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Giedrė Višinskienė

CADDISFLY (INSECTA, TRICHOPTERA) DIVERSITY IN LITHUANIA AND IMPACTS OF ENVIRONMENTAL FACTORS ON THEIR DISTRIBUTION AND ABUNDANCE

Summary of doctoral dissertation

Biomedical Sciences, Ecology and Environmental Science (03 B)

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External defense of the dissertation.

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GAMTOS TYRIMŲ CENTRO EKOLOGIJOS INSTITUTAS
VILNIAUS UNIVERSITETAS

Giedrė Višinskienė

LIETUVOS APSIUVŲ (INSECTA, TRICHOPTERA) ĮVAIROVĖ IR APLINKOS VEIKSNIŲ ĮTAKA JŲ PAPLITIMUI IR GAUSUMUI

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Introduction

Relevance of the study. The loss of biodiversity is now one of the most important environmental problems in the world. Aquatic ecosystems are particularly important for biodiversity and productivity of the biosphere. They are sensitive to various environmental changes. For the assessment and conservation of biological diversity it is important to estimate the influence of environmental factors on aquatic invertebrate species distribution and abundance, on their community structure, and also to predict community alternations in the conditions of global and local changes.

Caddisflies (Insecta, Trichoptera) are one of the most important groups of benthic macroinvertebrates in freshwater ecosystems. They are sensitive to changes of physical and chemical parameters in water bodies, so often used to assess the ecological status of the water body (Kiss *et al.* 2002; Czachorowski, Buczyński 2004; Kownacki, Soszka 2004). The highest diversity of caddisfly larvae usually is in rapid, cold-water rivers of different size. Information about distribution of caddisfly species in Lithuania, their importance in benthic invertebrate communities, influence of environmental factors on larval distribution and abundance and other ecological characteristics of caddisflies in river habitats is incomplete. Caddisfly species rarity in our country has not been analyzed. All this is important in assessing biological diversity and ecological status in Lithuania or particular regions of the country, protected areas, in different water bodies. It is also important in examining current ecological processes in river communities and in predicting possible alterations under global environmental change.

Objective and tasks of the study.

The main objective of this work is to investigate the caddisfly (Trichoptera) fauna, diversity, species distribution and rarity in Lithuania, to evaluate the influence of environmental factors on the distribution and abundance of caddisflies in different habitats of Lithuanian rivers.

The following **tasks** were defined to achieve the main objective:

1. To evaluate Lithuanian caddisfly species rarity, to assess rarity categories and interrelation between caddisfly distribution and abundance;
2. To update checklist of Lithuanian caddisfly and to estimate distribution of caddisfly species;
3. To estimate the seasonal dynamics of caddisfly adults flight activity and factors affecting the number of generations;
4. To assess the influence of environmental factors on distribution and abundance of caddisfly larvae (at family, genus and species taxonomic ranks) in Lithuanian rivers;
5. To evaluate the significance of caddisflies in the structure of benthic invertebrate communities in different Lithuanian rivers;
6. To evaluate caddisfly bioindicative value for assessment of ecological status in Lithuanian rivers.

Novelty of the study.

In this study following aspects were investigated for the first time:

1. Lithuanian caddisfly rarity and the relationship between caddisfly distribution and abundance were determined;

2. New species of caddisfly were discovered and the checklist of Lithuanian caddisfly was updated;
3. Patterns of seasonal flight of caddisfly adults were established, and the factors affecting the number of generations were estimated;
4. The environmental factors impacting the distribution and abundance of caddisfly larvae (at family, genus and species taxonomic ranks) in Lithuanian rivers were estimated;
5. The significance of caddisflies in the communities of benthic invertebrates of different Lithuanian rivers was evaluated;
6. The bioindicative properties of selected caddisfly taxa in Lithuanian running waters were specified and recommendations for improvement of assessment of ecological status were proposed.

Scientific and practical significance:

1. The results obtained supplement the knowledge of diversity, distribution, and abundance of caddisflies and other benthic macroinvertebrates of Lithuanian rivers;
2. The determined patterns of caddisfly distribution and abundance are important in optimizing biodiversity conservation measures;
3. The results are important for improvement of methods for biotic assessment of ecological status of Lithuanian rivers.

Defended statements:

1. The distribution and abundance of caddisfly species are interrelated: widespread species are more abundant;
2. Caddisfly species could be divided into 5 rarity categories in Lithuania;
3. Four types of seasonal flight are characteristic of caddisfly adults; the dynamics of seasonal flight depends on species identity and variation in air temperature;
4. Distribution and abundance of particular caddisfly family, genus and species in Lithuanian rivers depends upon different environmental factors that importance varies between the taxonomic ranks. The main factors for the most caddisfly taxa are current velocity, water temperature regime, river discharge, bottom structure, and oxygen saturation.
5. The ecological status indices in which caddisflies are used are recommended to be adjusted with regard to information obtained in the current study on the impacts of environmental factors on caddisfly larvae distribution and abundance in Lithuanian rivers.

Presentation and approval of results. Results of this study have been published in 31 publications: 23 articles and 8 abstracts of scientific conference reports. The material of the dissertation was presented at 15 conferences: conference of young hydro-ecologists ‘Biodiversity and Functioning of Aquatic Ecosystems’ (Plateliai, Lithuania, 2002), the 2th and 4th international conf. ‘Research and Conservation of Biological Diversity in Baltic Region‘ Daugavpils, Latvia, 2003, 2007), national conf. ‘Lithuanian Biodiversity (Status, Structure, Protection)’ (Vilnius, Lithuania, 2003), international Baltic conf. ‘Long-term Ecological Research‘ (Vilnius, Lithuania, 2004), international conf. ‘The Relevance of Ecology, Social and Economy Research in Forestry and Environmental Science‘ (Kaunas, Lithuania, 2004), regional conf. ‘Biodiversity and Functioning of Aquatic Ecosystems in the Baltic Sea Region‘ (Palanga, Lithuania, 2004), national (2003–2005) and international (2006–2009) conf. ‘Man and Nature Protection‘ (Kaunas, Lithuania), international conf. ‘Biodiversity, Protection and Prospects of Baltic Seashore Habitats‘ (Klaipėda, Lithuania, 2009).

Dissertation structure and scope. The dissertation is presented in the following chapters: Introduction, Literature Review, Material and Methods, Research Results (consisting of 5 subchapters), Discussion of the Results, Conclusions, References, List of Author‘s Publications, and Appendices. All the material is presented in 229 pages; The list of references includes 298 sources. The list of the author‘s publications contains 31 entries. The dissertation is written in Lithuanian with summaries in English and Lithuanian. The text contains 19 tables, 58 figures, and 6 appendices.

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LITERATURE REVIEW

This part of the dissertation presents a historical summary of caddisfly investigations related to the topic of this work and conducted in Europe and Lithuania. The bioindicative significance of caddisfly larvae in benthic invertebrate communities and criteria for the assessment of ecological statues of rivers are discussed.

MATERIAL AND METHODS

Research material. The material of caddisfly larvae and other benthic invertebrates was collected in 33 Lithuanian rivers (Būka, Dysna, Dubysa, Elmė, Grabuosta, Graisupis, Grūda, Juodupis, Lėvuo, Merkys, Musė, Mūša, Mūšia, Nemunas, Nemunėlis, Riešė, Sasna, Siesartis, Skroblus, Sudervė, Susiena, Šelmenta, Širvinta, Šventoji, Pajūrio Šventoji, Ūla-Pelesa, Varius, Venta, Verkė, Vilnia, Virinta, Vyžuona, Žeimena) in 2003–2004 and 2006–2008. Single and seasonal investigations of caddisfly adults were performed by the author and other persons in 115 study sites in Lithuania during 1987–2008. In total, 254 quantitative samples of benthic invertebrates and 238 quantitative samples of caddisfly adults were collected during the studies in 193 localities (Fig. 1). The collected material is deposited in the Institute of Ecology of Nature Research Centre (Akademijos str. 2, Vilnius).

Methods of research. The physical and chemical environmental parameters were taken from literature or, when relevant, measured at each study site: river size, discharge, depth at study site, current velocity, water temperature regime, bottom structure, bottom coverage by aquatic vegetation and deposits of coarse and fine particulate organic matter, site illumination (shading), amounts of nitrites, nitrates and phosphates, dissolved oxygen, water hardness, pH, oxygen saturation, amount of organic matter (ChDSMn). For statistical analysis, some factors were divided into categories.

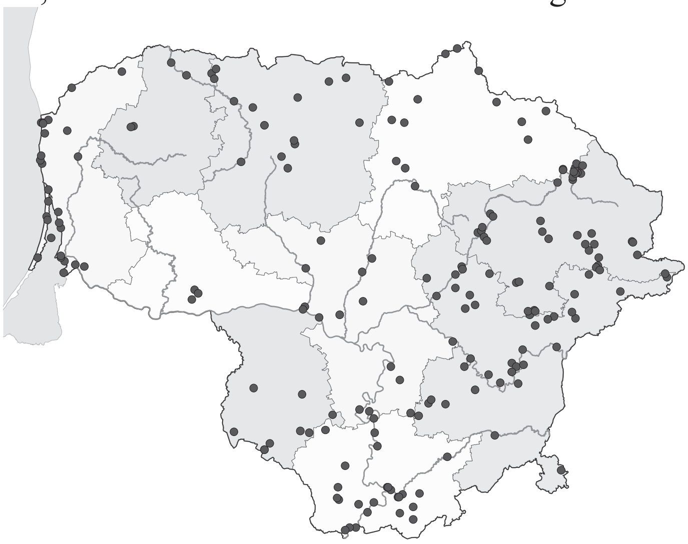


Fig.1. Study sites of caddisflies and benthic macroinvertebrates
1 pav. Apsiuvų ir bentoso makrobestuburių tyrimų vietos

The samples of benthic macroinvertebrates were collected by standard kick-sampling in a particular biotope (microhabitat) or by taking multihabitat samples collected over the 10 minutes period with a hydrobiological dip net from all possible biotopes at each study site (LAND 57–2003, Arbačiauskas 2009). In laboratory, the collected samples were picked out, separated and preserved in 70% ethyl alcohol. Specimen animals were identified to the lowest possible taxon, all individuals were counted and usually weighted.

Entomological net and light traps of different construction were used for caddisfly imago sampling. Adults were placed in the tubes dried or fixed in alcohol, further fixed on entomological pins and preserved in the collections. Genital structures used for insect description were prepared in 5% KOH solution, analyzed and preserved in glycerin.

Analysis of the material. The individuals of each species (or higher taxon) were counted and weighed separately; their abundance and biomass were recalculated as per square meter and provided as ind. m^{-2} and g m^{-2}. Species dominance (D) was evaluated with respect to their share (%) in the community. Diversity was estimated using Shannon-Wiener species diversity index. Species occurrence frequency (F), assessed as proportion of study sites where species was present, was used for species separation between rarity categories. Whereas different research methodologies were used for different life cycle stages, the rarity of caddisflies was estimated for adults and larvae separately. The rarity of species was estimated according to caddisfly imago occurrence in 40 localities and larvae occurrence in 26 localities. Sampling localities were considered to be representative of species richness if more than 10 caddisfly species were identified at a site. The quantitative data from 8 light-traps were used to estimate the species abundance (ind. per flight season) per site and further the mean species abundance in different rarity categories was evaluated. Analogically, the mean species abundance of larvae (ind. m^{-2}) in different rarity categories was also calculated. Differences in abundance between rarity categories were analysed using Kruskal-Wallis ANOVA and a multiple comparison test.

