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VERTICAL DISTRIBUTION OF TRICHOPTERA IN THREE MASURIAN LAKES – RESULTS OF PRELIMINARY STUDIES

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ABSTRACT

It was found that vertical (depth) distribution of caddis larvae is influenced by the trophic conditions: shredders are dominant in the most shallow littoral, whereas collectors and predators predominate at deeper sites. It is assumed that larvae of typical lake species migrate deep into the lake for the winter, and in spring – in parallel with their development – they get closer to the shore. On the other hand, larvae of the species populating small water bodies winter in shallow littoral.

1. INTRODUCTION

In spite of abundant literature dealing with the lake invertebrate fauna, there is but little information on zone distribution of caddis larvae in lake waters. The most important papers have been contributed by Demel (1923), as well as by Lepneva (1928), Jakubisiakova (1933), and Grębecki et al. (1954), Bagge (1987). In many papers the problem of zone distribution of Trichoptera in lakes has been dealt within a vague and marginal way: namely, either only the occurrence of species in various lakes, together with a scarce ecological analysis, has been reported (e.g. Moon 1936, Szczepańska 1958), or studies have concerned only imagines (e. g. Spuris 1967). This approach fails to exhaust the subject.

Some information on habitat differentiation of Trichoptera distribution may be found in papers taking up lake ecology, in which caddisflies are considered in the rank of an order, without identification of species (e.g. Karassowska, Mikulski 1960, Kobuszewska 1973, Niewiadomska 1981, Pereyra-Ramos 1981, Pieczyński 1973). Other papers of a similar nature afford some scarce information about vertical distribution of caddis larvae; unfortunately, in most cases the results are given only for the order (Kajak et al. 1968, Kajak, Dusoge 1971, 1973, Pieczyńska 1972, Terek et al. 1987).

This paper presents the results of preliminary studies of the vertical (depth) distribution of caddisfly larvae in Masurian Lakeland lakes. These studies make part of the initiated complex investigations on the structure of aquatic insect distribution in lakes of North-East Poland, and on the phenological and successional changes in this structure.

2. MATERIAL AND METHODS

The material was collected in July 1987 in three lakes: Wulpińskie, Szeląg Wielki and Skanda (Olsztyn Lakeland). Nine transects: five in Wulpińskie Lake, three in Szeląg Wielki Lake and one in Skanda Lake, were marked out. Sampling stations were selected so as to include possibly all types of the littoral. In each transect samples were collected at depths of: ca. 0.1 – 0.2, 0.5, 1, 2, 3, 4, 5, 6, 8, 10, 12, 15, 20, 24 m (the last four depths failed to be present at some sampling stations). At 0.2 – 1 m depths samples were taken with a triangular bottom sampler, and at greater depths with a dredge and Ekman bottom sampler. A total of ca. 130 samples were collected.

The material was rinsed, *in situ* sorted out on a white developing tray and preserved in 70% ethanol.

3. RESULTS

Caddisfly larvae were found in 47 samples. In total, 265 larvae belonging in 21 species were collected (Table I). In Wulpińskie Lake we found 159 larvae belonging in 16 Trichoptera species; four of these species were represented only in this lake. In Szeląg Wielki Lake we caught 89 larvae belonging in 14 species, including three species occurring only in this lake. In Skanda Lake we collected only 17 larvae belonging in 7 species, two of which were represented only in this lake.

Most Trichoptera species occurred at a 0.5-m depth. In deeper parts of lakes the number of species systematically dropped, and below a 6-m depth no Trichoptera were present (Fig. 1). The slight increase in the number of species at a 5-m depth was supposedly accidental.

The number of larvae was greatest at a 0.1 – 0.2 m depth, whereas at deeper sites it evidently and successively dropped. At a 0.5 m depth, the

