Acta Zoologica Lituanica, 2004, Volumen 14, Numerus 3
ISSN 1392-1657

SPECIES COMPOSITION OF MACROINVERTEBRATES IN MEDIUM-SIZED LITHUANIAN RIVERS

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Abstract. The article is devoted to the analysis of the taxonomic composition of macroinvertebrates in 17 medium-sized Lithuanian rivers with different kinds of substrata. One hundred and sixty taxa of invertebrates were identified in the course of the study. The obtained results proved that in the same river the number of taxa and Shannon-Weaver's index of diversity are substratum type dependent. The greatest number of taxa was established in the stone substratum while the smallest was recorded in the sand one. The richest biodiversity and the highest Shannon-Weaver's index in the stone substratum were recorded in the Jiesia River. Rivers with increased organic contamination were dominated by Trichoptera of the genus *Hydropsyche*.
Key words: macroinvertebrate, species richness, medium-sized rivers

Introduction

In streams, species richness of macroinvertebrates is affected by a large number of biological (Feminella & Resh 1990) and environmental factors (Voelz & McArthur 2000), such as environmental stability (Ward & Stanford 1979). Species richness of aquatic invertebrates is also strongly influenced by natural and/or anthropogenic disturbance (Rosenberg & Resh 1993), which may lead to spatial discontinuities in predictable gradients (Ward & Stanford 1983) and losses of taxa (Brittain & Saltveit 1989). Resh and Jackson (1993) noted that species richness is susceptible to the impact of human activities on stream ecosystems, particularly on aquatic insects of the orders Ephemeroptera, Trichoptera or Plecoptera, which are often good indicators of environmental conditions in streams.

Aquatic insects such as Ephemeroptera, Plecoptera, Trichoptera, Coleoptera (EPTC) are known to be pollution-sensitive (Hynes 1957). Cayrou *et al*. (2000) showed the pertinence of EPTC species associations for stream classifications. Wallace *et al*. (1996) noticed that species richness of Ephemeroptera, Plecoptera, Trichoptera actually responds to variations in water quality.

Data on species richness of macrozoobenthos in medium-sized Lithuanian rivers are not abundant. Kazlauskas (1959, 1960, 1962) investigated stoneflies (Plecoptera), caddisflies (Trichoptera) and mayflies (Ephemeroptera) in different types of (medium-sized among them) Lithuanian rivers. In his study he described their species, indicating their sampling locations. Kazlauskas (1959, 1960, 1962) conducted a comprehensive study of the species composition of stoneflies, caddisflies, mayflies in the Peršokšna and Mera Rivers and that of mayflies – in the Verknė, Ūla-Pelesa Rivers. There were seven species of caddisflies recorded in the Peršėkė River by Spuris (1969). The occurrence of stonefly, caddisfly, mayfly species in the Ežerėlė, Jiesia, Lakaja, Lūšis, Siesartis (Šešupė), Šerkšnė Rivers was not reported. The aim of the current study has been to establish the species composition and diversity of macroinvertebrates in medium-sized Lithuanian rivers with different kinds of substrata.

Material and methods

The investigations were performed in summer 1998–2002 in 17 medium-sized rivers: the Armona, Ežerėlė, Jiesia, Lakaja, Lūšis, Mera, Peršėkė, Peršokšna, Siesartis (Šešupė), Spengla, Šerkšnė, Širvinta, Verseka, Verknė, Vilnia, Virinta, Ūla-Pelesa. The presence of the stone substratum, noted for higher species richness, was taken into consideration when selecting rivers for the investigation.

Description of sites

There are about 29.9 thousand streams (longer than 0.5 km) with the total length of 63,700 km in Lithuania. Small rivers up to 10 km long make up approximately 97.5% of the total number of rivers or 77% of the total length of riverbeds. 758 rivers and canals are longer than

10 km, 19 of them being longer than 100 km and nine – longer than 200 km (Kilkus 1998). The rivers investigated were classified as medium-sized in accordance with the EC Water Framework Directive (2000/60/EC).
In the course of sampling the water level in the investigated rivers with the stone substratum was 25–40 cm and 60–70 cm in those with the gravel, sand-silt and sand substrata. At the moment of sampling the water in the rivers was unturbid. The character of anthropogenic pollution was not studied in the course of sampling.
According to the classification of water contamination used in Lithuania the rivers were divided into six classes in accordance with Water quality monitoring programme; Table 1.

The majority of the investigated rivers were clean or cleanish (I–III class). According to the quality class of contamination the most contaminated rivers were the Jiesia, Siesartis, Peršėkė (IV–V class; Table 2).

Sampling methods and statistical analysis

Samples of macrozoobenthos were taken with a stovepipe sampler (cylindrical tube) from the gravel, sand-silt and sand substrata (Gasiūnas 1956). On study sites with the substrata of sand and stones 2–10 cm in diameter samples were dredged up from three 0.1 m^2 areas (stone substratum) by the method of kick-sampling (NBWE 1993). Samples were also collected from plants:

Table 1. Classification of river contamination used in Lithuania.

	Very clean	Clean	Low contaminated	Medium contaminated	Highly contaminated	Very highly contaminated
Quality class	I	II	III	IV	V	VI
BDS_5, mgO_2/l	<2.0	2.0–3.5	3.6–5.0	5.1–8.0	8.1–18.0	>18
Inorganic nitrogen, mg N/1	<0.3	0.3–0.75	0.8–2.5	2.6–7.5	7.6–15.0	>15
Phosphates, mg P/1	<0.025	0.025–0.050	0.055–0.125	0.130–0.250	0.300–0.500	>0.500

Table 2. Parameters of the investigated rivers.

