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ANALYSIS OF THE DISTRIBUTION OF CADDIS LARVAE
(TRICHOPTERA) IN THE ELODEID ZONE OF TWO LAKES OF EAST
POLAND, BASED ON THE CONCEPT OF HABITATUAL ISLANDS

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ABSTRACT

In the elodeid zone of two lakes differing in trophy, two communities of caddis larvae were singled out. One of them was characteristic of mesotrophy, and the other one – of eutrophy. For interpretation of the differences in species composition and quantitative structure between different habitats of the submerged vegetation zone, the model of habitatual island was proposed. The model takes into account the seasonal and accidental migrations of larvae from vicinal habitats or from waters of other types (e.g. rhitral).

Key words: habitatual islands, communities, lakes

1. INTRODUCTION

In studies of the distribution of caddis larvae in the littoral of the Masurian lakes (Czachorowski 1992), two main synecological groups of caddis flies colonizing lake littoral have been found. This confirms the earlier results of Wichard (1974) and Czachorowski (1989). The first group comprises small-pond species occurring mainly in the zone of emerged vegetation, and penetrating into the deeper zone only sporadically. This is related to the origin of these species, as well as to their biological adaptations to surviving winter under conditions of freezing and periodic oxygen deficit in the most shallow littoral under ice cover (Czachorowski 1989). This group includes mainly species of the family Limnephilidae (which winter mostly as eggs, or there occurs the diapause of the early larval stages) and Phryganeidae (resistance to freezing).

The second synecological group inhabiting lake littoral comprises typically lacustrine species associated with the elodeid zone and lake bottom. They display different biological adaptations, e.g. they seasonally migrate inside the lake during winter (Demel 1923, Solem 1973, Czachorowski 1989). This group comprises species of the families Polycentropodidae, Ecnomidae and Leptoceridae. In contrast to the first group, the species of the second group have small larvae, this pointing to adaptation to life among densely growing elodeids (in dense elodeid thickets) (Demel 1923).

This paper presents the results of studies on habitatual distribution of caddis larvae in the submerged vegetation zone of two lakes in East Poland, with consideration of lake trophy, depth and vegetation type. In the paper it is attempted to verify the earlier mentioned hypotheses based on the results carried out in another geographic region (Czachorowski 1992).

General pattern of the distribution of other macrofauna with special consideration of the Chironomidae in the elodeid zone of the investigated lakes, has been reported by Kornijów (1988, 1989a, 1989b).

2. TERRAIN OF STUDIES

The terrain of studies comprised the mesotrophic Piaseczno Lake and eutrophic Głębokie Lake, situated in the Łęczna-Włodawa Lakeland. The lakes have a relatively small surface area and considerable maximum depth (84 ha and 38.8 m, and 12 ha and 6 m, respectively). In the littoral of both lakes, according to the classification by Bernatowicz, Zachwieja (1966) we singled out the atrophic phytolittoral adjoining intermediate peat-bogs and accounting for ca. 25% of lake shore in the Piaseczno Lake and ca. 40% in the Głębokie Lake. The remaining part of the littoral is constituted by the psammolittoral in the Piaseczno Lake and by the marsh phytolittoral in the Głębokie Lake. They border on cultivated fields and pastures.

In the Piaseczno Lake emerged vegetation was represented mainly by scarcely growing *Phragmites communis* Trin. Submerged vegetation occurring to a ca. 5-m depth was dominated by *Myriophyllum alternifolium* DC., *Ceratophyllum demersum* L. and *Elodea canadensis* Rich. In the Głębokie Lake the helophyte zone was well established and comprised mainly *Ph. communis*, *Typha angustifolia* L. and *T. latifolia* L., whereas the elodeid zone included densely growing *C. demersum* and *Potamogeton lucens* L.

3. METHODS

Sampling stations were selected in the littoral of the above-mentioned types at 0.5 and 2-m depths (in the Piaseczno Lake – also at a 4-m depth). Their detailed characterization comprising the kind of bottom sediments, physicochemical properties of waters and description of the vegetation has been reported in earlier papers (Kornijów 1988, 1989a). Field studies were performed at 1-month intervals between January 1983 and December 1984. The fauna living on plants was collected together with the dominant plants, using a specially designed sampler with trapping surface of 1520 cm² (Kornijów 1987).

Benthic material was collected with a core-type sampler having transparent walls of organic glass, with trapping surface of 20 cm² (Kajak et al. 1965). Samples containing macrophytes were disregarded. The material was screened through a net of (0.18 x 0.18 mm mesh size). Living invertebrates were picked up macroscopically from both the plant and sediment samples, after exposing portions of the material on white cuvettes filled with water; they were then preserved in 4% formalin.

Faunistic similarity between habitats and similarity of species co-occurrence were calculated from the known formula of Jaccard:

$$P_{xy} = \frac{c}{a + b - c} 100 \%, \quad W_{xy} = \frac{f}{d + e - f} 100 \%$$

where: P_{xy} – faunistic similarity between two habitats; a – no. of species occurring in habitat X; b – no. of species occurring in habitat Y; c – no. of species common to both habitats (X, Y); W_{xy} – co-occurrence between species x and y; d – no. of samples containing species x; e – no. of samples containing species y; f – no. of samples containing both species.

