EKOLOGIJA. 2007. Vol. 53. No. 3. P. 51–57

Environmental impacts on macroinvertebrate community in the Babrungas River, Lithuania

Tomas Ruginis

Coastal Research and Planning Institute, Klaipėda University, Manto 84, LT-92294 Klaipėda, Lithuania
E-mail: tomas@corpi.ku.lt

The studies were performed in the Babrungas River (Plungė district) during May–October in 2003. Samples were collected by the pipe sampler (sampling area 0.01 m^2) and metallic frame (0.09 m^2). In total, 103 taxa of benthic macroinvertebrates were dissected, 33 of which belonged to the Diptera. The highest biodiversity index was established for the hard type ground (pebble and gravel). There is no significant difference in Shannon index value between seasons (except sand bottom). The greatest significant mean density and biomass of macroinvertebrates was at the sites below the lake or reservoir. Molluscs (*Dreissena polymorpha*) were dominating. The results suggest that substrate is a very important abiotic factor for macrozoobenthos community structure in streams, but it is not the main one.

Key words: stream, macrozoobenthos, Shannon biodiversity, substrate

INTRODUCTION

The river's macrozoobenthos is the main part of the water ecosystems of the small flowing water. In Lithuania the greatest attention of hydrobiological surveys of the flowing water is concentrated on big rivers, with some attention devoted to streams. However, small rivers are very important habitats for salmonids and for the preservation of biodiversity. The ecosystems of streams and small rivers were studied by R. Kazlauskas (1963), who gave priority to diversity of mayflies, stoneflies and caddis flies in water. The species composition of macrozoobenthos in flowing water was also investigated by J. Virbickas, V. Pliūraitė (2002) and V. Pliūraitė, V. Kesminas (2004).

Many studies have tried to elucidate the main factors influencing macroinvertebrate community composition and abundance in streams (Giller, Twomey, 1993; Chertoprood, 2002; Žbikowski, 2000). Considerable attention has been paid to substratum type and season (Ward, 1992, Verberk et al., 2002; Chertoprood, 2002).

According to the river continuum concept (Vannote et al., 1980), from headwater to the mouth, the physical variable within a river system presents a continuous gradient of physical condition. This gradient should elicit a series of responses within the constituent populations resulting in a continuum of biotic adjustment and consistent pattern of loading, transport, utilization, and storage of organic matter along the length of a river.

The main purpose of this work was to investigate the influence of substratum and season effect on the species composition, abundance and biomass of macrozoobenthos in the Babrungas River, also the influence of the dams and lakes on the macrozoobenthos community in the Babrungas River.

MATERIALS AND METHODS

The Babrungas River is the right tributary of the Minija River in Plungė district (Fig. 1). The river runs out of from Lake Plateliai, its length is 47.3 km., drainage area 270.4 km^2, channel width in the headwater is 4–8 m, in the mouth 10–15 m; the slope is

