişte, Chitu and Trântoru. Lowest values of Shannon-Wiener index (under 1) were calculated for stations Bratcu at quarry, Meri ponds and Jiu at Meri (Fig. 1).

Margalef diversity index takes values between 1.18 and 4. The highest values (over 3) were calculated for stations Strâmbuța, Polătişte, Chitu, Bratcu at 1100 m and Trântoru. The sites with the highest values were, except Bratcu at 1100 m, the same as for Shannon-Wiener index (Fig. 1).

The lowest values of Margalef index (between 1 and 2) were calculated for stations Gambrinus, Bratcu at quarry and Meri.

Simpson diversity index has the highest values in stations Strâmbuța, Valea Ursului and Trântoru. The lowest values of the index were calculated at both Bratcu sites (1100 m and quarry) (Fig. 2). Because the values that are recorded by Simpson index, which vary in a wide range of values, we also used Simpson inverted index calculation, which variation is between 0 and 1 and can be easily followed to interpret. As the value of the Simpson inverted index is closer to one, the diversity is lower and as the value is closer to 0 the diversity is greater (Fig. 1).

The evenness index has in most sampling sites high values (above 0.7), namely Gambrinus, Strâmbuța Polătişte, Chitu, Bratcu at 1100 m, Trântoru (Fig. 3). The lowest values of the evenness were calculated for Bratcu at quarry, Meri (Fig. 3).

After determining the values IBGN (Normalised Global Biotic Index) in the sampling stations it has been found that there is no water with very high purity, characterized as excellent and represented conventionally in blue (Fig. 4). We reported good water quality, represented conventionally by green, on Trântoru and Chitu streams. This category is followed by the average water quality in seven of the 11 stations (Fig. 4). Poor quality waters are those of Jiu (IBGN 5) and very poor water quality, high-polluted are Meri at ponds (IBGN 1).

Discussions

Analyzing the relationship between the number of individuals and species at each station we found that Chitu meets both the highest number of species and highest number of individuals, reflecting a clean water with good conditions for development of benthic communities. In Valea Ursului, which is second by the density of individuals, number of species is only 15

since nearby the sample site the creek is affected by anthropogenic hydro-technical works to prevent erosion caused by torrents. The affected part by hydro-technical work, made from concrete and thus interrupting the stream's longitudinal continuum, makes impossible the communication of benthic fauna in the upstream direction. High density of community in this place is due to development of large population of Gammaride and the community structure has a great similarity with the Jiu sample site (Table 1), which is in communication with Valea Ursului.