Faunistic similarities and co-occurrence were calculated also from Jaccard's formula valorized by the numbers (Biesiadka 1977):

$$P_{xy} = \frac{\sum_{i=1}^s \frac{a_i}{b_i}}{n} 100\%, \quad W_{xy} = \frac{\sum_{i=1}^z \frac{a_i}{b_i}}{m} 100\%$$

where: P_{xy} , W_{xy} – as above, n – no. of species found in both habitats; s – no. of species common to both habitats; a_i – lower numbers of the i -th species; b_i – higher numbers of the i -th species; z – no. of samples containing both species; m – no. of all samples.

In both formulae the similarities and co-occurrences assume values from 0 (lack of any similarities and co-occurrences) to 100% (maximum similarities). The values of the calculated similarities were arranged in Czekanowski's diagram, and the values of the co-occurrences – in the shortest dendrite (Wrocław dendrite).

4. RESULTS

The 175 collected samples contained 907 caddis larvae belonging in 18 taxa (Table I). *Cyrnus crenaticornis* occurred most abundantly (368 larvae), whereas

Table I. Distribution of caddis larvae in different types of littoral. 1 – marsh phytolittoral, 2 and 4 – atrophic phytolittoral, 3 – psammolittoral, N – total no. of larvae

Taxa	Głębokie Lake		Piaseczno Lake		N
	Station				
	2	1	4	3	
<i>Cyrnus</i> sp. juv.	1	1			2
<i>Holocentropus picicornis</i> (Steph.)	3	3			6
<i>Athripsodes aterrimus</i> (Steph.)	1				1
<i>Cyrnus flavidus</i> McL.	3	4	22		29
<i>Holocentropus dubius</i> (Ramb.)	3	2	1		6
<i>Cyrnus crenaticornis</i> (Kol.)	120	143	33	72	368
<i>Ecnomus tenellus</i> (Ramb.)	1	8	54	2	65
<i>Leptocerus tineiformis</i> (Curt.)	15	29	53	97	194
<i>Mystacides longicornis</i> (L.)	2	1	9	14	26
<i>Cyrnus insolutus</i> McL.			6		6
<i>Orthotrichia</i> sp.		1		4	5
<i>Oxyethira</i> sp.		1	16	17	34
<i>Oecetis furva</i> (Ramb.)			1	1	2
<i>Mystacides nigra</i> ? (L.)			1	2	3
<i>Triaenodes conspersa</i> (Ramb.)			45	91	136
<i>Hydropsyche angustipennis</i> (Curt.)				1	1
<i>Oecetis lacustris</i> (Pict.)				1	1
<i>Athripsodes cinereus</i> (Curt.)				17	17
No. of individuals	149	193	249	319	907
No. of taxa	9	10	11	12	18

Leptocerus tineiformis (194) and *Triaenodes conspersa* (136) were less numerous. Also *Ecnomus tenellus* (65 individuals), *Oxyethira* sp. (34), *Cyrnus flavidus* (29), and *Mystacides longicornis* (26) were present in fairly high numbers (Table I). The occurrence of a *Hydropsyche angustipennis* larva, being a typically rheophilic species, was noteworthy.

There were differences between both lakes in species composition of caddis flies. *Athripsodes cinereus*, *Cyrnus insolutus*, *Triaenodes conspersa*, *Oecetis furva*, *Mystacides nigra* (?) and *Hydropsyche angustipennis* occurred only in the Piaseczno Lake. *Leptocerus tineiformis*, *Ecnomus tenellus*, *Mystacides longicornis*, *Oxyethira* sp. and *Cyrnus flavidus* were more abundant in the Piaseczno Lake.

On the other hand, *Athripsodes aterrimus* and *Holocentropus picicornis* were found only in the Głębokie Lake. In this lake *Holocentropus dubius* was more abundantly than in the Piaseczno Lake.

With the use of Jaccard's formula, the faunistic similarity between both seasons under survey (1983, 1984), for the two lakes considered jointly, amounted to 50%. It seems that the least abundant species occurring sporadically in the submerged vegetation zone were decisive of so low the similarity.

VERTICAL DISTRIBUTION

Distribution of larvae was examined at three depths: 0.5, 2 and 4 m (Table II). Four species were caught only at a 0.5-m depth. Further four species occurred most abundantly at a 0.5-m depth but were caught also at 2- or 4-m depths. Six taxa were present at all depths. All these species (apart from *Cyrnus* sp. juv.) displayed the greatest numbers at a 2-m depth and the smallest ones at a 0.5-m depth (Table II). *Orthotrichia* sp. occurred at 2- and 4-m depths, and *Oecetis furva* and *O. lacustris* – only at a 4-m depth (Table II).

DISTRIBUTION IN DIFFERENT TYPES OF LITTORAL

Psammolittoral (sampling station 3, Piaseczno Lake). This type of littoral was characterized by the greatest number of individuals. Only in this type of littoral *Hydropsyche angustipennis* (rheophile!), *Athripsodes cinereus* and *Oecetis lacustris* were caught. At this station *Orthotrichia* sp., *Leptocerus tineiformis*, *Mystacides longicornis* and *Triaenodes conspersa* exhibited the greatest numbers.

Atrophic phytolittoral (station 4, Piaseczno Lake). Only one species – *Cyrnus insolutus* – occurred exclusively at this station. *Cyrnus flavidus* and *Ecnomus tenellus* (Table I) were characterized by the greatest numbers (Table I).

Atrophic phytolittoral (station 2, Głębokie Lake). *Athripsodes aterrimus* occurred exclusively at this station (Table I).