For the assessment of the ecological status of investigated rivers in accordance with the composition of benthic invertebrates, different biotic indices were used: EPT, abundance proportion of trophic groups of invertebrates, BMWP, BMWP–PL, (*Biological Monitoring Working Party score system*), ASPT (*Average Score Per Taxon*), DSFI (*Danish Stream Fauna Index*). The calculations were carried out in accordance with methodical guidelines (Appendix 1, Arbačiauskas 2009) or using program Asterics 3.1.1. The analysis of variance (one-way ANOVA) was used to assess the relation between quality classes in river sites according to these indices and annual average of organic matter. Spearman Rank Correlation (r_s) was used to assess relationship of trophic groups, EPT index values and abundance of taxa with biotic indices of ecological status.

The amount of data used in statistical analysis depended on the hypothesis to be tested. To estimate the significance of variation differences between distinguished categories after checking statistical analysis presumptions, the analysis of variance (ANOVA), Kruskal-Wallis analysis and multiple comparison (*post hoc*) tests (*Tukey HSD, Unequal N HSD*) were used. For analysing the impact of environmental factors on the distribution of caddisflies in Lithuanian rivers correlation analysis and analysis of variance were used. The number of caddisfly taxa and abundance of analysed taxa were log transformed before analysis. The correlation analysis, multifactor analysis of variance and multiple regression were used for establishment of important environmental factors influencing caddisfly families, genera and species distribution and abundance in the rivers. The repeated measures ANOVA and Tukey HSD tests were used to test the air temperature effect on the number of caddisfly generations. The Bray–Curtis Index of Similarity was used for the comparison of benthic communities. The data were processed employing Microsoft Excel, Statistica 7.0 and BioDiversity software programmes.

RESEARCH RESULTS AND DISCUSSION

Fauna of Lithuanian caddisflies. 152 species and 1 subspecies of caddisflies were recorded in 193 localities during the studies. 22 caddisfly taxa (21 species and 1 subspecies) were found in Lithuania for the first time. The current checklist also includes 20 species, which were defined before 1969 (Ulmer *et al*. 1917; Racięcka 1931, 1937; Kazlauskas 1960; Spuris 1969), and one recently reported new species (Pliūraitė 2001; Pliūraitė, Kesminas 2004; Virbickas, Pliūraitė 2002) that has not been observed during the current study. The general distribution of all these species in Europe supports the possibility of their occurrence in Lithuania. Currently, the caddisfly species list comprises 173 species and 1 subspecies representing 18 families and 71 genera. 33% (58 species) of Lithuanian caddisfly fauna belongs to Limnephilidae family. Other families constitute no more than 19% of caddisfly fauna. The most common Lithuanian caddisfly species (founded in >25% of study sites) belonged to Limnephilidae (*Limnephilus flavicornis* F., *L. rhombicus* L.*, L. griseus* L.*, Glyphotaelius pellucidus* Retz.), Phryganeidae (*Phryganea grandis* L.) and Hydropsychidae families (*Hydropsyche pellucidula* Curt.). Eighteen rarest species (founded in a single locality) belonged to Hydroptilidae, Polycentropodidae, Ryacophylidae, Hydropsychidae, Phryganeidae, Leptoceridae, and Limnephilidae families. Only *Apatania wallengreni* McL. and *Limnephilus centralis* Curt. were registered in larva stage, the remaining species were identified in adult stage. This fact confirms a more accurate species identification of adults and a more detailed evaluation of species diversity in the study area by encompassing investigations into all caddisfly stages. When investigating caddisflies in the habitats of water bodies, we estimated biological diversity and ecological status of the particular water body. However, the fauna of temporary water bodies, canals, marshes and other water bodies suitable for particular caddisfly species becomes accessible, which is hardy accessible for investigation by hydrobiological methods.

Nevertheless, 174 caddisfly taxa should not be considered a complete species list in Lithuania. Some other species such as *Hydroptila cornuta* Mos., *Oxyethira frici* Klap., *Molanna albicans* Zett., *Beraea maurus* Curt., *Ernodes articularis* Pict., *Potamophylax cingulatus* Steph., *Limnephilus hirsutus* Pict. could also be expected in our country because of their wide distribution in Europe and occurrence in Poland, Latvia and/or Belarus (Barnard, Malicky 2007). Currently, 145 caddisfly species are known in Belarus (Гигиняк 2009), 196 species in Latvia (Kalniņš, Spuņģis 2002), and 288 species in Poland (Czachorowski, Pietrzak 2003).

Caddisfly species rarity in Lithuania. Caddisfly species rarity becomes important for biodiversity investigations in different localities, from small water bodies, protected areas in Lithuania to species distribution in Europe. Some authors recommend using only species presence/absence data, while others also use species abundance, frequency and distribution data (Nógrádi, Uherkovich 1995, 1999; Schmera 2001). Until now, however, classification of Lithuanian caddisflies into rarity categories has not been attempted, although such categorization is of particular interest in evaluating the status of the country, separate regions or water bodies, examining the current and future ecological processes in river communities. It is also important, because some caddisfly species definitely need protection status. The Lithuanian Red Data Book currently lists only two caddisflies species (*Holostomis phalaenoides* L. and *Philopotamus montanus* Don.) (Rašomavičius *et al.* 2007); however, data on the current status of these species are not quite clear. Red Data Lists of neighbouring countries include a larger number of rare and protected caddisfly species (Czachorowski *et al.* 2004).

Hanski's Rule states that common species are more abundant than rare (Krebs 2001). If this rule applies to caddisflies, the abundance of caddisfly species (estimated as the mean number of adult specimens per flight season in a site or as the mean abundance of individuals per area unit (ind. m^{-2}) in an aquatic habitat) should be associated with species rarity.

The majority caddisfly species were detected during adult caddisfly studies, i.e. 143 species and 1 subspecies from 40 localities, have been used for the assessment of species rarity. On the basis of species frequency (F), caddisfly imago were classified into 5 rarity categories: 1) very rare, ≤2% (species which are present in 1–2 localities per 100 studied localities should be included into this category; as in this study data on caddisfly adults were available from 40 localities, we classified as very rare those species which were detected at only one locality); 2) rare, 3–10%; 3) common, 11–50%, 4) very common, >50%; and 5) locally abundant, ≤5%, but abundance of specimens exceeds 150 individuals per locality. According to collected data, 23, 36, 70, 13 and 2 species were categorized as very rare, rare, common, very common and locally abundant, correspondingly. The most frequent species according to imago occurrence were

Glyphotaelius pellucidus Retz., *Phryganea grandis* L., *Limnephilus flavicornis* F., and *L. rhombicus* L. (F>70%), while 23 species were classified as very rare and were present only in one site. Rarity of species was estimated also with respect to larvae occurrence (92 lowest taxa) over 26 localities in flowing waters. Caddisfly larvae were classified into 4 rarity categories following the same pattern as for adults (one locality per all studied localities was interpretated as indication of very rare species). According to species occurrence, 24, 11, 48, and 9 species were assessed as very rare, rare, common and very common, respectively. The most frequent species according to larvae occurrence were *Hydropsyche pellucidula* Curt., *Hydropsyche* sp., and *Ithytrichia lamellaris* Eaton (F>70%).

Most caddisfly species were common according to both stages – 70 and 48 species according to imago and larvae, respectively. 24 species were common both as larvae and imago. Evaluation of rarity on the basis of collections of larvae and adults has revealed that rarity results may differ. These results suggest that rarity estimates by larvae occurrence should be interpreted with caution for the following reasons: first, larvae sampling, which is usually performed in shallow waters of rivers and lakes, may not cover all habitats suitable for caddisfly development; and, secondly, larvae sampling may be inaccurate due to larger allocation of sampling effort to certain habitat types.

According to quantitative data of caddisfly adults and larvae, the mean number of individuals per flight season and abundance of larvae per square meter were calculated for different rarity categories. More common species turned out to be more abundant than rare species. The effect of rarity class on abundance in both caddisfly stages was highly significant: Kruskal-Wallis: $H_{3,\ 128}=42.1$, $p<0.001$ – for adults and $H_{3,\ 92}=35.8$, $p<0.001$ – for larvae (Fig. 2).

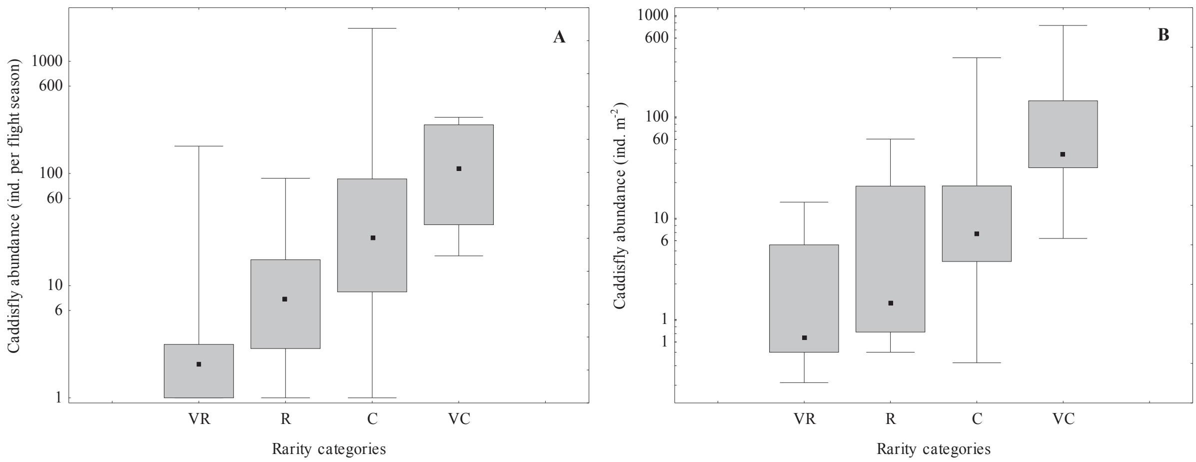


Fig. 2. Variation of caddisfly abundance (median, quartiles and range) assessed as the number of specimens per flight season (A) and as the number of specimens per square meter (B) in different rarity categories: very rare (VR), rare (R), common (C), very common (VC). Note logarithmic scale

2 pav. Apsiuvų gausumo, išreikšto kaip individų skaičius per skraidymo sezoną (A) ir individų skaičius kvadratiniame metre (B), variacija (mediana, kvartiliai, intervalas) skirtingose retumo kategorijose: labai reta (LR), reta (R), dažna (D), labai dažna (D). Gausumas pateiktas logaritminėje skalėje

Although caddisfly imago abundances between rare and very rare species and between common and very common species did not vary (multiple comparison tests; $p=1.0$ and $p=0.06$, correspondingly), differences between species classified as rare and common were significant ($p<0.001$). Although caddisfly larvae abundances between very rare and rare species and between rare and common species did not vary too (multiple comparison tests; $p=1.0$ and $p=0.44$, correspondingly), differences between species classified as common and very common were significant ($p=0.03$). Abundance of very common species differed significantly from other rarity categories.