At Polătişte and Strâmbuţa sites the number of spe-

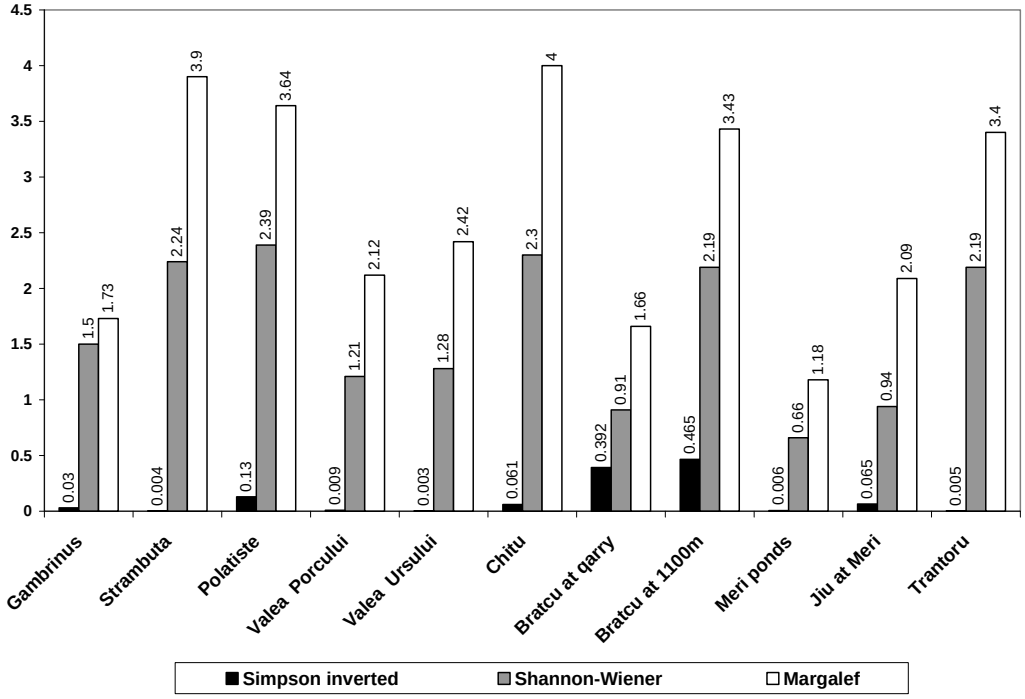

Figure 1. The values of the diversity indexes Shannon-Wiener, Simpson inverted and Margalef in the sampling sites.

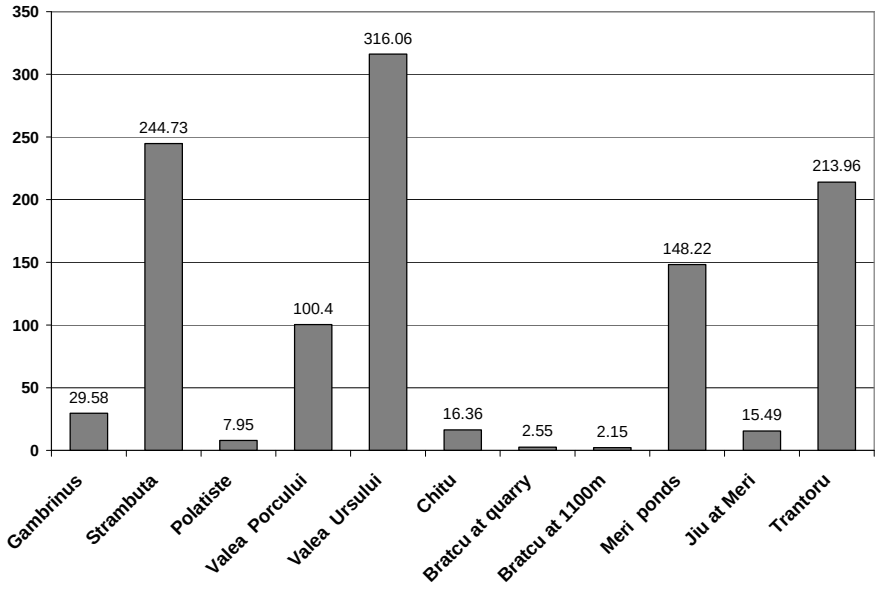

Figure 2. The values of the Simpson diversity index in the sampling sites.

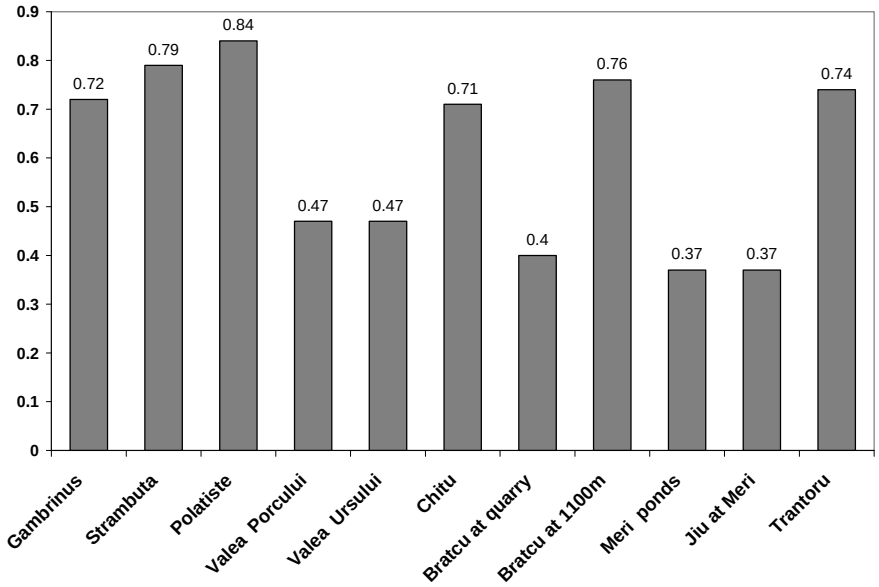

Figure 3. The values of the evenness in the sampling sites.

