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CLASSIFICATION OF SMALL WATER BODIES ON THE BASIS OF THE PRESENCE OF CADDISFLIES

ABSTRACT: On the basis of the dominance of species of Trichoptera, six types of water bodies were distinguished. Differences in the caddis fauna of these types are not discrete, but continuous. Caddisfly communities and water bodies are grouped according to three main factors: (a)statism, trophic status and temperature/oxygen.
KEY WORDS: standing water bodies, classification, caddisflies, communities.

1. INTRODUCTION

Classification of water bodies on the basis of morphological, chemical or physical characteristics is one of the basic concepts in limnology (Marcuzzi 1979). In many cases, however, such a classification lacks univocality and precise criteria (Danks and Rosenberg 1987). If groups of organisms are attributed to classes of waters, only rough divisions can be made. A more promising procedure is the grouping of organisms and classifying the water bodies accordingly. Multivariate analysis techniques allow nowadays to analyse relationships between groups of organisms and dominating abiotic factors (Verdonschot 1990). It is essential that there are no sharp boundaries between watertypes, but only gradual changes from one type to another.

There have been several studies concerning caddis larvae in small waters, but either limnological types of these waters were unprecisely discerned (Krey 1937, 1938, Kreuzer 1940) or the authors restricted themselves to one subgroup of water like f. e. ditches (Higler et al. 1987). A gradual change in the occurrence of caddis larvae as a result of changing environmental parameters has been demonstrated for pH (Krey 1937, 1938, Leuven et al. 1987), periods of water level fluctuations (Wiggins et al. 1980, Williams 1983), saprobity (Simanov 1975) and zonation of *Stratiotes* plants (Higler 1969).

The objective of this study is to classify small water bodies in Poland on the basis of caddis larvae distribution and to present a general model of the main gradients of change.

2. STUDY SITES, MATERIALS AND METHODS

During the years 1956–1957 and 1985–89 investigations were carried out in 127 small water bodies in Northern and Southwestern Poland (Fig. 1), comprising different water types such as temporary pools, forest ponds, fens, bogs, mountains ponds and bogs, oxbow pools etc. (Czachorowski and Szczepańska 1991, Czachorowski 1991, 1992 a). Caddis larvae were collected at more or less two-week intervals from April till December 1956 and from January 1988 till

Fig. 1. The study area
1 – the Olsztyn area, 2 – the Mikołajki area, 3 – the Łomża area, 4 – the Nowogard area, 5 – the Karkonosze Mountains

December 1989, occasionally in 1957, 1985–89. The larvae were caught by means of a manual hydrobiological sampler with a triangular hoop. The investigated areas belong to zoogeographical regions of Central and Eastern Lowlands (Illies 1978). In the vicinity of Mikołajki 25 water bodies (caddis larvae occurred in 17 water bodies only) and in the vicinity of Olsztyn 15 water bodies have been studied intensely during 12–18 months, other only occasionally.

A total of 54 species and 5046 specimens of caddisflies (Trichoptera) were collected as larvae and pupae (Table 1). Intensely studied water at Mikołajki showed that the species composition of similar pools in the same area tends to be identical in the long term (Czachorowski and Szczepańska 1991). For this reason a number of different water bodies in the same area, similar in limnological character were taken together as an "integrated water body" to be compared with individual water bodies. Thus we treated two groups of similar waters (16 and 17 in Fig. 2).

Table 1. List of species (after Czachorowski and Szczepańska 1991, Czachorowski 1991, changed)

Mik – the Mikołajki area, Łom – the Łomża area, Olsz – the Olsztyn area, Now – the Nowogard area, Kar – the Karkonosze Mountains; frequency of larvae: + rare, ++ numerous, +++ very numerous

Species (taxa)	Mik	Łom	Olsz	Now	Kar
Orthotrichia sp.		+			
Oxyethira sp.		+			
Hydropsyche contubernalis McL.		+			
Plectrocnemia conspersa Curt.				+	+
Holocentropus dubius Rbr.		+			
Holocentropus picicornis Steph.		+			
Holocentropus stagnalis (Alb.)	+++				
Cyrnus crenaticornis Kol.			+		
Trichostegia minor Curt.			+	+	
Agrypnia obsoleta Hag.			+		
Agrypnia pagetana Curt.		+			
Agrypnia picta Kol.	+		+		
Agrypnia sp. juv.				+	
Phryganea bipunctata Retz.			+		+
Phryganea grandis L.		+			
Phryganea sp. juv.			+		
Oligotricha striata L.			+		+
Oligostomis reticulata L.				+	
Drusus biguttatus (Pict.)					+
Drusus monticola McL.					+
Limnephilus auricula Curt.	+++	+++	+++	+++	
Limnephilus bipunctatus Curt.					+

