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## Concomitance of caddis fly (Trichoptera) larvae in four Masurian lakes differing trophically (north-eastern Poland)

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**Abstract** - Changes in the communities of caddis fly larvae typical of various lake habitats showed a gradient-like configuration. The concomitance structure of the caddis fly fauna of the lake as a whole was marked by certain individualism. This individual character of communities was due to regional differences, the trophic differences and habitat composition of the particular lake, as well as to the close vicinity of habitats in the lakes, and most probably arose from the sharing of resources in the individually forming habitats. Five types of community were initially distinguished for the various habitats of the studied lakes, taking into consideration their regional (local) and general character.

**Key words:** lakes, communities, caddis fly larvae, habitat, distribution, heterogeneous environment.

### 1. Introduction

The concomitance of caddis fly larvae in European water courses is relatively well known. Generalizations and models distinguishing the particular zones and the corresponding habitats have also been suggested (Ilieş, Botosaneanu 1963, Szczęsny 1986). There are, however, far fewer studies concerning stagnant waters and there is a lack of general conclusions.

In the investigations on caddis fly distribution in the Polish lakes (Demel 1923, Jakubisiakowa 1933, Rzóńska 1935, Czachorowski 1992, 1993, 1994, Czachorowski, Kornijów 1993, Czachorowski, Kurzątkowska

unpubl. data) a fairly high repeatability of species occurring in similar habitats was reported. At the same time, certain differences between lakes in the various regions of Poland were observed. Thus the question may be raised whether the communities of caddis flies specific for particular lake habitats are "universal", i.e. are the same in all lakes, or whether the species composition of communities has a regional character, determined by the local conditions.

The aim of the present study was to define the character of the concomitance of caddis fly larvae in four lakes of the Olsztyn Lake District, trophically differing, in connection with the characteristics of the habitats and succession changes occurring during eutrophication of the lakes. An attempt has also been made to answer the question whether in the various Polish lakes, differing trophically and in their location, the same communities occur there.

## 2. Material and methods

Caddis fly larvae were collected in four lakes of the Olsztyn Lake district (north-eastern Poland): the mesotrophic Lake Narckie, the eutrophic Lake Warchałdzkie, eutrophic-polytrophic Lake Skanda and the polytrophic Lake Brajnkie (C z a c h o r o w s k i 1993).

The material was collected at 27 stations, in the period 1987-1990 at monthly intervals. The larvae were caught from all developed habitats using a hydrobiological hand sampler and a dredge. Altogether 19 types of littoral habitat were taken into consideration (C z a c h o r o w s k i 1992, 1993). About 800 samples were collected, caddis flies being present in 714 of them. A total of 15 856 larvae belonging to 55 species were collected (C z a c h o r o w s k i 1992, 1993).

The concomitance of the species was calculated for each lake separately, using B i e s i a d k a ' s formula (1977), the basis for the calculations being a single sample:

$$W_{xy} = \frac{\sum_{i=1}^s \frac{a_i}{b_i}}{n} 100\%$$

where:

- $W_{xy}$  – concomitance of the species x and y,
- $s$  – number of samples in which the species x and y occurred together,
- $a_i$  – smaller numbers of the i-th species,
- $b_i$  – greater numbers of the i-th species,
- $n$  – total number of samples.

The calculation results were compiled using the method of the shortest dendrite and the particular fragments of the dendrite, analysed utilizing the habitat preferences of the species (Czachorowski 1992). Concomitance calculated by the above method defines the simultaneous presence of larvae on a small area (the size of a single sample) at the same time. The communities were distinguished in two stages (at two levels): communities of greater concomitance and those of smaller concomitance (the consideration of a greater number of intervals would not be legible).

### 3. Results

#### 3.1. Mesotrophic Lake Narckie

In the concomitance class above 20% 5 groups of species were identified (fig. 1): N3A (*Limnephilus stigma*, *L. auricula*), N3B (*Cyrrnus flavidus*, *C. crenaticornis*), N3C (*Cyrrnus insolutus*, *Holocentropus dubius*), N3D (*Holocentropus picicornis*, *Erotesis baltica*, *Limnephilus marmoratus* and *L. politus*). This last community with some features indicating its connection with atrophic littoral neighbored with the community N3C, which was also characteristic of atrophic littoral. The community N3A may be regarded as characteristic of small temporary water bodies, and N3B as characteristic of the elodeid zone. In the similarity class above 10% most of the species joined to form one community (N3). Besides, three successive communities – N1, N4 and N2 – could be distinguished. *Limnephilus vittatus* – indicated as community N2 – was distinguished by zero concomitance with all the species.