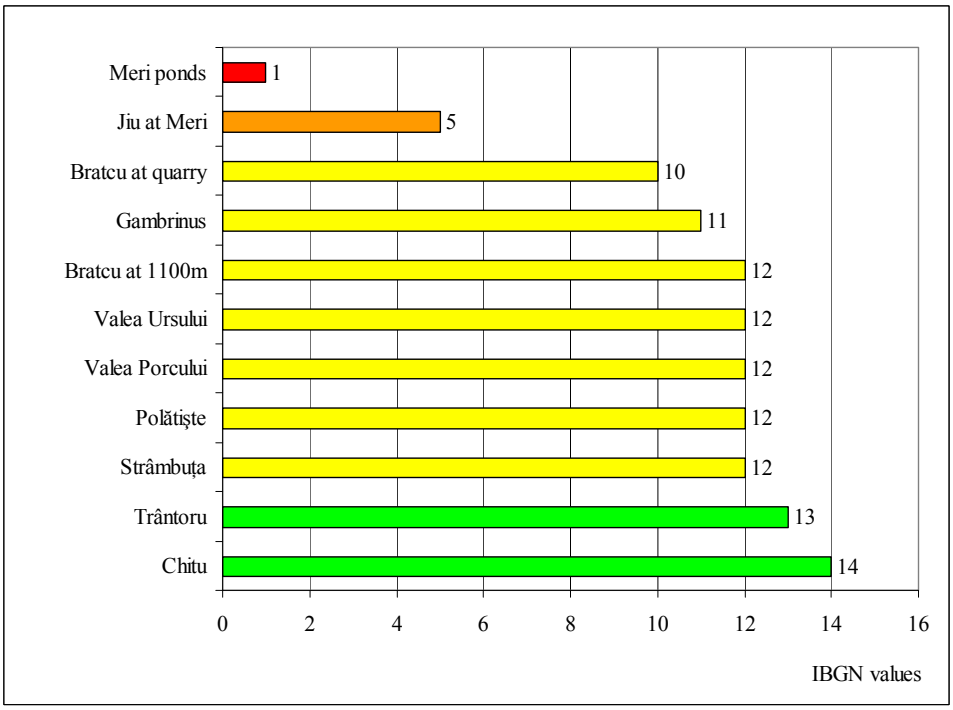

Figure 4. The value of the IBGN in the sampling sites.

cies is relatively high (17), but the number of individuals is low (76 and respectively 82). This is due to the hydrological characteristics of the two streams, crossing a mountain course, eventful, the substrate of the riverbed is covered with boulders and large stones, on which is hard to install for the benthic community, due to high speed water flow and lack of an appropriate feeding substrate. Therefore here we find only rheofile species with low densities, which can handle strong water current.

At Meri in the ponds both species number and density of individuals is low, because of the permanent suspensions in the water in this sector. These suspensions are limiting the development of the branhiate

organisms which are primarily affected by the action of this factor and are hindered in the process of breathing (Zivic 2009). Therefore we can see that here there are present, especially different groups of insect larvae and gastropods which are breathing the atmospheric oxygen (Table 1).

The great abundance of Ephemeroptera and Chironomida at Gambrinus together with the low abundance of the Trichoptera, Plecoptera and other benthic groups is due to specific feature of the riverbed, which is very low, so the track undergoes many changes and many sections remain mostly dry in drought periods. Besides being in the middle of a forest the riverbed is very rich in allochthonous detritus, from the foliage of trees. These phenomena favour the installation of the Chironomida as high organic content indicator and disadvantage the Trichoptera and Plecoptera which are oxyfile and rheofile.

