NEW DATA REGARDING THE STRUCTURE OF THE MACROZOOBENTHIC INVERTEBRATE COMMUNITY FROM THE VÂLSAN RIVER (ARGEŞ COUNTY, ROMANIA)

CUPŞA Diana, BADAR Larisa, TELCEAN Ilie Cătălin, COVACIU-MARCOV Severus Daniel

Abstract. The present study proposes to assess the state of the Vâlsan river invertebrate macrozoobenthic community. Studies of this kind along the river have been carried out also in the past, but permanent anthropogenic operations along the river, as well as the existence of drastically threatened endemic fish species *Romanychthys valsanicola*, justify the monitoring of the ecological condition along the Vâlsan River. The research was carried out throughout the entire river, aiming at the following of the structural changes at taxonomic level in relation to various sectors of the river, as well as under the action of anthropogenic pressure. It was also assessed the abundance of different taxonomic groups correlated to various river sectors, especially in the distribution sector of sculpin perch. We determined as well the ecological indices, Cody index and IBGN, designed to indicate water quality status and the degree of change in the invertebrate macrozoobenthic community due to the human factor.

Keywords: macrozoobenthos, the Vâlsan River, anthropogenic impact, water quality, conservation.

Rezumat. Noi date privind structura comunităţilor de nevertebrate macrozoobentice din râul Vâlsan (jud. Argeş, România). Studiul de faţă îşi propune să evalueze starea comunităţilor de nevertebrate macrozoobentice din râul Vâlsan. Studii de acest gen de-a lungul râului au mai fost realizate şi în trecut, dar intervenţiile antropice permanente asupra râului, precum şi existenţa speciei de peşte endemic *Romanychthys valsanicola*, drastic ameninţat, justifică reluarea acestor studii cu caracter de monitorizare a stării ecologice a râului Vâlsan. Cercetările s-au desfăşurat de-a lungul întregului râu, urmărindu-se modificările de structură taxonomică în raport cu diferitele sectoare de râu, cât şi sub acţiunea presiunii antropice. De asemenea, s-a urmărit abundenţa diferitelor grupe taxonomice pe sectoare, cu atenţie deoserbită asupra sectorului de distribuţie a aspretelui. S-au determinat indici ecologici precum indicele Cody şi IBGN meniţi să indice starea calităţii apei şi gradul de modificare a comunităţii macrozoobentice datorată factorului uman.

Cuvinte cheie: macrozoobentos, râul Vâlsan, impact antropic, calitatea apei, conservare.

INTRODUCTION

Macrozoobenthic invertebrates are distributed along rivers and make up communities with different species composition depending on the type of substrate (see in: FUMETTI et al., 2006). Macrozoobenthic invertebrates represent an important component of aquatic ecosystems, as biological indicators of water quality (see in: SHARMA & CHOWDHARY, 2011; SYED et al., 2012). The present research focused on the study of the macrozoobenthic invertebrate community from the Vâlsan river along its entire course, from the upper sector to the flow in the Argeş river. The study area also includes the sector where an endemic species of fish *Romanychthys valsanicola* lives (BĂNĂRESCU, 1994, 1998, 2005; BĂNĂRESCU et al., 1995; BĂNĂRESCU & VASILIU-OROMULU, 2004a, b; STĂNESCU, 1971; PERRIN et al., 1993; IONAŞCU & CRĂCIUN, 2009; TELCEAN et al., 2011), which has benthic feeding, therefore being directly dependent on the quality and quantity of macrozoobenthos (GĂLDEAN et al., 1997). The recent several studies have been carried out upon the macrozoobenthic fauna of the Vâlsan river (STOICA, 1967; TATOLE, 1993; VLĂDUŢU, 2002; 2006), but it has been noticed that, due to the major anthropogenic impact in the area, the modification of the benthic community is continuous in the direction of quality depreciation (TATOLE, 1993). Our aim is to evaluate the actual state of the macrozoobenthic community and the quality of the Vâlsan river water, through the biological indicators represented by the zoobenthos. After this assessment we will be able to emphasize the tendency of the water quality evolution as well as of the speed of these modifications. The Vâlsan River is almost entirely situated in the Natura 2000 ROSCI 0268 Valea Vâlsanului site. The samples were taken from, all the sectors of the river, with different natural characteristics of the water and different degrees of human impact. The area between Brădet and Mălureni, where the sculpin perch is located, was of particular interest.