The elodeid communities occupied the central position in the dendrite. The particular branches of the dendrite may be associated with the different zones of the lake: the zone of bulrushes, astatic sedgeland (small temporary water bodies), the elodeid zone, and the atrophic littoral. The species formed groups according to similar ecological requirements and clearly reflected the zones in the lake, differing in habitat conditions.

#### 3.2. Eutrophic Lake Warchałdzkie

In the concomitance class above 20% three groups were distinguished (fig. 2). W2A comprised species specific for the zone of submersed vegetation and the muddy bottom of eutrophic lakes (*Ecnomus tenellus*, *Cyrrnus flavidus* and *Athripsodes aterrimus*), W2B comprised species typical of a bottom covered with detritus -

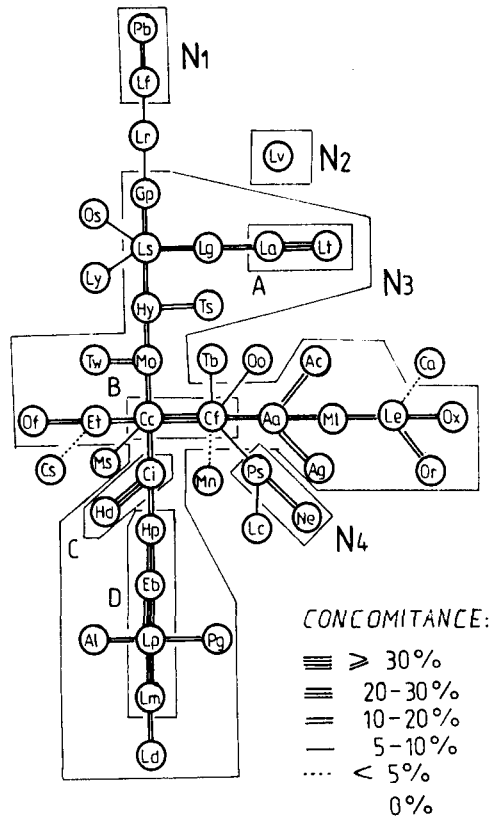


Fig. 1. Dendrite of concomitance of species in Lake Narekie. Denotations of species: Aa - *Athripsodes aterrimus* (Steph.), Ac - *A. cinereus* (Curt.), Ag - *Agraylea multipunctata* Curt., Al - *Anabolia laevis* (Zett.), Ao - *Agrypnia obsoleta* (Hag.), Ca - *Ceraclea annulicornis* (Steph.), Cc - *Cyrnus crenaticornis* (Kol.), Cf - *C. flavidus* Mcl., Ci - *C. insolutus* Mcl., Cs - *C. spp. juv.*, Eb - *Erotesis baltica* Mcl., Et - *Ecnomus tenellus* (Ramb.), Gi - *Grammotaulius signatipennis* Mcl., Gn - *G. nigropunctatus* (Retz.), Gs - *G. sp. juv.*, Gp - *Glyptotaelius pellucidus* (Retz.), Ha - *Halesus* sp., Hd - *Holocentropus dubius* (Ramb.), Hp - *H. picicornis* (Steph.), Hy - *Hydroptila* sp., La - *Limnephilus auricula* Curt., Lb - *L. borealis* (Zett.), Lc - *L. fuscicornis* Ramb., Ld - *L. decipiens* (Kol.), Le - *Leptocerus tineiformis* Curt., Lf - *Limnephilus flavicornis* (Fab.), Lg - *L. griseus* (L.), Ll - *L. lunatus* Curt., Lm - *L. marmoratus* Cut., Ln - *L. nigriceps* (Zett.), Lp - *L. politus* Mcl., Lr - *L. rhombicus* (L.), Ls - *L. spp. juv.*, Lt - *L. stigma* Curt., Lu - *L. sparsus* Curt., Lv - *L. vittatus* (Fab.), Ly - *Lype* sp., Ma - *Mystacides azurea* (L.), Ml - *M. longicornis* (L.), Mn - *M. nigra* (L.), Ms - *M. spp. juv.*, Mo - *Molanna angustata* Curt., Ne - *Nemotaulius punctatolineatus* (Retz.), Of - *Oecetis furva* (Ramb.), Ol - *O. lacustris* (Pict.), Oo - *O. ochracea* (Curt.), Os - *O. spp. juv.*, Or - *Orthotrichia* sp., Ox - *Oxyethira* sp., Pb - *Phryganea bipunctata* Retz., Pg - *P. grandis* L., Ps - *P. spp. juv.*