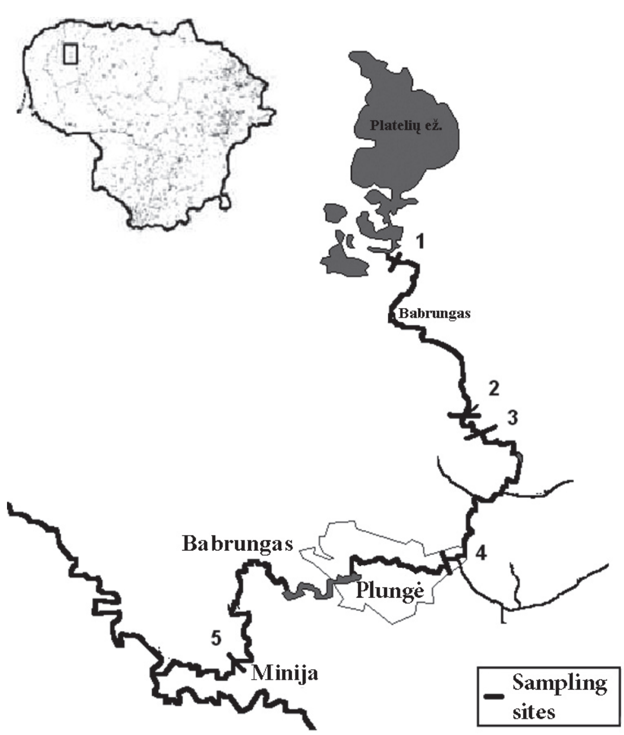

Fig. 1. Map of the Babrungas River with sampling localities

155 cm/km. Mean annual discharge at the mouth is 3.24 m^3/s (Jablonskis et al., 1992).

The studies were performed during May–October (except August) in 2003. Samples were collected by a pipe sampler (sampling area 0.01 m^2) in soft substrate and metallic frame (0.09 m^2) in hard substrate type (Алимов, 1988). All in all, three random samples were taken at each stream site. General physical and hydrological characteristics are given in Table 1.

The macrozoobenthos samples were fixed in formalin solution (4%). In total, 75 samples were collected and lab-analysed according to the generally accepted hydrobiological methods. The organisms were defined according to the lowest possible taxa. The systematic groups of Oligochaeta, Turbellaria, Ceratopogonidae, Psychodidae, Hydracarina were not determined.

The diversity of species in different hydrocenoses was calculated according to the index of Shannon (SB) (Shanon, Wiener, 1949):

$$H = -\sum_{i=1}^{S} P_i Log_e P_i ,$$

where S is the number of species per sample, and Pi is the proportion of total individuals in the ith species.

Before subsequent statistical analysis, the data on invertebrate abundance (expressed in terms of density and biomass) were log-transformed ($\log_{10}(1 + x)$) to improve normality (Sokal, Rohlf, 1997).

To estimate the impact of environmental factors on macrozoobenthos diversity, abundance and biomass, the main effects one way and factorial ANOVA was applied. When significant differences were found by ANOVA ($p < 0.05$), Tukey test was performed for post-hoc comparisons.

Statistical analysis was done using the STATISTICA 5.0 computer program.

RESULTS

103 macrozoobenthos taxa were recorded from the five sites studied in the Babrungas River (Appendix). The most abundant taxa were Diptera, 33 (midges (Chironomidae) consisting of 18 taxa), other abundant taxa were caddis flies and molluscs, 24 and 15, correspondingly. The highest number of species was in the stone substratum (site 3, 51 taxa in total), at another study site the total taxon number was equal (41–42), and at sand substrate (site 2) the lowest taxon number (32 taxa) was found.

The Shannon biodiversity (SB) index was calculated at each site in the Babrungas River. The biodiversity index showed a clear difference among the sites (one-way ANOVA, $F = 36.41$ $df = 4$; $p < 0.001$) (Fig. 2). The highest diversity was established on hard (study sites 3–5) substrate type (Tukey HSD test, $p = 0.05$).

The (SB) indices yielded similar results for seasonal comparisons of different stream sites except in sandy bottom (one-way ANOVA, $df = 4$; $F = 5.76$, $p < 0.02$).

In the Babrungas River, the abundance of invertebrates ranged from 30467 individuals m^{-2} at site 1 to 1667 organ-

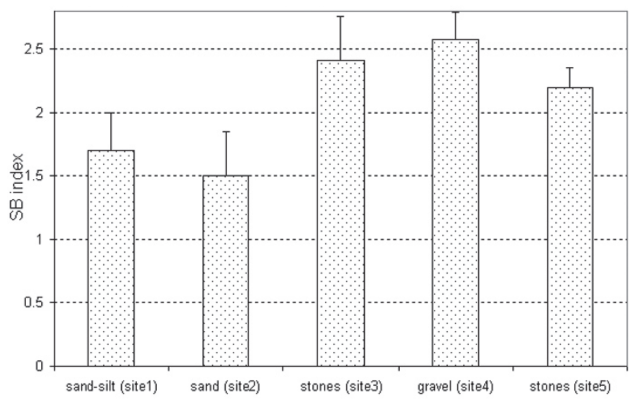

Fig. 2. Index of Shannon biodiversity in different substrates in the Babrungas River