River basin	Name of the affluent	Area of the river basin in Lithuania km^2	Average long-term annual yield m^3/s	Current velocity m/s	Water temperature in the course of sampling °C	Sampling dates	Quality class
Merkys	Spengla	148.3	1.0	0.28	17.2	July 1999	I
	Verseka	384.4	2.7	0.55	19.4	June 1998	I
	Ūla-Pelesa	752.9	5.5	0.35	17.0	July 1999	I
Šventoji	Armona	218.9	1.4	0.3	21.0	July 1999	II
	Širvinta	918.1	6.5	0.4	21.0	July 1999	III
	Virinta	566.3	4.4	0.45	14.0	June 1998	II
Žeimena	Lakaja	432.1	2.51	0.31	20.1	July 1999	I
	Mera	204.4	1.9	0.4	16.5	July 1999	II
	Peršokšna	105.3	0.7	0.3	18.9	July 1999	I
Venta	Lūšis	113.6	1.03	0.5	12.5	August 2001	II
	Šerkšnė	285.2	1.9	0.3	15.8	August 2001	III
Nemunas	Jiesia	473.7	3.0	0.3	17.0	July 2002	IV
	Peršėkė	561.8	2.5	0.5	20.0	August 2001	V
	Verknė	727.5	5.7	0.5	16.8	June 1998	III
Neris	Vilnia	623.5	5.5	0.5	20.5	July 2002	II
Šešupė	Siesartis	197.6	1.0	0.4	19.0	August 2001	IV–V
Mūša	Ežerėlė	156.2	0.74	0.3	16.0	August 1998	II

In Table 2 the river basin area is presented in accordance with Gailiušis et al. (2001)

benthic fauna having been collected, plants were weighed (phytophilic species), the abundance of zoobenthos being calculated ind/1 kg of plants and the biomass – g/1 kg of plants. The more common plant species from which samples of macroinvertebrate were collected in the investigated rivers included *Elodea canadensis*, *Ceratophyllum demersum*, *Potamogeton* spp. In total there were 117 samples gathered and analysed in the laboratory by conventional methods employed in hydrobiology.

The following indices were calculated: Shannon-Weaver's diversity index (Shannon & Weaver 1949) and Sørensen's similarity index (Sørensen 1948). Oligochaeta and Simuliidae were identified only to the family level and therefore were excluded from statistical analyses when calculating indices. Mean ±SE and Student's *t*-test was used for estimates of macroinvertebrate abundance in the stone substratum of rivers. Correlations were calculated according Pearson (StatSoft 2001). Similarities in the abundance of taxa between invertebrate samples collected from the stone substratum and plants were calculated using the Bray-Curtis similarity measure (Bray & Curtis 1957), which is recommended by Bloom (1981), Faith *et al*. (1987) and Jackson (1993). When applied to binary data the Bray-Curtis index is exactly equivalent to Sørensen's index (Sørensen 1948). These similarities were calculated using the Cluster Program of the Primer package.

Results

Species composition of macroinvertebrates in investigated medium-sized rivers

In the course of the investigation performed in 17 medium-sized rivers in different districts of Lithuania 160 taxa of macrozoobenthic organisms were identified: Hirudinea – 4 (2.5% of the total number of taxa), Isopoda – 1 (0.6%), Amphipoda – 1 (0.6%), Ephemeroptera – 20 (12.5%), Plecoptera – 6 (3.7%), Odonata – 2 (1.2%), Heteroptera – 4 (2.5%), Coleoptera larvae – 4 (2.5%), Coleoptera imago – 6 (3.7%), Megaloptera – 1 (0.6%), Trichoptera – 31 (19.4%), Lepidoptera – 1 (0.6%), other Diptera – 10 (6.2%), Chironomidae – 44 (27.5%), Mollusca – 25 (15.6%; Table 3).

Table 3. List of taxa of benthic macroinvertebrates in rivers.

Group	Family/ Subfamily	Taxon	Jiesia	Siesartis	Peršėkė	Lūšis	Šerkšnė	Ežerėlė	Ūla-Pelesa	Spengla	Verseka	Vilnia	Širvinta	Armona	Virinta	Mera	Lakaja	Peršokšna	Verknė
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Oligochaeta			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Hirudinea	Glossiphonidae	*Glossiphonia complanata* (Linnaeus)		+			+						+		+		+		+
		Helobdella stagnalis (Linnaeus)	+		+	+	+										+		+
	Erpobdellidae	*Erpobdella octoculata* (Linnaeus)	+	+	+		+			+			+	+	+	+	+	+	
	Pisciolidae	*Piscicola geometra* (Linnaeus)												+					+
Mollusca	Dreissenidae	*Dreissena polymorpha* (Pallas)															+		
	Unionidae	*Anodonta piscinalis* Nilsson	+								+						+		
		Unio tumidus Philipsson									+								
	Planorbidae	*Ancylus fluviatilis* Müller	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+
		Anisus septemgyratus (Rossmässler)															+		
		Planorbarius corneus (Linnaeus)		+													+		
		Anisus albus (Müller)	+		+		+					+					+		

Table 3 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		Hippeutis complanatus (Linnaeus)									+				+				
		Planorbis planorbis (Linnaeus)						+											
	Bithyniidae	*Bithynia leachi* (Sheppard)											+						
		Bithynia tentaculata (Linnaeus)	+		+		+	+		+	+	+	+		+		+		
	Lithoglyphidae	*Lithoglyphus naticoides* Pfeiffer						+											
	Lymnaeidae	*Lymnaea palustris* (Müller)				+	+										+		
		Lymnaea auricularia (Linnaeus)					+		+	+			+		+		+		
		Lymnaea ovata (Draparnaud)							+		+				+	+	+		
		Lymnaea peregra (Müller)	+	+		+	+		+				+						
	Physidae	*Physa fontinalis* (Linnaeus)											+		+		+		
	Pisidiidae	*Pisidium amnicum* (Müller)						+		+			+				+		
		Euglesa nitida Jenyns	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
		Euglesa supina (Schmidt)	+	+				+			+		+		+		+		
		Sphaerium corneum (Linnaeus)	+	+	+	+													
		Sphaerium rivicola (Lamarck)	+					+		+	+		+	+	+		+		
	Neritidae	*Theodoxus fluviatilis* (Linnaeus)			+		+				+		+				+		
	Valvatidae	*Valvata naticina* Menke						+											
		Valvata piscinalis (Müller)			+		+					+	+				+		
Isopoda		*Asellus aquaticus* (Linnaeus)	+	+				+					+		+		+		
Amphipoda		*Gammarus pulex* (Linnaeus)			+	+				+	+						+		
Odonata	Calopterygidae	*Calopteryx splendens* (Harris)															+		+
	Gomphidae	*Gomphus vulgatissimus* (Linnaeus)								+	+	+			+	+	+		
Ephemeroptera	Baetidae	*Baetis* (*Baetis*) *pumilus* Burmeister	+	+	+		+		+		+	+	+	+	+	+			+
		Baetis (*B.*) *rhodani* (Pictet)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Cloeon (*Centroptilum*) *luteolum* (Müller)	+					+				+			+		+		+
		Cloeon (*Cloeon*) *dipterum* (Linnaeus)	+	+		+	+							+			+	+	
		Cloeon (*Procloeon*) *bifidum* Bengtsson							+										+