Marsh phytolittoral (station 1, Głębokie Lake). There were no species present exclusively at this station; *Cyrnus crenaticornis* displayed the greatest numbers at this site (Table I).

Similar results were obtained for the faunistic similarities between the four types of littoral, when calculated by considering only the fact of species occurrence (Jaccard's formula), as well as when calculated with valorization of the numbers of the species present (Bicsiadka's formula) (Fig. 1). In both cases the sampling

Table II. Distribution of caddis larvae in vertical profile

Taxa	Depth (m)		
	0.5	2	4
<i>Hydropsyche angustipennis</i>	1		
<i>Athripsodes aterrimus</i>	1		
<i>Holocentropus dubius</i>	6		
<i>Cyrrnus insolutus</i>	6		
<i>Ecnomus tenellus</i>	63	2	
<i>Athripsodes cinereus</i>	16	1	
<i>Holocentropus picicornis</i>	5	1	
<i>Cyrrnus flavidus</i>	22	7	
<i>Mystacides nigra?</i>	2		1
<i>Cyrrnus crenaticornis</i>	135	140	93
<i>Mystacides longicornis</i>	8	14	4
<i>Triaenodes conspersa</i>	17	76	43
<i>Leptocerus tineiformis</i>	26	88	80
<i>Oxyethira</i> sp.	1	22	11
<i>Cyrrnus</i> sp. juv.	1	1	5
<i>Orthotrichia</i> sp.		1	4
<i>Oecetis furva</i>			2
<i>Oecetis lacustris</i>			1
No. of individuals	310	353	244
No. of taxa	15	11	10

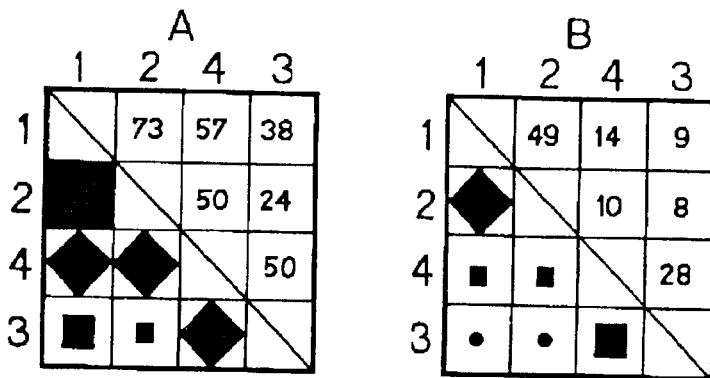


Fig. 1. Faunistic similarities P_{xy} between sampling stations, calculated according to the formula of Jaccard (A) and Biesiadka (B). 1 – marsh phytolittoral of Głębokie Lake, 2 – atrophic phytolittoral of Głębokie Lake, 3 – psammolittoral of Piaseczno Lake, 4 – atrophic phytolittoral of Piaseczno Lake

stations formed the following sequence: station 2 (atrophic phytolittoral, Głębokie Lake), st. 1 (marsh phytolittoral, Głębokie Lake), st. 4 (atrophic phytolittoral, Piaseczno Lake) and st. 3 (psammolittoral, Piaseczno Lake). In the diagram of the similarities calculated using Jaccard's formula, the psammolittoral differed most from the remaining types of littoral. In Czekanowski's diagram, with similarities calculated according to Biesiadka's formula, the similarities between sampling stations of one lake exceeded those between stations of different lakes. Therefore, qualitative analysis of the similarities reflected more evidently the caddis fly fauna changes resulting from succession (increase in trophy and overgrowth with vegetation). On the other hand, from the quantitative standpoint the lakes displayed greater similarity than littoral types.

HABITAT DISTRIBUTION

Caddis fly distribution in different habitats is recorded in Table III. *Potamogeton* sp. (pond-weed) proved to be the poorest habitat, both qualitatively and

Table III. Distribution of caddis larvae in habitats (both lakes jointly). My – *Myriophyllum*, Ce – *Ceratophyllum*, Po – *Potamogeton*, El – *Elodea*, Bo – bottom

Taxa	Habitat				
	My	Ce	Po	El	Bo
<i>Cyrtus</i> sp.		5			2
<i>Cyrtus flavidus</i>	21	4			4
<i>Cyrtus insolutus</i>	5				1
<i>Cyrtus crenaticornis</i>	5	236	8	10	109
<i>Holocentropus dubius</i>		2			4
<i>Holocentropus picicornis</i>					6
<i>Ecnomus tenellus</i>	48	3			14
<i>Orthotrichia</i> sp.		5			
<i>Oxyethira</i> sp.	22	12			
<i>Hydropsyche angustipennis</i>	1				
<i>Oecetis furva</i>		1			1
<i>Oecetis lacustris</i>		1			
<i>Leptocerus tineiformis</i>	71	114		4	5
<i>Athripsodes aterrimus</i>		1			
<i>Athripsodes cinereus</i>	16				1
<i>Mystacides longicornis</i>	19	6			1
<i>Mystacides nigra</i>	2			1	
<i>Triaenodes conspersa</i>	92	40		2	2
No. of individuals	302	430	8	17	150
No. of species	11	13	1	4	12

quantitatively. Also the caddis fly fauna inhabiting *Elodea canadensis*, as compared with the remaining habitats, seems to be less rich.