Table 1. **Characteristics of sampling sites of the Babrungas River**

Site	Location	Dominant substrate	Velocity, m/s	Depth,m	Submerged vegetation
1	Below Lake Plateliai	Sand, silt, wooden debris	0.1–0.3	0.30–0.50	Nymphar lutea
2	Near Pauošniai village	Sand	0.2–0.7	0.40–0.50	–
3	Near Nugariai village	Stones	0.5–1	0.30–0.50	Water moss
4	Above Plungė town	Gravel	0.2–0.4	0.40–0.50	Potamogeton sp.
5	Near Stonaičiai village	Stones	0.6–1	0.20–0.30	Water moss

Table 2. **Abundance and biomass of benthic invertebrates at the five study sites at different time in 2003**

Site	Sampling time				
	May	June	July	September	October
	ind/m² g/m²	ind/m² g/m²	ind/m² g/m²	ind/m² g/m²	ind/m² g/m²
1	8000	30467	14600	12267	7950
	240.5	2857.8	832.3	2276.2	1418.1
2	4800	3566	2067	3833	1667
	18.5	16.7	22.9	22.1	11.0
3	2000	3267	4967	2900	7400
	5.9	17.4	53.2	18.4	16.8
4	2366	5467	3100	2833	1900
	33.4	33.3	35.8	28.4	23.0
5	14400	17667	11200	9167	6200
	87.0	105.8	298.4	89.6	116.8

isms m^{-2} at site 2, and the biomass of invertebrate varied from 2857.8 g/m^2 at site 1 to 5.9 g/m^2 at site 3 (Table 2).

Total densities and biomass of benthic invertebrates showed significant difference depending on the season of the year, and among sites within seasons (Table 3).

Spatial differences were significant for macrozoobenthos abundance and biomass. They were the highest at sites 1 and 5 (Table 3). Different species of macroinvertebrates dominated by abundance at different sites: at site 1 molluscs (*Dreissena polymorpha* and *Sphaerium corneum*) dominated, they comprised 67.1% of zoobenthic community, at site 2 dipterans (chironomids) made up 61.9%, at site 3 no dominant species were identified, at site 4 – dipterans (47.8%), at site 5 – trichopterans (34.4%) (Fig. 3).

Molluscs were the dominant macroinvertebrate taxa by total biomass at all the investigated sites (Fig. 4). They constituted 45.5–97.4% of the total invertebrate community biomass. At different sites the following molluscs species dominated: at site 1 – *Dreissena polymorpha* and *Sphaerium corneum*, at site 2 – *Pisidium amnicum*, at site 3 – *Theodoxus fluviatilis* and *Ancylius fluviatilis*, at site 4 – *P. amnicum*, *Radix ovata*, at site 5 – *D. polymorpha*.

At the same site the abundance of macroinvertebrates was significantly different depending on the season investigated (Table 4). The highest invertebrate abundance was established at all the sites in May–June, and only at site 3 in October. Significant differences of macroinvertebrate biomass were observed at the sites investigated, but statistically significant peak between the seasons was not found (Tukey test HSD) (Table 4).

DISCUSSION

A total of 103 taxa were found from five localities. Insects and molluscs were the main taxonomic groups of macro-zoobenthos community in the Babrungas River. Diptera was the most abundant (particularly, the Chironomidae family). The chironomids are always an important component of the fauna in streams (Sharapova, 1998; Shubina et al., 2001).

The SB index was the highest in the gravel-stone substrate habitats (sites 3–5) covered by aquatic plants, mainly moss. These plants make the physical environment of the river more diverse, and such heterogeneous river habitats provide favourable conditions for various species of invertebrates to live (Verberk et al., 2002).