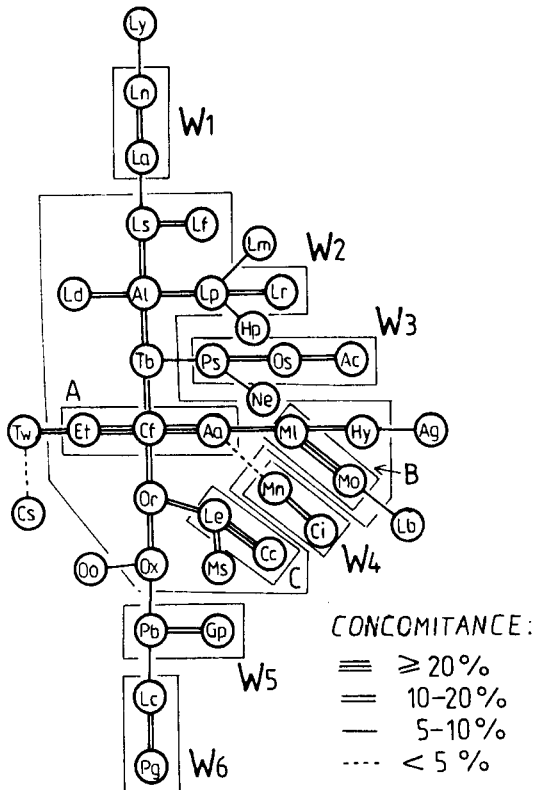


Fig. 2. Dendrite of concomitance of species in Lake Warchałdzkie. Denotations as in fig. 1

*Mystacides longicornis* and *Molanna angustata*, and W2C the phytophilous species characteristic of the communities *Ceratophyllum* and *Myriophyllum* (*Leptocerus tineiformis* and *Cyrrnus crenaticornis*). In the class above 10% six communities were distinguished (fig. 2), W2 representing a large group comprising the three mentioned earlier and also *Mystacides* sp. juv., *Orthotrichia* sp., *Tinodes waeneri*, *Hydroptila* sp., *Tiaenodes bicolor*, *Anabolia laevis*, *Limnephilus decipiens*, *Limnephilus* sp. juv., *L. flavicornis*, *L. politus* and *L. rhombicus*. Some of the species were characteristic of the elodeid zone and a muddy bottom, and others (*Triaenodes bicolor* and species from the family Limnephilidae) of the bulrush zone. Five further groups were distinguished, among them W1 (*Limnephilus nigriceps* and *L. auricula*) typical of small astatic waters and W5 (*Phryganea bipunctata* and *Glyptotaelis pellicidus*) typical of bulrushes. The W3 group may be regarded as one associated with a sandy, not overgrown bottom, and W4 with the

zone of elodeid vegetation and muddy bottom. Two species characteristic of sandy littoral (*Athripsodes cinereus* and *Limnephilus fuscicornis*) occurred far from each other. This may be put down to their occurrence in the habitat in different phenological periods. *A. cinereus* was most numerous in the psammolittoral in spring, while in winter it occurred in the elodeid zone. *L. fuscicornis* was most numerous in autumn. In spite of their occurrence in the same habitat, these species do not appear simultaneously (they do not compete for the resources of the environment), this being clearly evidenced by the dendrite of concomitance.

