TEMPORAL-SPATIAL PATTERN OF TRUE BUG ASSEMBLIES (HETEROPTERA: GERROMORPHA, NEPOMORPHA) IN LAKE BALATON

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Abstract. The present study was carried out at lake Balaton during 1999 and 2000, collecting Heteroptera species from 44 sampling sites. The different basins and the surrounding streams were compared based on temporal-spatial patterns of bug assemblies. The dominance and constancy values of the present species were used in the analysis. The Szemes Basin shows the least values of diversity and the streams have the greatest values.
Keywords: *aquatic bugs, semiaquatic bugs, freshwater, community, pattern-analysis,hydrobiology*

Introduction

The lake Balaton is reckoned among the most frequently examined lakes in the world, but the knowledge of its ecosystem is still imperfect. Beside the lake scientists have to pay attention also to the catchment areas.

Hydrocenological researches on Nepomorpha or Gerromorpha in Hungary have been being in progress for decades [1, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 29, 30, 33], but few of them have been dealing with ecological pattern analysis [5, 6, 16, 29].

The exploration of the pattern in time and space of the Heteroptera communities beside the supply of data for basic research can contribute to reply some practical questions too. Based on former observations bugs can be suitable to show the change of their environment, so they can use to indicate the change in time and space of the water quality [3, 5, 7, 8, 10, 12, 13].

Consequently the goal of the fieldwork was to collect informations for the development of a monitoring system of the biological water quality.

Materials and methods

The sampling sites were designated in the north and south shoreline of lake Balaton and along the bank of streams flowing into the Balaton (Mitkovics stream, Balatonfenyves stream, River Zala, Egervíz stream, Koloska stream, Lovas stream, Balatonendréd stream). 204 samples were collected from the 44 sampling sites (*Fig. 1*) in 1999 and 2000.

Insects were collected by hand net. The obtained semiquantitative sample shows well the ratios of the species, but do not give information about the real quantity of the species. The works of Benedek [2], Hufnagel and Vásárhelyi [17], Jansson [18,19], Péricart [20], Savage [24], Soós [25], Štusák [26], Vepsäläinen and Krajewski [31], and

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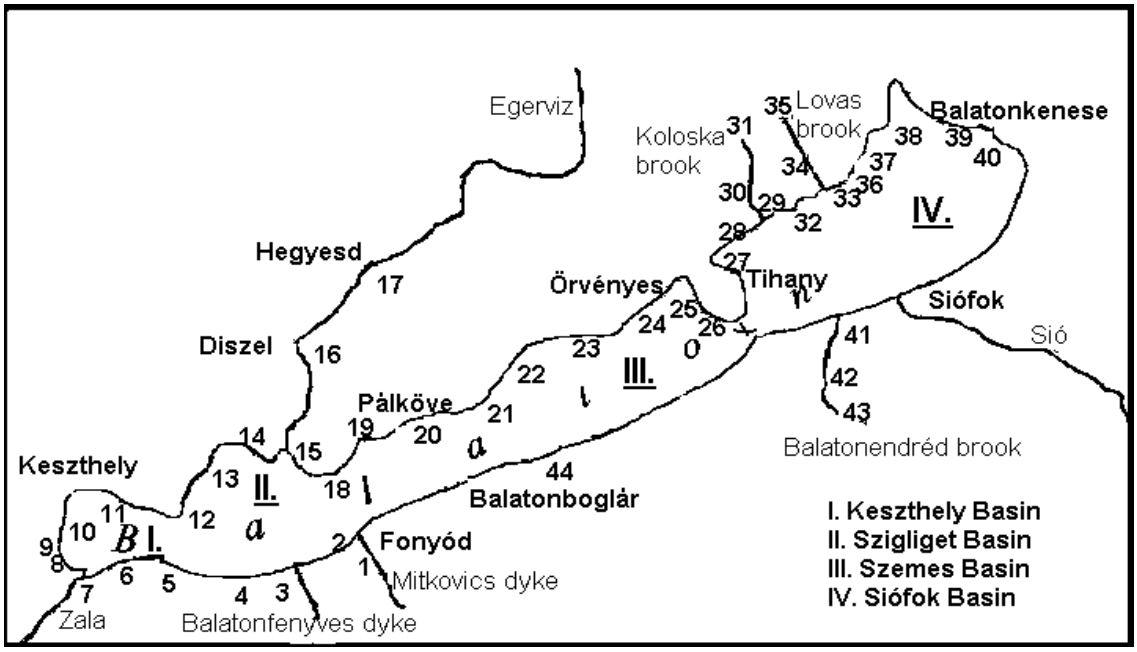