Table 3 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Caenidae	*Caenis horaria* (Linnaeus)													+	+	+	+	+
		Caenis macrura Stephens	+	+	+		+				+	+	+		+		+		+
		Brachycercus harrisella Curtis																	+
	Heptageniidae	*Ecdyonurus venosus* (Fabricius)	+		+	+	+	+		+		+	+	+	+	+	+	+	+
		Heptagenia (*Heptagenia*) *flava* Rostock								+									
		Heptagenia (*Docnogenia*) *coerulans* Rostock	+		+	+	+		+	+		+	+	+	+	+	+	+	
		Heptagenia (*H.*) *sulphurea* (Müller)					+					+							
	Ephemeridae	*Ephemera danica* Müller	+		+	+	+		+	+	+		+	+	+	+	+	+	+
		Ephemera vulgata Linnaeus															+		
	Ephemerellidae	*Ephemerella* (*Serratella*) *ignita* (Poda)	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+
	Leptophlebiidae	*Habrophlebia fusca* (Curtis)				+	+								+				
		Lephtophlebia (*Lephtophlebia*) *marginata* (Linnaeus)					+						+						
		Lephtophlebia (*Paraleph-tophlebia*) *cincta* (Retzius)		+	+	+	+												
	Potamanthidae	*Potamanthus luteus* (Linnaeus)	+				+					+					+		+
	Siphlonuridae	*Siphlonurus* spp.	+						+	+			+		+		+		+
Plecoptera	Capniidae	*Capnia* spp.				+	+					+							
		Capnioneura spp.										+							
	Nemouridae	*Nemurella pictetii* Klapálek										+							
	Leuctridae	*Leuctra* spp.		+	+	+	+	+	+	+		+	+	+	+	+	+	+	
	Perlidae	*Perla abdominalis* Klapálek								+									
		Perla sp.						+											
Megaloptera		*Sialis lutaria* (Linnaeus)	+										+						
Heteroptera	Aphelocheiridae	*Aphelocheirus aestivalis* (Fabricius)	+		+		+			+	+	+	+	+	+		+		+
	Corixidae	*Corixa* spp.										+							
		Micronecta minutissima (Linnaeus)										+							
	Gerridae	*Gerris* spp.													+				+
Coleoptera larvae	Elmidae	*Elmis aenea* (Müller)	+	+	+	+	+		+	+		+	+	+	+	+	+	+	+
		Riolus cupreus (Müller)	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+
	Gyrinidae	*Aulonagyrus concinnus* (Klug)					+						+			+			
	Dytiscidae	*Acilius* spp.					+												
Coleoptera imago	Dytiscidae	*Dytiscus* spp.						+											
		Hydaticus spp.													+				
		Ilybius spp.	+												+	+			

Table 3 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Haliplidae	*Haliplus* spp.			+	+	+												
	Hydrophilidae	*Hydrobius fuscipes* (Linnaeus)																	+
	Hydrochidae	*Hydrochus* spp.	+		+				+	+		+	+	+	+	+	+		
Trichoptera	Brachycentridae	*Brachycentrus* (*Brachycentrus*) *subnubilus* Curtis					+			+	+	+	+		+		+	+	+
	Hydropsychidae	*Hydropsyche angustipennis* Curtis	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+
		Hydropsyche pellucidula Curtis	+	+	+	+	+	+	+	+	+	+	+	+	+			+	+
		Hydropsyche ornatula MacLachlan			+	+	+	+		+			+		+				+
	Hydroptilidae	*Hydroptila* spp.	+	+	+														
		Ithytrichia lamellaris Eaton	+											+	+	+	+	+	+
	Goeridae	*Goera pilosa* (Fabricius)	+			+	+			+				+	+				
	Lepidostomatidae	*Lepidostoma hirtum* (Fabricius)				+										+			+
	Leptoceridae	*Ceraclea annulicornis* (Stephens)	+		+	+			+			+			+	+	+	+	+
		Athripsodes cinereus (Curtis)				+	+									+			+
		Athripsodes aterrimus (Stephens)										+							
		Leptocerus tineiformis Curtis	+			+	+					+				+	+		
		Mystacides azureus (Linnaeus)	+			+	+					+		+	+				
		Triaenodes bicolor (Curtis)	+								+				+		+		
	Apataniidae	*Apatania fimbriata* (Smidt)						+											
	Limnephilidae	*Anabolia soror* MacLachlan	+	+		+	+	+					+	+	+				+
		Chaetopteryx villosa (Fabricius)																	+
		Grammotaulius atomarius Fabricius		+		+	+			+					+				
		Halesus tessellatus (Rambur)						+						+					
		Limnephilus flavicornis (Fabricius)						+											
		Limnephilus politus MacLachlan																	+
		Limnephilus stigma Curtis											+						
		Nemotaulius punctatolineatus (Retzius)	+	+				+	+								+		+
		Stenophylax spp.		+		+		+			+		+		+		+		
	Molannidae	*Molanna angustata* Curtis															+		
	Odontoceridae	*Odontocerum albicorne* (Scopoli)						+											

Table 3 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Polycentropodidae	*Cyrnus flavidus* MacLachlan				+					+	+			+		+		+
		Polycentropus flavomaculatus Pictet				+						+	+	+	+		+		
	Rhyacophilidae	*Rhyacophila nubila* Zetterstedt	+		+				+	+	+	+	+		+	+		+	+
		Rhyacophila septentrionis MacLachlan																	+
	Sericostomatidae	*Sericostoma personatum* (Kirby et Spence)					+												
Lepidoptera		*Paraponyx stratiotata* Linnaeus			+	+										+			
Diptera	Cylindromidae	*Anopheles* spp.															+		
	Limoniidae	*Dicranota bimaculata* (Schummel)	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+
	Empididae	*Hemerodromia* spp.								+			+		+		+	+	
	Rhagionidae-Leptodae	*Atherix* spp.	+		+	+	+		+	+	+	+	+		+	+	+	+	+
	Ceratopogonidae	*Bezzia* spp.	+																
	Sciomyzidae	*Sciomyza* spp.													+				
	Simuliidae	*Simulium* spp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Tabanidae	*Tabanus* spp.	+	+	+						+		+		+				+
	Tipulidae	*Tipula* spp.	+				+	+	+			+	+		+	+			
		Triogma spp.			+											+			
	Chironomidae Chironominae	*Chironomus* (*Chironomus*) *plumosus* (Linnaeus)									+		+				+		
		Chironomus plumosus-reductus sensu Lipina											+						
		Cladotanytarsus gr. *mancus* (Walker)						+	+			+			+				+
		Cryptochironomus gr. *defectus* (Kieffer)	+								+								
		Cryptochironomus gr. *macropodus* Lyakhov	+																+
		Demicryptochironomus (*Demicryptochironomus*) *vulneratus* (Zetterstedt)		+	+							+	+						+
		Glyptotendipes gripekoveni (Kieffer)	+									+							
		Glyptotendipes pallens (Meigen)															+		
		Endochironomus tendens (Fabricius)		+													+		
		Microtendipes gr. *pedellus* (Meigen)															+		
		Microtendipes gr. *tarsalis* (Walker)			+	+							+				+		
		Micropsectra junci (Meigen)	+						+				+				+		+
		Paracladopelma camptolabis (Kieffer)																	+
		Paratanytarsus lauterborni (Kieffer)		+	+	+	+	+	+	+			+			+	+	+	+