Table 1, continued

Limnephilus borealis (Zett.)	+	+		+	
Limnephilus coenosus Curt.					+
Limnephilus decipiens (Kol.)	+	+	+	+	
Limnephilus extricatus McL.		+			
Limnephilus flavicornis (Fabr.)	+	+	+++	+	
Limnephilus griseus (L.)	+++	+	+++	+++	+
Limnephilus lunatus Curt.			+	+	
Limnephilus marmoratus Curt.	+	+	+		
Limnephilus nigriceps Zett.		+			
Limnephilus rhombicus (L.)	+++	+	+	+	+
Limnephilus sparsus Curt.	+		+	+++	+
Limnephilus stigma Curt.		+	+	+	+
Limnephilus vittatus (Fabr.)	+	+	+++	+	
Limnephilus sp. juv	+	+	+++	+	
Grammotaulius nigropunctatus Retz.		+			+
Grammotaulius nitidus Mtll.			+	+	
Grammotaulius signatipennis McL.	+	+	+		
Grammotaulius sp. juv.			+		
Glyphotaelius pellucidus (Retz.)	+		+		
Nemotaulius punctatolineatus (Retz.)	+	+	+		
Anabolia sp. (*laevis*?) Zett.		+	+	+	+
Phacopteryx brevipennis Curt.			+		
Potamophylax latipennis (Curt.)					+
Potamophylax rotundipennis (Brau.)					+
Halesus sp.	+		+		+
Melampophylax nepos (McL.)					+
Allogamus auricollis (Pict.)					+
Chaetopteryx villosa (Fab.)					+
Chaetopterygopsis maclachlani Stein					+
Chaetopterygini spp. juv.		+			
Limnephilidae indet.	+			+	
Athripsodes aterrimus Steph.		+++	+	+	+
Mystacides longicornis L.		+			
Mystacides sp. (*nigra*?)					+
Triaenodes bicolor (Curt.)	+	+++	+	+	
Oecetis furva (Ramb.)	+	+			
Oecetis lacustris (Pict.)					+
Sericostoma sp.					+
Nos. taxa	18	26	25	18	24
Nos. specimens	1342	752	1973	670	309
Total 54 taxa, 5046 larvae					