1. Alsóbélatelep, Mitkovics dyke
2. Alsóbélatelep, next to the beach
3. Balatonfenyves dyke, at the narrow-gauge railway
4. Balatonmáriafürdő
5. Balatonberény I.
6. Balatonberény II.
7. River Zala
8. Fenékpuszta I.
9. Fenékpuszta II.
10. Keszthely
11. Vonyarcvashegy, Szent Mihály Hill
12. Balatongyörök
13. Szigliget bay, Anglers camping
14. Szigliget bay
15. Egervíz, at the mouth
16. Egervíz, at Diszel
17. Egervíz, at Hegyesd
18. Badacsonylábdihegy
19. Ábrahámhegy
20. Pálköve
21. Balatonszepezd I.
22. Balatonszepezd II.
23. Balatonakali, near to the Dörgicse railway station
24. Örvényes, next to the beach
25. Sajkod, beach
26. Sajkod, far away from the beach
27. Diós-Gödrös
28. Balatonfüred, near to the pier
29. Koloska brook, at the mouth
30. Koloska brook
31. Koloska brook, at the spring
32. Palóznak bay, at Csopak
33. Lovas brook, at the mouth
34. Lovas brook, at Lovas
35. Lovas brook, at the spring
36. Alsóörs I.
37. Alsóörs II., Riviera camping
38. Balatonalmádi
39. Balatonkenese, at Törökverő
40. Balatonakarattya, at the sewage farm
41. Balatonendréd brook, at the mouth
42. Balatonendréd brook, at Bocsida field
43. Balatonendréd brook, at the spring
44. Between Balatonlelle and Balatonszemes

Figure 1. *The sampling sites at lake Balaton and surrounding streams*

Vásárhelyi [32] were used for identification of bugs. The detailed summary of the collecting methods can be found in Bakonyi's [1] and Hufnagel's [10] dissertations. At all place and time, habitat and water quality characteristics were measured. These data were published formerly [3, 4]. The four basins of Balaton and the streams were compared in this work. After the identification of the collected imagos and larvae zoocenological tables were made which were analysed using multivariate statistical methods. By means of Syn-Tax program package [21, 22, 23] ordinations (PCoA, PCA) and classifications (hierarchical clustering) were used for reconnaisance of the similarity

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patterns. In addition number of species, number of individuals, dominance, constancy values were calculated. The measurement of the biodiversity has many problems. This analysis was made based on the methodological recommendations by Hufnagel et al. [14]. Comparing the basins of Balaton and the surrounding streams Rényi's diversity ordering was applied with the help of NuCoSA program package [27, 28].

Results

As a result of our study 31 Heteroptera species were found in Balaton and in the examined streams (*Table 1*). Next to the species the constancy and dominance values are indicated in *Table 1*. The serial numbers of bugs were used in multivariate statistical methods to identify them. During the examination in 147 from the 204 samples were found Heteroptera species and 4247 bugs were identified. The basins of Balaton were compared to streams based on Heteroptera species. The streams unambiguously differ from all basins of Balaton. The main difference among the basins was between the Szemes Basin and Szigliget Basin (*Fig. 2*).