At Strâmbuţa station the Chironomide are installed in places where water flow is smoother and accumulate debris, the Ephemeroptera, Trichoptera and Plecoptera are represented by an important proportion in the community in places where water is fast flowing and well oxygenated (Celik 2002).

At Polătişte the high abundance of Plecoptera together with Trichoptera is characteristic to mountain streams with clean water and rapid flow. The abundant Oligochaeta from this site are from Naidide family which are present in higher rates in clean water.

At Valea Porcului the high abundance of Gammarida is due to slower water flow and development bioderm on the substrate, which stimulates the installation of Gammarida populations and concomitant decrease the abundance of Plecoptera and Trichoptera, which are rheofile (Ailenei 2005, Duran 2007, Fleituch 2003, Petrescu 2002).

At Valea Ursului the high abundance of Oligochaeta, Chironomida and Gammarida indicate a degradation of water quality due to hydraulic works, in this case upstream of the sampling point (Compin & Céréghino 2003, Cooksey & Hyland 2007, Dobre & Tatole 2000).

Chitu site contains both the highest number of species and taxa but the very low abundance of Plecoptera indicates an organic content which exceeds the capacity of this group to install in mass. The high organic content comes from allochthonous detritus made from the leaves of trees that surround the river banks.

The community from Bratcu at quarry is dominated by Chironomidae followed by Ephemeroptera larvae. But Plecoptera are missing from this sampling site, where the water is always turbid due to suspensions from the limestone quarry, suspension which prevents breathing of the Plecoptera. Ephemeroptera easier bear the human impact and Chironomidae have plenty of organic matter with which to feed (Stefanovic 2009).

Bratcu at 1100 m is located at the highest altitude, in the mountain region. Here the stream flow characteristics and abundance determine the absence of the Chironomida and the great abundance of Ephemeroptera, Plecoptera and Trichoptera. There is a typical mountain community in this station (Stefanovic 2009, Găldean 2002, Petrovich & Tudorancea 2000).

At Meri station, the number of groups is extremely small, Plecoptera and Trichoptera missing due to suspensions that are constantly in water and their gill breathing being impossible. At this station there are present predominantly species which breathe atmospheric oxygen or those that are not sensitive to the presence of the suspensions in the water table (Chiriac & Udrescu 1965, Gage et al. 2004).

In Jiu, the installation of Gamaridae is favoured by a slower flow than in the tributary streams, greater stability of the flow and more intense development of bioderm. These features eliminate the Plecoptera benthic community (Florea & Grigoraş 2000).

At the station Trântoru, the benthic structure is given by the characteristics of the riverbed which is located in a former lake bed across a deciduous forest. The riverbed is sinuous, with the appearance of a torrent without a very accurately route. The substrate is covered with mud, from place to place in areas where water is very low and flows intermittent grass land vegetation grows. Following the high water organic load, it stimulates the development of Chironomida and Gammarida, but the cold water with a high content of oxygen allows installation of Plecoptera, Trichoptera and Ephemeroptera (Ribeiro & Uieda 2005, Nitu & Decu 2002).

Shannon-Wiener diversity index has the highest values at Strâmbuţa, Polătişte, Chitu and Trântoru. These stations have the greatest number of species of all sampling points, which is a prerequisite for a high diversity. The lowest values of Shannon-Wiener index were calculated for stations Bratcu quarry, Meri pond and Jiu at Meri. These stations are the most affected in terms of environmental conditions, the first two due to permanent suspension from nearby quarries. Low diversity reported in Jiu is due to influx of polluted water from nearby quarries and coal mines. In addition to Jiu flows there are a series of sewage waters which rise the organic charge in the substrate.

Margalef diversity index has the highest values in stations Strâmbuţa, Polătişte, Chitu, Bratcu at 1100 m and Trântoru. This index reflects the individuals and species' richness in a site, so it has high values in those stations in which both species and the number of individuals is high, although the proportion of indivi-

duals of different species is very small. Greater importance in enhancing the value of this index has a large number of species in detriment of the large number of individuals (Table 1). The lowest values of Margalef index were calculated for stations Gambrinus, Bratcu quarry and Meri, areas affected by the presence of suspension in water, characterized by a very low riverbed, shallow water and flow variations (Baptista et al. 2001).

