New methods in estimating biodiversity: a case study on aquatic and semi-aquatic Heteroptera in the Arieş River Basin (Romania)

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1 Introduction

Biodiversity is an important indicator of wildlife quality. It can be measured by different techniques; most commonly used are indices that reflect particular aspects of the flora and fauna in study. Comparing several methods may reveal with greater precision the way the target community has adapted to the habitats in the study area; moreover, new techniques facilitating the evaluation are always welcome.

Our target group, aquatic and semi-aquatic Heteroptera belong, according to the latest classifications, to Infrasuborder *Nepomorpha* Popov 1968 and *Gerromorpha* Popov 1971, respectively (Gaby Viskens, 2005, on www.earthlife.net). They are insects associated, more or less, with water surfaces, forming a part of the nekton and epineuston. They inhabit a large variety of micro-biotopes, from those lacking vegetation, to those completely covered (Andersen, 1982; Davideanu, 1999). The typical habitats of Heteroptera are ponds, lakes, slow flowing creeks or little bays formed at the banks of rivers. Most species are not sensitive to moderate human impact on the habitat and to the presence of vegetation.

We investigated the quality of specific Heteroptera habitats in the Arieş River Basin that drains the central part of Apuseni Mountains in western Romania, being one of the largest tributaries of Mureş River. The upper basin is formed by two separate rivers (Arieşul Mare and Arieşul Mic) wich unite near the city of Câmpeni to the main river. In the upper basin crystalline rocks prevail, while the lower basin is characterized by sedimentary rocks (especially limestone).

2 Material and methods

The study took place in June 2009 encompassing 16 sampling stations in the upper and lower basin of Arieş River (Fig. 1). They covered the entire diversity of habitats preferred by Heteroptera and an altitudinal gradient for β-biodiversity (S 1 at highest, S 16 at lowest altitude). One sample from each station was taken, 8 to 15 meters in lenght, covering the entire habitat (water surface and body, aquatic vegetation if present, bottom); the samples were collected with an entomological net (mesh-size 60 cm^2).

Species were identified under a stereo binocular by the morphological features or, where necessary, by genitalia, using data from other specialists (Jansson, 1986; Davideanu, 1999). Larvae could not be identified at species level except those of *Nepa cinerea* Lineé 1758; therefore, they were not considered in the biodiversity analysis. In this respect, two of the sampling stations, S 2 and S 8, are not included in the analysis, since only larvae were sampled. At station S 10, one female *Dichaetonecta sp.* Hutchinson, 1940 was found, impossible to identify at species level in the absence of the male (Jansson, 1986).

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However, because it is the only *Dichaetonecta* individual found in the entire area, it was considered as one species in the biodiversity analysis.

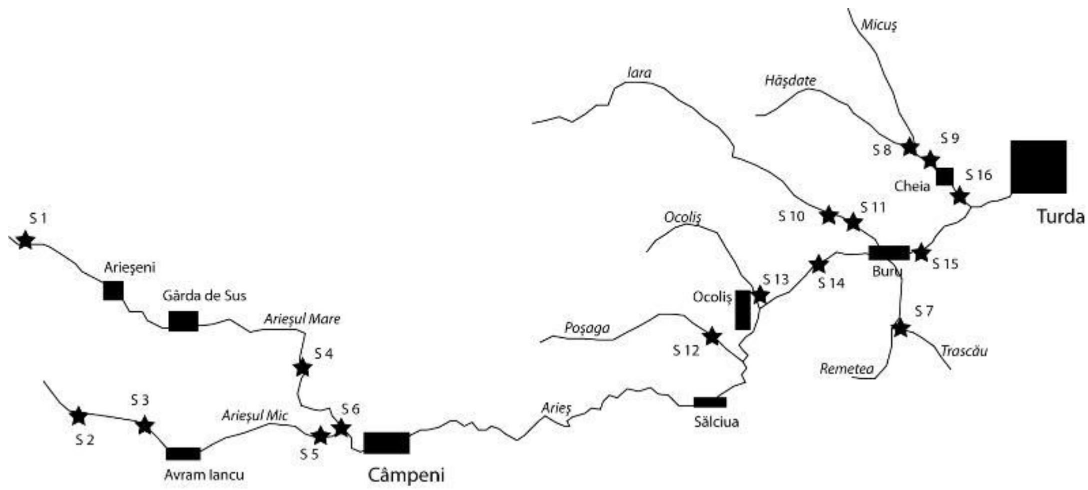

***Figure 1**. The location of sampling stations (stars) in the Arieş River and its tributaries. Rectangles represent cities and villages.*