Table 3 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		Paratendipes albimanus (Meigen)											+						
		Polypedilum (*Pentapedilum*) *exsectum* (Kieffer)		+								+					+		+
		Polypedilum (*Tripodura*) *bicrenatum* Kieffer											+				+		
		Polypedilum (*Polypedilum*) *pedestre* (Meigen)											+						
		Polypedilum (*Tripodura*) *scalaenum* (Schrank)	+	+	+				+			+	+						
		Polypedilum sp.	+								+	+	+		+	+	+	+	
		Sergentia gr. *longiventris* Kieffer																	+
		Stempellina bausei (Kieffer)						+	+										
		Stenochironomus spp.							+				+						
		Stictochironomus gr. *psammophilus* Tshernovskij		+	+	+									+	+	+		+
		Tanytarsus gr. *holochlorus* Edwards											+						
		Tanytarsus gr. *gregarius* Kieffer															+		
		Xenochironomus xenolabis (Kieffer)		+															
	Orthocladiinae	*Brillia* spp.	+			+													
		Cricotopus (*Cricotopus*) gr. *algarum* (Kieffer)	+	+	+	+	+	+			+	+	+	+		+	+	+	
		Cricotopus (*C.*) gr. *bicinctus* (Meigen)	+						+				+						
		Cricotopus (*C.*) gr. *fuscus* (Kieffer)							+										
		Cricotopus (*Isocladius*) *sylvestris* (Fabricius)	+		+			+	+	+	+	+	+	+		+		+	
		Eukiefferiella gr. *coerulescens* (Kieffer)	+	+	+	+		+				+		+			+		
		Orthocladius (*Orthocladius*) *saxicola* Kieffer			+	+						+	+				+		+
		Psectrocladius (*Allopsectrocladius*) *obvius* (Walker)										+							
		Psectrocladius (P.) *psilopterus* Kieffer																	+
		Zalutschia gr. *mucronata* (Brudin)												+			+		
	Diamesinae	*Diamesa insignipes* Kieffer									+		+		+				
	Prodiamesinae	*Monodiamesa bathyphila* (Kieffer)							+				+				+		
		Prodiamesa olivacea (Meigen)	+	+	+						+				+		+		
	Tanypodinae	*Natarsia punctata* (Meigen)															+		
		Thienemannimyia gr. *lentiginosa* (Fries)	+					+				+	+		+		+		
		Zavrelimyia melanura (Meigen)																	+
		Procladius spp.	+		+			+					+		+		+		

In different rivers the number of taxa of invertebrates varied from 26 to 78. The smallest number of taxa was established in the Peršokšna River, the greatest being recorded in the Lakaja River.

In the investigated medium-sized rivers of Lithuania the richest species diversity was observed in the order of Diptera. This order was found to include 42 species (31.6% of the total number of species) and 12 other taxa (not identified to the species level), 41 species (Fig. 1) and three other taxa of which belonged to the family Chironomidae. Chironomids of the subfamily Chironominae exhibit the highest species richness – 26 species (19.6%) and one taxon of chironomids were found. The greatest number of chironomid taxa was detected in the Lakaja and Širvinta Rivers. The dominant species of chironomids *Cricotopus* gr. *algarum* was recorded in 13 rivers (76.5% of the number of investigated rivers), the subdominant species *Paratanytarsus lauterborni* being recorded in 12 (70.6%) and *Cricotopus sylvestris* in 11 rivers (64.7%; Fig. 2).

The blackflies *Simulium* spp. (in all rivers investigated) and *Dicranota bimaculata* (not recorded only in one of the investigated rivers) proved to be most common among Diptera.

Another abundant order of insects is that of caddisflies (Trichoptera). Twenty nine species (Fig. 1; 21.8% of the total number of species) and two other taxa, belonging to 13 families were detected. The highest species richness was recorded in the family Limnephilidae (eight species and one taxon). The greatest number of Trichoptera species was established in the Virinta – 16, Verknė – 15, Ežerėlė – 14, Lūšis – 14. The most common species of Trichoptera included: *Hydropsyche angustipennis* (94.1%), *Hydropsyche pellucidula* (88.2%), *Rhyacophyla nubila* (64.7% of the number of investigated rivers; Fig. 2). The third in abundance insect order is that of Ephemeroptera – 19 species (Fig. 1) and one other taxon, belonging to eight families were found. The family Baetidae, comprising five species, had the highest species richness. The greatest number of Ephemeroptera species was recorded in the Šerkšnė River – 13, Verknė – 12, Lakaja – 12. *Baetis rhodani* (Ephemeroptera) were detected in all investigated medium-sized rivers. *Ephemerella ignita* (Ephemeroptera) were detected in 16 (94.1%), and *Ephemera danica* – in 14 of the investigated rivers (88.2% of the number of investigated rivers; Fig. 2). Mollusca were represented by two classes – Bivalvia and Gastropoda, a total of 25 species (Fig. 1), belonging to 11 families. The highest species richness was found in the families Planorbidae (six species) and Pisidiidae (five species). The greatest number of Mollusca species was recorded in the following rivers: the Lakaja – 17 species, the Širvinta – 12 and the Ežerėlė – 11. The most common mollusc species were *Ancylus fluviatilis*, *Euglesa nitida* (Fig. 2). Other groups of macrozoobenthic fauna which were not distinguished for a greater number of species but were widespread in medium-sized rivers, included Hirudinea – *Erpobdella octoculata*, Plecoptera – *Leuctra* spp., Heteroptera – *Aphelocheirus aestivalis*, Coleoptera larvae – *Elmis aenea* and *Riolus cupreus* (Fig. 2).