MATERIAL AND METHODS

The benthic samples were taken during May 2011, from 9 sampling sites along the Vâlsan River. The sampling was carried out with a benthometer (200 µm mesh size). The samples were preserved in 4% formalin in the field, sorted in the laboratory and transferred in 70% ethylic alcohol. The 9 sampling sites were the following:

V1 - Dobroneag upstream gorges - the site is situated at the confluence between the Vâlsan River and a left side tributary, the Dobroneag. The river has a mountainous course; the riverbed is narrow, covered by stones and boulders. The banks of the river are shadowed by the nearby forest.

V2 - Vâlsan gorges exit - the site is situated downstream the gorges passed by the river, in the mountainous sector. The riverbanks are protected by antierosional dams; the riverbed is covered by stones and boulders. The riversides are shadowed by the nearby forest.
V3 - Brădetu is situated in the proximity of Brădetu village, where there is a functioning sanatorium. The site is hardly affected by anthropogenic pressure; the river course is slower, undulating, the riverbanks are not shadowed anymore because the forest misses in this sector.
V4 - Musăteşti 1. The riverbed is narrowing and the banks become steeper. In the riverbed, there are stones and boulders, which modify the velocity of water. The flowing speed is higher in these sectors. Local people discharge domestic water in the river.
V5 - Musăteşti 2. The riverbed becomes wider, 15-20 m; along the banks, there are several trees. In the riverbed there are stones and boulders. The river has the tendency to split in branches. Near the banks there are some sand deposits. The speed of the water is relatively high 0.8-1 m/s. The banks area is used for gravel and stone exploitation.
V6 - Vâlsăneşti. The riverbed is mobile and the water has deposited sand near the banks. The rest of the riverbed is covered by stones and gravels. The river forms meanders. In some places, in the riverbed we can see boulders, but not as frequent as upstream. The riverbanks have few portions covered by forests. The human impact is not very visible.
V7 - Stroieşti-Argeş. The riverbed becomes very large. The river has the tendency to form branches. The riverbed is covered by stones and gravels. The human impact is more visible that in the upper sector. Tree vegetation is present only in some places at distance from the water course.
V8 - Upstream Mălureni. The riverbed has the same parameters as at the former site. There are not many trees and the river is more illuminated.
V9 - Upstream the confluence with the Argeş River. The riverbed is large and very illuminated. The trees are almost absent. The riverbed is covered by gravels. There are several gravel exploitations.

The organisms from the samples were determined using the Romanian and European literature (e.g. STOICA, 2002; GROSSU, 1956; AUBERT et al., 1959; BAUERNFEIND & SOLDÁN, 2010). The ecological indexes, such as abundance, frequency, Cody index, IBGN were calculated according to the literature (SÎRBU & BENEDEK, 2004; AFNOR, 2004).

RESULTS

Analysing the collected samples from the 9 sites, we identified 10 taxonomic groups of invertebrates, 4 less evolved groups (Oligochaeta, Gasteropoda, Bivalva and Gammarida); the other 6 groups are aquatic larval stages of insects.

The insect larvae are well represented from the point of view of number of species, most of them belonging to Ephemeroptera, Plecoptera and Trichoptera orders. The number of individuals in samples varies between large limits (Fig. 1). Generally we have found a smaller number of specimens in the upstream sites, an increasing number in the middle sector of the river, while in the downstream sites, we noticed a second decrease.