Simpson diversity index has highest values in stations Strâmbuța, Valea Ursului and Trântoru. These are stations with great numbers of species and individuals in which no single group of benthic invertebrates is dominant, but this increased abundance is shared by several groups. Lowest values of the index were calculated at both sites on Bratcu creek. These are stations where we have observed one group that dominates the community through increased abundance (Chironomide – in case of Bratcu at quarry) by 2-3 high abundance groups respectively, while the remaining groups have a very low abundance.

Evenness records, in most sampling stations, great values due both to high biodiversity in these stations, and abundance of values close to those stations with high evenness.

The great diversity and evenness was observed in those stations where the environment is less affected and are created the prerequisites for the settlement of a stable community of benthic invertebrates, which themselves help to ensure a good quality of water (Callisto et al. 2001, 2004, Vidinskiene 2005).

IBGN values indicate good quality water just for the Chitu and Trântoru, followed by water with average quality in seven stations. The large proportion of this category of waters indicates an anthropogenic impact which determines changes of substrate or of flow regime, chemistry or organic load (Kazanci & Dugel 2000).

Poor quality waters are those of Jiu, due mainly to the influx of water from quarries and mines, but the domestic pollution and high anthropogenic pressure, represented by the existence of road and railway that winds along the waters of Jiu throughout the gorge, should not be neglected.

We found very poor water quality, high-polluted at Meri, mainly derived from suspension which came from the quarry. However, the macrozoobenthic community structure and lack of the poisonous chemical pollutants in the water, creates the premise for their quality soon return, if the effluent would stop.

General state of water for the tributaries of Jiu on the Jiu Gorge National Park territory is good, but because of strong human influence in the region (mining, road and rail traffic, many towns and tourist attractions) it is affected to a greater extent than we have expected for this water category and in this altitudinal area (Simic & Simic 2002).

Just Jiu water and the creek crossing area of Meri career ponds are strongly affected because it is collecting all types of pollutants.

Benthic community structure in the analyzed waters indicates the installation of groups of indicator organisms for good quality, since in some waters they are present in a minimum number of individuals, and where they are missing, they can repopulate these streams because they communicate among themselves (Principe et al. 2007, Tullos & Neumann 2006).

References

Ailenei, C. (2005): Data regarding the diversity of Caddish flies (Insecta, Trichoptera) from the Bistrița River middle basin. Analele Ştiinţifice ale Universitatii "Al.I.Cuza" Iaşi, s. Biologie Animală 51: 85-89.

Andriev, S., Harus, L., Stoica, I., Ştefan, A. (2008): Quality evaluation of the water of Nicolina River based on aquatic macroinvertebrate fauna. Analele Ştiinţifice ale Universitatii "Al. I. Cuza" Iaşi, s. Biologie Animală 54: 163-168.

Aubert, J. (1959): Plecoptera. Insecta Helvetica (Fauna) 1: 1-140.

Baptista, D.F., Buss, D.F., Dorville, L.F.M., Nessimian, J.L. (2001): Diversity and habitat preference of aquatic insects along the longitudinal gradient of the Macae River basin. Rio de Janeiro, Brazil. Revista Brasiliera de Biologia 61(2): 249-258.

Callisto, M., Moreno, O.P., Barbosa, F.A.R. (2001): Habitat diversity and benthic functional trophic groups at Sierra do Cipo, Southeast Brasil. Revista Brasiliera de Biologia 61(2): 239-266.

Callisto, M., Goulart, M., Medeiros, A.O., Moreno, P., Rosa, C.A. (2004): Diversity assessment of benthic macroinvertebrates, yeast and microbiological indicators along a longitudinal gradient in Serra Do Cipo, Brasil. Brazilian Journal of Biology 64(4): 743-755.

Celik, K. (2002): Community structure of macrozoobenthos of a Southeast Texas Sand-Pit Lake related to water temperature, pH and dissolved oxygen concentration. Turkish Journal of Zoology 26: 333-339.