The central position in the dendrite was occupied by communities and species characteristic for the elodeid zone, while the particular branches of the dendrite may be linked with the various lake habitats. In comparison with Lake Narckie the species preferring the helophyte zone were more numerous, this most probably being due to the higher percentage of these habitats in Lake Warchałdzkie.

### 3.3. Eutrophic-polytrophic Lake Skanda

In the class of concomitance above 20% three pairs of taxa were distinguished (fig. 3): *Grammotaulis* spp. juv. and *Limnephilus vittatus* (S1), *Oxyethira* spp. with *Hydroptila* spp. (S5A) and *Ecnomus tenellus* and *Phryganea* spp. juv. (S5B). The concomitance of *Ecnomus tenellus* and *Phryganea* spp. juv. might be interpreted as indicating periodical migration of the *Phryganea* larvae to the elodeid zone. The community S5B may be associated with the elodeid zone and partly with that of bulrushes. At the level above 10% 5 communities were distinguished (fig. 3). The community S1 comprised species characteristic of periodical waters, S2 consisted of species of the helophyte zone of periodical character (the zone of sedge and rushes), S3 of helophytes of the afforested bank, S4 of the deeper zone of helophytes, and S5 of species characteristic of the elodeid zone.

In the similarity class above 10% one large community was distinguished, mainly comprising the elodeid species (S5), as well as four smaller communities: S4, S3, S2, and S1. Two communities may be regarded as belonging to the bulrush communities i.e. S3 and S4. The community S2, comprising *Halesus* sp., *Glyptotaelius pellucidus*, *Limnephilus auricula*, *L. vittatus*, *L. borealis*, *L. nigriceps*, appears to be connected with a high oxygen content and low temperatures, as it contains a rheophilous species and those occurring in water bodies in spring. Here belongs *Limnephilus fuscicornis*, which may be interpreted as a confirmation of this

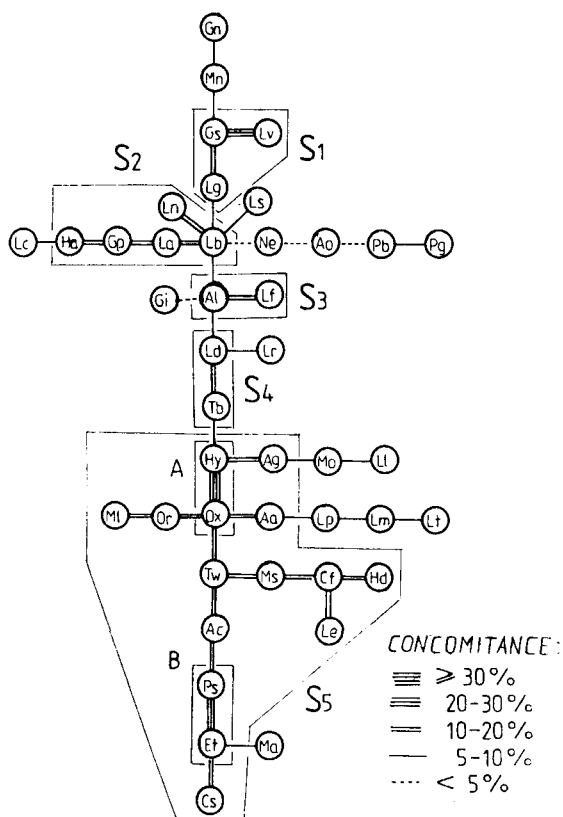


Fig. 3. Dendrite of concomitance of species in Lake Skanda. Denotations as in fig. 1

thesis. The community S1 may be associated with astatic spring waters, occurring in the lakes in the zone of periodically drying-up sedges (rushes). In Lake Skanda the elodeid species were less important and distinct domination of the bulrush-rush species and communities could be observed, as well as a fairly great importance of communities characteristic of temporary water bodies in spring.