With respect to species composition of caddis flies, the similarities between the fauna colonizing *Ceratophyllum*, the bottom and *Myriophyllum* were highest (Fig. 2A). The *Potamogeton* habitat proved to be most dissimilar. Similarities between habitats in quantitative composition assumed the form of a fairly clear-cut continuum, when listed in order of decreasing similarity (Fig. 2B).

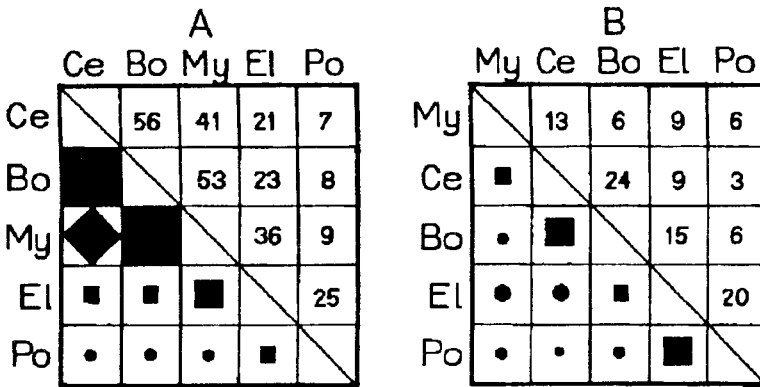


Fig. 2. Faunistic similarities P_{xy} between habitats. A and B – as in Fig. 1

PHENOLOGICAL ANALYSIS

The number of species was nearly the same throughout the year, showing only slight fluctuations (Fig. 3A). On the other hand, the numbers of larvae displayed considerable seasonal fluctuations. These numbers were greatest in February. Moreover, the total numbers of caddis larvae increased in May, September and November. The fewest larvae were caught in summer months (July, August). Changes in the numbers of larvae of the five most abundant species are illustrated in Fig. 3B. In contrast to the remaining species, *Athripsodes cinereus* exhibited the greatest numbers in late spring and summer.

Great numbers of larvae in February were mostly due to the numbers of *Cyrnus crenaticornis* and *Ecnomus tenellus*. The peak of the numbers in May resulted from an increase in *Leptocerus tineiformis* numbers. The great numbers of larvae in autumn were caused by the numbers of *Cyrnus crenaticornis*, *Triaenodes conspersa* and *Leptocerus tineiformis*.

ANALYSIS OF SPECIES CO-OCCURRENCE

The co-occurrence of species was calculated from Jaccard's formula, and the results were presented in the form of the shortest dendrite (Fig. 4A).

The community of four species: *Cyrnus crenaticornis* (13), *Leptocerus tineiformis* (22), *Mystacides longicornis* (25) and *Triaenodes conspersa* (27), definitely stood out; it could be defined as a phytophilic community. On a lower similarity level, *Oxyethira* sp. (18) joined the above species, and a second