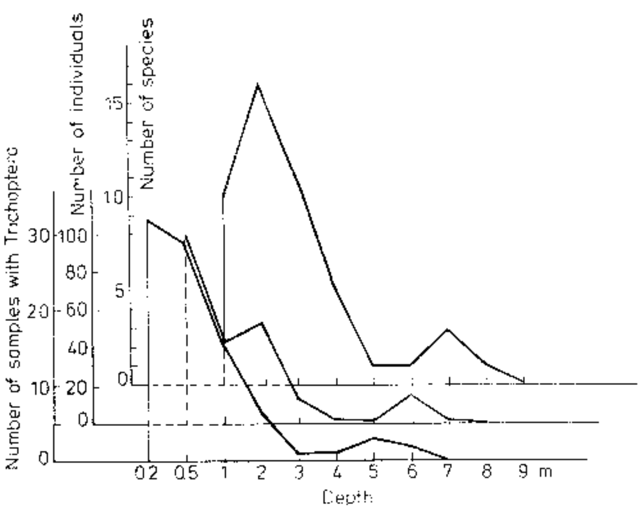

Fig. 1. Numbers, number of species and frequency of Trichoptera in vertical profile

Table I. Number and distribution of caddisflies in three Masurian lakes. N – total number of individuals

Species	N	Lakes: Wulpińskie					Szeląg Wielki			Skanda
		stations (transects)								
		1	2	3	4	5	6	7	8	9
Tinodes waeneri (L.)	1						1			
Ecnomus tenellus (Ramb.)	2						2			
Molanna angustata Curt.	35			15			14	4		2
Agraylea sp. Curt.	7					5			2	
Agraylea multipunctata Curt.	1					1				
Orthotrichia sp. Eat.	36	1		1		4	30			
Hydroptila sp. Dal.	26					5	21			
Leptocerus tineiformis Curt.	50			4	40	3	3			
Mystacides longicornis (L.)	27	3		4	4	5	9		1	1
Mystacides nigra (L.)	4				2		2			
Mystacides azurea (L.)	1									1
Triaenodes bicolor (Curt.)	10			1	7		2			
Triaenodes sp. McLach.	17			6	7		2		1	1
Athripsodes cinereus Curt.	29	13	4	2	1		1	2		6
Athripsodes atterimus Steph.	1		1							
Oecetis furva (Ramb.)	5			5						
Oecetis ochracea (Curt.)	1						1			
Anabolia sp. Steph.	8		3							5
Halesus sp. Steph.	2				1		1			
Limnephilus stigma Curt.	1									1
Limnephilus flavicornis Fabr.	1				1					
Total	256	17	8	38	63	23	89	6	4	17

number of individuals was inversely proportional to the number of species (Fig. 1).

Changes in the numbers of the six most numerous species in vertical profile were analysed in detail. *Leptocerus tineiformis* and *Athripsodes cinereus* (Leptoceridae) were most frequent in the most shallow parts of the bottom, particularly at a 0.1 – 0.2 m depth. Below a 2-m depth, these species did not occur (Fig. 2).

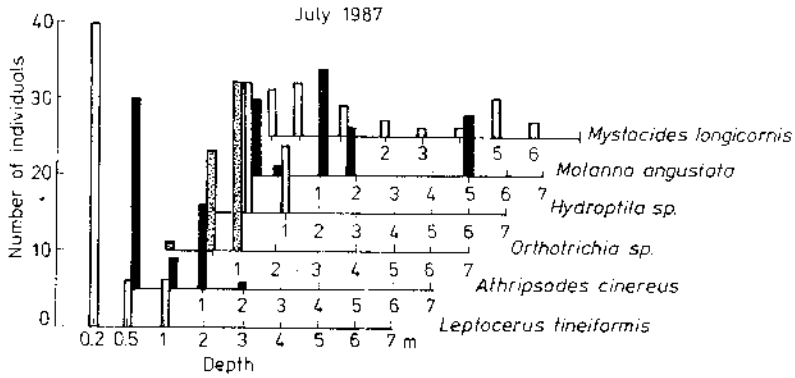

Fig. 2. Numbers of six most numerous caddis fly species in vertical profile

Hydroptila sp. and *Orthotrichia* sp. (Hydroptilidae) were most frequent at a 0.5 – 1 m depth; *Hydroptila* sp. was represented in greatest numbers at a 0.5-m depth, and *Orthotrichia* sp. – at an 1-m depth.

Molanna angustata (Molannidae) and *Mystacides longicornis* (Leptoceridae) exhibited the greatest vertical distribution ranges (from 0.2 to 6 m) and occurred most deeply.

4. DISCUSSION

According to the present results, the caddis fly fauna is richest and most numerous in the littoral at the smallest depths: 0.2 – 1 m. This is consistent with the findings of Kajak et al. (1968), and Kajak, Dusoge (1971) (data for June), 1973. Caddis larvae have been caught also at greater depths than in the present studies; for example, Kajak, Dusoge (1971) have reported their occurrence at a 16-m depth.