We used two different approaches to calculate biodiversity: (1) The classic approach of areal biodiversity (γ biodiversity) obtained by multiplying medium α values by β values (Sîrbu & Benedek, 2004). For α biodiversity of each sampling station we used the Menhinick Index; the Whittaker Index indicated β biodiversity, using altitude as a gradient. (2) Jost (2006, 2007) proposed a new type of calculation, based on what he believes is the confusion made by biologists between the value of the biodiversity index and the true value of biodiversity. He proposed a number equivalent for entropy-like indices (Shannon, Renyi, Gini-Simpson etc.), number equivalent that will reflect the true value of biodiversity. The methodology is appliable for the calculation of α and γ (total) biodiversity, β values being obtained from the previous two (each index has its own formula for the number equivalent and for β diversity calculation). Where community weights are different, the use of Shannon Entropy ($-\Sigma p_i * \ln(p_i)$) is recommended, with the number equivalent of $\exp(-\Sigma p_i * \ln(p_i))$, for which the β value is obtained by dividing γ by α (Jost, 2007).

3 Results and discussions

The specific Heteroptera habitats are scarce in the area for two reasons: (1) prevailing crystalline rocks in the upper Arieş Basin cause fast run-off and unfavorable lotic habitats; (2) intense human impacts in the middle basins of Arieş and Arieşul Mare Rivers on the hydromorphology (enbankments) and terrain levelling destroyed favorable habitats such as still waters, puddles and lentic river stretches.

We found 17 species of Heteroptera, ten belonging to Infrasubordo *Gerromorpha* (semi-aquatic Heteroptera) and seven to Infrasubordo *Nepomorpha* (aquatic Heteroptera) (Table 1).

All species are first time mentions in the area (Paina, 1975), but only the lack of studies made in the area can be the reason for that, because they were all sampled in the nearby regions (between Aiud and Cluj-Napoca).

Considering *Dichaetonecta* and *Velia*, the Arieş River Basin encompasses 19 out of 67 species found so far in Romania (Davideanu, 1999, Ilie, 2008). This is about 29% of the aquatic and semi-aquatic Heteroptera species sampled in the entire country found on only 14 sampling stations covering a very small area along a medium size river. The 71 adults sampled result in an individual/species ratio of 3.94, not considering *Velia*, and they belong to a high number of 9 Heteroptera families, which means nearly 8 individuals per family. The genus *Gerris* Fabricius 1794 is represented by six out of nine species present in Europe (Viskens, 1995, on earthlife.net), a comparatively large portion if we consider the relatively poor conditions of the area and the gathering of only one sample from each station.

Table 1. *List of aquatic and semi-aquatic Heteroptera sampled in the Arieş River Basin*

Nr	TAXONS (families, species)	STATIONS (S)															
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
	Infrasuborder Gerromorpha																
	Fam. Gerridae																
1	*A. paludum*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
2	*G. lacustris*	-	-	-	1	4	5	4	-	3	-	8	-	4	-	-	-
3	*G. costae*	1	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
4	*G. argentatus*	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
5	*G. gibbifer*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	*G. odontogaster*	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
7	*G. thoracicus*	-	-	-	-	-	-	-	-	-	-	-	-	2	4	-	-
8	*Gerris sp. larvae*	5	-	20	1	12	34	5	-	-	-	15	-	-	-	-	-
	Fam. Veliidae																
9	*Velia sp. larvae*	7	3	-	-	-	-	-	5	-	-	-	-	-	-	-	-
	Fam. Microveliidae																
10	*M. reticulata*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
	Fam. Hebridae																
11	*H. pusillus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	Fam. Hydrometridae																
12	*H. stagnorum*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
	Infrasuborder Nepomorpha																
	Fam. Corixidae																
13	*S. nigrolineata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
14	*S. lateralis*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	
15	*S. striata*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
16	*H. sahlbergi*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
17	*Dichaetonecta sp.*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
	Fam. Nepidae																
18	*N. cinerea*	-	-	-	-	-	-	-	-	-	1	4	2	-	-	-	-
19	*N. cinerea larvae*	1	-	-	-	-	-	-	-	1	-	10	-	-	-	-	4
	Fam. Notonectidae																
20	*N. glauca*	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-