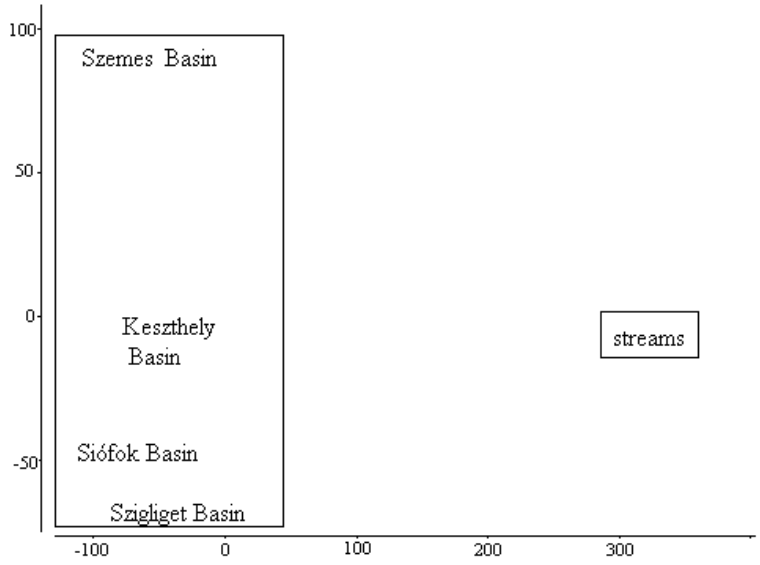

Figure 2. *The result of the ordination on the basins of Balaton and streams.*

Fig. 3 shows the result of the ordination on the Heteroptera species of Balaton and streams. From the living water to still water continuity is on the vertical axis (axis 2), while the number of individuals can be found on the axis „z". In the figure we can sepatate some groups of the Heteroptera species, according to the followings. The I marks the species with high number of individuals, the II marks the group of medium number of individuals, and the III marks the small number of individuals. To the group I/1 belongs only *Aquarius paludum*, which is a typical species of the standing waters. *Sigara striata* (group I/2) can be found in the streams or in the standing water, *Gerris lacustris* in the group I/3 was collected in the streams with high number of individuals. *Gerris argentatus* and *Micronecta meridionalis* belong to the II/1 group, these species are mainly typical of the Siófok Basin, while *Plea leachi* and *Cymatia coleoptrata* (II/2) characterize the Szemes Basin. The species in II/3 (*Sigara lateralis, Ilyocoris*

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Table 1. *The collected Heteroptera species and their constancy (c%), dominance (d%) and serial number (No.).*

Taxa	*c*%	*d*%	No.
Gerromorpha			
Gerridae			
Aquarius paludum paludum (Fabricius, 1794)	34.80	16.84	6
Gerris argentatus (Schummel, 1832)	25.98	9.07	5
Gerris asper (Fieber, 1860)	7.84	1.53	3
Gerris lacustris (Linnaeus, 1758)	16.67	7.82	2
Gerris odontogaster (Zettersedt, 1828)	8.33	0.64	4
Gerris thoracicus (Schummel, 1832)	6.86	1.37	1
Veliidae			
Microvelia reticulata (Burmeister, 1835)	7.35	1.27	7
Velia saulii saulii (Tamanini, 1947)	1.96	0.54	8
Velia caprai caprai (Tamanini, 1947)	1.47	0.35	9
Mesoveliidae			
Mesovelia furcata (Mulsant & Rey, 1852)	7.35	0.87	10
Hydrometridae			
Hydrometra gracilenta (Horváth, 1899)	0.98	0.05	11
Hydrometra stagnorum (Linnaeus, 1758)	5.39	1.46	12
Nepomorpha			
Nepidae			
Nepa cinerea (Linnaeus, 1758)	12.25	4.05	13
Ranatra linearis (Linnaeus, 1758)	6.37	0.45	28
Notonectidae			
Notonecta glauca glauca (Linnaeus, 1758)	17.16	4.87	14
Pleidae			
Plea minutissima minutissima (Leach, 1817)	16.18	6.26	15
Corixidae			
Callicorixa praeusta praeusta (Fieber, 1848)	1.47	0.09	16
Corixa punctata (Illiger, 1807)	0.49	0.02	21
Cymatia coleoptrata (Fabricius, 1777)	14.22	4.73	27
Hesperocorixa linnaei (Fieber, 1848)	14.22	5.30	22
Hesperocorixa sahlbergi (Fieber, 1848)	0.98	0.05	23
Micronecta meridionalis (Fieber, 1860)	7.35	5.63	26
Micronecta minutissima (Linnaeus, 1758)	0.49	0.02	25
Micronecta pusilla (Horváth, 1895)	1.47	0.99	24
Paracorixa concinna (Fieber, 1848)	0.49	0.02	31
Sigara falleni (Fieber, 1848)	12.75	1.51	18
Sigara lateralis (Leach, 1817)	6.37	2.94	17
Sigara limitata (Fieber, 1848)	0.49	0.09	30
Sigara nigrolineata nigrolineata (Fieber, 1848)	3.43	4.24	20
Sigara striata (Linnaeus, 1758)	29.41	11.30	19
Naucoridae			
Ilyocoris cimicoides cimicoides (Linnaeus, 1758)	25.98	5.63	29