Lepneva (1928) has reported vertical distribution of several Trichoptera species in lakes of North-East Europe, e.g. of *Molanna angustata* larvae; she found that this species was strongest represented at 0.1 – 3 m depths and that the vertical range of its occurrence attained 10 m. This is in agreement with the present results (Fig. 2). Lepneva (1928) has reported similar regularities for *Mystacides azurea* L.

According to Pieczyńska (1972), the maximum density of Trichoptera larvae in the eulittoral has been shown to be 2150 individuals·m^{-2}. This value greatly exceeds the density of caddis flies in the profundal where they have often been found to be absent (Kajak, Dusoge 1971, Kajak et al. 1968). Niewiadomska (1981) has investigated the occurrence of macrobenthos on stones and *Potamogeton perfoliatus* in dependence on water pollution. She has found that the numbers of caddis flies were greatest at a 0.2 m depth; only at sampling stations polluted with municipal sewage the numbers of Trichoptera were greatest at a 5-m depth.

The distribution of caddisflies, characterized by evident preference of larvae to shallow littoral, is undoubtedly related to food availability. The major part of larvae of lake Trichoptera are detritophagous or phytophagous. Detritophages and phytophages, which from the functional standpoint are shredders, may find optimal trophic conditions in vegetation-overgrown littoral. It has been found that this trophic group displays different preference to various lake plant communities. Among submerged plants of this Lemnaceae association, as compared with floating plants of this association, two times more caddisfly larvae have been found to be present, and 16 times more – with respect to biomass (Kobuszewska 1973). Pereyra-Ramos (1981) has observed that in Characeae associations the numbers of Trichoptera accounted for 1–26% of those of all benthic organisms, in dependence on the species composition of plants forming a given Characeae association. In studies of the invertebrate fauna, Karassowska et al. (1960) have found the greatest number of caddisflies on *Myriophyllum* and *Stratiotes*, and much fewer individuals – on *Ceratophyllum*, *Ranunculus*, *Potamogeton*, *Nymphaea*, *Nuphar* and *Limnenthemum*; there were differences between plant species not only in the numbers of caddisflies, but also in their percentage in the total amount of invertebrates occurring on the investigated plants. Pieczyński (1973) has observed greater numbers of Trichoptera larvae on *Stratiotes* than on *Elodea*; moreover, the numbers and biomass of caddisflies were smaller at sampling stations characterized by intense fish predation.

Both – *Molanna angustata* and *Mystacides longicornis* are omnivores, and from the functional standpoint – collectors. These species find food also in the deeper parts of the bottom, devoid of macrophytes, i.e. sedimented dead plankton and broken up detritus. Thus it is not surprising that these species occur at much greater depths than other Trichoptera species belonging in shredders (Fig. 2).

Kajak and Dusoge (1971) have reported the occurrence of caddis larvae in the Mikołajskie Lake at a 16-m depth; this concerned two predator species: *Polycentropus* sp. and *Ecnomus* sp. This may confirm the hypothesis of a trophic cause of the differentiation of Trichoptera vertical distribution in lakes.

Demel (1923) has stated that many species of larvae of aquatic insects, including Trichoptera, changed their depth distribution in the course of ontogeny; younger larval stages occurred in the deeper parts of lake, whereas the older ones – in parallel with their development – approached the shore. It may be assumed that the presence of young larval stages in the deeper parts of lake bottom results from migration aimed at finding shelter from adverse winter conditions in the eulittoral (water freezing, oxygen deficit). Thus, the spring and summer migration of larvae to shallow littoral would be not only due to trophic causes, but also to the necessity – for pupae – to go up onto the emersed parts of plants, stones etc. This cycle of phenological migrations could be assumed to be typical of the lake species, as it is evolutionally adapted to the ecological conditions of stagnant large water bodies.

Astaticism of the environmental conditions: changes in temperature and oxygen content of water, periodic drying up, water freezing to the bottom, makes lake littoral similar to small periodic reservoirs and natural shallow ponds. This is reflected by the kind of fauna. According to Klimowicz (1970), there is a greater similarity in the Rotifera fauna between lake littoral and small periodic reservoirs than between the littoral and profundal.