Fam. Pleidae																	
21	*P. minutissima*	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
TOTAL (imago)		**3**	**-**	**5**	**1**	**8**	**5**	**4**	**-**	**3**	**2**	**18**	**2**	**6**	**4**	**1**	**9**

Biodiversity analysis (Table 2) using the two methods described above is showing remarkably similar results: low α values and relatively high β values, leading to a high γ for the lower basin and for the entire area; in the upper basin five out of six stations comprise only Gerridae, resulting in a lower β component and in overall diversity. The similarity of results obtained with two different methods confirms the practical applicability of Jost's method that, however, is much easier to use.

Low α values may be due to the poor quality of habitats and the small amount of samplings. Being well adapted to specific habitat conditions, particular aquatic and semi-aquatic Heteroptera species are in need of a suitable bottom, flow, presence of vegetation etc., difficult to be found in small sampling stations we studied. Therefore, the only stations with high α values are relatively large, for example S1 or S11, where different habitat conditions allow different species to coexist. This is explained best by the high number of stations with only one species found (9 out of 16, particularly the smallest and the most homogenous ones).

Table 2*. Biodiversity indices values for the study area (α1, β1 and γ1 calculated with classical indices, α2, β2 and γ2, with Jost's method)*

Station	**α 1**	**average α 1**	**β 1**	**γ 1**	**α 2**	**average α 2**	**β 2**	**γ 2**
S 1	*3.32*	*Upper basin: 1.11*	*Upper basin: 2.22*	*Upper basin: 2.45*	*2.00*	*Upper basin: 1.53*	*Upper basin: 2.32*	*Upper basin: 3.55*
S 2	*-*				*-*			
S 3	*0*				*1.00*			
S 4	*0*				*1.00*			
S 5	*2.22*	***Total: 1.31***	***Total: 7.50***	***Total: 9.82***	*2.65*	***Total: 1.61***	***Total: 5.32***	***Total: 8.58***
S 6	*0*				*1.00*			
S 7	*0*				*1.00*			
S 8	*-*				*-*			
S 9	*0*				*1.00*			
S 10	*3.32*				*2.00*			
S 11	*3.98*				*4.86*			
S 12	*0*				*1.00*			
S 13	*1.29*	*Lower basin: 1.42*	*Lower basin: 5.00*	*Lower basin: 7.10*	*1.89*	*Lower basin: 1.66*	*Lower basin: 4.71*	*Lower basin: 7.80*
S 14	*0*				*1.00*			
S 15	*0*				*1.00*			
S 16	*4.19*				*4.17*			

The relatively high variation of β diversity is due to the fact that most aquatic and semi-aquatic Heteroptera species are well adapted to particular habitat conditions, so different types of habitats are occupied with different species (Andersen, 1982). Due to the small dimension of the sampling stations, almost each station offered few ecological niches for Heteroptera species, reflected by the α diversity results described above. The change of geographical conditions along the altitudinal gradient influences habitat type and Heteroptera species composition. The low β values of the upper basin are in consistence with the relatively homogenous geological conditions.

4 Conclusions

The species sampled are new to the area, as far as we know, probably because of the lack of research made on the group. The results of this study can be improved by further research in the area.

Nevertheless, the results are important for the overall picture of Romanian aquatic and semi-aquatic Heteroptera, because it is proved by earlier work of the authors that most species can be found in montane regions (Ilie, 2008; Olosutean & Ilie, 2008, 2010). Some species have key roles in pioneering semi-aquatic habitats; therefore, research on Heteroptera is important and needs further studies.

As for the biodiversity analysis, Jost's number equivalent method proved to be useful, easy to apply and reliable, recommending further use.

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