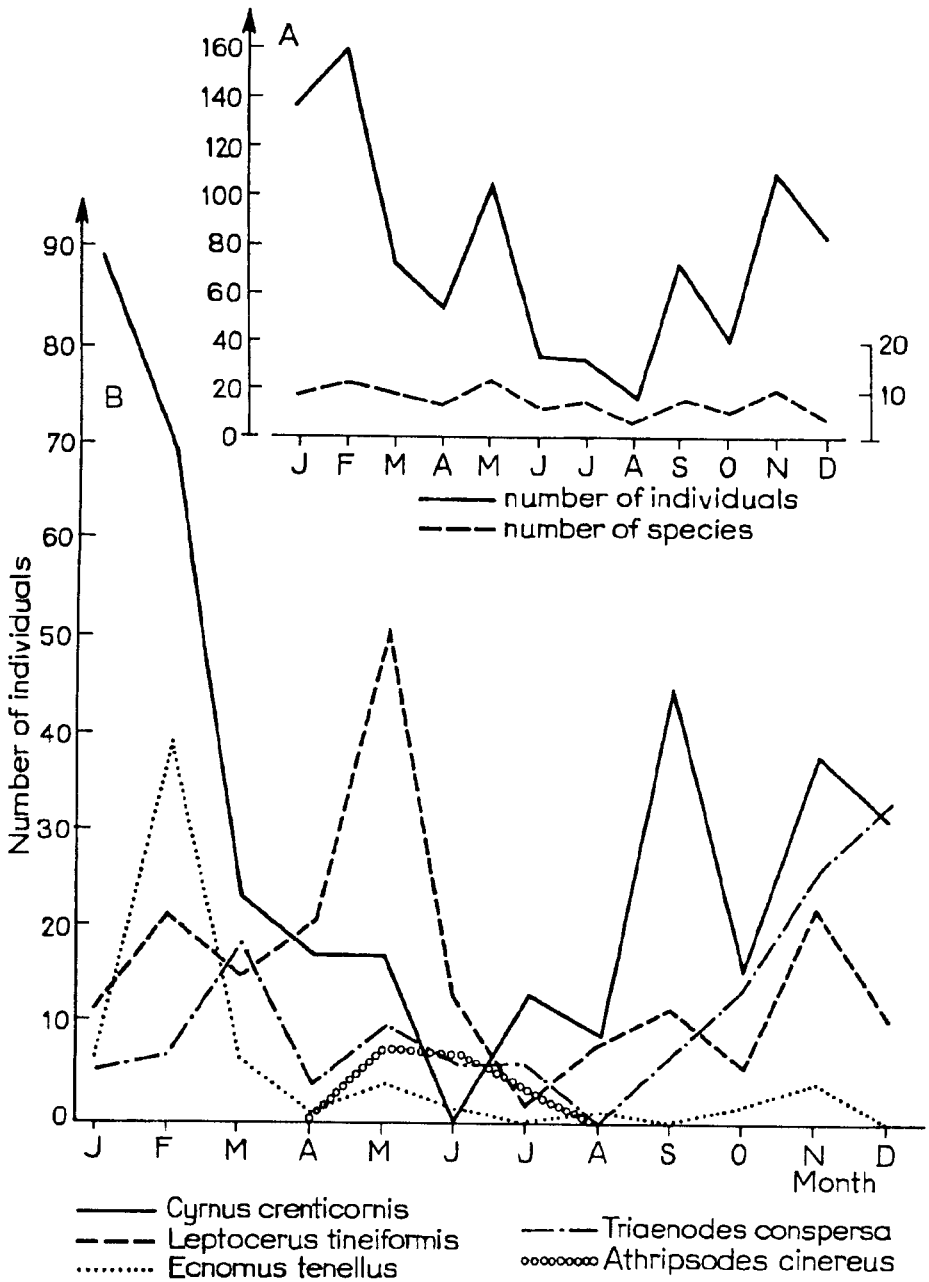


Fig. 3. Phenological changes in the total number of species and larvae (A), as well as changes in the numbers of five most numerous species (B)

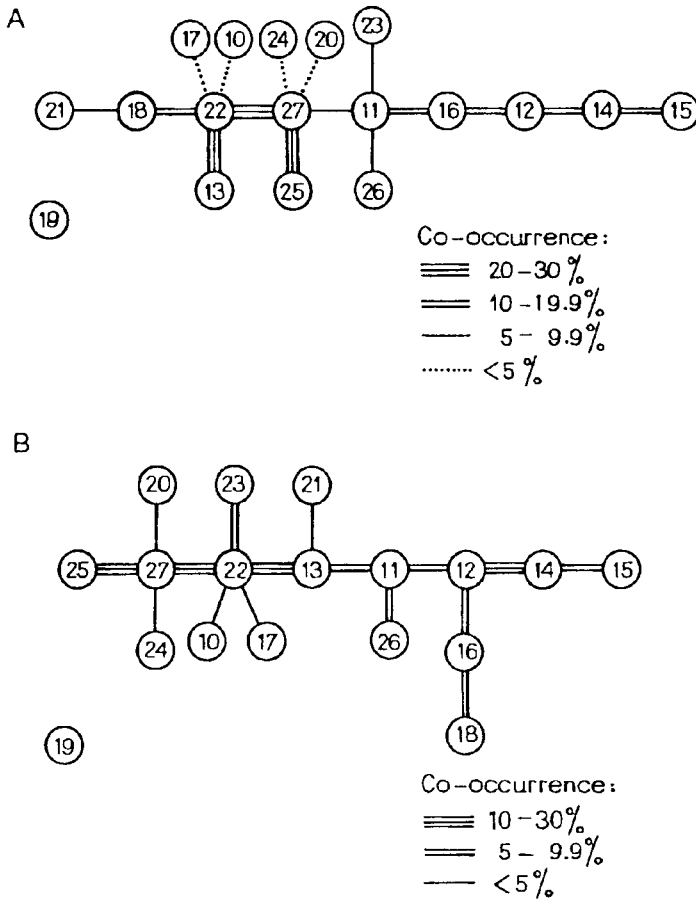


Fig. 4. The dendrite of species co-occurrence, calculated according to the formula of Jaccard (A) and of Biesiadka (B)

community comprising: *Cyrnus flavidus* (11), *Encomus tenellus* (16), *Cyrnus insolutus* (12), *Holocentropus dubius* (14) and *H. picicornis* (15), stood out. In contrast to the former community, the latter one could be associated with marsh littoral, higher trophy and muddy bottom.

The co-occurrence was also calculated from Biesiadka's formula, and the results were presented as the shortest dendrite (Fig. 4B). On a 10-20% similarity level, two communities could be distinguished. The first one comprised 4 species: *Cyrnus crenaticornis* (13), *Leptocerus tineiformis* (22), *Mystacides longicornis* (25) and *Triaenodes conspersa* (27). The second community included 2 species: *Cyrnus insolutus* (12) and *Holocentropus dubius* (14). On a lower co-occurrence level one community was formed; it comprised, apart from the above species, also: *Athripsodes aterrimus* (23), *Cyrnus flavidus* (11), *Holocentropus picicornis* (15), *Economus tenellus* (16) and *Oxyethira* sp. (18). In the case of the quantitative approach, the co-occurrence were arranged in a more "transitional" way, and the

changes were more gradual (more clear-cut substitution of species consistently with habitat gradients).

According to both methods, *Hydropsyche angustipennis* (19) was unrelated to the remaining species.

5. DISCUSSION

TOWARDS THE THEORY OF HABITATUAL ISLANDS

In Piaseczno Lake psammolittoral, one larva of the rheophilic species *Hydropsyche angustipennis* was found. Analysis of the co-occurrence testified to its being unrelated to the singled out communities of caddis larvae (Fig. 4). This could point to a completely accidental character of the larva's occurrence.