Many species of Trichoptera found in lake littoral may be regarded as small-reservoir species adapted to astaticism of the environmental conditions. Their life cycle displays adaptations to surviving the adverse winter conditions, which differ from the adaptations present in the above-mentioned typical lake species. The possibility of satisfactory development of caddis larvae in small astatic reservoirs depends, e.g., on their biological resistance to freezing. Solem (1983) lists four species occurring in small astatic reservoirs of Norway: *Asynarchus contumax* McLach., *Asynarchus lapponicus* (Zett.), *Grammotaulius signatipennis* McLach, and *Limnephilus stigma*, which spend the winter period in the form of eggs or first larval stages in a gelatinous substance (matrix) which surrounds the eggs at oviposition. In the Masurian Lakeland, in autumn eggs at oviposition of caddis flies of the genus *Limnephilus* have been observed on leaves and roots at a distance of up to 10–20 cm from water area (Czachorowski, unpubl.). Probably in spring, during ice thawing and water level elevation, they (eggs or hatching first-stage larvae) penetrate into water bodies. Larvae of other small-reservoir species, e.g. *Agrypnia obsoleta* (Hag.) and *Molanna albicans* (Zett.), winter in the form of the last larval stages from into ice (Solem 1983).

The above-mentioned biological adaptations of the small-reservoir species allow for their wintering in the littoral. Typical lake species which have not developed these adaptations are compelled to winter migrations deep into the lake.

Thus it can be assumed that two main factors influence the structure of vertical distribution of caddis larvae in lakes as well as the phenological changes in this structure; these factors consist of food availability (species belonging in various functional trophic groups) and formation of ice cover, which causes migrations of lake species. It is not yet feasible to specify the role played by these factors towards various Trichoptera species. This specification calls for further analogous studies performed in spring and autumn as well as for additional qualitative and quantitative investigations in different aquatic plant communities. Such studies are under way in four lakes differing in trophy: Skanda, Narty, Warchały and Brajnickie (all in the vicinity of Olsztyn).

5. SUMMARY

In July 1987, preliminary studies of vertical distribution of Trichoptera larvae in three lakes of the Masurian Lakeland were carried out. In total, 265 larvae belonging in 21 species were collected (Table I). The caddis fly fauna was richest and most numerous in the most shallow littoral (Fig. 1).

The vertical ranges of occurrence of six most numerous species were examined (Fig. 2). It was assumed that food availability is one of the main factors influencing the structure of depth distribution of caddis flies in lakes. Shredders were predominant in shallow littoral. Below 2-m depths only collectors and predators occurred.

According to literature data, the possibility of phenological changes in the structure of vertical distribution of Trichoptera larvae can be assumed. Probably the larvae of the typical lake species migrate for the winter to deeper parts of lake, whereas in spring and summer they undertake migration towards the shore. On the other hand, larvae of small-reservoir species probably winter in the littoral and do not undertake winter migration, because of biological adaptations (resistance to low temperatures and to freezing).

6. STRESZCZENIE

W lipcu 1987 roku przeprowadzono wstępne badania nad pionowym rozmieszczeniem larw Trichoptera w trzech jeziorach Pojezierza Mazurskiego. Ogółem zebrano 265 larw należących do 21 gatunków (Tabela I). Stwierdzono, że najbogatsza i najliczniejsza fauna chruścików występuje w najpłytszym litoralu (rys. 1).

Prześledzono pionowe zasięgi występowania sześciu najliczniejszych gatunków (rys. 2). Przypuszcza się, że dostępność pokarmu jest jednym z głównych czynników wpływających na strukture głębokościowego rozmieszczenia chruścików w jeziorach. Rozdrabniacze dominują w płytkim litoralu. Poniżej dwóch metrów stwierdzono wyłącznie zbieraczy i drapieżców.

Na podstawie danych z literatury można zakładać możliwość fenologicznych zmian struktury pionowego rozmieszczenia larw Trichoptera. Przypuszcza się, że larwy gatunków typowo jeziornych wędrują na zimę w głębsze partie jeziora, a wiosną i latem podejmują wędrówkę ku brzegowi. Natomiast larwy gatunków drobnozbiornikowych dzięki biologicznym przystosowaniom (odporność na niskie temperatury i zamarzanie) prawdopodobnie zimują w litoralu i nie podejmują zimowej wędrówki.

7. REFERENCES

Bagge, P. 1987. Emergence and distribution of Hydroptilidae in the littoral and outlet biocenoses of Lake Konnevesi (Central Finland). *Proc. 5th Int. Symp. on Trichoptera*, 337–341.