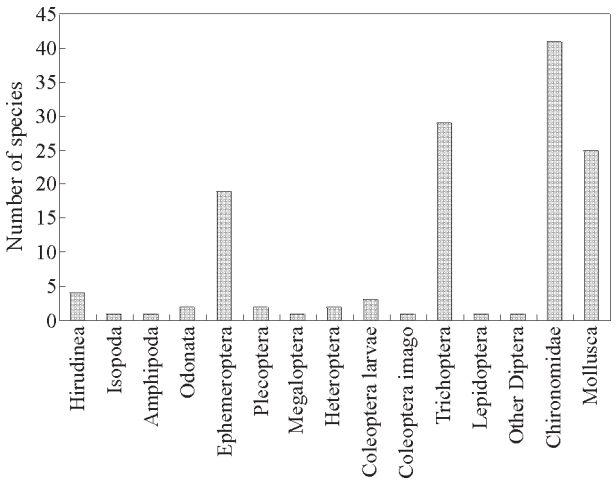

Figure 1. Species richness of benthic communities in rivers.

Species composition of macroinvertebrates in different kinds of substrata

The species composition of macroinvertebrates is substratum type dependent. In the stone substratum of the investigated rivers there were 148 taxa of

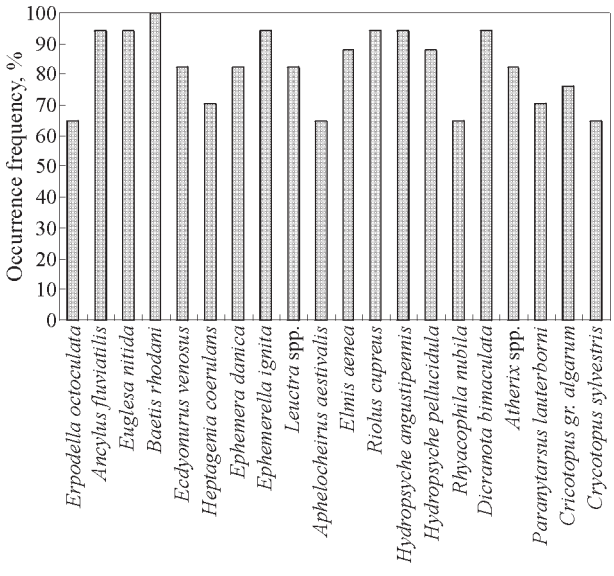

Figure 2. Occurrence frequency of benthic invertebrates (% of the number of rivers investigated).

Table 4. Dominance of benthic macroinvertebrate taxa in different kinds of river substrata and on aquatic plants.

River	Stone substratum	Gravel substratum	Sand-silt substratum	Sand substratum	Plants
1	2	3	4	5	6
Peršėkė	*Theodoxus fluviatilis*, *Riolus cupreus*, *Hydropsyche pellucidula*				
Lūšis	*Gammarus pulex*, *Ephemera danica*, *Elmis aenea, Riolus cupreus*				
Šerkšnė	*Heptagenia coerulans, Riolus cupreus*				
Ežerėlė	*Halesus tessellatus, Nemoura* spp.				*Simulium* spp.
Siesartis	*Hydropsyche angustipennis*, *H. pellucidula*, *Euglesa nitida*, *Elmis aenea*, *Cricotopus* gr. *algarum*				*Simulium* spp., *Asellus aquaticus*
Mera	*Elmis aenea*, *Ancylus fluviatilis*	*Cricotopus* gr. *algarum*			*Simulium* spp., *Hydropsyche angustipennis*, *Cricotopus sylvestris*
Lakaja	*Caenis macrura*, *Riolus cupreus*	*Leuctra* spp.	*Sphaerium rivicola*		*Simulium* spp., *Brachycentrus subnubilus, Ephemerella ignita*
Peršokšna	*Elmis aenea*, *Riolus cupreus*, *Atherix* spp., *Ancylus fluviatilis*	*Ephemera danica*			*Simulium* spp., *Brachycentrus subnubilus*, *Polypedilum* sp., *Hydropsyche pellucidula*
Verknė	*Ephemerella ignita*, *Leuctra* spp.		*Pisidium amnicum*		*Simulium* spp., *Brachycentrus subnubilus*, *Chaetopteryx villosa*
Jiesia	*Ephemerella ignita*, *Atherix* spp., *Hydropsyche angustipennis*, *H. pellucidula*				*Simulium* spp., *Cricotopus sylvestris*, *Cricotopus* gr. *algarum*
Virinta	*Ephemerella ignita*, *Riolus cupreus*, *Leuctra* spp., *Elmis aenea*	*Polypedilum* sp.			*Simulium* spp., *Brachycentrus subnubilus*

Table 4 continued

1	2	3	4	5	6
Verseka	*Ephemerella ignita*, *Riolus cupreus*	*Sphaerium rivicola*	*Chironomus plumosus*		*Simulium* spp.
Spengla	*Baetis rhodani*, *Ancylus fluviatilis*, *Elmis aenea*, *Brachycentrus subnubilus*, *Atherix* spp.	*Sphaerium rivicola*			*Brachycentrus subnubilus*
Ūla-Pelesa	*Baetis rhodani*, *Ancylus fluviatilis*	*Cricotopus* gr. *algarum*		*Euglesa nitida*	*Simulium* spp., *Brachycentrus subnubilus*, *Cricotopus sylvestris*, *Athripsodes aterrimus*
Armona	*Baetis rhodani*, *Ancylus fluviatilis*, *Riolus cupreus*	*Eukieffe riella* gr. *coerulescens*			*Simulium* spp., *Cricotopus sylvestris*, *Riolus cupreus*
Širvinta	*Ancylus fluviatilis*, *Elmis aenea*, *Baetis rhodani*	*Polypedilum bicrenatum*		*Polypedilum bicrenatum*	*Bithynia leachi*
Vilnia	*Baetis rhodani*, *Ephemerella ignita*, *Aphelocheirus aestivalis*	*Sphaerium rivicola*, *Cricotopus* gr. *algarum*			*Simulium* spp., *Eukiefferiella* gr. *coerulescens*, *Athripsodes aterrimus*

macroinvertebrates found (Fig. 3). The highest species richness among them was observed in Chironomidae (36), Trichoptera (27), Mollusca (25).