The presence of rheophiles in lakes is not, however, accidental. They mainly appear in well oxygenated littoral of low-trophy (mesotrophic) lakes. For example, *Hydropsyche angustipennis* has been found in the Kierskie Lake (Rzóska 1935) and in some German lakes (Wichard 1988). Also other rheophiles have been reported from lakes (particularly from mountain lakes or northern lakes), e.g. *Hydropsyche pellucidula* (O'Connor, Wise 1984), *Lepidostoma hirtum* (Lepneva 1928, O'Connor, Wise 1984, Solem 1973), *Goera pilosa* (Lepneva 1928, O'Connor, Wise 1984, Wichard 1988), *Sericostoma personatum* (O'Connor, Wise 1984), *Notidobia ciliaris* (Wichard 1988), *Glossosoma boltoni* (O'Connor, Wise 1984), *Agapetus fuscipes* (O'Connor, Wise 1984), *Polycentropus flavomaculatus* (Demel 1923, Lepneva 1928, O'Connor, Wise 1984, Solem 1973), *Polycentropus irroratus* (O'Connor, Wise 1984), *Athripsodes albifrons* (O'Connor, Wise 1984).

These species inhabit the rhitral (particularly in the mountains) or the potamal. Their presence in lakes may be interpreted in terms of accidental egg laying by females. Whereas the presence of rheophile imagines over lakes has been reported very often, they were disregarded in considerations of the lake caddis fly fauna, because of their rheophily (e.g. Spuris 1967). The development of larvae is possible in only few lakes. Thus, this is a testimony to colonization of new habitual islands via migrations of imagines. The adaptability of larvae to the conditions prevailing at so colonized an island is decisive of the success or failure of migration. Certainly eggs are laid in lakes of all types; however, the development of at least a part of larvae is only possible in oligo- and mesotrophic lakes, and in only some habitats. Therefore, the rheophilic species of caddis flies are reported only from these lakes and habitats.

Moreover, the larvae may migrate between the habitats within one water body, as well as between different reservoirs by water route. The latter kind of migration is possible only at small distances. Migration between vicinal habitats may be testified to also by the low similarities between seasons of studies.

Two communities of the submerged vegetation zone stood out fairly distinctly. One of them (*Cyrnus creaticornis*, *Leptocerus tineiformis*, *Mystacides longicornis* and *Triaenodes conspersa*) (Fig. 4) seems to be stronger associated with vegetation and mesotrophy. The second community (*Cyrnus flavidus*, *Ecnomus tenellus*, *Cyrnus insolutus*, *Molocentropus dubius* and *H. picicornis*) could also be described

as phytophilic, but it is more characteristic of eutrophy and muddy bottom. This is pointed to by its distribution in lakes and littoral types (Table I), and is consistent with the results of analogous studies performed in the Masurian Lakeland (Czachorowski 1992).

Athripsodes cinereus, a species characteristic of psammolittoral, was but slightly related to both above-mentioned communities. The species was found on submerged vegetation only in the Piaseczno Lake, i.e. in a lake with psammolittoral habitats. Therefore, its presence among elodeids is due to migration from the adjoining principal habitat, i.e. from psammolittoral; this is also indicated by the results of other studies carried out in the Masurian Lakes (Czachorowski 1992).

The studies: *Orthotrichia* sp., *Oecetis furva* and *Oecetis lacustris*, were also only slightly related to both principal communities of submerged vegetation (Fig. 4). There is, however, no sufficient evidence for indicating the characteristic habitats of these species, from which they could have migrated to elodeids. It is also possible that these species are uncommon in the lakes under study; their low numbers may be due to the fact that the physicochemical conditions prevailing in these lakes are unfavourable to them.

The collected material displayed a lack of species of the families Limnephilidae and Phryganeidae. This group of species is characteristic of the emerged vegetation zone. Their absence from the collected material does not have to signify that they do not occur in the lakes studied. It only indicates that their migration to the elodeid zone is minimal, if any. This conclusion is in agreement with the results of studies on the zonal distribution of caddis flies in the Masurian Lakes (Czachorowski 1992).

There were no species of the family Molannidae, strongly represented in many European lakes. Their geographic distribution (Botosanneanu, Malicky 1978) and the fact that many of them occur in North European lakes (e.g. Solem 1973) suggest, however, that the distribution of this family is of a boreal-mountainous nature. Therefore, it remains uncertain whether some species of this family occur in the lakes under study.

Analysis of the similarities between the investigated habitats (Fig. 2) and distribution of the taxa in these habitats (Table III) indicate that the communities of *Ceratophyllum*, *Myriophyllum* and not overgrown bottom were the main, principal habitats for caddis flies of the elodeid zone of the investigated lakes. Both *Elodea canadensis* and *Potamogeton* proved to be of minor importance as caddis fly habitats. In the case of *Potamogeton*, the low frequency and low numbers of caddis flies colonizing this plant could be related to its short life cycle. Namely, the aboveground shoots die-back in autumn, and the short vegetation period suffices only for plant colonization by animals of high mobility, e.g. the *Chironomidae* (Kornijów 1989a, c). Moreover, in this later period the colonization may be influenced by the phenomena of competition and territorialization on the part of the earlier colonized *Chironomidae* larvae (Hargeby 1990). In the case of *Elodea canadensis*, the qualitative and quantitative scarcity of caddis larvae could be related directly to the considerable depth at which the plants grew (ca. 4 m), and

indirectly to the composition of the phytoperiphyton being the main food of many larvae.