Chiriac, E., Udrescu M. (1965): Ghidul naturalistului în lumea apelor dulci. Editura Ştiinţifică, Bucharest. [in Romanian]

Compin, A., Céréghino, R. (2003): Sensitivity of aquatic insect species richness to disturbance in the Adour–Garonne stream system (France). Ecological Indicators 3(2): 135-142.

Cooksey, C., Hyland, J. (2007): Sediment quality of the Lower St. Jones River, Florida: An integrative assessment of benthic fauna, sediment-associated stressors, and general habitat characteristics. Marine Pollution Bulletin 54: 9-21.

Covaciu-Marcov, S.D., Cicort-Lucaciu, A.Ş., Dobre, F., Ferenti, S., Birceanu, M., Mihuţ, R., Strugariu, A. (2009): The herpetofauna of the Jiului Gorge National Park, Romania. North-Western Journal of Zoology 5(Suppl 1): S01-S78.

Cupşa, D. (1997): Aspecte privind compoziţia specifică a faunei bentonice din bazinul superior al Crişului Negru. Analele Universitatii din Oradea, fasc. Biologie 4: 56-63. [in Romanian]

Cupşa, D., Telcean, I.C., Caiser, D. (2002): Contribuţii la studiul faunei de nevertebrate bentonice din lacul şi râul Peţea (jud.

Bihor). Nymphaea, Folia Naturae Bihariae 29: 101-116. [in Romanian]

Cupşa, D., Covaciu-Marcov, S.D., Telcean, I., Banyai, G. (2003a): Studii privind structura comunităţilor de nevertebrate macrozoobentice din bazinul râului Nucsorul (Muntii Retezat, judetul Hunedoara). Analele Universităţii din Oradea, Fasc. Biologie 10: 181-189. [in Romanian]

Cupşa, D., Covaciu-Marcov, S.D., Telcean, I., Tobias, E. (2003b): Aspecte privind dinamica lunară a comunităţilor de nevertebrate macrozoobentice din zona termală Mădăras. Analele Universitatii din Oradea, Fasc. Biologie 10: 171-180. [in Romanian]

Cupşa D., Vaida, D. (2005): Some aspects of the distribution and dynamics of the benthic macroinvertebrate groups from Nimăieşti Valley river. Scientific Annals of the Danube Delta Institute for Research and Development (Tulcea, Romania) 11: 9-15.

Cupşa, D., Banyai, G. (2006): Contributions on the Study of the Macrozoobenthic Invertebrates from the Glacial Lakes of the Lăpuşnicu Mare River Basin (Retezat Mountains, Romania). pp. 101-116. In: Bănăduc, D., Sirbu, I., Curtean-Bănăduc, A. (eds) Transylvanian Review of Systematical and Ecological Research 3, "The Retezat National Park", Sibiu, Romania.

Cupşa, D., Birkas, M., Telcean, I. (2009): Studies upon the structure and dynamics of the benthic macroinvertebrate communities from two habitats of The Ier River's Channel (Bihor county, Romania). Biharean Biologist 3(1): 59-70.

Curtean-Bănăduc, A. (2005): Study regarding Târnava Mare and Târnava Mică rivers (Transylvania, Romania) stonefly (Insecta, Plecoptera) larvae communities. pp. 75-84. In: Curtean-Bănăduc, A., Bănăduc, D., Sirbu, I. (eds): Transylvanian Review of Systematical and Ecological Research 2, "The Târnava River Basin", Sibiu, Romania.

Dobre, F., Bucur, D. M., Mihuţ, R., Birceanu, M., Gale, O. (2007): Date asupra compoziţiei hranei a unei populaţii de *Triturus cristatus* (Laur. 1768) din Parcul Naţional Defileul Jiului, România. Biharean Biologist 1: 23-28. [in Romanian]

Dobre, A., Tatole, V. (2000): Some considerations regarding the impact of Cerna-Belareca hydropower harnessing on aquatic invertebrata fauna. Acta Oecologica, Studii şi Comunicări de Ecologie şi Protecţia Mediului 7(1-2): 111-117.