The lowest SB index was in the sand substrate. Sand substrate is generally considered to be a bad habitat for macroinvertebrates, compared to coarser substrates. For example, J. Allan

Table 3. **Results of factorial ANOVA comparing the macrozoobenthos abundance and biomass found at the five study sites at different seasons. (The values linked by the same line do not show any significant differences)**

Factor	Abundance			Biomass		
	df	F value	P	Df	F value	P
Site	4	325.6	<0.0001	4	223.3	<0.0001
Season	4	44.5	<0.0001	4	10.3	<0.0001
Site*season	16	22.0	<0.0001	16	4.8	<0.0001
Tukey test between sites	1; 5 > 2; 3; 4			1; 5 > 2, 3, 4		

Table 4. **Seasonal dynamics of macrozoobenthos abundance and biomass at different investigation site (one-way ANOVA, Tukey test) (the values linked by the same line do not show any significant differences)**

Site	Abundance at different seasons			Biomass at different seasons		
	F value	P	Tukey test	F value	p	Tukey test
1	17.86	>0.0001	06 > 05; 07; 09; 10	13.78	<0,001	06; 07; 09; 10 > 05
2	54.20	>0.0001	05; 06 > 07; 10 > 09	1.50	0.272	–
3	29.72	>0.0001	10 > 05; 06; 07; 09	6.55	0.07	07 > 10
4	9.18	0.003	06 > 05; 07; 09; 10	0.62	0.661	–
5	84.84	>0.0001	06; 05 > 07; 09 > 10	4.60	0.023	07 > 09

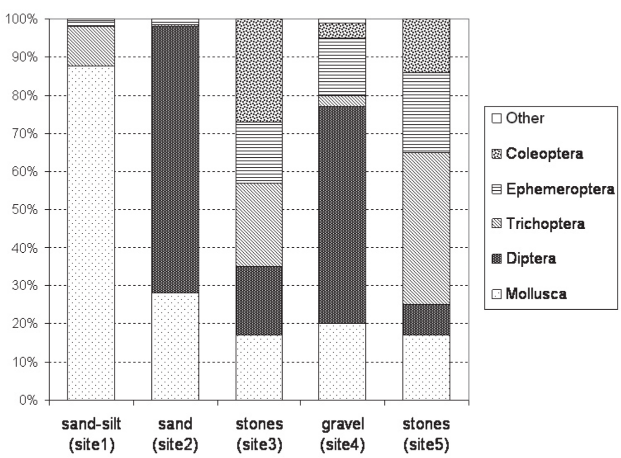

Fig. 3. Relative abundance of invertebrates at different investigated sites

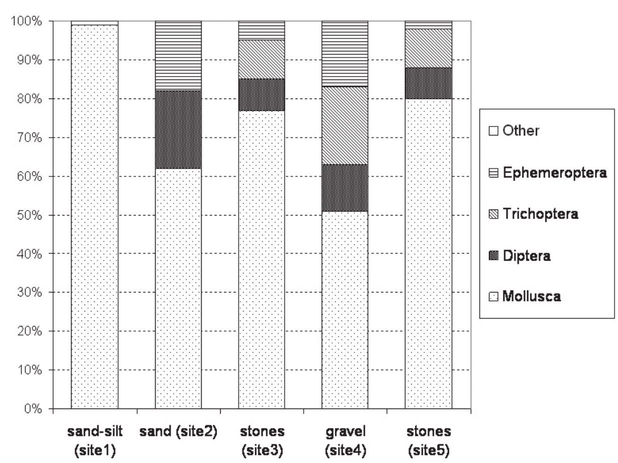

Fig. 4. Relative biomass of invertebrates at different investigated sites

(1995) states that sand is generally a poor substrate for macroinvertebrates, due to its instability and because of the tight packing of particles, reducing the amount of detritus trapped and leading to poor oxygen conditions.

The seasonal variation of Shannon index was significant only in sandy substrate in the Babrungas River. SB index value depends on the number of species and on the abundance of each species in the study area. The sandy ground habitat contained a few invertebrate species, mainly chironomids. In June, chironomids leave the water and become imagos. For this reason the invertebrates community consists of a few species, the abundance of which is low, and the SB index value becomes higher. So, the invertebrate communities with the small number of species are observed because the insect larvae are dominant, and the SB index is differing depending on the season.