### 3.4. Polytrophic Lake Brajnackie

In the concomitance class above 50% three communities were distinguished (fig. 4): B2 (*Cyrrnus flavidus*, *Tinodes* sp. and *Leptocerus tineiformis*), B5A (*Athripsodes aterrimus*, *Limnephilus rhombicus*), and B5B (*Limnephilus politus*, *L. marmoratus*). In the concomitance class above 10% six communities were distinguished (fig. 4): B1 (*Oxyethira* sp. and *Oecetis ochracea*), B3 (*Cyrrnus crenaticornis*, *Ecnomus tenellus* and *Cyrrnus* sp. juv.) and B5 - a community comprising the bulrush species; B4 (*Orthotrichia* sp.,

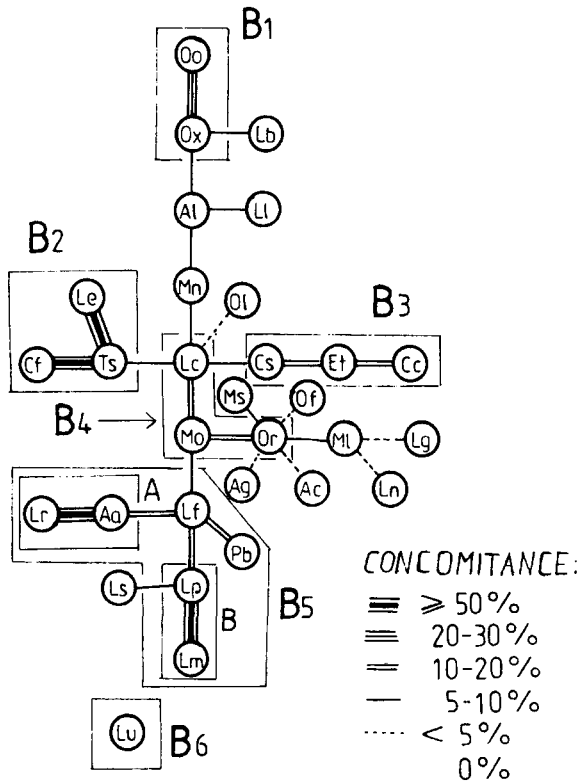


Fig. 4. Dendrite of concomitance of species in Lake Brajnickie. Denotations as in fig. 1

*Molanna angustata* and *Limnephilus fuscicornis*) may be regarded as associated with a bottom covered with detritus, while B6 comprised one species of zero concomitance.

Species of submersed vegetation could be fairly well distinguished in spite of their rather small numbers in this lake. They did not, however, occupy any central position in the dendrite. In comparison with the dendrites of concomitance in Lakes Narckie and Warchałdzkie the formation of groups can be observed comprising species of the elodeid zone and of the rush-bulrush one.

#### 4. Discussion

Brantjes and Higler (1970) illustrated the changes in the population of Trichoptera in communities with *Stratiotes aloides* at various stages of succession. With the ageing of the water body the



communities of *Stratiotes* emerged from the water. In mesotrophic lakes *Stratiotes aloides* does not come up to the surface (D z i e d z i c, personal information). In Lake Narckie these plants appeared in small numbers at one of the stations among the elodeids, forming greater or smaller agglomerations. At another station, however, in an isolated bay, they formed compact patches emerging from the water. Brantjes and Higler (1970) reported the occurrence of *Cyrnus crenaticornis* and *Cyrnus flavidus* at submersed stations; *Cyrnus insolutus* among more emerged plants, *Holocentropus picicornis* and *H. dubius* among mostly emerged plants neighbouring upon the communities of rushes and bulrushes. These changes were gradual and quantitative. When comparing this situation with the concomitance dendrite of species (fig. 1) a great similarity may be seen. The mentioned species formed a sequence: *Cyrnus flavidus*, *C. crenaticornis*, *C. insolutus*, *Helocentropus dubius*, and *H. picicornis* (the last two forming a bifurcation). This conformity with other investigations serves as confirmation of the applicability of the concomitance method of distinguishing the communities.