cimicoides, Hesperocorixa linnaei, Nepa cinerea, N. glauca, S. nigrolineata) are mostly in streams. *Gerris asper, Microvelia reticulata, Velia caprai, Mesovelia furcata, Hydrometra gracilenta, Callicorixa praeusta, Sigara falleni, Corixa punctata, Hesperocorixa sahlbergi, Micronecta pusilla, Micronecta minutissima, Ranatra linearis, Sigara limitata, Paracorixa concinna* (group III/1) characterize the standing water, but they were collected in small cuantity of individuals. *Gerris odontogaster* and *Velia saulii saulii* were found both in the streams and in the basins, while the *Gerris*

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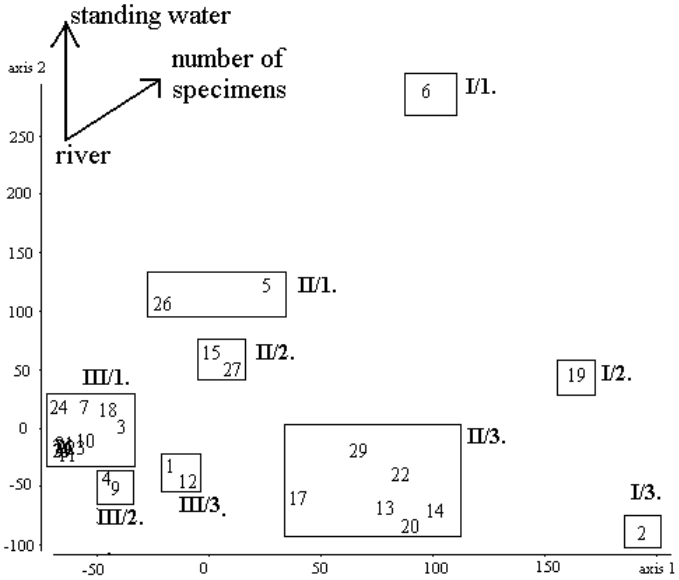

Figure 3. *The result of the ordination on the Heteroptera species of Balaton and streams.*

thoracicus and *Hydrometra stagnorum* were collected only from the streams (groups III/2 and III/3).

Among the Heteroptera species the *Aquarius paludum* and the *Cymatia coleoptrata* are typical of the Szemes Basin, the *Micronecta meridionalis* and the *Gerris argentatus* are mainly peculiar to the Szigliget Basin and the Siófok Basin. The *Gerris lacustris, Notonecta glauca, Sigara lateralis, Sigara nigrolineata, Hesperocorixa linnaei, Nepa cinerea, Sigara striata* and *Ilycoris cimicoides* are characteristic of the streams. But none of the Heteroptera species are unique in the Keszthely Basin (*Fig. 3*).