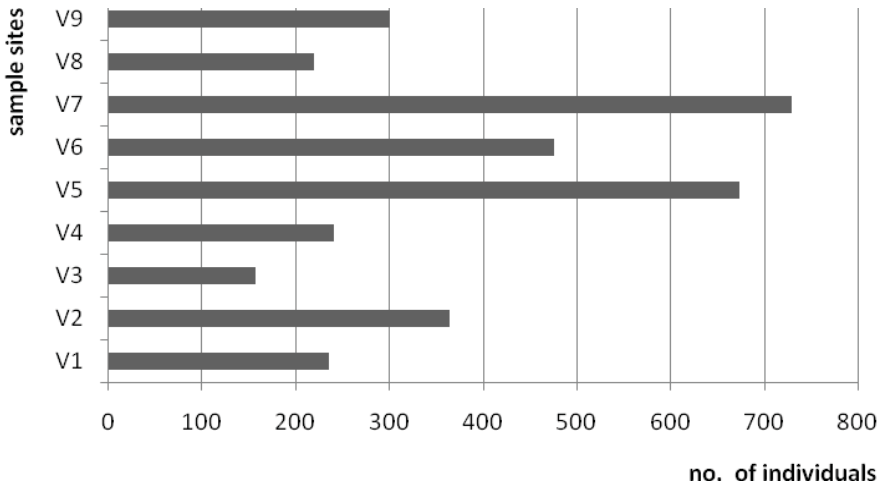

Figure 1. Number of individuals from the benthic community in each sample site.

Regarding the abundance of species and groups, we have observed that the Oligochaeta has a very low abundance except the sampling site Musăteşti 2; Hirudinea, Gasteropoda and Gammarida do not have great abundance values in any sites along the Vâlsan River. Bivalva group is present only in one sampling site, but here their abundance is high. Ephemeroptera is the best represented group from the point of view of number of species, together with Plecoptera. The

abundance of both groups is high in the upper stream, but, downstream, the abundance decrease, Plecoptera larvae are not present in the last downstream site. Odonata and Coleoptera larvae were found only in one site each, downstream, with very low abundance. Trichoptera representatives are not very abundant and, in some portions of the middle course of the river, they miss. (Fig. 2). Diptera group is found in all sample sites; the highest values of abundance are reached by Chironomida larvae in the river sectors where the organic content is high.

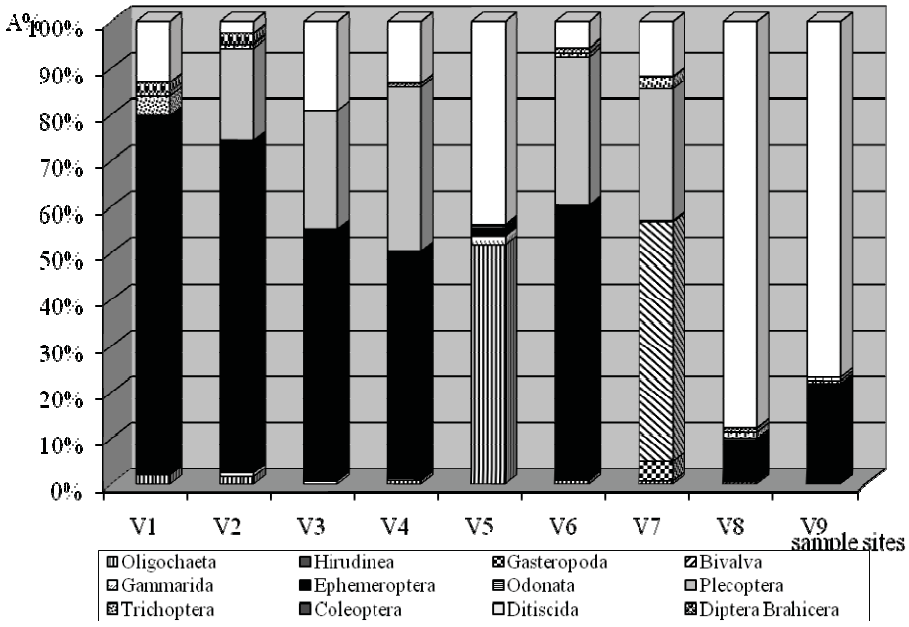

Figure 2. Species abundance in each sample site.