At the same time there were differences between lakes in the colonization of habitats; this could be explained in terms of the effects of lake trophy and of the features of the lake taken as a whole.

For interpretation of the above observations we propose the model of a habitatual island (Fig. 5) analogous to those earlier proposed for small water bodies (Czachorowski, Szczepańska 1991) and for springs (Czachorowski 1993). We assume that in the case of lakes, a habitatual islands represents a patch of vegetation or another homogeneous habitat singled out from the surroundings.

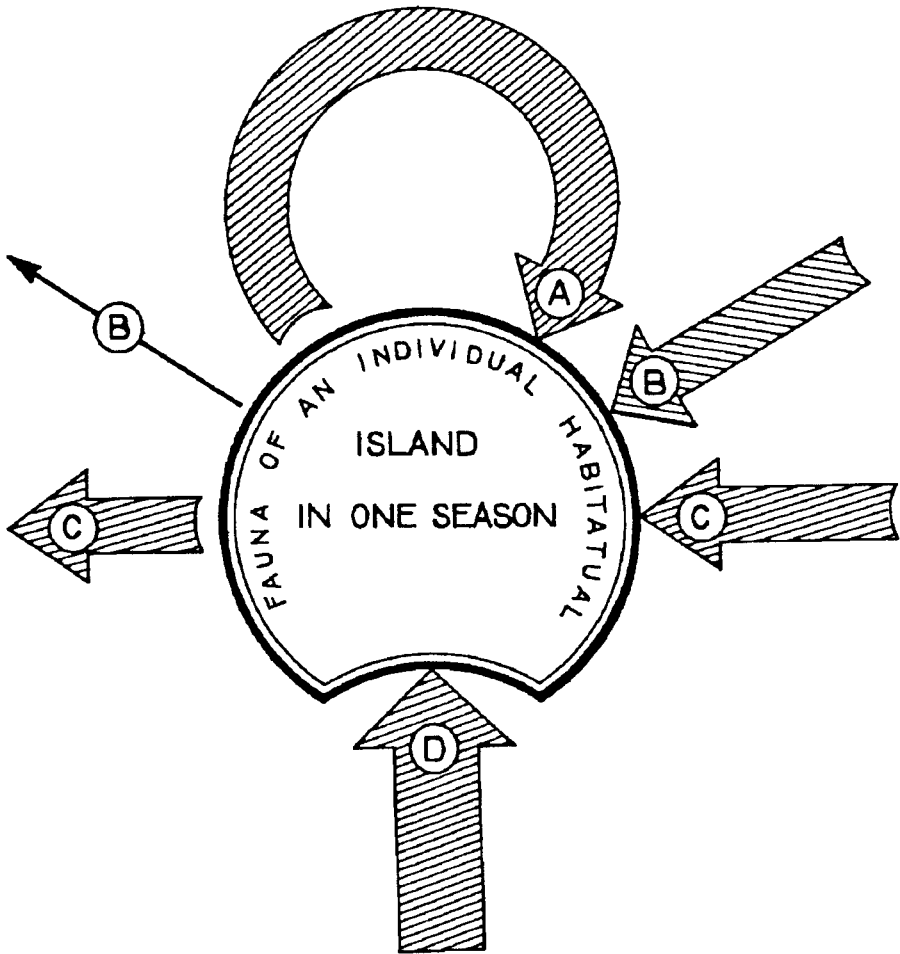


Fig. 5. The model of habitatual island. A – species obligatorily associated with the type of lake habitat, B – species migrating accidentally from other types of water bodies (e.g. the Hydropsychidae) or from other habitats (e.g. the Limnephilidae), C – species migrating seasonally (e.g. the Athripsodes), D – adverse habitat conditions eliminating mainly the immigrants (modified from Czachorowski, Szczepańska 1991)

The species composition of a given habitatual island (characterized by a certain spatial and temporal specificity) results from the occurrence of taxa specific for and characteristic of this habitat (habitat preferences, tolerance ranges) and from migrations of larvae from the adjoining islands. The affectiveness of migrations depends on the mobility of larvae, vicinity and distance of other habitatual islands (consistently with the theory of oceanic islands – MacArthur, Wilson 1967) and seasonal migrations of some species for which the investigated islands represent transitional islands or periodic habitats. This situation may account for the impression that caddis flies are characterized by high ubiquitousness and lack of habitat preference.

The present results confirm that caddis flies occurring in lakes comprise two main synecological groups.

THE EFFECT OF TROPHY ON CADDIS LARVAE DISTRIBUTION

The maximum mean density of caddis flies in the Głębokie Lake and the mean numbers at sampling stations, listed in a decreasing order, assumed the form of the following sequence: marsh phytolittoral (Głębokie L.), atrophic phytolittoral (Głębokie L.), atrophic phytolittoral (Piaseczno L.) and psammolittoral (Piaseczno L.) (Kornijów 1988). Thus, this is a similar succession as in the case of the results obtained by the similarity method (Czekanowski diagrams, Fig. 1).

Apart from the evident connection with the type of habitat, the communities singled out could be assigned to different trophies. Thus it seems that the trophy of a water body could modify the habitatual distribution which is principal for caddis larvae.

The present results and data from the literature testify to differences in the caddis fly distribution in habitats of dissimilar trophy and astaticism. These differences seem to follow certain regularities (Czachorowski 1992). On these grounds this group may prove to be an indicator of the state of lakes: species differences in intolerance to O₂ content, pH, temperature, stability, bottom vegetation etc.