Duran, M. (2007): Life Cycle of *Gammarus pulex* (L.) in the River Yeşilirmak. Turkish Journal of Zoology 31: 389-394.

Fleituch, T. (2003): Structure and functional organisation of benthic invertebrates in a regulated stream. International Review Hydrobiology 88(3-4): 332-344.

Florea, L., Grigoraş, G. (2000): Considerations regarding the zoobenthos of the lower corse of Prut (second note). Studii şi Cercetări Ştiinţifice, Universitatea Bacău, seria Biologie 5: 207-210.

Gage, M.S., Spivak, A., Paradise, C.J. (2004): Effects of Land Use and Disturbance on Benthic Insects in Headwater Streams Draining Small Watersheds North of Charlotte, NC. Southeastern Naturalist 3(2): 345-358.

Găldean, N. (2002): Ordo. Ephemeroptera, Efemere. pp. 483-493. In: Godeanu, S.P. (ed.): Diversitatea lumii vii. Vol. 2, Part. 2. Editura Ştiinţifică şi Enciclopedică, Bucharest. [in Romanian]

Iftime, A. (2005): Reptilia (Reptile) pp. 173-198 / Amphibia (Amfibieni) pp.197-214. In: Botnariuc N., Tatole V. (eds.): Cartea roşie a Vertebratelor din România. Ed. Academiei Române, Bucharest. [in Romanian]

Kazanci, N., Dugel, M. (2000): An evaluation of the water quality of Yuvarlakcay Stream, in the Koycegiz-Daylan Protected Area, SW Turkey. Turkish Journal of Zoology 24: 69-80.

Nitu, E., Decu, I. (2002): Ordo Coleoptera, Gândaci, pp. 552-571. In: Godeanu, S.P. (ed.): Diversitatea lumii vii. Vol. 2, Part. 2. Editura Ştiinţifică şi Enciclopedică, Bucharest. [in Romanian]

Petrescu, I. (2002): Ordo. Amphipoda (Specii dulcicole), Amfipode, lăţăuşi, pp. 469-471. In: Godeanu, S.P. (ed.): Diversitatea lumii vii. Vol. 2, Part. 2. Editura Ştiinţifică şi Enciclopedică, Bucharest. [in Romanian]

Petrescu, A., Petrescu, I., Răduleţ, N., Iftime, Al., Ban, C. (2004): Date faunistice preliminare din zona viitorului Parc National Defileul Jiului. Oltenia, Studii şi Comunicări, Ştiinţele Naturii 21: 229-240. [in Romanian]

Petrovici, M., Tudorancea, C. (2000): Structure and dynamics of mayflies community (Insecta, Ephemeroptera) of Crişul Repede river and its tributaries. Studii şi Cercetări Ştiinţifice, Universitatea Bacău, seria Biologie 5: 201-206.

Popescu-Marinescu, V., Elian-Tălău, L. (1980): Contribuţii la studiul hidrobiologic al râului Olt în sectorul Făgăraş-Avrig. Hidrobiologie (Bucharest) 16: 185-195. [in Romanian]

Posea, G., Badea, L. (1984): România, Harta Unităţilor de relief (Regionarea geomorfologică). Ed. Ştiinţifică şi Enciclopedică, Bucharest. [in Romanian]

Principe, R.E., Raffaini, G.B., Gualdoni, C.M., Oberto, A.M., Corigliano, M.C. (2007): Do hydraulic units define macroinvertebrate assemblages in mountain streams of central Argentina? Limnologica 37: 323-336.

Ribeiro, L.O., Uieda, V.S. (2005): Estrutura da comunidade de macroinvertebrados bentonicos de um riacho de serra em Itatinga, Sao Paulo, Brasil. Revista Brasileira de Zoologia 22(3): 613-618.

Robert, S., Curtean-Bănăduc, A. (2005): Aspects concerning Târnava Mare and Târnava Mică rivers (Transylvania, Romania) caddish fly (Insecta, Trichoptera) larvae communities. pp. 89-98. In: Curtean-Bănăduc, A., Bănăduc, D., Sirbu, I. (eds): Transylvanian Review of Systematical and Ecological Research 2, "The Târnava River Basin", Sibiu, Romania.