The greatest frequency is reached by Ephemeroptera and Chironomida, which were found in all sample sites. They are followed by Plecoptera with a frequency of 88.88% and Oligochaeta with 77.77%. These four groups are euconstant in the sites along the Vâlsan River.

High frequencies are reached also by Trichoptera and Diptera Brahicera with values of 66.66%. These are constant groups and are followed by Gammarida, which with a frequency of 44.44%, is accessory (Fig. 3). The lowest frequencies are reached by Hirudinea, Bivalva, Gasteropoda, Odonata, Coleoptera and Simuliidae with 11.11%, these being accidental species.

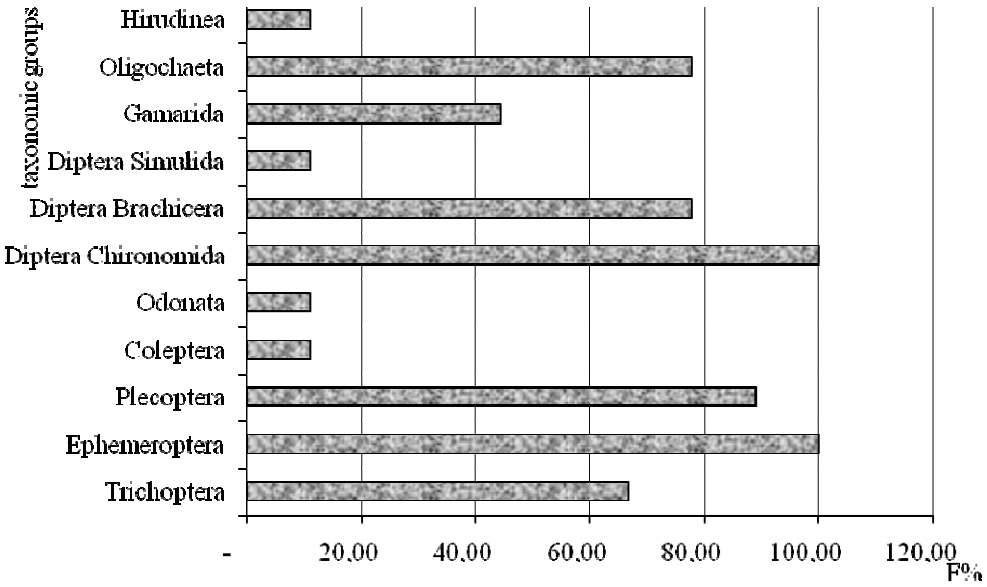

Figure 3. Frequency of the taxonomic groups in the Vâlsan River.

The values of beta diversity index Cody are the highest as the differences between the taxonomic structure is more different in successive sample sites. In this situation we mention the sample sites V1 and V2, V3 and V4 where the community structure modifies very much from the point of view of species number and abundance.

High values of Cody index were found between sites 6 and 7 (Vâlsăneşti and Stroieşti) respectively 7 and 8 (Stroieşti and upstream Mălureni) (Fig. 4).