The performed investigations established, that the abundance of macroinvertebrates in the stone substratum is not always biodiversity-dependent. In the stone substratum the poorest biodiversity was established in the Peršokšna River (16 taxa) where the abundance of invertebrates totalled 1,263 ± 404 ind/m². In the Ežerėlė River the abundance of invertebrates proved to be the smallest (330 ± 74 ind/m²), the number of taxa being great enough (32). The abundance of invertebrates (2,084 ± 383 ind/m²) as well as their diversity (53 taxa) was found to be the greatest in the stone substratum of the Jiesia River in comparison with other rivers.

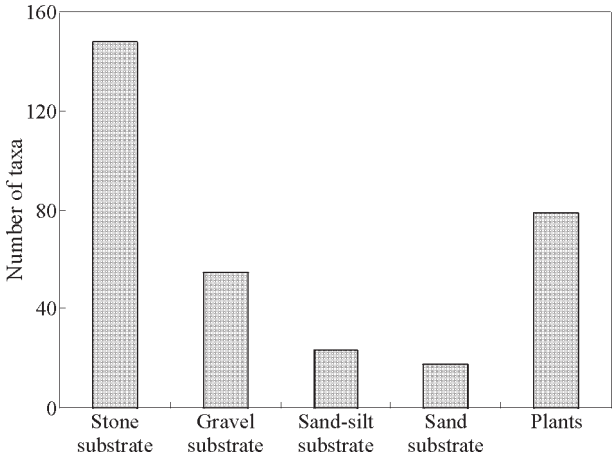

Figure 3. Number of macroinvertebrate taxa in different kinds of river substrata and on aquatic plants.

In the majority of the investigated rivers in the stone substratum the most common were Coleoptera larvae – *Elmis aenea*, *Riolus cupreus*. *Baetis rhodani*, *Ephemerella ignita* were more abundant among Ephemeroptera. In the Lakaja most abundant among them were *Caenis macrura* and in the Šerkšnė – *Heptagenia coerulans* (Table 4). Species that are abundant in the stone substratum also include *Leuctra* spp. (Plecoptera) (Virinta and Verknė), *Nemoura* spp. (Ežerėlė). *Ancylus fluviatilis* (Mollusca) are widespread in the stone substratum. They are more common in the Armona, Mera, Peršokšna, Spengla, Širvinta and Ūla-Pelesa Rivers. As a dominant species *Theodoxus*

fluviatilis (Mollusca) was recorded only in the Peršėkė River. Some Trichoptera species were often detected in the stone substratum. Amphipoda *Gammarus pulex* are not widespread in the investigated medium-sized rivers of Lithuania. They were dominant only in the Lūšis River. Heteroptera *Aphelocheirus aestivalis* proved to be more abundant only in the Vilnia River. Other Diptera *Atherix* spp. were abundantly recorded in the Jiesia, Peršokšna, Spengla and Ūla-Pelesa Rivers. Chironomidae *Cricotopus* gr. *algarum*, *Paratanytarsus lauterborni* proved to be more abundant in the stone substratum of rivers too. Trichoptera *Brachycentrus subnubilus* occurred more frequently in the Spengla River while *Chaetopteryx villosa*, *Limnephilus flavicornis* and *Halesus tessellatus* were more common in the Ežerėlė River. The study showed that Trichoptera of the genus *Hydropsyche* prevail in the stone substratum of rivers (Jiesia, Siesartis, Peršėkė) with high-level organic contamination (IV–V class). Meanwhile, in clean-water rivers (I–III class) their abundance was not great.

A positive statistically significant correlation between the overall number of taxa and Ephemeroptera, Plecoptera, Trichoptera, Coleoptera taxa was established in the stone substratum of the Virinta ($r = 0.91$, $p < 0.01$), Jiesia ($r = 0.82$, $p < 0.01$) and Šerkšnė ($r = 0.94$, $p < 0.05$) Rivers. A positive statistically significant correlation between the number of taxa and the abundance of invertebrates ($r = 0.87$) as well as between the number of taxa and Shannon-Weaver's index ($r = 0.93$) was established in the Jiesia River.

The number of taxa found in the stone substratum in different rivers varied from 16 (Peršokšna) to 53 (Jiesia; Table 5). The highest Shannon-Weaver's index of diversity was recorded in the Širvinta ($H' = 4.62$) and Jiesia ($H' = 4.60$) Rivers, the smallest being established in the Verseka River ($H' = 2.06$; Table 5).

According to the Bray-Curtis similarity matrix the closest similarity in the macroinvertebrate species composition in the stone substratum was found between the Armona and Mera (53.3%), Verknė and Virinta (50.6%) Peršėkė and Jiesia (49.9%), Vilnia and Virinta (47.5%) Rivers. The lowest similarity coefficients were established between the Ežerėlė and Spengla (2.5%), Ežerėlė and Peršokšna (2.8%) (Fig. 4).

There were 55 taxa of macroinvertebrate organisms identified in the gravel substratum in the investigated rivers (Fig. 3). The highest species richness among them was recorded in Chironomidae (15) and Mollusca (11). In the gravel substratum of this type Ephemeroptera *Ephemera danica*, Mollusca *Sphaerium rivicola*, Chironomidae *Cricotopus* gr. *algarum*, *Polypedilum* sp. and other species proved to be more abundant (Table 4). The number of taxa detected in the gravel substratum biotope in different rivers varied from three to 25 (Table 5).

Table 5. Total number of macroinvertebrate taxa and Shannon-Weaver's diversity index in different kinds of river substrata and on aquatic plants.

Rivers	Total number of macroinvertebrate taxa					Shannon-Weaver's diversity index				
	Substratum				Plants	Substratum				Plants
	stone	gravel	sand-silt	sand		stone	gravel	sand-silt	sand	
Jiesia	53				9	4.60				2.83
Siesartis	36				11	4.25				2.31
Peršėkė	43				8	4.25				2.75
Lūšis	45					3.88				
Šerkšnė	50					4.19				
Ežerėlė	32				11	3.94				1.78
Ūla-Pelesa	32	9		6	17	3.94	2.44		2.23	2.60
Spengla	35	8			11	3.48	2.65			1.15
Verseka	28	6	7		14	2.06	2.03	1.93		0.30
Vilnia	49	13			8	4.32	3.32			1.37
Širvinta	50	10		9	27	4.62	2.16		2.47	3.88
Armona	27	11			14	3.90	2.26			2.71
Virinta	49	10			20	3.84	2.51			0.87
Mera	27	4			19	3.81	1.80			3.52
Lakaja	45	25	5		42	4.66	3.84	2.24		3.14
Peršokšna	16	3			22	2.71	1.12			3.42
Verknė	33		15		19	3.44		3.34		2.49

In the gravel substratum values of the Shannon-Weaver's diversity index ranged from 1.12 to 3.84. The smallest values of this index were established in the Peršokšna River where the number of taxa was also the smallest. In the biotope of the gravel substratum the highest index of diversity was recorded in the Lakaja River, in which the number of taxa also proved to be the greatest (Table 5).