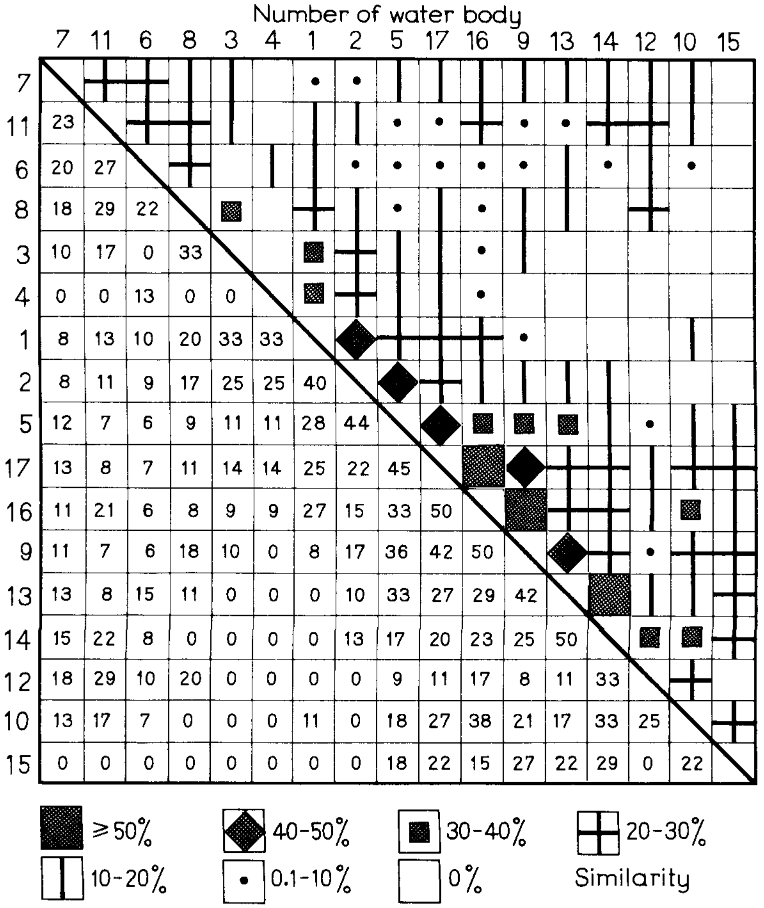

Fig. 2. Faunistic similarity of small standing waters bodies of Olsztyn area expressed by percentage and the Czekanowski's diagram
1 – 15 numbers of individual water bodies, 16 – aggregated group of astatic forest bodies, 17 – aggregated group of astatic field bodies

In order to compare material from different sources and numbers, an analysis of dominance structure was applied. Groups of water bodies were distinguished according to the percentage of caddis larvae per water body or an integrated group of waters. In the same way, faunistic similarities between the watertypes of Krey (1938) and Kreuzer (1940) were estimated. The formula of Jaccard was used:

$$P = \frac{c}{a + b - c}\ 100\%$$

where: P – faunistic similarity of two water bodies, c – number of species common in two water bodies, a – number of species in the first water body, b – the number of species in the second water body.

2.1. DESCRIPTION OF SMALL WATER BODIES IN THE OLSZTYN AREA

1. Woodland dystrophic pool situated on a peat-bog. On the bottom a thin mud layer, as well as branches and leaves. Poor vegetation, in the middle of the pool *Sphagnum* sp., *Drosera rotundiflora* L. and *Eriophorum* sp. Maximal area 100 m^2, depth 1 m.

2. Woodland pool with brown water, small water level fluctuations. In years 1985–1989 it did not disappear. Poor vegetation on muddy bottom branches and leaves. Maximal area 215 m^2, depth 1.8 m.

3. Woodland, dystrophic pond, never disappearing, maximal area 1000 m^2, depth 2 m.

4. Small woodland pool, bottom with branches and leaves, overgrown with *Carex* sp., *Lemna trisulca* L. and grasses. In the years 1985–1989, it did not disappear. Maximal area 10 m^2, depth 0.6 m.

5. Temporary woodland pool, overgrown with *Carex* sp. In 1985–1989 it dried out in June. Maximal area 40 m^2, depth 0.2 m.

6. Eutrophic pool situated on cultivated field, dried out in summer. Muddy bottom overgrown with: grasses, *Carex* sp., *Polygonum amphibium* L. and *Lemna minor* L. Maximal area 20 m^2, depth 0.4 m.

7. Eutrophic natural pond, small water level fluctuation, disappears once in several years (in 1993 it dried out for 14 d). One part with fen' shore overgrown with *Carex* and trees. The second part is not shaded, overgrown with *Phragites communis, Schoenoplectus lacustrus, Polygonum amphibium, Nuphar luteum.* Maximal area about 1000 m^2, depth 2 m. In the years 1985–89 it did not dry out completely.

8. Permanent eutrophic never disappearing pond, part with a shore overgrown with alders and brush. The other one is not shaded and is overgrown with *Carex, Typha latifolia, Glyceria aquatica, Lemna minor* and *Lemna trisulca.* Maximal area 120 m^2, depth 1.6 m.

9. Eutrophic field pool disappearing every summer, overgrown with tufts of rushes, grasses and *Hottonia palustris* L.. Maximal area 80 m^2, depth 0.8 m.

10. Eutrophic outflow pool between a mixed forest and a meadow, muddy bottom overgrown with: *Phragmites communis, Glyceria aquatica, Typha latifolia, Equisetum limosum* L. and tufts of rushes. In 1985–1989 it was not disappearing. Maximal area 800 m^2, depth 1.3 m.

11. Natural eutrophic never disappearing field pond, muddy bottom overgrown with *Elodea canadensis* Rich., *Hottonia palustris, Equisetum limosum, Lemna trisulca.* Maximal area 65 m^2, depth 2 m.

12. Eutrophic never disappearing field pond, overgrown with: *Elodea canadensis, Potamogeton* sp., *Hottonia palustris, Scirpus* sp. Maximal area 50 m^2, depth 1.4 m.

13. Temporary field pool, disappearing in summer. Sandy-muddy bottom overgrown with: *Carex* sp., grasses, *Hottonia palustris.* Maximal area 30 m^2, depth 0.4 m.