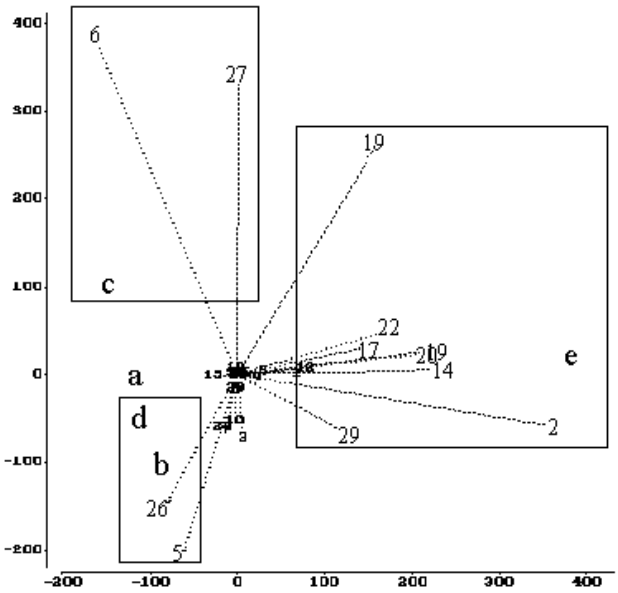

Figure 4. *The result of the PCA on the Heteroptera species of Balaton and streams.* a: *Keszthely Basin,* b: *Szigliget Basin,* c: *Szemes Basin,* d: *Siófok Basin.*

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Various diversity indices were used for characterization the basins and streams. The average number of species and the avarege number of individuals can be seen in *Fig. 5*.

The values of the average number of species and the number of individuals are the greatest in the streams and the least in the Szemes Basin. The average number of species compared to the average number of individuals has the greatest value at the Szigliget Basin (*Fig. 6*). Rényi's diversity ordering was used by means of NuCoSA program package and the values are given in *Fig. 7*. The decreasing lines show the run of thediversity values of the basins and streams on different parameters. Number 1 marks the Keszthely Basin, number 2 is the Szigliget Basin, number 3 is the first group of Szemes Basin, number 4 is the second group of Szemes Basin, number 5 marks the Siófok Basin, number 6 and number 7 are the two groups of streams. Because of the high number of sampling sites in the Szemes Basin and along the streams these were divided into 2–2 parts to get more homogeneous samples.

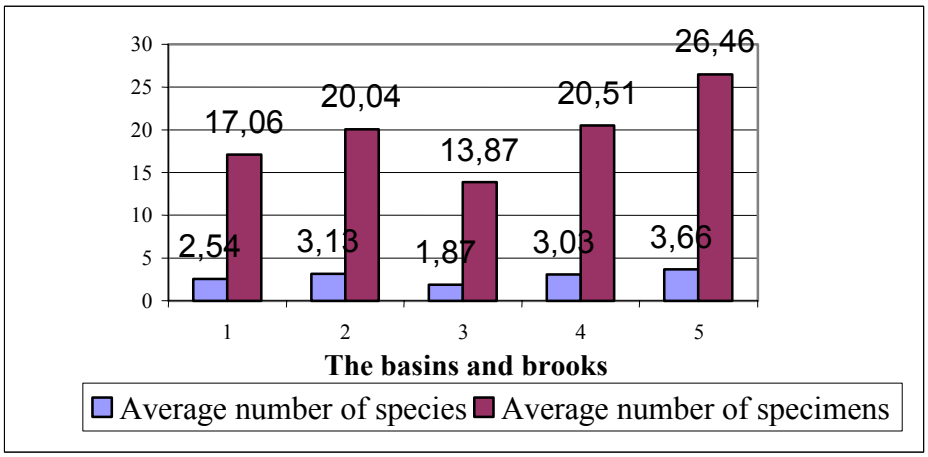

Figure 5. *The average number of species and average number of individuals of Heteroptera in lake Balaton and streams.* 1: *Keszthely Basin,* 2: *Szigliget Basin,* 3: *Szemes Basin,* 4: *Siófok Basin,* 5: *streams.*