Division of caddisfly species into rarity classes in our country may change over time, but the currently used method for rarity assessment is suitable and adequate, which can be explained not only by species distribution, but also by abundance of individuals (adult and larvae). For example, *Hagenella clathrata* Kol. was recorded in 4 sites in Lithuania (1–3 ind./site) and it is classified as a very rare species. This species with originally Palearctic distribution is rare and disappearing all over Europe. It is included into the Red Data Book of Poland (Czachorowski 2004b) and recommended for red-dating in Belarus (Czachorowski *et al*. 2004). *H. clathrata* inhabits water bodies related to raised bogs and is threatened due to destruction or anthropogenic transformation of its habitat. Therefore, this species should be included into the Lithuanian Red Data Book.

Seasonal flight activity of Lithuanian caddisflies. During the studies in different areas of Lithuania, caddisfly adults were observed from April to December. The latest records (*Chaetopteryx villosa* F.) were done during the last week of November and in early December. The earliest records were done in the third week of April, with two species of Brachycentridae – *Brachycentrus subnubilus* Curt. and *Micrasema setiferum* Pict., registered and observed until the second week of June. The greatest number of caddisfly species was in summer (July–August). Most information about caddisfly phenology was obtained from the material of weekly samples of caddisfly adults collected by automatic light traps during the season (from April to December). According to the material obtained from six different localities, flight activity periods were determined for 47 species. The following four types of seasonal flight activity periods have been determined for separate caddisfly families, genera and species:

1. One generation per year, spring flight activity.

The caddisfly species falling under this type were flying in spring. During the investigations from 21 April to 23 June and later no individuals were registered. This flight type was characteristic of 8 caddisfly species: *Brachycentrus subnubilus* Curt., *Micrasema setiferum* Pict., *Agapetus ochripes* Curt, *Oligostomis reticulata* L., *Oligotricha striata* L., *Holostomis phalaenodes* L., *Notidobia ciliaris* L., and *Limnephilus dispar* McL. The spring flight activity of some species was confirmed by larval development. For example, *M. setiferum* adults were observed from 21 April to 9 June; at that time larvae or pupae were found only in small numbers or not found at all. The greatest larval abundance and biomass in the rivers was registered in October.

2. One generation per year, autumn flight activity.

The caddisfly species falling under this type were flying in autumn. No specimens were found before 28 July during the studies. This flight activity type was characteristic of 12 caddisfly species from Limnephilidae family (*Anabolia concentrica* Zett., *A. laevis* Zett., *Halesus digitatus* Sch., *H. radiatus* Curt., *H. tesselatus* Ramb., *Chaetopteryx villosa* F., *Potamophylax rotundipennis* Br., *Limnephilus borealis* Zett., *L. coenosus* Curt., *L. fuscinervis* Zett., *L. germanus* McL., *L. politus* McL.). At the time of greatest abundance of caddisfly adult, larvae were found sparsely or not found at all. For example, the adults of caddisfly genus *Halesus* were observed since early August, but the highest abundance (56 specimens per week) was from 25 September to 09 October. Meanwhile, *Halesus* spp. larvae were found in different rivers from spring until the end of August, and pupae from 10 August.

3. Two generations, two flight periods per year.

The caddisfly adults falling under this type were flying in spring and in autumn. This flight activity was characteristic of 4 caddisfly species of *Limenphilus* genus (*Limnephilus affinis* Curt., *L. incisus* Curt., *L. nigriceps* Zett., *L. sericeus* Say). The first flying period was observed in spring, from the middle of May till the middle of June or only in June, and the second from late July till the end of October. No data on larval abundance of these species is known yet.

4. Flexible number of generations, extended flight activity.

The caddisfly adults falling under this type are flying for a long time throughout the season, and several generations can develop. The number of generations, however, often remains unclear for several reasons. First, generations are separated from each other by very short intervals, or merged into a single extended flight period. Second, it is difficult to verify these periods in larval stages, because there are different larval instars at the same time in the rivers. This flight activity is characteristic of most caddisfly species from Hydropsychidae, Hydroptilidae, Polycentropodidae, Phryganeidae, Molannidae, Sericostomatidae, Limnephilidae, Leptoceridae, Rhyacophilidae, Psychomyiidae families. Based on the abundance of caddisfly individuals per flying period, this period can be divided further: 4.1. The extended flying period with a single clear increase of individuals was characteristic of *Hydropsyche contubernalis* McL., *H. siltalai* Doehl., *Mystacides nigra* L., *Oecetis lacustris* Pict., *O. tripunctata* F., *Setodes punctatus* F., *Limnephilus ignavus* McL. caddisflies. These caddisfly species were flying about 8 weeks, but the greatest abundance of individuals was observed one or two weeks in the summer period. Meanwhile, larval abundance in rivers was the lowest during this period. For example, the highest abundance of *Hydropsyche siltalai* Doeh. Adults (83 ind. per week) was observed in last July – middle August. Meanwhile, in July the lowest *H. siltalai* larval abundance and biomass was observed, which confirmed the largest caddisfly emerging to adults in July. 4.2. The extended flying period with two or more clear increases of individuals was characteristic of *Hydroptila simulans* Mos., *Agraylea multipunctata* Curt., *A. sexmaculata* Curt., *Oxyethira flavicornis* Pict., *Limnephilus flavicornis* F. The greatest abundance of *H. simulans, A. multipunctata* and *A. sexmaculata* adults was in June – August, but two clear increases of individuals were observed. Three overlapping flight activity peaks of *O. flavicornis* specimens were observed in May, July and August. *L. flavicornis* caddisflies were more numerous in autumn, September–October. However, one or two flight activity peaks were observed in different localities. 4.3. The extended flight period with flexible increases of individuals was characteristic of *Ceraclea dissimilis* Steph., *Oecetis ochracea* Curt., *Limnephilus sparsus* Curt., *Glyphotaelius pellucidus* Retz. The number of generations within the same species was different in different localities or in different years. A significant influence of air temperature on the number of generations was observed for two species of the Leptoceridae family: *Ceraclea dissimilis* and *Oecetis ochracea*. At higher air temperatures during the species flight period, two activity peaks per year were established. The average air temperature during *C. dissimilis* flight season (26 05–18 08) was in Verkiai higher than in Viešvilė and Rūgšteliškis: 18.7 °C in Verkiai and 15.6 °C in other localities. Differences between air temperature in Verkiai locality and other places were significant (Tukey HSD, p <0.001). The difference between air temperature in Viešvilė and Rūgšteliškis was not significant (p = 0.38). *C. dissimilis* produced one generation in Viešvilė and Rūgšteliškis and two generations in Verkiai. During *O. ochracea* flight period (12 05–01 09) in Rūgšteliškis and Viešvilė localities the mean air temperatures were lower: 15.2 °C and 14.6 °C, respectively, while in Juodkrantė locality the mean air temperature was 18,7 °C. Differences between air temperature in Juodkrantė and other localities (Viešvilė and Rūgšteliškis) were significant (Tukey HSD, p <0.001). The difference between air temperature in Viešvilė and Rūgšteliškis was not significant (p = 0.18). 4.4. Extended flying activity without clear increases of individuals was characteristic of *Hydroptila sparsa* Curt., *H. pulchricornis* Pict., *Ithytrichia lamellaris* Eat., *Oecetis notata* Ramb., *Mystacides longicornis* L., *Limnephilus griseus* L., *Rhyacophila nubila* Zett. These caddisfly species were flying throughout the season without clear peaks of increase in the abundance of individuals. It was found that during this period a few generations per year could overlap.

The impact of environmental factors on caddisfly distribution in rivers. Investigations were carried out in 33 rivers different in physical and chemical parameters: 10 small, 14 medium, 8 large and 1 very large river were investigated; 13 rivers were of low discharge, 12 of medium discharge, 7 of high and 1 of very high discharge; 14 rivers were cold-water and 19 warm-water.

The influence of category-ranked environmental factors (river size (small, medium, large, very large rivers) river discharge (low, medium, high, very high), temperature regime (cold-water, warm-water), bottom structure (stones, pebble, gravel, sand)) and other factors grouped into categories according to their values (depth in the sampling site (shallow, medium depth, deep), current velocity (slow, medium, strong), coverage of aquatic vegetation (no vegetation, fragmental coverage, abundant) site illumination (good, medium, low) on the number of caddisfly taxa and abundance was analyzed by one-way ANOVAs (Table 1).

Table 1. Analysis of the impact of environmental factors on the number of caddisfly taxa and abundance. Results of one-way ANOVAs for 33 rivers. Significant probabilities are in bold

1. lentelė. Aplinkos veiksnių įtakos apsiuvų taksonų skaičiui ir individų gausumui analizė. 33 upių vienfaktorinės dispersinės analizės rezultatai. Reikšmingos tikimybės paryškintos

Environmental factors	**Number of taxa**						**Abundance**					
	Impact		**Error**				**Impact**		**Error**			
	df	**MS**	**df**	**MS**	**F**	**p**	**df**	**MS**	**df**	**MS**	**F**	**p**
River size	3	1.22	31	0.11	11.36	**<0.001**	3	4.23	31	2.10	2.00	0.134
River discharge	3	1.30	31	0.10	12.97	**<0.001**	3	5.82	31	1.63	3.56	**0.025**
Temperature regime	1	0.23	33	0.21	1.10	0.302	1	0.14	33	2.06	0.07	0.794
Depth at study site	2	0.13	18	0.25	0.53	0.596	2	5.09	18	1.41	3.58	**0.049**
Bottom structure	3	0.99	27	0.11	8.82	**<0.001**	3	16.86	27	2.12	7.97	**<0.001**
Current velocity	2	0.76	18	0.18	4.20	**0.032**	2	2.48	18	1.70	1.46	0.258
Bottom coverage by aquatic vegetation	2	0.23	17	0.25	0.92	0.418	2	5.76	17	1.34	4.30	**0.031**
Site illumination	2	0.24	18	0.24	1.01	0.386	2	2.12	18	1.74	1.22	0.319

River size and current velocity significantly influenced the number of caddisfly taxa, but did not affect the abundance. Depth and aquatic vegetation coverage in the study sites significantly influenced the abundance of individuals, but did not affect the number of caddisfly taxa. River discharge and bottom structure had a significant impact on the number of caddisfly taxa and abundance of individuals. Other environmental factors had no significant impact on the number of caddisfly taxa or abundance.

Obtained results suggest that generally the highest caddisfly taxa richness is the characteristic of large-size, high-discharge, cold-water rivers at sites with medium depth, stony bottom, medium current velocity, abundant coverage of aquatic vegetation and medium site illumination (Fig. 3). Whereas the highest caddisfly abundance is typical for medium-size, medium-discharge, cold-water rivers at deep sites with stony bottom, strong current velocity, abundant coverage by aquatic vegetation and medium site illumination (Fig. 4).

Different environmental factors showed different importance for caddisfly families, genera and species. The impact of environmental factors has been analyzed in 15 caddisfly families, 18 genera and 26 species.

The abundance of caddisfly larvae of **Rhyacophilidae** family and *Rhyacophila* genus was found to be significantly affected by four environmental factors: river discharge, bottom structure, oxygen saturation, and amount of organic matter. Caddisflies were more abundant in rivers of lower discharge with hard bottom structure, high oxygen saturation and lower amount of organic matter. *Rhyacophila nubila* larvae prefered lower discharge, hard bottom structure, higher oxygen saturation, and stronger current velocity (Table 2). Rhyacophilidae takes high positions in the river water quality assessment: it belongs to the second indicator group (IG2) of DSFI method and is given a 7-point value in BMWP systems.

The abundance of **Glossosomatidae** family in the rivers was affected by two important physical environmental factors – hard bottom and cold-water temperature regime (Table 2). Due to the restricted distribution of larvae in the rivers, environment factors were not analyzed for the genera and species level.