14. Eutrophic field pond never disappearing, overgrown with: *Typha latifolia, Phragmites communis, Glyceria aquatica, Elodea canadensis, Ceratophyllum* sp., *Lemna trisulca.* Maximal area 45 m^2, depth 1.6 m.

15. Small forest temporary fen' pool, disappearing in summer. Maximal area 15 m^2, depth 0.3 m

16. Aggregated group of several astatic forest pools

17. Aggregated group of several astatic field pools.

2.2. THE MIKOŁAJKI AREA

18. "Sfagnusik" – no data.

19. "Cyrkowy", woodland pool with daylong shadowing, small water level fluctuations, disappears once in several years. In 1956 it did not disappear. On the bottom plenty of mud, leaves and branches. In the middle a small island with *Calla palustris* L. In 1956 the maximal length was 29.5 m, width 16.5 m, depth 0.85 m, area 308 m^2, volume 30 m^3.

20. "Rzęsisty", one of the larger pools is a woodland water body, not disappearing. Bottom without vegetation. In the middle – flowing island and *Lemna minor, Bidens cernuus* L. and *Juncus* sp. In 1956 maximal area 1208 m^2, volume 106.8 m^3.

21. "Huczkowy", field pool surrounded by fallow ground, on one shore – a poplar and willows. Substantial water level fluctuations; water completely disappears once per several years in summer, muddy bottom with detritus, completely overgrown with: *Sparganium ramosum* Huds., *Carex stricta* Good., *Comarum palustre* L. and *Lysimachia thyrsiflora* L. In 1956 the maximal pool length was 52 m, width 48 m, depth 1 m, area 700 m^2, volume 53.4 m^3. Never dried out completely.

22. "Krzaczkowy", pool situated on a meadow; the part with a shore overgrown with alders and brush is a post-peat excavation. The other one is not shaded and is drying out. Disappears completely once per several years, bottom very muddy, overgrown with: *Carex vesicaria* L., *Glyceria fluitans* (L.) R. Br., *Lythrum salicaria* L., *Alisma plantago aquatica* L., *Polygonum amphibium* and *Lysimachia thyrsiflora.* In 1956 did not dry out completely, maximal length 14 m, with 6 m, depth 0.78 m, area 29.4 m^2, volume 8.19 m^3.

23. "Szczawiowy", field pool, shaded, disappears completely in summer. On the bottom a thin mud layer, as well as branches and leaves. Poor vegetation, in the middle of the pool *Carex vesicaria* and *Carex alongata* tufts. In 1956, the pool once dried out in June for 17 days, maximal length 13.5 m, with 4 m, depth 0.6 m, area 22 m^2, volume 1.5 m^3.

24. "Efemeryczny", field pool, bottom overgrown with grasses. In 1956 it dried out three times over 90 days, maximal area 51 m^2, volume 4.16 m^3.

25. "Trójkątny", flow-through field pool, distinctly astatic, sandy-muddy bottom, overgrown with: *Carex vesicaria, Equisetum limosum, Comarum palustre.* In June

1956 it dried out completely for 10 days. Maximal length 30 m, width 14 m, depth 0.6 m, area 216 m^2, volume 17 m^3.

26. "Chirocephallusowy" – flat depression among cultivated fields, artificially deepened in the middle part. Water disappears at the beginning of May and appears in autumn; staying longer in the deepened part. The bottom is not muddy, overgrown with: *Polygonum hydropipe* L., *Glyceria fluitans, Carex stricta, Agromyza reptans* and *Cirsium palustre* (L.) Scop. In 1956 it dried out three times for a total of 99 days, maximum length 20 m, width 15 m, depth 1.25 m, area 217 m^2, volume 19 m^3.

27. "Ósemkowy", flow-through pool on fallow ground, on the shore – alders and brush. Small water level fluctuations, bottom slightly muddy with *Carex vesicaria* and *Alisma plantago aquatica*. Brown colour of water. In July 1956 the pond dried out for 3 days, maximal length 38 m, width 11 m, depth 0.7 m, area 242 m^2, volume 19 m^3.

28. "Serdelkowy" – no data.

29. "Zosinek" – no data.