It seems, moreover, that the species of the more stable zones (e.g. clodeids), characterized by more narrow ranges of ecological preferences, may be more suitable in this respect than the species of the astatic habitats.

6. SUMMARY

Studies were performed at 1-month intervals between January 1983 and December 1984 in mesotrophic Piaseczno Lake and eutrophic Głębokie Lake. Four sampling stations were selected in atrophic phytolittoral, marsh phytolittoral and psammolittoral. The material was collected separately from bottom sediments and from four species of submerged plants.

In 175 samples there occurred 907 caddis larvae belonging to 18 Trichoptera taxa, *Cynurus crenaticornis*, *Leptocorus tineiformis* and *Triaenodes conspersa* were found in the greatest numbers. Also the rheophile *Hydropsyche angustipennis* was present (Table I).

There were differences in species composition between the clodeid zones of both lakes and between the types of littoral (Table I). Faunistic (qualitative) similarity between the fauna of both lakes was 50%; likewise, the similarity between both seasons of studies amounted to 50%.

Similarities between sampling stations assumed the form of a sequence of decreasing trophy (Fig. 1). When estimated quantitatively, the similarities between sampling stations of one lake exceeded

those between sampling stations of different lakes. There were differences between vertical profiles in taxa distribution (Table II).

The dendrites of the similarities between habitats assumed the form of a continuum of decreasing similarities (Fig. 2). The richest caddis fly fauna colonized the *Myriophyllum* and *Ceratophyllum* habitats, whereas the *Potamogeton* and *Elodea* habitats were poorest in this respect (Table III).

Phenological changes in the number of species and numbers of larvae in the elodeid zone were investigated. There were phenological differences between different species in quantitative dominance (Fig. 3).

Upon use of both – the qualitative and quantitative methods, two communities of species characteristic of the elodeid zone were singled out (Fig. 4). These communities differed in trophic preferences (mesotrophy and eutrophy).

For interpretation of the individual character of the elodeid zone habitats, we proposed the model of a habitatual island, taking into account the effect of habitat conditions, occurrence of species typical of the given habitatual island, species migrating seasonally from vicinal habitats as well as species migrating accidentally from adjoining habitats and from water bodies of other types (Fig. 5).

It seems that caddis flies may be a good indicator of the lake trophic state. This particularly concerns the elodeid zone species characterized by relative narrow ranges of ecological preferences.

7. STRESZCZENIE

Badania prowadzono w odstępach miesięcznych od stycznia 1983 do grudnia 1984 roku w mezotroficznym Jeziorze Piaseczno i eutroficznym Jeziorze Głębokim. Wyznaczono cztery stanowiska w fitolitoralu zanikającym, fitolitoralu bagiennym i psammolitoralu. Materiał pobierano oddzielnie z osadów dennych oraz z porastających je czterech gatunków roślin zanurzonych.

W 175 próbach stwierdzono występowanie 907 larw należących do 18 taksonów Trichoptera. Najliczniejszymi były: *Cyrnus crenaticornis*, *Leptocerus tineiformis* i *Triaenodes conspersa*. Stwierdzono także obecność reofila *Hydropsyche angustipennis* (tab. I).

Zauważono różnice w składzie gatunkowym pomiędzy strefami elodeidów dwu badanych jezior, a także pomiędzy typami litoralu (tab. I). Podobieństwo (jakościowe) faunistyczne pomiędzy fauną jezior wynosiło 50%, także podobieństwo pomiędzy badanymi sezonami wynosiło 50%.

Podobieństwa między stanowiskami układały się w ciąg o malejącej trofii (rys. 1). W ujęciu ilościowym podobieństwa pomiędzy stanowiskami jednego jeziora były większe niż podobieństwa pomiędzy stanowiskami różnych jezior.

Stwierdzono różnice w pionowym rozmieszczeniu taksonów (tab. II).

Dendryty podobieństw pomiędzy siedliskami ułożyły się w kontinuum o malejących podobieństwach (rys. 2). Najbogatsza fauna chruścików zamieszkiwała siedlisko wywłócznika i rogatka. Najuboższe pod względem Trichoptera były siedliska rdestnic i moczarki (tab. III).

Zbadano fenologiczne zmiany liczby gatunków i liczebności larw w strefie elodeidów. Stwierdzono różnice fenologiczne w ilościowym dominowaniu różnych gatunków (rys. 3).

W oparciu o metodę jakościową i ilościową wyróżniono dwa zgrupowania gatunków charakterystycznych dla strefy elodeidów (rys. 4). Zgrupowania te różniły się preferencjami trofii (mezotrofia i eutrofia). Dla zinterpretowania indywidualizmu siedlisk strefy elodeidów zaproponowano model wyspy siedliskowej, uwzględniający wpływ warunków siedliskowych, występowanie gatunków typowych dla danej wyspy siedliskowej, gatunków migrujących sezonowo z siedlisk sąsiadujących oraz gatunki migrujące przypadkowo z siedlisk sąsiednich oraz innych typów środowisk wodnych (rys. 5).

Wydaje się, że chruściki mogą być dobrym indykatorem stanu trofii jeziora. Dotyczy to zwłaszcza gatunków strefy elodeidów, charakteryzujących się stosunkowo wąskimi zakresami preferencji ekologicznych.

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