Demel, K. 1923. Ugrupowanie etologiczne makrofauny w strefie litoralnej jeziora Wigierskiego [Le groupement ethologique de la macrofauna dans la region littorale du lac de Wigry (Pologne)]. *Pr. Inst. Nenckiego*, 29, 1–49 [French summ.].

Grębecki, A., Kinastowski, W., Kuźnicki, L. 1954. Uwagi o ekologii larwy *Molanna angustata* Curtis w związku z jej rozmieszczeniem w jeziorach [Observations sur l'ecologie de la larve de *Molanna angustata* Curt. et sa repartition dans le milieu]. *Pol. Arch. Hydrobiol.*, 2, 191–235 [French summ.].

Jakubisiakowa, J. 1933. Chruściki (Trichoptera) Jeziora Kierskiego [The caddisflies (Trichoptera) of Lake Kierskie]. *Pr. Kom. Mat. Przyr. Pozn. Tow. Przyjaciół Nauk*, 6(B): 1–46.

Kajak, Z., Dusoge, K. 1971. The regularities of vertical distribution of benthos in bottom sediments of three Masurian lakes, *Ecol. pol.*, 19, 385—499.

Kajak, Z., Dusoge, K. 1973. Experimentally increased fish stock in the pond type Lake Warmiak. IX. Numbers and biomass of bottom fauna. *Ekol. pol.*, 21 568—573.

Kajak, Z., Dusoge, K., Prejs, A. 1968. Application of te flotation technique to assessment of absolute numbers of benthos. *Ekol. pol.*, 16, 607—620.

Karassowska, K., Mikulski, J. S. 1960. Studia nad zbiorowiskami zwierzęcymi roślinności zanurzonej i pływającej jeziora Drużno [Studies of animal aggregations associated with immersed and pleustonic vegetations in Lake Drużno]. *Ekol. pol.*, 8, 335—353 (Engl. summ.].

Klimowicz, H. 1970. Wrotki (Rotatoria) wód astatycznych [Rotifers (Rotatoria) of astatic waters]. *Zesz. Nauk. Inst. Gospod. Komun.*, 30, 1—254 [Engl. summ.].

Kobuszewska, D. M. 1973. Experimentally increased fish stock in the pond type Lake Warmiak. XIII. Distribution and biomass of the Lemnaceae and the fauna associated with them. *Ekol. pol.*, 21, 611—629.

[Lepneva, S. G.] Лепнева, С. Г. 1928. Личинки ручейников Олонецкого края [Die Trichopterenlarven des Olonetz Gebietes]. *Trudy Olon. Naučn. Exp.*, 6 (5). 1—125 [Engl. summ.].

Moon, H. P. 1936. The shallow littoral region of a by the northwest end of Windermere. *Proc. Zool. Soc. Lond.*, 2, 491—515.

Niewiadomska, U. 1981. Influence of the communal sewage on periphyton in the littoral of Mikołajskie Lake. *Ekol. pol.*, 29, 3—33.

Pereyra-Ramos, E. 1981. The ecological role of Characeae in the lake littoral. *Ekol. pol.*, 29, 167—209.

Pieczyńska, E. 1972. Ecology of the eulittoral zone of lakes. *Ekol. pol.*, 20, 637—732.

Pieczyńska, E. 1973. Experimentally increased fish stock in the pond type Lake Warmiak. XII. Numbers and biomass of the fauna associated with macrophytes. *Ecol. pol.*, 21, 595—610.

Solem, J. O. 1983. Temporary pools in the Dovre mountains, Norway, and their fauna of Trichoptera. *Acta Entomol. Fenn.*, 42, 82—85.

[Spuris, Z. D.] Спурис, З. Д. 1967. Фауна ручейников озер Латвии [The caddisflies of lakes of Lithuanial. *Latv. Entomol.*, Suppl. 1, 3—114.

Szczepańska, W. 1958. Chruściki Pojeziera Mazurskiego [Trichopterenlarven der Mazurischen Seenplatte]. *Pol. Arch. Hydrobiol.*, 5, 143—160 [Germ. summ.].

Terek, J., Brazda, J., Halatova, K. 1987. Net plankton and macrozoobenthos of the lake Izra. *Biologia*, 42, 127—143.

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