30. "Gospodarski", outflow pool ("Trójkątny") between cultivated field and meadow. Small water level fluctuations, disappearing once per several years. Bottom muddy, densely overgrown with: *Carex stricta, Comarum palustre, Polygonum amphibium* and *Typha latifolia*. In the other part of the pool the bottom is overgrown with: *Equisetum limosum, Galium palustre* L. and *Iris pseudoacorus* L. In 1956 without drying out completely, maximal length 110 m, width 50 m, depth 0.7 m, area 600 m^2, and volume 18.2 m^3.

31. "Don Quichote's" – no data.

32. "Świerkowy", pool at a slope distant by 300 m from the Mikołajskie Lake. In 1956 it did not disappear, whereas in 1957 it disappeared completely. Muddy bottom overgrown with: *Carex stricta, C. vesicaria, Glyceria fluitans, Polygonum amphibium, Comarum palustre, Alisma plantago* and *Lemna minor*. In 1956 maximal length 22.5 m, width 7.5 m, depth 1 m, area 97 m^2, volume 7.8 m^3.

33. "Olszynkowy", shallow pool often disappearing. Shore – alders and brush. Bottom with a thick layer of leaves and branches, in some places overgrown with: *Carex vesicaria, Comarum palustre, Glyceria fluitans*. Sometimes freezes to the bottom. In 1956 it dried out for 50 d (June and July), maximum length 24 m, width 9 m, depth 0.27 m, area 138 m^2, volume 8 m^3.

34. "Stały" – natural eutrophic never disappearing field pool, overgrown with tufts of: *Phragmites communis, Equisetum limosum, Elodea canadensis, Alisma plantago aquatica* and *Polygonum amphibium*. In 1956 the maximum length was 55 m, width 28 m, depth 2 m (minimal 1.7 m), area 1101 m^2, volume 97 m^3.

2.3. THE ŁOMŻA AREA

35. Aggregated group of 8 eutrophic oxbow pools, area 50–2000 m^2, depth 1.5–3 m.

36. Aggregated group of 5 temporary fens of valley of the Narew River, area: 20–500 m^2, maximum depth 0.4–0.8 m. Dried out completely in June.

37. A dystrophic pool on peat-bog, which did not dry out, Maximum area 16 m^2, depth 1.9 m.

38. Aggregated group of 3 permanent eutrophic ponds outside the Narew River valley.

2.4. THE NOWOGARD AREA

39. Aggregated group of 15 natural eutrophic field and forest ponds.
40. Aggregated group of 3 gravel excavations.
41. Aggregated group of 10 astatic field pools.
42. Aggregated group of 4 astatic alder's pools.
43. Aggregated group of 8 fens.

2.5. THE KARKONOSZE MOUNTAINS

44. Aggregated group of 4 bogs – altitude 850–1280 m.
45. Aggregated group of 2 artificial eutrophic ponds, altitude 430–440 m.
46. Aggregated group of 3 natural valley ponds, altitude 400–500 m.
47. Aggregated group of 5 mountain ponds, altitude 1120–1240 m.

3. RESULTS

Similarities between small standing water bodies in the area of Olsztyn are presented in the form of Czekanowski's diagram in Figure 2. The similarities can be arranged in the following sequence: pools number 1, 2, 5 and 17 (which is the aggregated group), 16 (the other aggregated group), 9, 13, 14, 12, 10. The character of bodies varied from dystrophic bogs through dystrophic forest ponds, astatic forest pools, astatic field pools to permanent forest ponds and permanent dystrophic water bodies. At low similarities this continuum is followed by the remaining water bodies (Fig. 2).

Comparing the domination structure of all bodies analysed (Figs. 3 A–C), their high individuality can be noticed, and at the same time the gradual change in species composition. The domination of some species is at first very distinct, then it decreases and the species are replaced by other. There are groups with similar dominant species. The small standing water bodies are grouped according to the most numerous species distinguishing six groups and several sub-groups. The word statism is used both for individual water bodies and complexes.

Group I. These are bodies with a marked dominance of *Oligotricha striata* – water bodies 1, 2, 4 and 44 (Fig. 3A). These are permanent (or disappearing in summer for several days) bodies, dystrophic with distinctly brown water, scarce