For the distribution of **Hydroptilidae** family several important environmental variables were established: river discharge, depth at study site, carbonaceous water hardness and amount of phosphates in the water. Depth and carbonaceous water hardness positively influenced larval abundance, but river discharge and amount of phosphates had a negative effect. The larval abundance of *Hydroptila* genus in the rivers was mostly influenced by the amount of phosphates (negative effect), thermal condition, and carbonaceous water hardness (positive effect). The most important factor for the distribution of *Ithytrichia lamellaris* was the greater current velocity (Table 2).

The abundance of **Polycentropodidae** family in the rivers was limited by the higher river discharge and stronger current. Warm-water temperature regime and higher water saturation of oxygen had a positive impact. Greater amount of oxygen in water was the most important environmental factor for *Polycentropus* genus. *Polycentropus flavomaculatus* larval abundance was influenced by lower current velocity and higher concentration of oxygen in the water. pH was found to have a negative effect on the abaundance of caddisflies of *Cyrnus* spp. (Table 2).

No statistically significant environmental factors have been established for abundance of **Psychomyiidae**, *Psychomyia pusilla* and *Lype phaeopa,* in the rivers.

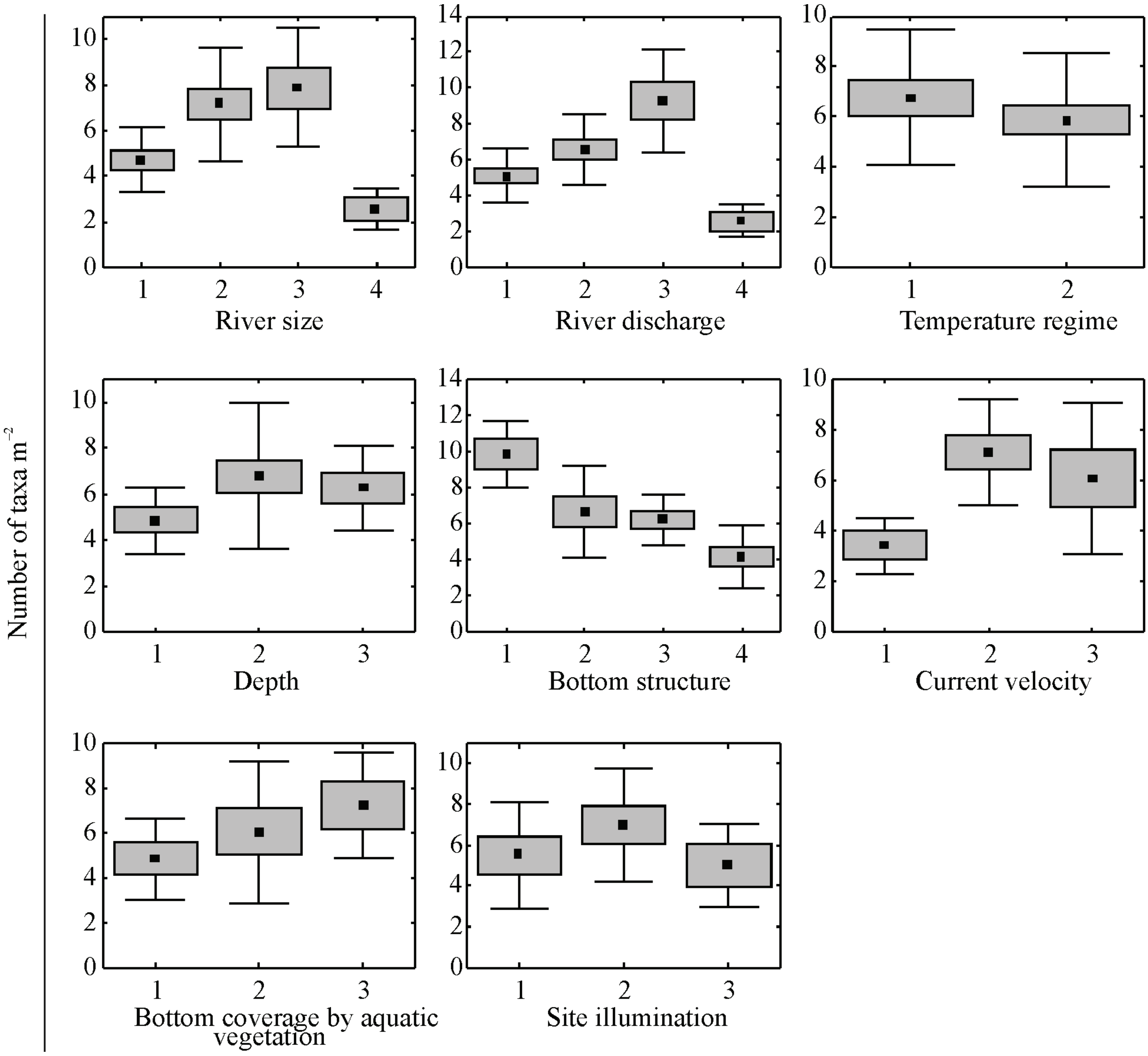
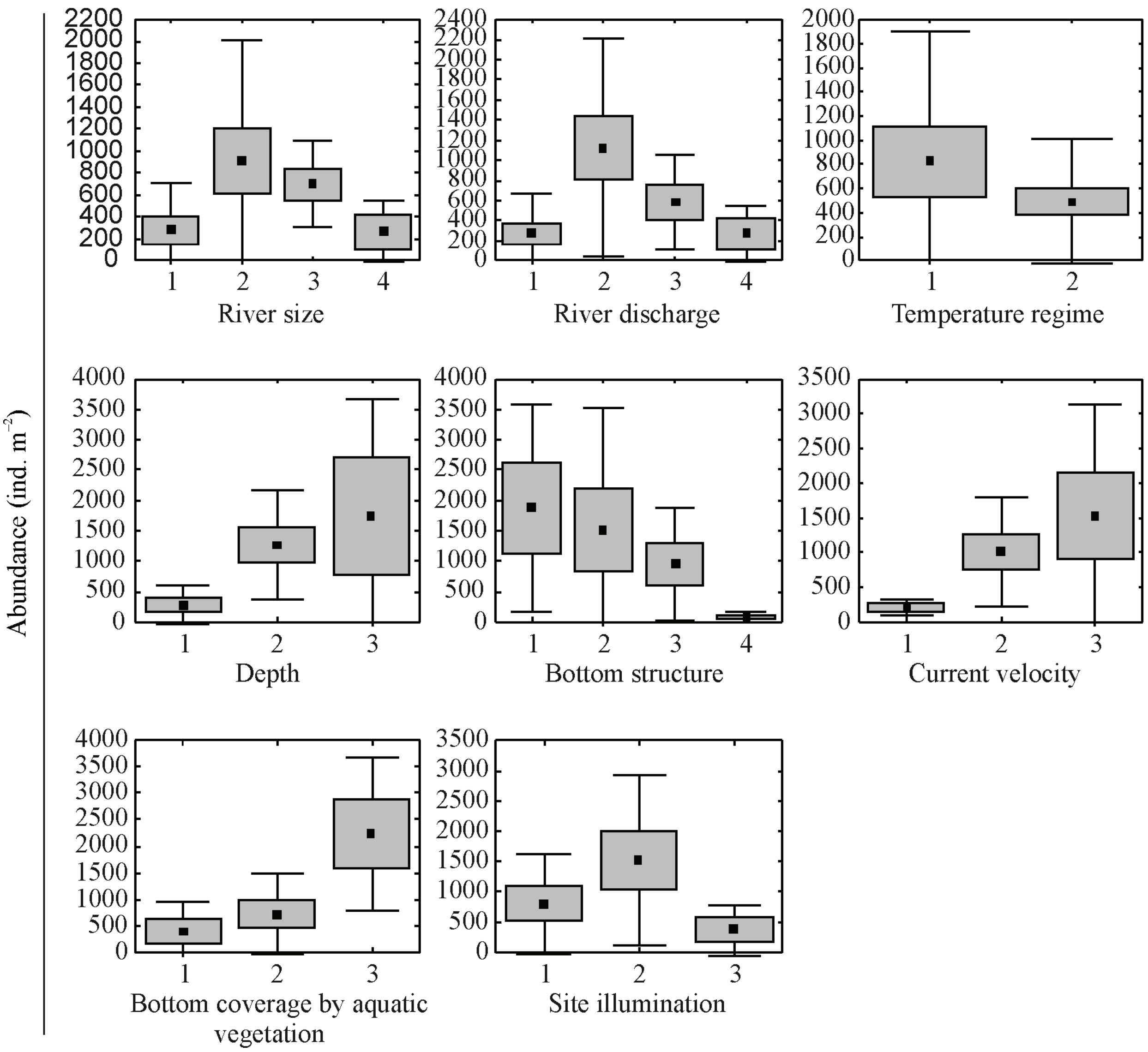


Fig. 3. The number of caddisfly taxa (mean, SE and SD) in the rivers of different size (1 – small, 2 – medium, 3 – large, 4 – very large), discharge (1 – low, 2 – medium, 3 – high, 4 – very high), temperature regime (1 – cold-water, 2 – warm-water), site depth (1 – shallow (<0.2 m), 2 – medium depth (0.2–0.5 m), 3 – deep (>0.5 m)); bottom structure (1 – stones, 2 – pebble, 3 – gravel, 4 – sand), current velocity (slow (<0.2 m/s), 2 – medium (0.2–0.5 m/s), 3 – strong (0.5–1.0 m/s)), bottom coverage by aquatic vegetation (1 – no vegetation, 2 – fragmental coverage, 3 – abundant), and site illumination (1 – good, 2 – medium, 3 – low)

3 pav. Apsiuvų taksonų skaičius (vidurkis, standartinė paklaida (SE) ir standartinis nuokrypis (SD)) skirtingo dydžio (1 – mažos, 2 – vidutinės, 3 – didelės, 4 – labai didelės upės), debito (1 – mažo, 2 – vidutinio, 3 – didelio, 4 – labai didelio), terminio režimo (1 – šaltavandenės, 2 – šiltavandenės), vietos gylio (1 – seklu, 2 – vidutinis gylis, 3 – gilu), grunto sudėties (1 – akmenys, 2 – gargždas, 3 – žvyras, 4 – smėlis), srovės stiprumo (1 – lėta, 2 – vidutinė, 3 – stipri), dugno padengimo vandens augmenija (1 – nėra, 2 – fragmantiškas padengimas, 3 – gausus), vietovės apšviestumo (1 – didelis, 2 – vidutinis, 3 – mažas) sąlygomis



FigFig. 4. The abundance of caddisfly larvae (mean, SE and SD) in the rivers of different size (1 – small, 2 – medium, 3 – large, 4 – very large rivers), discharge (1 – low, 2 – medium, 3 – high, 4 – very high), temperature regime (1 – cold-water, 2 – warm-water), depth (1 – shallow (<0,2 m), 2 – medium depth (0,2–0,5 m), 3 – deep (>0,5 m)); bottom structure (1 – stones, 2 – pebble, 3 – gravel, 4 – sand), current velocity (slow (<0,2 m/s), 2 – medium (0,2–0,5 m/s), 3 – strong (0,5–1,0 m/s)), coverage of aquatic vegetation (1 – no vegetation, 2 – fragmentic coverage, 3 – abundant), and locations lightness (1 – good, 2 – medium, 3 – bad)

4 pav. Apsiuvų individų gausumas (vidurkis, standartinė paklaida (SE) ir standartinis nuokrypis (SD)) skirtingo dydžio (1 – mažos, 2 – vidutinės, 3 – didelės, 4 – labai didelės upės), debito (1 – mažo, 2 – vidutinio, 3 – didelio, 4 – labai didelio), terminio režimo (1 – šaltavandenės, 2 – šiltavandenės upės), gylio (1 – seklu, 2 – vidutinis gylis, 3 – gilu), grunto (1 – akmenys, 2 – gargždas, 3 – žvyras, 4 – smėlis), srovės stiprumo (1 – lėta srovė, 2 – vidutinė, 3 – stipri), padengimo vandens augmenija (1 – augmenijos nėra, 2 – fragmantiškas padengimas, 3 – gausus), vietovės apšviestumo (1 – didelis, 2 – vidutinis, 3 – mažas) sąlygomis

The abundance of **Hydropsychidae** caddisfly family in the rivers was influenced by a complex of environmental factors: higher water oxygen saturation, greater current velocity, warm-water temperature regime, and hard river bottom. The abundance of caddisflies of genus *Hydropsyche* was significantly influenced by warm-water regime and increased oxygen saturation. The abundance of *Hydropsyche angustipennis* was influenced by oxygen saturation and thermal regime. *H. contubernalis* larval abundance was affected by river discharge and hard bottom (positive effect). *H pellucidula* larvae abundance was negatively affected by river discharge and positively by greater current velocity and warm-water regime. *H. siltalai* and *Cheumatopsyche lepida* larvae were more abundant in greater current velocity conditions (Table 2).