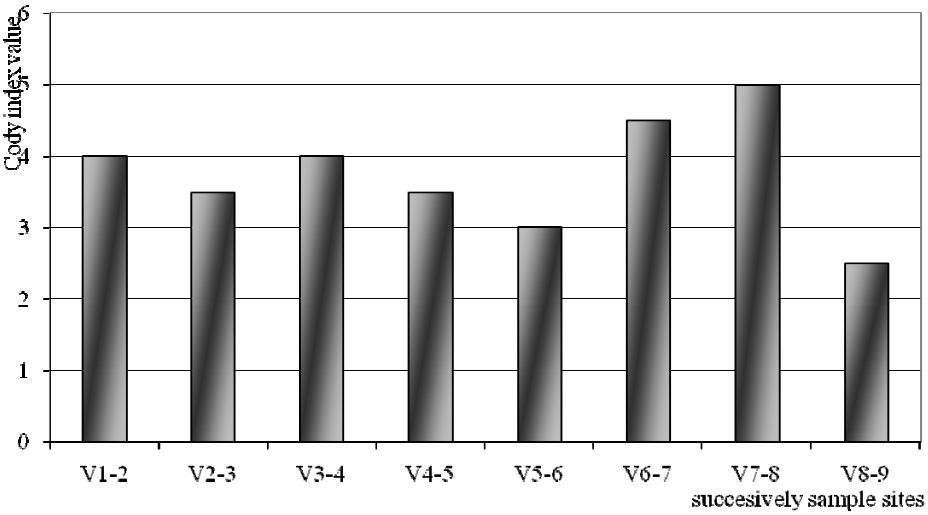

Figure 4. Cody index values between consecutive sample sites.

The value of IBGN index reveals the quality of the water from the point of view of macrozoobenthic community. It is not an absolute qualitative index because the macrozoobenthic organisms are influenced differently by different natural and anthropogenic factors. However, it helps us form an image upon the quality of the water, from the point of view of the phenomenon which takes place at the riverbed level. Along the river we found two sites with good water V2 and V6, four sites with medium water quality V1, V3, V4, V7, one site with low quality V5 and two with very low quality V8 and V9 (Fig. 5).

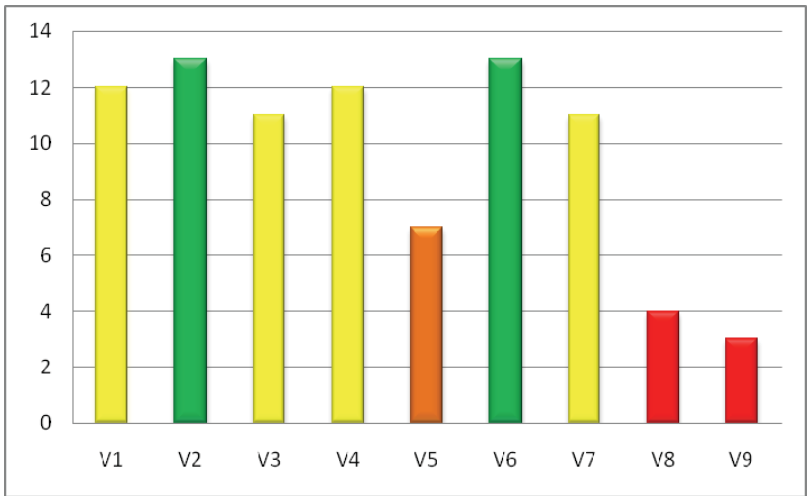

Figure 5. IBGN index values in the sample sites.

DISCUSSIONS

Ephemeroptera, Plecoptera and Trichoptera found in very high number are the most sensitive insect larvae from the benthic community, most of them being quality indicators of the waters in which they live (e.g. MARKOVIČ & ŽIVIČ, 2002; BISPO et al., 2002; PÂRVU & PACIOGLU, 2012). The richness of macrozoobenthic invertebrates indicates a varied trophic base which can support a rich aquatic community and a good quality of the Valsan River, at least in some studied sectors. The small number of specimens from the upstream sector is due to the fact that the river flows through a mountainous sector, where the water velocity and the characteristics of the riverbed with stones and boulders make the riverbed have a very small organic content. This substrate is very poor in organic substances and the almost completely lack of the bioderma on the rocks determines a poor trophic base, which cannot support a high

density of benthic macrozoobenthic invertebrate community. In the middle sector of the river the flow of the water is slower, the bioderma can cover the rocks, the organic substances can deposit in the riverbed and the localities along the water course bring also a quantity of organic matter. In these conditions the trophic base for the macrozoobenthic invertebrates is richer and their density increases. In the lower sector, close to the confluence with the Argeş, the riverbed is affected by anthropogenic impact such as gravel exploitation, and the organic content is increased because of the human activities but the density of the specimens decreases again.