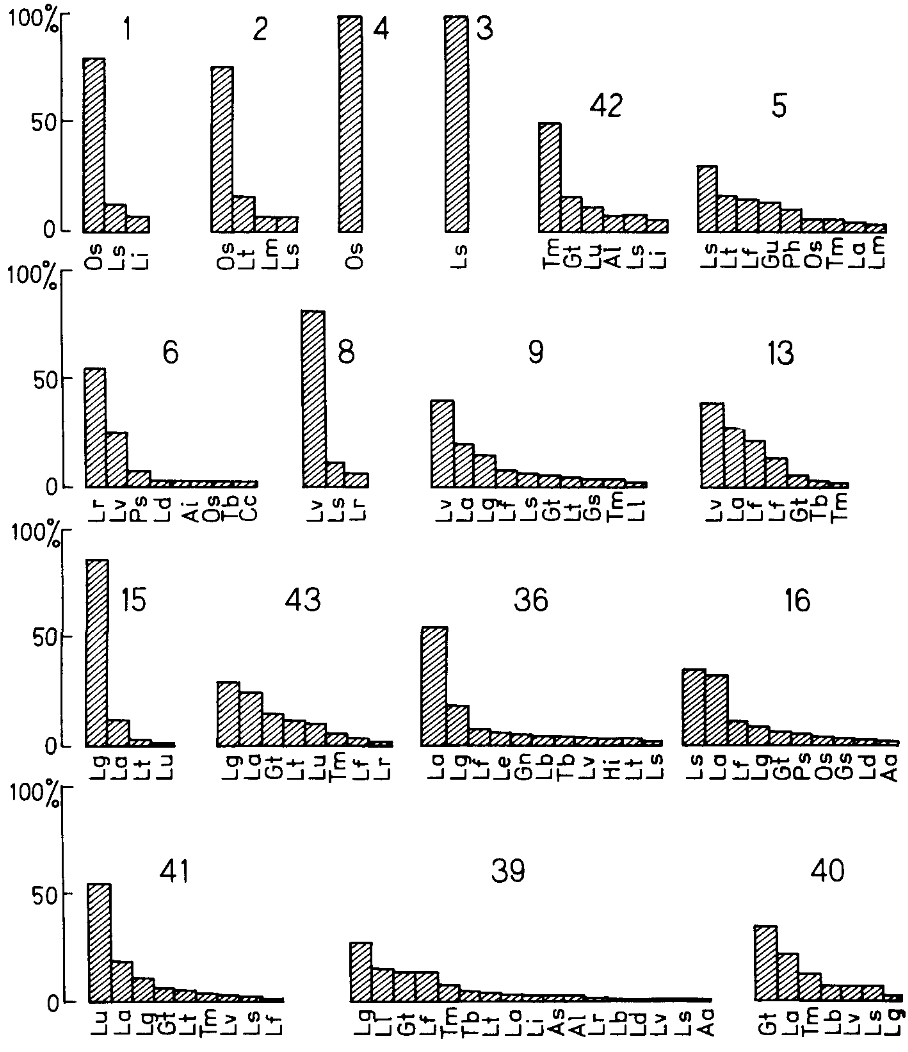

Fig. 3A. The dominance structure of caddis larvae in the water bodies (100% – total number of caddis larvae in one water body or aggregated group)

1 – 47 – numbers of water bodies (see descriptions of small water bodies), abbreviations are given for the following species: Aa – *Athripsodes aterrimus*, Ai – *Agrypnia picta*, Al – *Anabolia laevis*, Ao – *Agrypnia obsoleta*, Ap – *Agrypnia pagetana*, As – *Agrypnia* sp. juv., Cc – *Cyrnus crenaticornis*, Gi – *Grammotaulius signatipennis*, Gn – *Grammotaulius nigropunctatus*, Gs – *Grammotaulius* sp. juv., Gt – *Grammotaulius nitidus*, Gu – *Glyphotaelius pellucidus*, Ha – *Halesus* sp., Hc – *Hydropsyche contubernalis*, Hd – *Holocentropus dubius*, Hi – *Holocentropus picicornis*, Hs – *Holocentropus stagnalis*, La – *Limnephilus auricula*, Lb – *Limnephilus borealis*, Ld – *Limnephilus decipiens*, Le – *Limnephilus extricatus*, Lf – *Limnephilus flavicornis*, Lg – *Limnephilus griseus*, Li – *Limnephilidae indet.*, Ll – *Limnephilus lunatus*, Lm – *Limnephilus marmoratus*, Lp – *Limnephilus politus*, Lr – *Limnephilus rhombicus*, Ls – *Limnephilus* sp. juv., Lt – *Limnephilus stigma*, Lu – *Limnephilus sparsus*, Lv – *Limnephilus vittatus*, Ml – *Mystacides longicornis*, Np – *Nemotaulius punctatolineatus*, Of – *Oecetis furva*, Ol – *Oecetis lacustris*, Os – *Oligotricha striata*, Pb – *Phryganea bipunctata*, Ph – *Phacopteryx brevipennis*, Ps – *Phryganea* sp. juv., Tb – *Triaenodes bicolor*, Tm – *Trichostegia minor*