The abundance of **Phryganeidae** family was negatively affected by pH (Table 2). The larvae of three Phryganeidae species were found in small numbers in the rivers, which were likely to live in quite different conditions.

Brachycentridae family abundance in the rivers was influenced by sufficient current velocity. Three important environmental factors were detected for *Brachycentrus* caddisfly genus: lower river discharge, greater current velocity, and higher amount of oxygen in the water. *B. subnubilus* larval abundance was significantly higher in the habitats of abundant aquatic vegetation, and *B. maculatus* larval abundance in greater current velocity conditions. *Micrasema setiferum* larval abundance in the rivers was mostly influenced by lower river discharge and greater current velocity (Table 2).

The caddisflies of **Goeridae** family confirms a good ecological status of the river (9 points in BMWP–PL and IG2 in DSFI methods). Hard bottom was found to have a positive effect and amount of nitrate had a negative effect on the abundance of this family. The influence of bottom structure remained the most important factor for the abundance of two species (*Silo pallipes, Goera pilosa*). Other environmental factors were significant: greater current velocity for *S. pallipes*, and cold-water temperature regime for *G. pilosa* (Table 2).

The abundance of **Lepidostomatidae** caddisfly family was significantly influenced by cold-water thermal regime and higher current velocity. *Lepidostoma* genus richness was positively influenced by higher current velocity and greater oxygen saturation. *Lepidostoma basale* abundance was influenced by cold-water temperature regime and low amount of organic matter, and *L. hirtum* abundance was affected by lower river discharge and higher oxygen saturation (Table 2).

Limnephilidae abundance was positively influenced by carbonaceous water hardness and negatively by warm-water regime, current velocity and amount of phosphates. Three important environmental factors were detected for the abundance of *Limnephilus* caddisfly genus: current velocity, oxygen saturation and amount of organic matter. The abundance of *Halesus* spp. and *Halesus digitatus* in the rivers was positively influenced by cold-water and higher carbonaceous water hardness. For the distribution of *H. digitatus* and *H. radiatus* site illumination was a significant factor. In accordance to feeding pattern, these larvaewere more abundant in shadowed river sites overgrown with forests rather than in open river sites. *Potamophylax* genus and *P. latipennis* larval abundance was mostly positively affected by cold-water temperature regime, higher carbonaceous water hardness and lower current velocity. *P. latipennis* larval abundance was negatively influenced by the amount of organic matter. Only one environmental factor was significantly limiting the distribution of genus *Micropterna* in the rivers – higher amount of organic matter.

Table 2. The most important environmental factors affecting caddisfly family, genera and species abundance in the rivers. The results of multiple linear regression (coefficient of regression (Beta), partial correlation (r_d) and coefficient of determination (r^2)), and multifactor (main effects) ANOVA. Only significant results are provided

2 lentelė. Svarbiausi aplinkos veiksniai darantys įtaką apsiuvų šeimų, genčių ir rūšių gausumui upėse. Daugialypės tiesinės regresijos (regresijos koeficientas (Beta), dalinė koreliacija (r_d) ir determinacijos koeficientas (r^2)) ir daugiafaktorinės (pagrindinių efektų) dispersinės analizės rezultatai. Parodyti tik reikšmingi rezultatai

Environmental factors	Family	Genera	Multiple regression				ANOVA		Species	Multiple regression				ANOVA	
			Beta	r_d	r^2	p	F	p		Beta	r_d	r^2	p	F	p
River discharge	Rhyacophilidae		-0.54	-0.37	0.75	0.004			*Ryacophila nubila*	-0.30	-0.32	0.13	0.005		
	Hydroptilidae		-0.41	-0.41	0.19	0.007			*Hydropsyche contubernalis*	0.72	0.46	0.75	0.007	7.2	<0.001
	Polycentropodidae		-0.94	-0.61	0.61	0.001			*Hydropsyche pellucidula*	-0.54	-0.56	0.38	0.005		
		Rhyacophila	-0.54	-0.37	0.75	0.004			*Athripsodes albifrons*	-0.66	-0.44	0.72	0.002		
		Athripsodes	-0.28	0.29	0.13	0.01	6.16	0.003	*Micrasema setiferum*	-0.49	-0.31	0.72	0.03		
		Brachycentrus	-0.65	-0.43	0.72	0.003			*Lepidostoma hirtum*	-0.26	-0.27	0.13	0.02		
Bottom structure	Hydropsychidae						2.80	0.05	*Rhyacophila nubila*					6.5	0.001
	Goeridae						3.41	0.02	*Hydropsyche contubernalis*					2.7	0.02
	Sericostomatidae						6.40	0.002	*Silo pallipes*	0.42	0.42	0.02	0.03		
	Rhyacophilidae		0.67	0.56	0.46	0.005	3.61	0.03	*Goera pilosa*					2.85	0.046
	Glossosomatidae		0.68	0.56	0.46	0.004									
		Rhyacophila	0.67	0.56	0.46	0.005	3.61	0.035							
Current velocity	Polycentropodidae		-0.71	-0.58	0.45	0.003			*Rhyacophila nubila*	0.45	0.42	0.16	<0.001		
	Hydropsychidae		0.30	0.28	0.17	0.03			*Ithytrichia lamellaris*	0.48	0.41	0.29	<0.001		
	Leptoceridae		0.51	0.46	0.69	0.04			*Polycentropus flavomaculatus*	-0.57	-0.44	0.48	0.03		
	Brachycentridae		0.40	0.28	0.58	0.03			*Cheumatopsyche lepida*	0.27	0.24	0.20	0.04		
	Lepidostomatidae		0.35	0.32	0.15	0.004			*Hydropsyche pellucidula*	0.40	0.42	0.48	0.04		
	Limnephilidae		-0.45	-0.44	0.30	0.001			*Hydropsyche siltalai*	0.25	0.25	0.14	0.03		
		Oecetis	0.54	0.35	0.67	0.01			*Athripsodes albifrons*	0.57	0.41	0.66	0.004		
		Athripsodes	0.45	0.44	0.14	<0.001			*Brachycentrus maculatus*	0.74	0.61	0.48	0.001		
		Triaenodes	0.29	0.28	0.17	0.03			*Micrasema setiferum*	0.44	0.31	0.66	0.03		
		Mystacides	-0.54	-0.58	0.38	0.002			*Silo pallipes*	0.32	0.31	0.17	0.009	3.73	0.03
		Brachycentrus	0.72	0.49	0.67	<0.001			*Lepidostoma hirtum*	0.31	0.31	0.14	0.008		
		Limnephilus	-0.36	-0.34	0.17	0.008			*Potamophylax latipennis*	-0.26	-0.31	0.28	0.02		
		Lepidostoma	0.34	0.32	0.14	0.006			*Chaetopteryx villosa*	-0.35	-0.33	0.28	0.01		
		Potamophylax	-0.56	-0.41	0.67	0.004									
Depth at study site	Hydroptilidae		0.34	0.33	0.23	0.02									
		Mystacides	0.61	0.67	0.22	<0.001									
Temperature regime	Glossosomatidae		-0.63	-0.57	0.36	0.004			*Hydropsyche pellucidula*	0.75	0.69	0.36	<0.001		
	Polycentropodidae		0.86	0.61	0.54	0.001			*Hydropsyche angustipennis*	0.50	0.43	0.36	0.04		
	Hydropsychidae						5.90	0.02	*Athripsodes albifrons*	0.43	0.32	0.67	0.03		
	Sericostomatidae		-1.0	-0.56	0.86	0.03			*Goera pilosa*					7.09	0.01

	Lepidostomatidae						7.36	0.01	*Sericostoma personatum*	-0.97	-0.60	0.86	0.01		
	Limnephilidae		-0.63	-0.51	0.46	<0.001			*Lepidostoma basale*	-0.46	-0.41	0.36	0.047		
		Hydroptila	0.30	0.29	0.11	0.01			*Potamophylax latipennis*	-0.60	-0.56	0.36	<0.001	6.05	0.02
		Hydropsyche	0.50	0.44	0.29	0.03			*Chaetopteryx villosa*	-0.40	-0.33	0.45	0.01		
		Ceraclea	0.69	0.46	0.60	0.03			*Halesus digitatus*	-0.45	-0.30	0.67	0.04		
		Halesus	-0.46	-0.29	0.68	0.05									
		Potamophylax	-0.56	-0.40	0.68	0.005									
Amount of organic matter	Rhyacophilidae		-0.34	-0.29	0.08	0.03			*Sericostoma personatum*	-0.28	-0.24	0.28	0.04		
	Baraeidae		-0.30	-0.28	0.26	0.05			*Potamophylax latipennis*	-0.24	-0.33	0.01	0.01		
		Rhyacophila	-0.34	-0.29	0.08	0.03			*Lepidostoma basale*	-0.60	-0.44	0.60	0.045		
		Limnephilus	0.34	0.32	0.25	0.002									
		Micropterna	-0.69	-0.50	0.77	0.04									
Amount of oxygen	Polycentropodidae		0.69	0.56	0.47	0.004			*Polycentropus flavomaculatus*	0.57	0.54	0.52	0.01		
		Polycentropus	0.78	0.50	0.84	0.04									
		Brachycentrus	0.55	0.34	0.76	0.02									
Oxygen saturation	Rhyacophilidae		0.42	0.35	0.46	0.005			*Rhyacophila nubila*	0.64	0.47	0.51	<0.001		
	Hydropsychidae		0.48	0.34	0.53	0.01			*Hydropsyche angustipennis*	0.63	0.63	0.15	0.002		
		Rhyacophila	0.42	0.35	0.46	0.005			*Polycentropus flavomaculatus*	0.36	0.46	0.22	0.04		
		Hydropsyche	0.64	0.63	0.14	0.002			*Lepidostoma hirtum*	0.42	0.32	0.51	0.02		
		Lepidostoma	0.50	0.37	0.52	0.006									
		Limnephilus	0.45	0.34	0.52	0.01									
Total hardness		*Oecetis*	0.39	0.34	0.40	0.02									
Carbonaceous water hardness	Limnephilidae		0.91	0.61	0.57	<0.001			*Halesus digitatus*	0.84	0.38	0.83	0.008		
	Hydroptilidae		0.58	0.49	0.35	0.001			*Potamophylax latipennis*	0.92	0.68	0.51	<0.001		
		Hydroptila	0.70	0.35	0.77	0.01			*Chaetopteryx villosa*	0.64	0.44	0.55	<0.001		
		Halesus	0.75	0.33	0.84	0.02									
		Potamophylax	1.26	0.57	0.84	0.001									
Amount of phosphates	Limnephilidae		-0.26	-0.29	0.18	0.028			*Chaetopteryx villosa*	-0.32	-0.31	0.18	0.02		
	Hydroptilidae		-0.38	-0.34	0.35	0.02									
		Hydroptila	-0.49	-0.36	0.49	0.008									
Amount of nitrates	Goeridae		-0.53	-0.29	0.78	0.046									
pH	Phryganeidae		-0.35	-0.29	0.40	0.04									
		Cyrnus	-0.64	-0.40	0.73	0.02									
Bottom coverage by aquatic vegetation									*Mystacides azurea*					5.3	0.01
									Brachycentrus subnubilus					8.79	<0.001
Site illumination									*Halesus digitatus*					5.9	0.006
									Halesus radiatus					5.9	0.006