In the sand substratum the number of established taxa of invertebrates was the smallest. In this community Shannon-Weaver's index of diversity was also the smallest in comparison with other kinds of substratum in the same river (Table 5). Chironomidae *Polypedilum bicrenatum* and Mollusca *Euglesa nitida* were also more common in this type of substratum (Table 4).

The sand-silt substratum was dominated by Chironomidae *Chironomus plumosus*, *Sphaerium rivicola* and Mollusca *Pisidium amnicum* (Table 4).

Seventy nine taxa of macrozoobenthic organisms were identified in samples taken from plants of the investigated rivers (Fig. 3). Trichoptera (18) and Chironomidae (17) exhibited the highest species richness among them. The number of taxa in samples collected from plants varied from eight (Vilnia) to 42 (Lakaja River; Table 5) in different rivers.

Macroinvertebrate samples taken from plants of the investigated rivers were dominated by Simuliidae *Simulium* spp., Trichoptera *Brachycentrus subnubilus*, *Athripsodes aterrimus*, Chironomidae *Cricotopus* gr.

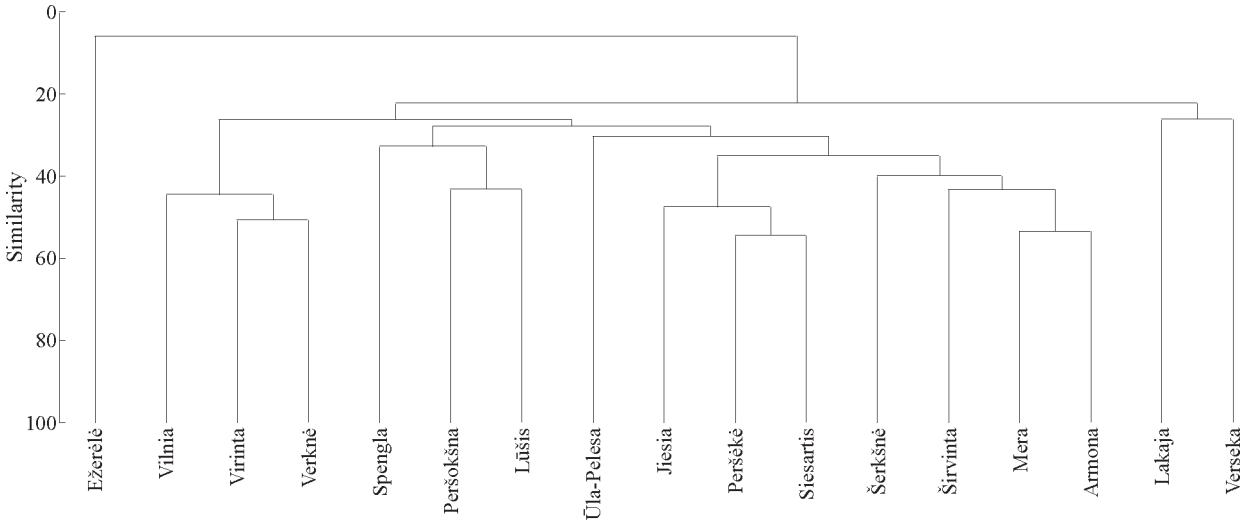

Figure 4. Hierarchical classification of sampling sites according to the abundance of macroinvertebrate taxa in the stone substratum of the investigated rivers using group-average clustering from Bray-Curtis similarities.

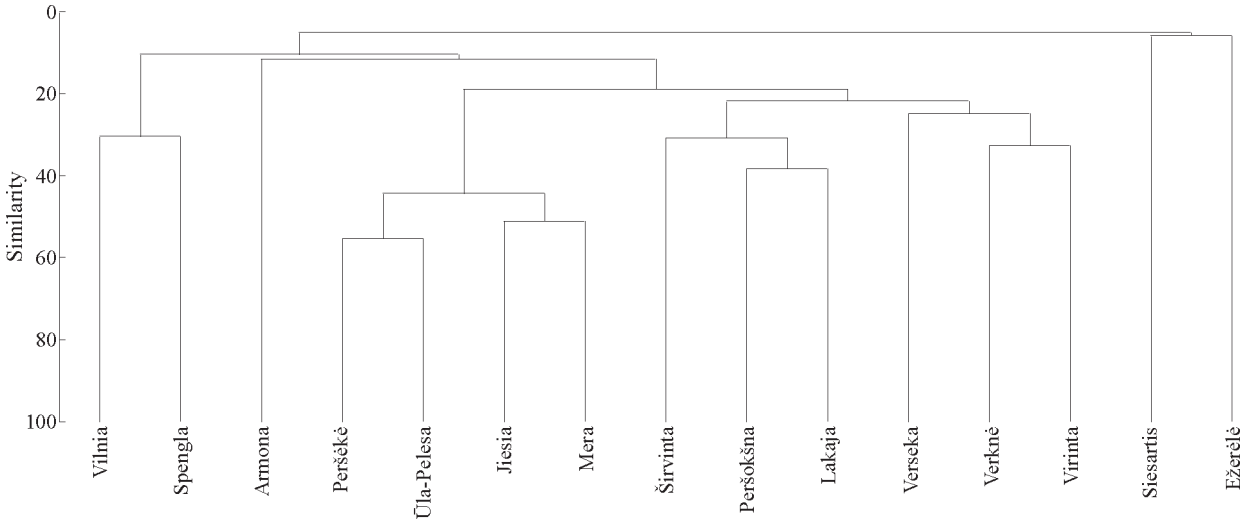

Figure 5. Hierarchical classification of sampling sites according to the abundance of macroinvertebrate taxa in samples collected from plants of the investigated rivers using group-average clustering from Bray-Curtis similarities.

algarum, *Cricotopus sylvestris*, Ephemeroptera *Ephemerella ignita*, Isopoda *Asellus aquaticus*. In some rivers, samples of macroinvertebrates collected from plants were dominated by typical phytophilic species of benthic fauna – Chironomidae *Cricotopus sylvestris*, Trichoptera *Nemotaulius punctatolineatus* and Mollusca *Bithynia leachi* (Table 4).