In the investigations on the distribution of the caddis fly larvae in the zone of submersed plants in lakes of the south-eastern part of Poland (C z a c h o r o w s k i, K o r n i j ó w 1993), applying the method of species concomitance, two communities related to the trophic condition of the lakes were distinguished. In a mesotrophic lake the characteristic community comprised *Cyrnus crenaticornis*, *Leptocerus tineiformis*, *Mystacides longicornis*, *Triaenodes conspersa*, and *Oxyethira* sp. In a eutrophic lake a community comprising *Cyrnus flavidus*, *Ecnomus tenellus*, *Cyrnus insolutus*, *Holocentropus dubius*, *H. picicornis*, *Athripsodes aterrimus* was found to be characteristic. This observation is consistent with the characteristics of concomitance in the studied lakes of the Olsztyn Lake District. The separation of the elodeid species *Cyrnus crenaticornis* and *Leptocerus tineiformis* from *C. flavidus* and *Athripsodes aterrimus* is also visible in the dendrites from the investigated lakes (e.g. in fig. 2).

In the dendrites of concomitance in the investigated lakes the species formed groups according to similar ecological requirements, fairly clearly separating the zones of the lake differing in habitat conditions. This distinction was most clearly marked in the case of elodeid communities separated from the bulrush and rush communities. Several other directions of changes could also be distinguished: psammolittoral, bottom, temporary water bodies of the eulittoral, atrophic littoral. Changes between these habitats had a step-like character. Groups characteristic of habitats poorly

represented in the investigated lakes were less distinctly visible or were situated on the borders of the dendrite.

One may also observe the penetration of species into communities not specific for them, e.g., in Lake Brajnickie, where the elodeid communities were in contact with and joined the groups of the shallowest littoral. This event may result from migration from neighbouring habitats.

In lakes of the poorest trophic conditions the elodeid communities were the dominants, while in trophically richer lakes the bulrush and rush communities prevailed. Thus it may be concluded that in the course of eutrophication the caddis fly communities specific for the zone of submersed vegetation are the first to disappear, which may be due to the dwindling of these habitats. Communities characteristic for other habitats formed relatively independently of the trophic conditions. This is most probably because the plant communities of rushes of the shallowest littoral depend rather more on the form of the littoral than on the trophic state of the lake (determined according to the level of biogens within the lake).

When analysing the species composition and the habitat distribution of the caddis fly larvae in the Masurian lakes, the lobelian lakes of the Pomeranian Lake District (Czachorowski 1994), and in those of south-eastern Poland (Czachorowski, Kornijów 1993, unpubl. data) some similarities may be seen between the elodeid communities in the last two lakes. With respect to the communities of bulrushes and rushes, on the other hand, a greater similarity is observed between the communities in the lakes in the north of Poland (Pomeranian and Masurian Lake Districts). It appears that, on the one hand, this is due to regional differences and on the other, to the habitat composition of the lakes and their trophic conditions, independently of their location in the region. This observation may serve as confirmation of the habitat distribution of the Trichoptera in a small overgrown sylvan lake in the Masurian Lake District (Czachorowski, Kurzątkowska, unpubl. data) and the occurrence of rheophilous species in Lake Wigierskie (Demel 1923, Rzóśka 1935) and in the lobelian lakes of Pomerania (Czachorowski 1994).

The great degree of similarity and repeatability of the caddis fly communities in identical lake habitats supports an earlier conclusion about the importance of the factor of habitat distribution for the occurrence of Trichoptera in lakes (Czachorowski 1993). But how to account for the simultaneously observed individualism and unrepeatability of certain communities? This may be possible by taking into consideration the modifying effect of

migration from neighbouring habitats. In certain lakes some habitats are distinctly spatially separated from each other (e.g. elodeids and rushes in lakes with highly transparent water), while in others they are situated close to each other (e.g. elodeids and rushes in lakes of poor water transparency). This observation is well defined by the model of a "habitat island" formulated earlier (Czachorowski, Kornijów 1993).

A second important conclusion which can be drawn from the analysis of concomitance is the observation that changes in the communities, and probably also in the environmental factors, had a gradient character. Accordingly, no definite boundaries between the communities can be expected. The gradient configuration of concomitance of species in the dendrite and their individual character in each lake may be associated with the sharing of resources and competitive supersedence (Begon, Mortimer 1981) formed in defined and unique habitat conditions. These conditions are determined by the varied neighbourhood of habitats and different size of the habitat patches (spots). The distinguishing habitats may be regarded as "habitat islands" (MacArthur 1972, Williams 1987). The existence of a relation between the number of species in a group of organisms occupying a similar niche (habitat island, patch) and its dimensions subject to division has also been indicated by the results of theoretical considerations of MacArthur (1965) and Levins (1968) as well as empirical data (Schoener 1974).