The results show that *Micropterna* spp. and *P. latipennis* can be described as caddisfly taxa sensitive to organic water pollution. *Chaetopteryx villosa* larval abundance was negatively affected by warm-water regime, stronger current velocity and higher concentration of phosphates, and positively by carbonaceous water hardness (Table 2). The abundance of widespread *Anabolia laevis* larvae was not affected significantly by any environmental factor. **Sericostomatidae** caddisfly abundance was negatively influenced by warm-water thermal regime and bottom grain size. *Sericostoma personatum* larval abundance was mostly affected by river thermal regime. Warm water and higher amount of organic matter negatively influenced *S. personatum* abundance (Table 2). Meanwhile, no important environmental factor was found to affect *Notidobia ciliaris* abundance.

No statistically important environmental factor has been established for **Molannidae** larvae abundance in the rivers.

Baraeidae caddisfly abundance was negatively influenced by higher amount of organic matter (Table 2). Baraeidae caddisflies are used in the assessment of ecological status of rivers. In BMWP and BMWP–PL systems Baraeidae is provided a 10-point value.

Leptoceridae family abundance was influenced by higher current velocity. This family consists of different genera and species found in different river habitats. One of the most important environmental factors for the distribution of some lower taxa (*Athripsodes* spp., *A. albifrons, Oecetis* spp., *Triaenodes* spp.) and the whole Leptoceridae family was sufficient current velocity. Only the larval abundance of genus *Mystacides* was negatively influenced by higher current. The abundance of this genus was positively influenced by greater depth at the study sites. The abundance of *Mystacides azurea* was positively affected by bottom coverage of aquatic vegetation. Increasing river discharge was negatively influencing *Athripsodes* spp. and *A. albifrons* larvae abundance in the rivers. The positive effect of total water hardness was detected for *Oecetis* spp. larvae abundance. The abundance of *Ceraclea* genus and *A. albifrons* species was positively affected by warm-water thermal regime (Table 2). No statistically important environmental factor was detected for caddisflies of *Leptocerus* genus.

Significance of caddisflies in the macroinvertebrate community structure of rivers. Different hydrobiont groups constituted different parts of taxonomic diversity in benthic macroinvertebrate communities. The most abundant were insects, 81.7±1.0% on average (hereinafter, average±SE) of all taxa. Among them, caddisflies accounted for 20.8±1.1%. Other benthic invertebrates (molluscs, water mites, crustaceans, leaches and other worms) constituted 18.3±1.0% on average (Fig. 5A). A similar tendency was observed in the abundance of individuals. The average abundance of caddisfly larvae in river benthos accounted for 20.2±2.7% of all benthic macroinvertebrates, other insects constituted 59.2±3.0%, and other macroinvertebrates 20.6%±2.5% of the total abundance of individuals (Fig. 5B).

Benthic groups dominating in separate study sites differed, though in most cases they were representatives of insects. The smallest share of caddisfly taxa and individuals in benthic macroinvertebrate communities was in the Nemunas River by Gerdašiai (0.6% and 2.9% by the number of taxa and abundance of individuals, respectively), and the largest share in the Grūda River (79.6% and 43.7%, respectively). Caddisflies shares in benthic communities were being estimated in the rivers of different size, discharge, thermal regime, bottom structure, and currency velocity.

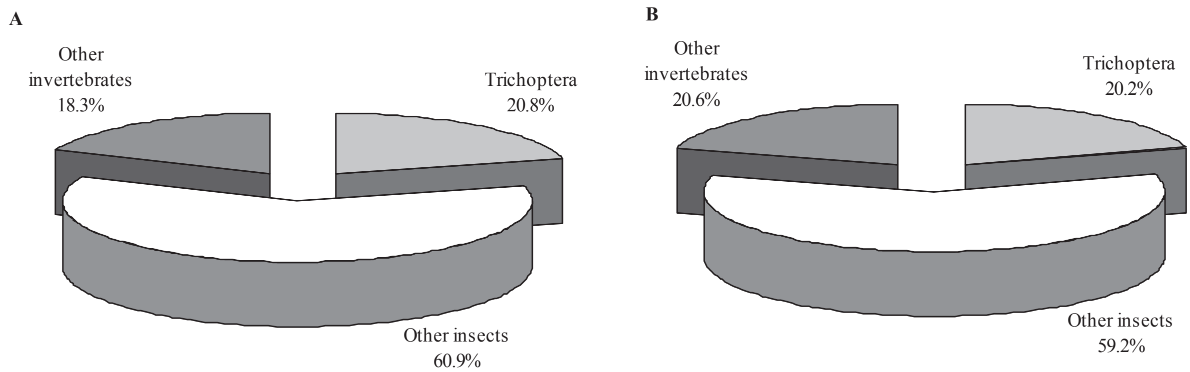


Fig. 5. The share of caddisfly, other insects and other invertebrate taxa (A) and individuals (B) in the benthic communities in the rivers
5 pav. Apsiuvų, kitų vabzdžių ir kitų makrobestuburių dalys upių bentose: A – pagal taksonų įvairovę, B – pagal individų gausumą

The data of earlier investigations demonstrated that the greatest abundance and biomass of caddisflies and mayflies was in Lithuanian rivers with stony bottom (Pliūraitė 2006). In spite of numerous literature on abundance and dominance of separate benthic macroinvertebrates in Lithuanian rivers (Pliūraitė 2001, 2006, 2007; Ruginis 2007), the shares of caddisflies in invertebrate communities under different environmental conditions have not been investigated. Research data show that caddisflies constituted the greatest part of macroinvertebrates according to the number of taxa in the rivers of small size (21.5%), medium discharge (21.3%), cold-water (23.5%), stony bottom (30.4%), and medium-velocity current (24.5%). By abundance of individuals, caddisflies constituted the greatest part of benthic macroinvertebrates in the rivers of medium size (33.3%), medium discharge (40.3%), cold-water (25.3%), stony bottom (43.2%) and strong current (32.1%). According to the number of taxa and abundance of individuals, the smallest share of caddisflies in macroinvertebrate communities was recorded in very large rivers with very high discharge (e.g. Nemunas) (9.9% and 3.4% according to of taxa richness and abundance, respectively), warm-water rivers (16.1% and 14.9%, respectively), at sites with sandy bottom (16.4% and 10.1%), and slow current velocity (15.9% and 9.5%). Thus, the greatest significance of caddisflies in river macroinvertebrate communities was recorded in medium-size, medium-discharge and cold-water rivers with stony bottom according to taxonomic contribution and in medium-size and medium-discharge rivers with stony bottom according to abundance. The mentioned categories of rivers with the greatest significance of caddisflies in macroinvertebrate communities according to taxa and abundance were also distinguished by the dominance of larvae biomass. In medium-size and medium-discharge rivers (the categories of size and discharge coincided over 15 study sites which were studied for macroinvertebrate biomass in 2004s) the biomass of caddisflies averaged 41.8%, in cold-water rivers that comprised 46.5% and at river sites with stony bottom that was 56.7% of the total macroinvertebrate biomass.

The results have revealed that the greatest significance of caddisfly larvae in the structure of benthic macroinvertebrate communities was the characteristic of medium-size, medium-discharge and cold-water rivers at sites with stony bottom.

Assessment of ecological status of rivers according to benthic macroinvertebrates A number of biotic indices have been suggested for quality assessment of European rivers, based on quantitative and qualitative indices of invertebrate macrofauna. The Danish Stream Fauna Index (DSFI) is officially used for quality assessment of Lithuania since 2005. The quality assessment of water in 33 studied Lithuanian rivers (67 sites) was carried out applying the widely used methods for assessment of ecological status of rivers: BMWP, ASPT, BMWP–PL, DSFI, EPT and proportion of trophic groups of invertebrates.

Some macroinvertebrates such as stoneflies, mayflies and caddisflies, the abundance of which is getting smaller with water quality getting poorer, are the first to react to pollution (Rosenberg, Resh 1993; Giller, Malmqvist 1998; Pastuchova 2006). The number of EPT taxa in the studied rivers varied from 1 (mouth of the Pajūrio Šventoji) to 30 (stony bottom of the Virinta). The greatest relative amount of EPT taxa (77.8% of the total) was in the Lėvuo River (by Šeškai), and the lowest (<20% of all taxa) in the mouth of the Pajūrio Šventoji and in the Vyžuona (downstream Juodupė). The greatest relative abundance of EPT taxa (>80% of all individuals in the sample) was in the Grūda, Riešė (downstream Dvarikščiai), Nemunėlis (by Smaltiškiai) and Venta (by Augustaičiai) rivers, and the lowest (<8% of individuals) in five study sites in the Nemunas, three study sites in the Pajūrio Šventoji and in the Sudervė River. EPT indices provided a realistic quality assessment of Lithuanian rivers and therefore could be used for the assessment of the status of rivers. The number of EPT taxa is positively related to other water quality assessment indices: the strongest positive correlation was found between EPT and DSFI (r_s=0.45), and weaker between EPT and BMWP–PL (r_s=0.29) and between EPT and BMWP (r_s=0.28).

The method for assessment of ecological status of rivers – ratio between trophic groups of invertebrates – is the best tool for estimation of organic pollution. It is common knowledge that food chain changes may be used when estimating changes in water bodies. With ecological situation in rivers worsening, the number of macroinvertebrates gatherers is increasing and the number of scrappers is decreasing. A good ecological status of a river is also demonstrated by a higher ratio of scrappers to gatherers and filterers (Schmidt-Kloiber et al. 2006). In Lithuanian rivers, the proportion of gatherers was from 0.4% (Nemunas River near Matiešonys and mouth of the Pajūrio Šventoji) to 63.1% (Sudervė) among invertebrates of all trophic groups, and the proportion of scrappers was from 0.05% (Dysna River, Ignalina district, below dam) to 77.1% (Širvinta). Evaluation of indices of trophic groups in the study sites showed that these indicates significantly correlated only with DSFI, and Spearman's correlation coefficient between DSFI and shares of scrappers and gatherers in benthos and the ratio of these groups was, accordingly, 0.48, -0.26 and 0.54. No significant correlation with other indices (BMWP and BMWP–PL) was found.