Molluscs (*Dreissena polymorpha* and *Sphaerium corneum*) were dominating in sand-silt substrate (site 1). The abundance of invertebrates was lower for this type of substrate in other investigated rivers (Ward, 1992). These differences can be explained by the export of a particular organic matter (POM, phyto- and zooplankton) from the lake (Sandlund, 1982). This study site is just below Lake Plateliai. Besides POM, the benthic invertebrates are also transferred from the lake to the river ecosystem. Due to these reasons the invertebrate community is characteristic of high biomass and abundance of filter feeders (i. e. bivalve molluscs). This pattern is also asserted in small Latvian rivers (Cimdinia, 1989).

At site 5 a great abundance of invertebrates was also observed. It can be explained by a high abundance of epilithons (algae) as trophic resource for the invertebrate community (Lamberti, Moore, 1984). The lower reaches of the Babrungas River usually show big amounts of epilithons due to the high irradiance reaching the streambed (Vannote et al., 1980).

Thus, the zebra-mussels (*Dreisena polymorpha*) are the dominant species by biomass in the community of invertebrates in stone substrate (site 5) with strong current and shallow water. It is not a typical habitat for these molluscs. Generally, this species is found in lakes and rivers with low current. These molluscs can migrate in larval stage from dams of the Babrungas River tributaries into the investigated site. It is interesting to note that zebra-mussels appear only in July. In spring these molluscs were not found in samples. Their seasonal disappearance may be affected by floods: molluscs could be flushed by strong water current.

The stone substrate is characteristic of site 3 and site 5 in the Babrungas River. The composition of invertebrate species is similar at these study sites, but their abundance and biomass are different. There was no clear dominant species at site 3. At site 5 the caddis fly (*Hydropsyche* sp.) was the dominant species by biomass, in addition, molluscs (*D. polymorpha*) also became dominating at the end of the summer. The above invertebrates are filtrators. This fact is explained by the river continuum concept (Vannote et al., 1980), which postulates that at the lowest part of the river the dominant functional group are the filter feeders.

According to H. Hynes (1970), the highest abundance in small rivers is in autumn. In the rivers which were investigated by H. Hynes, insects are the dominant component in macroinvertebrate community. In summer the adult water insects lay eggs, and young larvae hatch before autumn. This reason determines the high numbers of insects in macro-invertebrate community in the rivers. Due to winter mortality and predation, insect larval densities are lower in spring. In our study, this pattern is observed only at site 3. Due to the lack of studies during other investigated seasons the highest abundance of invertebrates may be expected in November. Therefore, in sand and sand-silt ground types, the dominant invertebrates are non-insect organisms, the highest abundance of which is related to warm season.

The river substrate is one of the main abiotic factors for macrozoobenthos community structure in streams. Our results suggest that molluscs are a dominant species by biomass in different substrate types in the Babrungas River. This river is dammed in some places. This factor is very important in influencing the invertebrates community structure. The nutrients and plankton are flushed from dams, and these materials are influencing the structure of macroinvertebrate communities. This evidence is shown in others works (Cimdinia, 1989).

The river continuum concept (Vannote et al., 1980) states that relative abundance of functional groups of benthic invertebrates changes in a stream from the springs to the ocean. Our results imply that the changes in functional groups abundance, predicted by the river continuum concept, could be caused by dams or lakes along the river (Sandlund, 1982; Allan 1995). This pattern is obvious in our results. At site 1 (the Babrungas River headwater) filtrators are the dominated functional group by biomass. According to R. Vannote et al. (1980) shredders are a typical dominant functional group in headwater stream.

In conclusion, molluscs are the main component of invertebrate community in the Babrungas River. It is determined by a few reasons: a lot of food (especially for filtrators (*Dreissena polymorpha*) is flushed from dams; the molluscs larvae can migrate from dams or the lake into the river; the Babrungas River is an unshaded one, the biotope of which is suitable for algae growing (the main food for molluscs-scrapers). Therefore, molluscs are a persistent invertebrate group, the population of which is abundant during the warm season, when this study was carried out.