The high abundance of Oligochaeta at Musăteşti 2 situated downstream the village with the same name is due to the enrichment of the substratum with organic residues resulting from domestic activities. This environment is favourable for the development of the detritivorous organisms as Oligochaeta. Hirudinea, Gasteropoda and Gammarida are accidental elements in the river. They are disadvantaged because of the lack of aquatic vegetation and the low organic content. Hirudinea and Gasteropoda are found in the sectors affected by anthropogenic activity. Gammarida are present in the upper and middle sectors, but their low abundance reveals unfavourable condition for them. Bivalva are found only in one sample site, but here their abundance is high. They have low mobility and small dimensions so there can be found numerous individuals on small surfaces. They indicate the presence of the organic suspensions in the water, which form their food (e.g. WARD et al., 1993). Odonata and Coleoptera were found each in one site downstream with very low abundance, because these groups need a water with a slower speed and richer in aquatic vegetation (BOUCHARD, 2004), which characterise the plane sector of the rivers and the lakes (SANDIN & VERDONSCHOT, 2006).

At Dobroneag the community is made up almost exclusively of Ephemeroptera and Plecoptera which have together an abundance of over 90% (Fig. 2). Together with them there are present Trichoptera, Oligochaeta and Chironomida. In the last two groups there are found species which can live in water with low organic content, specific to the clean water sectors (POLATDEMIR ARSLAN & ŞAHIN, 2003; SZITO & MOZES, 1999).

At the sample site Dobroneag the structure of the macrozoobenthic community is very much alike with the former site, but the number of species of Plecoptera and Ephemeroptera is higher. Here we can find species which were not present upstream due to the smaller riverbed and the worse quality of the trophic base. Also, there are present for the first time Gammarida which find the proper trophic base for their settlement, as in other cases (STEFANOVIC et al., 2009).

At Brădetu the abundance of Ephemeroptera and Plecoptera decreases slowly and it is situated below 90%; there are no Oligochaeta and Trichoptera and the abundance of Chironomida increases a lot. These facts indicate an anthropogenic pressure from the point of view of enrichment of the water with domestic organic residues, which determines a re-arrangement of the benthic community.

At Muşăteşti, we can observe a slight return of the macrozoobenthic community from the point of view of increasing abundance of Ephemeroptera and Plecoptera, recurrence of Oligochaeta and decreasing abundance of Chironomida. These phenomena show a less intense anthropogenic influence and the restoration of the macrozoobenthic community by water natural cleaning.

In these water sectors we observed that the benthic community is favourable to the feeding of the sculpin perch because the high abundance of the Ephemeroptera larvae which represent more than half of the food of the sculpin perch (GĂLDEAN et al., 1997). This fact allows us to say that the basic structure of macrozoobenthic community in the area populated by *Romanychthys valsanicola* is relatively constant in time, although some of the species living here before the dam construction become rare or disappeared (STOICA, 1967). The situation of the structure of macrozoobenthic community is better than it was shortly after the dam building (TATOLE, 1993) when at Brădetu site the Ephemeroptera completely disappeared. Lately the situation improved and the Ephemeroptera repopulated Brădetu site (VLĂDUŢU, 2002, 2006). The persistence of the Ephemeroptera larvae in the area populated by the sculpin perch has a major importance because the low mobility of the fish (GĂLDEAN et al., 1997) and for this reason the absence of the favourable food in habitat can be fatal. There are some laboratory studies during which the researchers found out that the sculpin perch can feed on Tubifex if the Ephemeroptera larvae miss (BĂNĂRESCU et al., 1995).