Rogoz, I. (1969):- Răspândirea organismelor bentonice în cursul superior al râului Olteţ şi afluenţii lui principali din această zonă. Hidrobiologie (Bucharest) 10: 193-205. [in Romanian]

Sîrbu I., Benedek A.M. (2004): Ecologie practica. (pp.195-197). Editura Universităţii "Lucian Blaga", Sibiu, Romania. [in Romanian]

Simic, V., Simic, S. (2002): Structure of the macrozoobenthos as an indicator of different type of pollutions in running waters. Archives of Biological Sciences (Belgrade) 54(3/4): 79-86.

Stefanovic, K.S., Nikolic, V.P., Tubic, B.P., Tomovic, J.M., Atanackovic, A.D., Simic, M., Paunovic, M.M. (2009): Aquatic macroinvertebrates of the Jablanica River, Serbia. Archives of Biological Sciences (Belgrade) 61(4): 787-794.

Stoiculescu, C., Vergheleţ, M., Epure, D.G., Bucur, D., Huidu, C., Biriş, I.A. (2005): Optimizarea zonării Parcului Naţional potenţial Defileul Jiului. Anale ICAS 2005: 3-29. [in Romanian]

Szito, A. (1995): Macrozoobenthos in the (Maros) Mures river. pp. 185-192. In: Sarkany-Kiss, A., Hamar, J. (eds): TISCIA Monograph Series. The Maros/Mures River Valley, A study of geography, hydrobiology and ecology of the river system. Szolnok-Szeged-Tg. Mureş, Hungary & Romania.

Szito, A., Mozes, K. (1997): The Oligochaeta and the chironomid fauna as pollution indicators in the Cris/Korozs river system. pp. 165-194. In: Sarkany-Kiss, A., Hamar, J. (eds): TISCIA Monograph Series. The Crişuri/Korozs Rivers Valley, A study of geography, hydrobiology and ecology of the river system and its environment. Szolnok-Szeged-Tg.Mureş, Hungary & Romania.

Szito, A., Mozes, K. (1999): The Oligochaeta and the chironomida fauna in the Rier Someş system. pp. 179-193. In: Sarkany-Kiss,

A., Hamar, J. (eds): TISCIA Monograph Series. The Someş/Szamos Rivers Valley, A study of geography, hydrobiology and ecology of the river system and its environment. Szolnok-Szeged-Tg.Mureş, Hungary & Romania.

Tudor, M., Crăciun, N., Burlacu, L. (2004): Preliminary report on herpetofauna of the becaming National Park "Jiului Gorge". Oltenia, Studii şi Comunicări, Ştiinţele Naturii 21: 269-272.

Tullos, D.D., Neumann, M. (2006): A qualitative model for analyzing the effects of anthropogenic activities in the watershed on benthic macroinvertebrate communities. Ecological Modelling 196: 209-220.

Ujvarosi, L. (2002): Ordo Trichoptera, Trichopterele adulte (muşte de arin), larvele (carabeţi, scorobeţi). pp.531-547. Diversitatea lumii vii. Vol. 2, Part. 2. Editura Ştiinţifică şi Enciclopedică, Bucharest. [in Romanian] [in Romanian]

Vidinskiene, G. (2005): Biodiversity, distribution and ecology of macrozoobenthos in small Lithuanian rivers. Ecologija 2: 15-21.

Waringer, J., Graf, W. (1997): Atlas der osterreichischen Kocherfliegenlarven. Facultas Universitatsverlag, Wien.

Zivic, I., Markovic, Z., Zivic, M. (2009): Influence of a trout farm on macrozoobenthos communities of the Tresnjica River, Serbia. Archives of Biological Sciences (Belgrade) 61(3): 483-502.

**** IBGN (Indice Biologique Global Normalise) NF – T 90 – 350 (2000): Guide Technique, Les Etudes des Agences de l'eau. Agences de l'eau (2eme edition): 3-36.

Submitted: 17 April 2010
/ Accepted: 05 August 2010

Published Online: 06 August 2010