Appendix. **Macrozoobenthos taxonomic composition in the Babrungas River**

Taxon	The investigated sites				
	Below Lake Plateliai	Near Pauošniai village	Near Nugariai village	Above Plung town	Near Stonaičiai village
1	2	3	4	5	6
Turbellaria undet.	+	+			
Oligochaeta undet	+	+	+	+	
Hirudinea					
Erpobdella octoculata (Linnaeus, 1758)	+				

Appendix continued

Glosiphonia complanata (Linnaeus, 1758)	+			+	
Mollusca					
Ancylius fluviatilis (Muller, 1774)			+	+	+
Anadonta complanata (Linnaeus, 1758)		+			
Bithynia tentaculata (Linnaeus, 1758)	+				
Anisus contortus (Linnaeus, 1758)	+				
Dreissena polymorpha (Pallas, 1771)	+				+
Gyraulis albus (Muller, 1774)					+
Physa phontinalis (Linnaeus, 1758)	+				
Pisidium amnicum (Muller, 1774)	+	+	+	+	+
P. casertanum (Poli, 1791)	+			+	
P. henslowanum (Sheppard, 1825)	+	+		+	
P. subtruncatum (Malm, 1855)				+	
Radix ovata (Draparnaud, 1805)		+	+	+	+
Sphaerium corneum (Linnaeus, 1758)	+				
Theodoxus fluviatilis (Linnaeus, 1758)			+	+	+
Viviparus contectus (Linnaeus, 1758)	+				
Crustacea					
Asellus aquaticus (Linnaeus, 1758)	+				
Gammarus pulex (Linnaeus, 1758)	+				
Plecoptera					
Amphinemura sp.			+		
Isoperla sp.			+	+	
Leuctra sp.		+	+	+	+
Perlodes sp.			+		
Taeniopteryx sp.			+		+
Ephemeroptera					
Baetis spp.	+	+	+	+	+
Caenis macrura (Stephens, 1835)		+		+	
Caenis sp.	+				
Cloeon sp.	+				
Ephemera lineata (Eaton, 1870)				+	
E. vulgata (Linnaeus, 1758)	+	+	+	+	
Ephemerella ignita (Poda, 1761)			+	+	+
Heptagenia sp.			+	+	+
Heptagenidae undet.	+				
Paraleptophlebia sp.					+
Leptophlebia sp.			+	+	
Habrophlebia sp.				+	
Odonata					
Calopteryx splendens (Harris, 1782).				+	
Gomphus sp.		+		+	+
Megaloptera					
Sialis lutaria (Linnaeus, 1758)	+				
Heteroptera					
Aphelocheirus aestivalis (Fabricius, 1794)	+	+	+	+	+
Sigara sp.		+			
Coleoptera					
Elmis maugeti (Linnaeus, 1758)			+	+	+
Gyrinus sp.				+	
Dytiscidae undet.	+	+			
Trichoptera					
Athripsodes aterrimus (Stephens, 1836)	+				
A. cinereus (Curtis, 1834)				+	
Athripsodes sp.	+	+	+	+	+
Anabolia soror (Mac Lachlan, 1875)				+	