At Musăteşti 2, downstream the village, the modification of the macrozoobenthic community is drastic. Oligochaeta and Chironomida made up together an abundance of over 95%; the number of Ephemeroptera and Plecoptera species decreases, as well as their abundance. So we can say that the impact of flowing through this village is drastic for the river, the domestic pollution being so severe that it seriously affects the water quality and radically modify the structure of the macrozoobenthic community in an area which otherwise is favourable for it.

At Vâlsăneşti the abundance of Ephemeroptera and Plecoptera reaches also over 92%, probably due to the self-cleaning process of the water. The river passes through a region where the substrate allows the installation of sensitive communities; the polluting factors disappear and the community indicates good water quality. In this site the Trichoptera larvae reappear so the community is almost similar to that from the first sample site. The anthropogenic influence is lower but revealed by the presence of Hirudinea in the water, which can be found in waters situated downstream the localities where domestic residues are discharged in the river (KOPERSKI, 2005).

At Stroieşti, the nature of the riverbed modifies radically being dominated by a soft substrate formed from sand or mud. This change determines important modifications in the macrozoobenthic community, the most

abundant group becoming that of the Bivalva with over 50%, the Ephemeroptera and Plecoptera larvae being reduced. The presence of Trichoptera larvae with a small abundance indicates a reduced degree of anthropogenic impact due to pollution. The lower speed of the current and the vegetal debris more abundant in this site favour the settlement of Gasteropoda and Coleoptera. The benthic community in this site is similar to the characteristic community for the middle and low sector of the rivers, where the riverbed is sandy.

At the site upstream Mălureni, the anthropogenic influence is again increased; the structure of the benthic community is highly modified and it is dominated by Oligochaeta and Chironomida. The Ephemeroptera, Plecoptera and Trichoptera larvae persist, but with only a small number of species which can adapt to the excessive organic charge of the water (ZIVIC et al., 2009).

At the last sample site before the confluence with the Argeş River the state of the river is very similar to that from the former site, namely the human impact persists, the river has no longer the self-cleaning capacity because of the permanent human impact induced by organic pollution and disturbance of the riverbed due to the gravel exploitation. The Trichoptera larvae disappear and the community becomes very simple, dominated by Chironomida larvae.

From the point of view of the abundance on each sample site we can observe that the oxyphilous and rheophilic groups (Ephemeroptera, Plecoptera, Trichoptera) are more abundant in upstream sites and those which are not affected by human activities (Fig. 2). These groups are less abundant together with the increasing of the pelophilous groups in the downstream sites and those which are affected by anthropogenic pressure.

The low frequencies of Hirudinea, Bivalva, Gasteropoda, Odonata, Coleoptera and Simulida, which are accidental indicate that the ecological conditions along the river are not favourable for these macrozoobenthic invertebrate groups, even in the lower sectors of the river, because the riverbed is covered predominantly by stones and gravels. These species can be found especially in the soft bottomed rivers or in lakes (SLAVEVSKA-STAMENKOVIĆ et al., 2009; TATOLE 2005). The groups adapted to hard substrates as Ephemeroptera, Plecoptera and Trichoptera have high frequencies, lacking only in the case of profound anthropogenic pressure over the riverbed.

The value of Cody index differs a lot between sites V1 and V2. The modification of the benthic community structure can be caused in the first place by the changing of hydrographic parameters and the geography of the section, as the river passes from a mountainous forested region to a hilly forestless sector, with anthropogenic influence. The high values of Cody index between sites 6 and 7 (Vâlsăneşti and Stroieşti) also 7 and 8 (Stroieşti and upstream Mălureni) is due to the specific characteristics of the riverbed at Stroieşti, where sand and mud dominates which determine a development of a specific community that is not found anywhere else along the river. As a consequence, at Stroieşti the benthic community is very specific and different from the community from the rest of the river. Together with these natural modifications we can also add the human impact which is important in this sector and determines a selection of species from the benthic community.