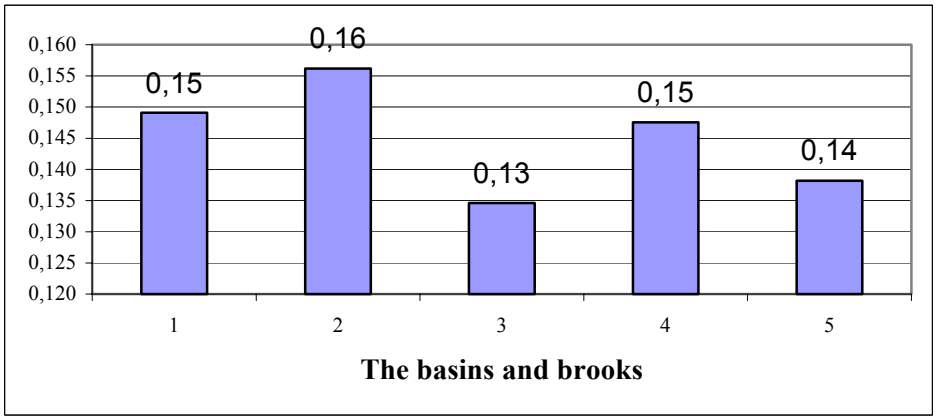

Figure 6*. The number of species divided by the number of individuals of Heteroptera in lake Balaton and streams.* 1: *Keszthely Basin,* 2: *Szigliget Basin,* 3: *Szemes Basin,* 4: *Siófok Basin,* 5: *streams.*

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If a diversity profile runs above another one means that this sample is more diverse in respect both of the rare and the frequent species. If two lines cross each other the samples can not be ordered accordig to the diversity. By inreasing the scale parameter the frequent species have more influence on the value of the Rényi's diversity. In our survey the Szemes Basin has the less diversity and the first group of the streams shows the greater diversity. The diversity of the Siófok Basin is less than the values of the others. The Keszthely Basin, the Szigliget Basin and the second group of the streams show similar diversity patterns.

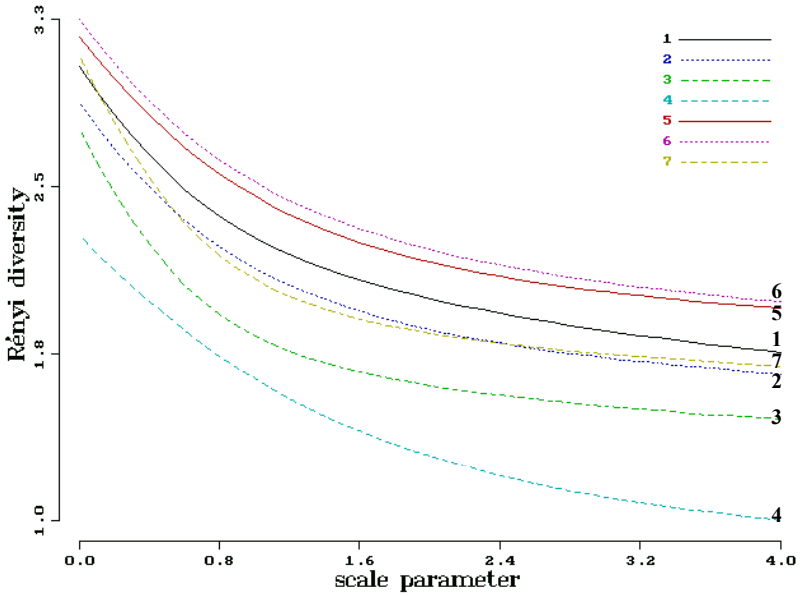

Figure 7. *The result of diversity ordering on basins and streams.* 1: *Keszthely Basin,* 2: *Szigliget Basin,* 3: *the first group of the Szemes Basin, 4: the second group of the Szemes Basin,* 5: *Siófok Basin,* 6: *the first group of streams,* 7: *the second group of streams.*

Discussion

31 Heteroptera species were found and 4247 bugs were identified in this work. The Heteroptera fauna of the streams is basically different from the fauna of lake Balaton, but also the four basins have differencies in their bug assemblies. The highest values of number of individuals and number of species of bugs were found in streams according to the environmental heterogenity. Among the streams was found both fast flowing parts without reed and slow flowing parts - with almost still water character - with reed. The reason of the differentation of the fauna in the basins is the quality of the founded reed. From the point of view of Heteroptera fauna the sampling sites can be analysed using multivariate statistical methods or diversity indices. Using these methods the cenological patterns were revealed. For the more precise description of the structure of the communities the examination of the food nets could be important. Besides it is essential to examine further sampling sites and collect further data.

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