Apart from certain individual differences, it is possible to describe typical communities of the Trichoptera larvae of various lake habitats and the trophic conditions in the studied lakes. One may roughly distinguish five communities associated with various lake habitats and zones, taking into consideration the local and regional character of this classification:

I. A community of species of astatic sedges characterized by great individualism of the species composition and local effect of migration from small water bodies: genus *Grammotaulis*, *Glyphotaelius pellucidus*, *Limnephilus griseus*, *L. auricula*, *L. stigma*, *L. vittatus*.

II. A community of species of the bulrush zone: *Limnephilus flavicornis*, *L. politus*, *L. decipiens*, genera *Anabolia*, *Halesus*, *Triaenodes bicolor*, *Phryganea* genus and *Tinodes waeneri* - on stones.

III. A community of atrophic littoral: besides the species occurring in Group II, also *Limnephilus marmoratus*, *Erotosis baltica*, genus *Holocentropus* and *Cyrnus insolutus*.

IV. A community of not-overgrown littoral: *Limnephilus fuscicornis*, *Athripsodes cinereus*, *Ceraclea annulicornis*, *Molanna angustata*.

VA. An elodeid community (mainly of mesotrophic lakes): *Cyrnus crenaticornis*, *Leptocerus tineiformis*, *Oxyethira* spp., genus *Mystacides*.

VB. An elodeid community (of eutrophic lakes): *Cyrnus flavidus*, *Ecnomus tenellus*, *Athripsodes aterrimus*, *Orthotrichia* sp., genera *Mystacides*, *Oecetis*.

## 5. Polish summary

### Współwystępowanie larw chruścików (Trichoptera) w czterech jeziorach mazurskich różniących się trofią (północno-wschodnia Polska)

Podstawą niniejszego opracowania jest materiał zebrany w latach 1987-1990 w czterech jeziorach Pojezierza Olsztyńskiego różniących się trofią. Ogółem zebrano ponad 15 000 larw zaliczonych do 55 taksonów. Współwystępowanie między gatunkami liczono według formuły ilościowej. Wyniki wyliczeń zestawiono metodą najkrótszego dendrytu.

W mezotroficznym Jeziorze Narckim zgrupowania elodeidowe znalazły się w centralnej części dendrytu, bardziej peryferyjnie usytuowały się zgrupowania charakterystyczne dla psammolitoralu, dna mulistego i strefy helofitów (ryc. 1). Podobną sytuację zaobserwowano dla eutroficznego Jeziora Warchałdzkiego (ryc. 2). Natomiast w eutroficzo-politroficznym Jeziorze Skanda dominowały zgrupowania typowe dla strefy helofitów oraz drobnych zbiorników okresowych (ryc. 3). W politroficznym Jeziorze Brajnickim centralną pozycję w dendrycie zajął gatunek najbardziej eurytopowy, a zgrupowania elodeidowe były nielicznie reprezentowane i usytuowały się w bezpośrednim sąsiedztwie zgrupowań szuwarowo-oczeretowych (ryc. 4). Zauważono, że wyodrębnione zgrupowania grupowały się zgodnie z podobnymi wymaganiami ekologicznymi, stosunkowo wyraźnie oddzielając różne siedliska jeziorne, zwłaszcza siedliska elodeidowe i helofitowe. Zaobserwowano również wpływ trofii jezior na kształtowanie się zgrupowań larw Trichoptera. Stwierdzono także powtarzalność pomiędzy zgrupowaniami pochodzącymi z jezior różnych regionów geograficznych z jednoczesnymi małymi różnicami, wynikającymi z regionalnego położenia, kompozycji siedliskowej (sąsiedztwa siedlisk w jeziorze) i stanu trofii jeziora.

Indywidualizm zgrupowań można powiązać z konkurencyjnym wypieraniem i podziałem zasobów, kształtujących się także pod wpływem wielkości siedlisk i ich wzajemnego sąsiedztwa. Wyróżniono pięć zgrupowań dla różnych siedlisk jeziornych, z zaznaczeniem ich regionalnego i ogólnego charakteru.

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