Appendix continued

Brachycentrus subnubilus (Curtis, 1834)			+		+
Ceraclea nigronervosa (Retzius, 1783)					+
Cheumatopsyche lepida (Pictet, 1834)					+
Goera pilosa (Fabricius, 1775)	+			+	+
Halesus digitatus (Schrank, 1781)	+		+	+	
Hydropsyche pellucidula (Curtis, 1834)			+	+	+
Lepidostoma hirtum (Fabricius, 1775)	+		+	+	+
Limnephilus rhombicus (Linnaeus, 1758)	+				
Limnephilus sp.	+				
Molana angustata (Curtis, 1834)	+				
Micrasema setiferum (Pictet, 1834)			+		+
Mystacides azurea (Linnaeus, 1761)				+	
Neuroclepsis bimaculata (Linnaeus, 1758)	+				
Oligoplectrum maculatum (Fourcroy, 1785)					+
Potamophylax latipennis (Curtis, 1834)				+	
Polycentropus flavomaculatus (Pictet, 1834)					+
Rhaycophyla nubila (Zetterstedt, 1840)					+
Sericostoma personatum (Kirby, Spence, 1826)		+			
Silo pallipes (Fabricius, 1781)			+		
Tinoides waeneri (Linnaeus, 1758)			+	+	+
Diptera					
Atherix ibis (Fabricius, 1798)	+		+	+	+
Antochia vitripenis (Meigen, 1830)					+
Ceratopogonidae undet			+	+	+
Chrysops sp.	+	+			
Dicranota sp.		+	+		+
Eloeophila sp.		+	+		
Euphylidorea sp.	+				
Helius longirostris (Meigen, 1818)		+			
Hexatoma vittata (Meigen, 1830)		+	+		+
Muscidae undet.			+	+	
Pedicia sp.					+
Phylidorea squalens (Zetterstedt, 1838)		+			
Psychodidae undet.					+
Simulium sp.				+	
Tipula lateralis (Meigen, 1804)			+		+
Chironomidae					
Ablabesmyia sp			+	+	
Chironominae undet.		+			+
Cladotanytarsus sp.	+	+	+	+	
Cricotopus gr. bicinctus			+	+	+
Cryptochironomus sp.	+	+		+	
Endochironomus stackelbergi (Goetghebuer, 1935)					+
Epoicocladius flavens (Molloch, 1915)		+			
Glyptotendipes glaucus (Meigen, 1818)	+	+			
Microtendipes sp.	+			+	
Orthocladiinae undet		+	+	+	
Paratanytarsus austriacus (Kieffer, 1924)				+	+
Paratendipes sp.		+			
Polypedilum bicrenatum (Kieffer, 1921)	+	+	+	+	+
Prodiamesa olivacea (Meigen, 1818)		+		+	
Psectrocladius barbimanus (Hirvenoja, 1973)	+		+	+	
Rheocricotopus sp.		+	+	+	
Tanypodinae undet.		+	+	+	+
Tanytarsus sp.	+	+	+	+	+
Total	42	32	41	51	41

ACKNOWLEDGEMENTS

I am grateful to dr. V. Podėnienė (Limonidae, Diptera), G. Višinskienė (Trichoptera) and G. Vaivilavičius (Mollusca) for macroinvertebrates identifications.

Received 5 February 2007
Accepted 9 July 2007

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Tomas Ruginis

APLINKOS VEIKSNIŲ ĮTAKA MAKROZOOBENTOSO BENDRIJOMS BABRUNGO UPĖJE LIETUVOJE

S a n t r a u k a

Tyrimai buvo atliekami 2003 m. gegužę–spalį (išskyrus rugpjūtį) Babrungo upėje. Mėginiai imti gruntotraukiu (skersmuo 0,01 m^2) ir metaliniu rėmu (0,09 m^2). Babrungo upėje aptikti 103 zoobentoso taksonai. Didžiausia rūšių gausa pasižymėjo dvisparniai (33). Tyrimais nustatyta, kad didžiausia bestuburių rūšinė įvairovė būdinga žvyro ir gargždo biotope, kuris tam tikrais mėnesiais mažai kinta (išskyrus smėlio biotopą). Didžiausi makrozoobentoso gausumas ir biomasė buvo nustatyti upės vietose žemiau patvankos ar ežero. Šiose tyrimų vietose vyrauja moliuskas dreisena (*Dreissena polymorpha*). Kaip parodė tyrimai, upės substrato tipas – svarbus veiksnys, upeliuose nulemiantis makrozoobentoso bendrijų struktūrą, tačiau ne vienintelis.

Raktažodžiai: upeliai**,** makrozoobentosas, Šenono rūšinė įvairovė, substratas