At Dobroneag site the IBGN shows a medium quality of the water. This value is due more to the selective factor which acts at Dobroneag, namely the scarce trophic base determined by the hydrological characteristics of this sector. The apparently poor structure which determines a moderate value of IBGN is the result of the reduced trophic resources which cannot support a rich community of species and individuals. At the next site the situation improves, the water quality becomes good, primarily because of a better trophicity of the water, which permits the development of a richer community in species and individuals. In the next two sites the water quality easily decreases and becomes medium, on one hand due to the hydrological modifications and on the other hand to the human impact which modifies the water quality. At Muşăteşti 2 the water quality decreases more and becomes low, because of the accumulation of the domestic pollutants discharged from upstream. Here the majority of the pollutants deposit and affect the benthic community. The exploitation in the riverbed also negatively influences the benthic community. At the next site, Vâlsăneşti, we can see a great recovery of the water quality as a result of the self-cleaning processes of the water. The anthropogenic influence is also lower, as the riverbed is not exploited. At Stroieşti, the IBGN shows a medium quality, but in reality the substratum suffers great modifications, becoming from a hard one with stones and gravels one dominated by sand and mud. The community which occupies this kind of substrate even if the chemical parameters of the water are optimal indicates a lower water quality (Mollusca, Odonata, and others) (MURALIDHARAN et al., 2010). In the last two sites the quality of the water decreases and becomes low, mainly due to the human impact represented by pollution with domestic residues, but also by the numerous gravel exploitations which permanently disturb the riverbed, act as a major stress factor for the zoobenthic organisms, determine the disappearance of many species of the community and the proliferation of those which are resistant to this type of impact (POND et al., 2008).

CONCLUSIONS

The number of individuals in the sample sites is increased in the sectors where the trophic base is well represented and it decreases in the sites where the trophic base is scarce or the river is polluted by domestic waste and in the sectors where the substratum is disturbed (gravel exploitation). The abundance of the species varies from the high abundance of Ephemeroptera and Plecoptera in the upper sectors and the unpolluted ones, to the Chironomida and Oligochaeta in the lower sectors and those polluted with organic substances. In one case, at Stroieşti, Bivalva are the most abundant due to the sandy substrate in this sector. The highest frequency is registered by Ephemeroptera and

Chironomida, which are present in each site, and the lowest by Hirudinea, Bivalva, Gastropoda, Odonata, Coleoptera, which are not characteristic for high velocity rivers along their entire course as it is the Valsan River. The water quality according to IBGN index shows a good or medium quality except Muşăteşti 2 site, where due to the accumulation of domestic pollutants we can observe a decrease of the water quality as well as in case of the last two sites, where the human impact determines a profound decrease of the water quality. The ecological status of the Vâlsan River maintains good and medium water quality and if the domestic discharge is controlled and gravel exploitation stops, the macrozoobenthic community can rapidly recover due to the existing potential from the other river sectors and as a result the quality of the benthic community will improve. The substrate, hydrological characters and geography of the region is favourable for the settlement of a good quality benthic community, because the river passes through a mountainous sector, has a hard riverbed with a natural low organic content which permits the settlement of the oxyphilous and rheophilic species. The recovery of the benthic community in the affected sections can advantage also the endemic species *Romanychthys valsanicola*, by creating the possibility of spreading in longer river sectors. The sculpin perch needs an adequate trophic base represented especially by Ephemeroptera larvae and also a favourable substratum represented by a riverbed covered by stones and boulders.

ACKNOWLEDGEMENTS

Our study was realised with the support of Freies Europa Weltanschauung Foundation, the caretaker of the Natural Protected Area Vâlsan River, to which we wish to thank in this manner. This study is part of the programme dedicated to the investigation of the biodiversity of the protected area Vâlsan River.

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Cupşa Diana, Badar Larisa, Telcean Ilie Cătălin, Covaciu-Marcov Severus-Daniel
University of Oradea, Faculty of Sciences, Department of Biology,
Universităţii Str., No. 1, 410087, Oradea, Romania.
E-mail: dcupsa@uoradea.ro

Received: March 25, 2013
Accepted: June 10, 2013