Samples of macroinvertebrates taken from plants in clean-water rivers (Lakaja, Peršokšna, Spengla, Ūla-Pelesa, Virinta, Verknė) were dominated by the Trichoptera *Brachycentrus subnubilus*. This species was not detected in the Jiesia, Siesartis and Peršėkė Rivers (IV–V class).

Values of Shannon-Weaver's index in samples taken from plants of the investigated rivers varied from 0.3 (Verseka River) to 3.9 (Širvinta River; Table 5).

The performed cluster analysis (Bray-Curtis similarity matrix) according to the abundance of macroinvertebrate taxa from plants revealed the closest similarity to exist between the following rivers: the Peršėkė and Ūla-Pelesa (55.3%), Jiesia and Mera (51.1%), Jiesia and Peršėkė (46.8%), Ūla-Pelesa and Mera (47.8%). The lowest similarity was established between the following rivers: the Ežerėlė and Verknė (0%), the Siesartis and Verknė (0.8%), the Ežerėlė and Jiesia (1.0%) (Fig. 5).

Discussion

In the course of the investigation performed in 17 medium-sized rivers in different districts of Lithuania 160 taxa of macrozoobenthic organisms were identified. In the investigated rivers the highest species richness was established in chironomids. This fact was ascertained by a number of researchers (Kamenev 1987; Rütten & Gellert 1993; Shubina 1986; Penak & Ward 1986; Pearson *et al*. 1986).

It has been established by scientists that the number of macrozoobenthic species is biotope-dependent (Dobrinsky 1990; Bogatov 1994). Nedostup (1988) also proved that the highest species richness in rivers is found in the stone substratum and the lowest – in the sand one. In medium-sized rivers of Lithuania the greatest number of taxa was also recorded in the stone substratum and the smallest – in the sand one.

In the stone substratum of the Virinta ($r = 0.91$, $p < 0.01$), Jiesia ($r = 0.82$, $p < 0.01$) and Šerkšnė ($r = 0.94$, $p < 0.05$) Rivers a strong correlation was established between the number of EPTC taxa and the overall number of taxa.

Compin and Céréghino (2003) proved, that the EPTC species richness significantly correlates with the overall macroinvertebrate species richness on both unstressed and stressed sites ($r^2 = 0.72$ and $r^2 = 0.56$, $p < 0.01$, respectively).

The stoneflies *Leuctra* spp. were dominant in the stone (Virinta, Verknė) and gravel substrata (Lakaja) only of clean-water Lithuanian rivers while *Nemoura* spp. – in the stone substratum (Ežerėlė). Plecoptera are very primitive aquatic insects, found only in waters of very good quality (Galdean *et al*. 2000).

Our studies demonstrated that Trichoptera of the genus *Hydropsyche* prevail in the stone substratum in rivers (Jiesia, Siesartis, Peršėkė) of high-level organic contamination (IV–V class). According to Whiles and Dodds (2002) hydropsychid caddisflies increase in abundance with organic material concentration. Meanwhile, in clean-water Lithuanian rivers (I–III class) their abundance is not great.

The greatest number of Trichoptera taxa was recorded in the Virinta (16) and Verknė (15) Rivers. According to the data obtained by Kazlauskas (1960), there were five species of caddisflies (Trichoptera) detected in the Virinta and four – in the Verknė River. Our findings about the number of mayfly (Ephemeroptera) taxa in the Verknė River are in line with those reported by Kazlauskas (Kazlauskas 1960) while the number of Trichoptera taxa in the Peršėkė River is in agreement with Spuris' findings (Spuris 1969). The obtained investigation results proved that some species of benthic organisms are typical of a particular kind of substratum. Trichoptera *Nemotaulius punctatolineatus*, Chironomidae *Cricotopus sylvestris* and Mollusca *Bithynia leachi* were recorded only in samples taken from plants. Chironomidae *Chironomus plumosus*, *Sergentia* gr. *longiventris*) and Ephemeroptera *Ephemera vulgata* were recorded only in the sand-silt substratum.

Macroinvertebrate samples taken from plants in clean-water rivers (Lakaja, Peršokšna, Spengla, Ūla-Pelesa, Virinta, Verknė) were dominated by Trichoptera *Brachycentrus subnubilus*. Trichoptera *Brachycentrus subnubilus* were not detected in the Jiesia, Siesartis and Peršėkė Rivers (IV–V class).

Shannon-Weaver's diversity index proved to be the highest in the stone substratum in almost all the investigated rivers. It was only in the Peršokšna River that the index of diversity in macroinvertebrate samples collected from plants was higher ($H' = 3.42$) than in those taken from the stone substratum ($H' = 2.71$). High values of Shannon-Weaver's diversity index show the diversity of fauna in the stone substratum, the even distribution of the main macroinvertebrate groups according to the number of species, which is characteristic of stable communities. The investigation results revealed that Shannon-Weaver's diversity index in samples taken from the

stone, sand-silt substrata and those collected from plants was the lowest in the Verseka River in comparison with the same type of substrata in other investigated rivers. Low values of this index in macroinvertebrate samples collected from the stone substratum and from plants in the Verseka River were determined by other Diptera (*Simulium* spp.), and in the sand-silt substratum – by Chironomidae – *Chironomus plumosus*. In the gravel substratum the lowest diversity index was found in the Peršokšna River.

Acknowledgements

Authors express gratitude to Dr Aloyzas Burba for valuable remarks and advice.

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Makrozoobentoso taksonominė sudėtis vidutinio dydžio Lietuvos upėse

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Santrauka

Straipsnyje nagrinėjama 17 vidutinio dydžio Lietuvos upių bestuburių gyvūnų taksonominė sudėtis įvairaus tipo gruntuose. Tyrimo metu identifikuota 160 bestuburių gyvūnų taksonų. Tyrimų rezultatai parodė, kad taksonų skaičius ir Shannon-Weaver bioįvairovės indeksas toje pačioje upėje priklausė nuo grunto tipo. Didžiausias taksonų skaičius nustatytas akmenuotame grunte, o mažiausias – smėlio grunte. Akmenuotame grunte didžiausia bioįvairovė ir didžiausias Shannon-Weaver indeksas nustatytas Jiesioje. Upėse, kuriose padidėjusi organinė tarša vyravo *Hydropsyche* genties apsiuvos.

Received: 20 October 2003
Accepted: 7 September 2004