According to a number of indices of ecological status (BMWP, ASPT, BMWP–PL, DSFI), which divide rivers into quality classes, no highly polluted rivers falling within water quality class V have been recorded. According to the indices mentioned above, the following rivers were of very good ecological status and fell within quality class I: Dysna (Ignalina district, by Molinė), Dubysa (Jurbarkas district, upstream Seredžius), Grūda, Lėvuo (Panevėžys district, by Skaistgiriai), Merkys (Varėna district, downstream Puvočiai and by the road to Druskininkai), Mūša (Joniškis district, high reaches by Trumpaitėliai), Mūšia, Nemunėlis (Biržai district, by Velniapilio Uola and by

Smaltiškiai), Riešė (Vilnius district, downstream Lake Gulbinas), Siesartis, Šelmenta (Marijampolė district, upstream Tribarčiai), and Širvinta rivers. Having compared these indices of ecological status it was found that DSFI was the most suitable method for quality assessment of Lithuanian rivers. The advantages of DSFI were as follows: 1. DSFI provided a more consistent and more precise division of rivers into quality classes (Fig. 6).

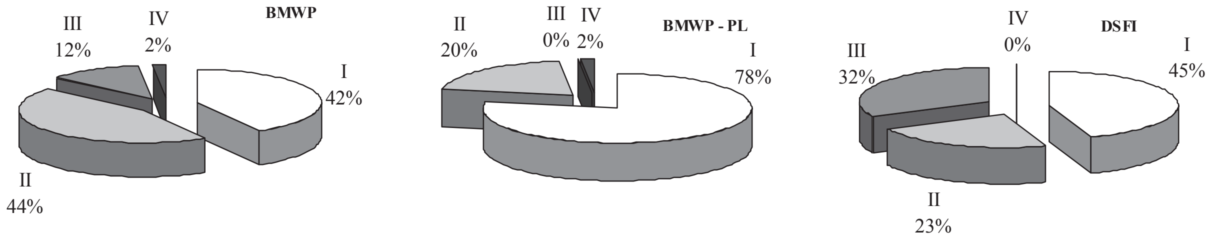


Fig. 6. Distribution (%) of studied river sites in water ecological state classes according to BMWP, BMWP–PL, DSFI
6 pav. Tyrimų vietų priskyrimo vandens ekologinės būklės klasėms pasiskirstymas (%) naudojant BMWP, BMWP–PL ir DIUF metodus

51 (78%) study sites fell within quality class I according to BMWP–PL system, 27 study sites (42%) fell within class I according to the original BMWP system, and only 29 (45%) fell within class I according to DSFI. 13, 29 and 15 study sites fell within quality class II; 0, 8 and 21 study sites fell within class III; and 1, 1 and 0 study sites fell within class IV according to BMWP–PL, BMWP and DSFI, respectively. 2. Significant negative effect of the amount of organic matter was detected only by DSFI method (r_s= -0.34, p<0.05; one-way ANOVA: F=5.92, p=0.005). No significant effect of the amount of organic matter was found by applying BMWP or BMWP–PL. 3. A frequent family of benthic invertebrates joins genera and species with quite different biological properties. For example, the family of Nemouridae stoneflies is given scale number 7 in the original BMWP system, and scale number 6 in BMWP–PL, whereas DSFI calculations include Nemouridae genera that correspond to different categories of ecological evaluation: *Protonemura spp*. found in the rivers of high ecological status and *Amphinemura spp.* found in the rivers of lower ecological status. It is obvious that family assessment by using BMWP system is not the best way to estimate river quality. Identification to genus and species ranks and estimation of abundance (DSFI) give considerably more information on the ecological status of a river. 4. It is likely that DSFI correctly evaluated the ecological status of rivers with a smaller number of taxa in a sample compared to BMWP method; however, this should be confirmed by more exhaustive investigations into macroinvertebrates and chemical parameters of rivers.

According to DSFI method, invertebrate taxa are divided into indicator groups as well as positive and negative diversity groups according to sensitivity to pollution. In different countries the sensitivity of the same benthic invertebrate taxa to organic pollution may be different. For this reason, the sensitivity of indicator (42) and additional (14) taxa to DSFI method and sensitivity of taxa to the amount of organic matter based on data from 33 study rivers (Spirmen’s correlation) was checked. It was found that indicator groups as well as negative and positive diversity groups used in quality assessment of Lithuanian rivers may be supplemented by new indicator taxa.

Additional negative diversity group taxa have been determined: significant positive correlation was observed with the amount of organic matter for Tabanidae (Diptera) (r_s=0.26) family and significant negative correlation with DSFI for Chironomidae (Diptera) and Glossiphoniidae (Hirudinea) families (r_s=-0.39, r_s=-0.43, respectively). The latter families may be used under Lithuanian conditions as negative taxa instead of the genera of this family, *Chironomus* and *Helobdella*, which are more difficult to identify. The following taxa sensitive to organic pollution have been identified: *Micropterna, Sericostoma personatum* (Trichoptera), *Aphelocheirus aestivalis* (Heteroptera), Athericidae (Diptera), *Hydraena spp.* (Coleoptera), the significant positive correlation of which with DSFI (r_s from 0.24 to 0.4) and negative correlation with the amount of organic matter (r_s from -0.25 to -0.30) allow using them as additional taxa of positive diversity group when evaluating the status of Lithuanian rivers. Besides, for Lepidostomatidae and Brachycentridae caddisfly families, strong positive correlation was found with DSFI (r_s= 0.53 and r_s= 0.48, respectively) and strong negative correlation with the amount of organic matter (r_s= -0.38 and r_s= -0.27). Therefore, we can recommend including Lepidostomatidae caddisfly family into the DSFI first indicator group (IG 1), and Brachycentridae into the DSFI second indicator group (IG 2) as indicators of very good ecological status in Lithuanian rivers.

CONCLUSIONS

1. The distribution and abundance of caddisfly species are interrelated: widespread species are more abundant.

2. According to distribution (occurrence frequency) and abundance, caddisfly species can be divided into five rarity categories: very rare, rare, common, very common, and locally abundant. Such categories can be applied for both, adult and larva stages. With respect to adults, 23 (16%) caddisfly species were classified as very rare, 36 (25%) as rare, 70 (49%) as common, and 13 (9%) as very common. Two species (*Rhyacophila pascoei* McL., *Limnephilus dispar* McL.) were categorized as locally abundant species. For caddisfly larvae from flowing water habitats, 24 (26%) species were classified as very rare, 11 (12%) – as rare, 48 (52%) – as common, and 9 (10%) – as very common species.

3. 22 new taxa (21 species and 1 subspecies) of Lithuanian caddisfly were discovered during the investigations. The updated checklist of Lithuanian caddisfly currently includes 173 species and 1 subspecies.

4. Four seasonal flight types for caddisfly species were established: one generation and spring flight activity were determined for 8 species; one generation and autumn flight activity were determined for 12 species; two generations and two flight periods per year were determined for 4 species; a flexible number of generations and seasonally extended flight activity were determined for 23 species.

5. Annual number of generations in some caddisfly species depends upon local or interannual variation in air temperatures during growing season. Two caddisfly species, *Ceraclea dissimilis* Steph. and *Oecetis ochracea* Curt., under conditions of higher temperature produced two generations, whereas at lower temperatures just one generation per year was observed.

6. Distribution and abundance of larvae of particular caddisfly family in Lithuanian rivers depends upon different environmental factors. The influence of current velocity was established for 6, river temperature regime – for 6, bottom structure – for 5, and river discharge – for 3 caddisfly families. The impact of amount of organic matter, oxygen saturation, carbonaceous water hardness, amount of phosphates, depth at study site, amounts of oxygen and nitrate, and pH was detected for 1–2 caddisfly families.

7. Distribution and abundance of particular caddisfly genera or species may depend on other environmental factors than those established for their families. The influence of current velocity, river temperature regime, river discharge, oxygen saturation, amount of organic matter, carbonaceous water hardness, and bottom structure was established for 8, 5, 3, 4, 3, 3, and 1 genus and 13, 9, 6, 4, 3, 3 and 4 caddisfly species, correspondingly. The amounts of oxygen or phosphates, depth at study site, total water hardness, pH, site illumination and bottom coverage by aquatic vegetation were found to be important for 1–2 caddisfly genera or species.

8. Among running water habitats the largest share in taxonomic richness of benthic macroinvertebrate communities caddisflies account in medium-size, medium-discharge, cold-water rivers on the stony bottom (20–30%), and the largest share of caddisflies according to their abundance is in medium-sized, medium-discharge rivers on the stony bottom (33–43%).

9. In Lithuanian rivers, the most sensitive to organic water pollution are caddisflies of the following taxa: Baraeidae and Rhyacophylidae families, *Rhyacophila* and *Micropterna* genera, *Sericostoma personatum* K&Sp., *Lepidostoma basale* Kol. and *Potamophylax latipennis* Curt. species.

10. The DSFI (Danish Stream Fauna Index) is the most suitable among currently used method for evaluation of ecological status of Lithuanian rivers. However, it needs to be improved. With respect to natural conditions in Lithuania, we recommend to include Lepidostomatidae and Brachycentridae caddisfly families into the first and the second indicator groups, correspondingly. The macroinvertebrate taxa *Micropterna* spp., *Sericostoma personatum* K&Sp., *Aphelocheirus aestivalis* F., Athericidae and *Hydraena* spp. may be used as additional taxa of positive diversity group, while Glossiphoniidae, Tabanidae and Chironomidae families as additional taxa of negative diversity group.

SANTRAUKA

Temos aktualumas. Biologinės įvairovės nykimas šiuo metu yra viena svarbiausių ekologinių problemų pasaulyje. Vandens ekosistemos yra ypač svarbios biosferos įvairovei bei produktyvumui. Jos jautriai reaguoja į įvairius abiotinius ir biotinius aplinkos pokyčius. Vertinant ir saugant biologinę įvairovę yra svarbu nustatyti biotinės ir abiotinės aplinkos veiksnių įtaką vandens bestuburių rūšių paplitimui ir gausumui, jų bendrijų sandarai, o taip pat prognozuoti bendrijų kaitą globalių ir lokalių pokyčių sąlygomis.

Apsiuvos, kurios lervinėje stadijoje gyvena vandenyje, yra vienas svarbiausių vidutinio klimato gėlavandenių ekosistemų bentoso komponentų. Jos yra jautrios vandens telkinių fizinių ir cheminių parametrų pokyčiams, todėl dažnai naudojamos vandens telkinių ekologinės būklės bioindikacijai (Kiss *et al.* 2002; Czachorowski, Buczyński 2004; Kownacki, Soszka 2004). Didžiausia apsiuvų lervų įvairovė yra srauniose, vėsiose įvairaus dydžio upėse. Informacijos apie apsiuvų rūšių paplitimą Lietuvoje, jų lervų reikšmę bentoso bestuburių bendrijose, aplinkos veiksnių įtaką lervų pasiskirstymui ir gausumui bei kitas jų ekologines ypatybes upių buveinėse iki šiol nepakanka. Apsiuvų rūšių retumas mūsų šalyje nebuvo analizuotas. Visa tai svarbu vertinant šalies ar atskirų jos regionų, saugomų teritorijų, skirtingų vandens telkinių biologinę įvairovę ir ekologinę būklę, nagrinėjant dabartinius ekologinius procesus upių bendrijose ir prognozuojant galimus pokyčius globalios aplinkos kaitos sąlygomis.

Darbo tikslas ir uždaviniai.

Darbo tikslas – ištirti apsiuvų (Trichoptera) fauną, įvairovę, rūšių paplitimą ir retumą Lietuvoje, įvertinti aplinkos veiksnių įtaką apsiuvų paplitimui ir gausumui skirtingose Lietuvos upių buveinėse.

Darbo tikslui pasiekti buvo iškelti šie **uždaviniai**:

1. Ištirti Lietuvos apsiuvų rūšių retumą, nustatyti retumo kategorijas bei rūšių paplitimo ir gausumo tarpusavio prilausomybę;
2. Patikslinti Lietuvos apsiuvų rūšinę sudėtį ir nustatyti rūšių paplitimą;
3. Ištirti apsiuvų suaugėlių skraidymo sezoninę dinamiką ir veiksnius, kurie turi įtakos generacijų skaičiui;
4. Ištirti aplinkos veiksnių įtaką apsiuvų taksonų (šeimų, genčių, rūšių) paplitimui ir gausumui Lietuvos upių buveinėse;
5. Įvertinti apsiuvų reikšmę skirtingų Lietuvos upių bentoso bestuburių bendrijų sudėčiai;
6. Ištirti apsiuvų bioindikacinę reikšmę Lietuvos upių ekologinės būklės vertinimui.

Mokslinis naujumas. Pirmą kartą:

1. Nustatytos Lietuvos apsiuvų retumo kategorijos bei priklausomybė tarp apsiuvų paplitimo ir gausumo;
2. Nustatytos naujos Lietuvos faunai apsiuvų rūšys ir atnaujintas Lietuvos apsiuvų faunos sąrašas;
3. Nustatyti apsiuvų suaugėlių sezoninio skraidymo tipai ir veiksniai turintys įtakos skraidymo dinamikai;

4. Išaiškinti aplinkos veiksniai turintys įtakos apsiuvų taksonų (šeimų, genčių, rūšių) paplitimui ir gausumui Lietuvos upėse;
5. Įvertinta apsiuvų reikšmė skirtingų Lietuvos upių bentoso bestuburių bendrijų sudėtyje;
6. Patikslintos apsiuvų taksonų bioindikacinės ypatybės Lietuvos sąlygomis ir pateiktos tekančių vandenų ekologinės būklės vertinimo rekomendacijos.

Mokslinė ir praktinė darbo reikšmė:
1. Gauti rezultatai papildo žinias apie apsiuvų ir kitų bentoso makrobestuburių įvairovę, paplitimą ir gausumą Lietuvos upėse;
2. Nustatyti apsiuvų paplitimo ir gausumo dėsningumai svarbūs optimizuojant bioįvairovės apsaugos priemones;
3. Darbo rezultatai svarbūs tobulinant Lietuvos upių ekologinės būklės biotinio vertinimo metodus.

Ginamieji teiginiai:
1. Apsiuvų rūšių paplitimas ir gausumas yra susieti: plačiau paplitusios rūšys yra gausesnės;
2. Apsiuvų rūšis Lietuvoje galima suskirstyti į 5 retumo kategorijas;
3. Apsiuvų suaugėliams būdingi 4 sezoninio skraidymo aktyvumo tipai, skraidymo sezoninės dinamikos ypatumai priklauso nuo apsiuvų taksonominės priklausomybės bei nuo oro temperatūros skirtumų;
4. Apsiuvų šeimų, genčių ir rūšių lervų paplitimui bei gausumui tekančiuose vandenyse įtakos turi skirtingi aplinkos veiksniai, kurių svarba tarp įvairių taksonų skiriasi. Didžiausiam apsiuvų taksonų kiekiui svarbiausi veiksniai yra srovės greitis, vandens terminis režimas, upės debitas, grunto struktūra bei vandens prisotinimas deguonimi.
5. Upių ekologinės būklės rodiklius, kuriuose naudojamos apsiuvos, rekomenduotina koreguoti atsižvelgiant į aplinkos veiksnių įtaką apsiuvų lervų paplitimui ir gausumui Lietuvos sąlygomis.

Rezultatų pristatymas ir aprobavimas. Darbo rezultatai skelbti 31 publikacijose, iš jų 23 straipsniuose ir 8 konferencijų tezėse. Disertacijos tema pristatyta 15 respublikinių ir tarptautinių konferencijų.

Disertacijos struktūra ir apimtis. Disertacijos rankraštį sudaro šie skyriai: Įvadas, Literatūros apžvalga, Tyrimų medžiaga ir metodai, Tyrimų rezultatai (5 skyriai), Rezultatų aptarimas, Išvados, Literatūros sąrašas, Disertacijos tema publikuoti darbai ir Priedai. Visa medžiaga pateikta 228 puslapiuose. Disertacijoje panaudoti 298 literatūros šaltiniai. Disertacija parašyta lietuvių kalba. Disertacijoje yra 19 lentelių, 58 paveikslai, 6 priedai.

Padėkos. Nuoširdžiai dėkoju savo vadovui dr. Kęstučiui Arbačiauskui už rūpestį, kantrybę, dėmesingumą, draugiškumą, visokeriopą supratimą, vertingus patarimus ir pagalbą per visus darbo metus bei rengiant disertaciją.

Dėkoju draugei ir kolegei dr. Rasai Bernotienei už draugiškumą, visokeriopą pagalbą renkant ir analizuojant disertacijos medžiagą. Dėkoju kolegoms Daivai Kalytytei ir Vytautui Rakauskui už draugiškumą, diskusijas ir pagalbą rengiant disertaciją. Esu dėkinga Entomologijos laboratorijos darbuotojams už kantrybę, supratingumą ir pagalbą renkant disertacijos medžiagą. Nuoširdžiai noriu padėkoti prof. dr. H. Malicky (Austria), prof. dr. S. Czachorowski, dr. P. Buczyński, dr. M. Przewoźny (Poland) už patarimus ir pagalbą identifikuojant vandens bestuburius gyvūnus.

Ypač dėkoju savo šeimai, vyrui Vytautui ir dukrai Gerdai, už jų meilę, supratimą, kantrybę ir palaikymą.

Neabejoju, kad prie šio darbo prisidėjo daugelis kitų čia nepaminėtų draugų ir kolegų. Visiems jiems nuoširdžiai dėkoju.

Išvados

1. Apsiuvų rūšių paplitimas ir gausumas yra susieti: plačiau paplitusios rūšys yra gausesnės.

2. Pagal sutinkamumo dažnį ir gausumą apsiuvų rūšys gali būti suskirstytos į 5 retumo kategorijas: labai retas, retas, dažnas, labai dažnas ir lokaliai gausias. Toks skirstymas gali būti naudojamas tiek suaugėliams tiek ir lervinėms stadijoms tirtose buveinėse. Pagal suaugėlius labai retoms priskirta 23 (16%), retoms – 36 (25%), dažnoms – 70 (49%) ir labai dažnoms – 13 (9%) rastų rūšių. Dvi rūšys (*Rhyacophila pascoei* McL., *Limnephilus dispar* McL.) priskirtos lokaliai gausioms rūšims. Pagal lervas tekančių vandenų buveinėse labai retoms priskirta 24 (26%), retoms – 11 (12%), dažnoms – 48 (52%) ir labai dažnoms – 9 (10%) rastų rūšių.

3. Nustatyti 22 nauji Lietuvos faunai apsiuvų taksonai (21 rūšis ir 1 porūšis). Lietuvos apsiuvų papildytame sąraše šiuo metu yra 173 rūšys ir 1 porūšis.

4. Išaiškinti keturi apsiuvų sezoninio skraidymo tipai: 8 rūšims nustatyta viena generacija, pavasarinis skraidymo aktyvumas; 12 rūšių – viena generacija, rudeninis skraidymo aktyvumas; 4 rūšims – dvi generacijos, du skraidymo aktyvumai per metus; 23 rūšims – kintantis generacijų skaičius ir sezoniškai ištęstas skraidymo aktyvumas.

5. Kai kurių apsiuvų rūšių metinis generacijų skaičius priklauso nuo vegetacijos sezono oro temperatūros lokalių ar tarpmetinių skirtumų. Dvi apsiuvų rūšys, *Ceraclea dissimilis* Steph. ir *Oecetis ochracea* Curt., aukštesnės temperatūros sąlygomis produkavo dvi, o žemesnės – vieną generaciją per metus.

6. Atskirų šeimų apsiuvų lervų paplitimui ir gausumui Lietuvos upėse skirtingų aplinkos veiksnių įtaka yra nevienoda. Srovės stiprumo įtaka nustatyta 6, terminio upės režimo – 6, grunto pobūdžio – 5, upės debito – 3 šeimų apsiuvoms. Organikos kiekio vandenyje, prisotinimo deguonimi, karbonatinio vandens kietumo ir fosfatų kiekio bei tyrimo vietos gylio, deguonies kiekio, nitratų kiekio ir pH įtaka nustatyta 1–2 šeimų apsiuvoms.

7. Atskirų genčių ir rūšių apsiuvų lervų paplitimui ir gausumui svarbūs gali būti kiti nei jų šeimoms nustatyti aplinkos veiksniai. Srovės stiprumo, terminio upės režimo, upės debito, prisotinimo deguonimi, organikos kiekio, karbonatinio vandens kietumo ir grunto pobūdžio poveikis nustatytas, atitinkamai, 8, 5, 3, 4, 3, 3 ir 1 genties bei 13, 9, 6, 4, 3, 3 ir 4 rūšių apsiuvoms. Deguonies ar fosfatų kiekio, tyrimo vietos gylio, bendrojo vandens kietumo, pH, tyrimo vietos apšviestumo ar padengimo vandens augalais įtaka nustatyta 1–2 genčių ar rūšių apsiuvoms.

8. Tarp tekančio vandens buveinių didžiausią dalį bentoso makrobestuburių taksonominės įvairovės apsiuvos sudaro vidutinio dydžio, vidutinio debito, šaltavandenėse upėse ant akmenuoto grunto (20–30%), o pagal gausumą jų dalis didžiausia vidutinio dydžio ir vidutinio debito upėse ant akmenuoto grunto (33–43%).

9. Jautriausios organiniam vandens užterštumui Lietuvos upių sąlygomis yra šių taksonų apsiuvos: Baraeidae ir Rhyacophylidae šeimos, *Rhyacophila* ir *Micropterna* gentys, *Sericostoma personatum* K&Sp., *Lepidostoma basale* Kol. ir *Potamophylax latipennis* Curt. rūšys.

10. DIUF (Danijos indeksas upių faunai) tarp dabar naudojamų metodų yra tinkamiausias Lietuvos upių vertinimui, tačiau jį būtina tobulinti. Atsižvelgiant į Lietuvos gamtines sąlygas, rekomenduojame Lepidostomatidae apsiuvų šeimą įtraukti į pirmąją, Brachycentridae – į antrąją indikatorinę grupę, o *Micropterna* spp., *Sericostoma personatum* K&Sp., *Aphelocheirus aestivalis* F., Athericidae ir *Hydraena* spp. makrobestuburių taksonus naudoti kaip papildomus “teigiamos” įvairovės grupės bei Glossiphoniidae, Tabanidae ir Chironomidae šeimas – kaip “neigiamos” įvairovės grupės taksonus.

LIST OF PUBLICATIONS ON THE DISSERTATION TOPIC
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ABSTRACTS OF SCIENTIFIC CONFERENCE
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