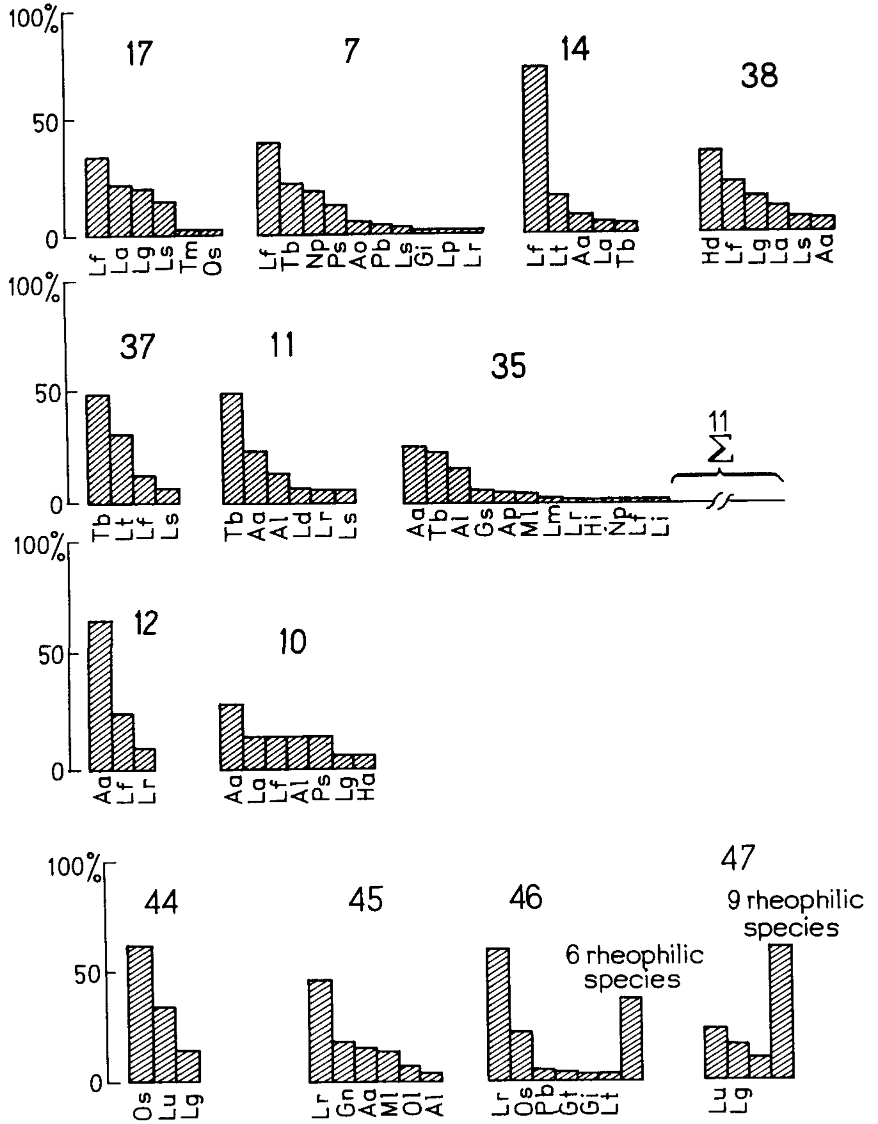

Fig. 3B. The dominance structure of caddis larvae in the water bodies (100% – total number of caddis larvae in one water body or aggregated group), abbreviations as Fig. 3A

vegetation with *Sphagnum* species. The water body No. 44 was represented by mountain bogs. Beside the dominant species, a few other but rather incidental species, were recognized, for example *Limnephilus marmoratus* and *L. stigma.* Numerous *Limnephilus* larvae were found exclusively at a younger larval instar, which may suggest that many of them cannot successfully complete their ontogenesis in these waters. In the mountain bogs also *Limnephilus sparsus* and *L. griseus* were found.

Group II. Bodies with exclusive occurrence of young larvae from the genus Limnephilus (water body number 3). These caddis larvae die before 3 and 4 larval

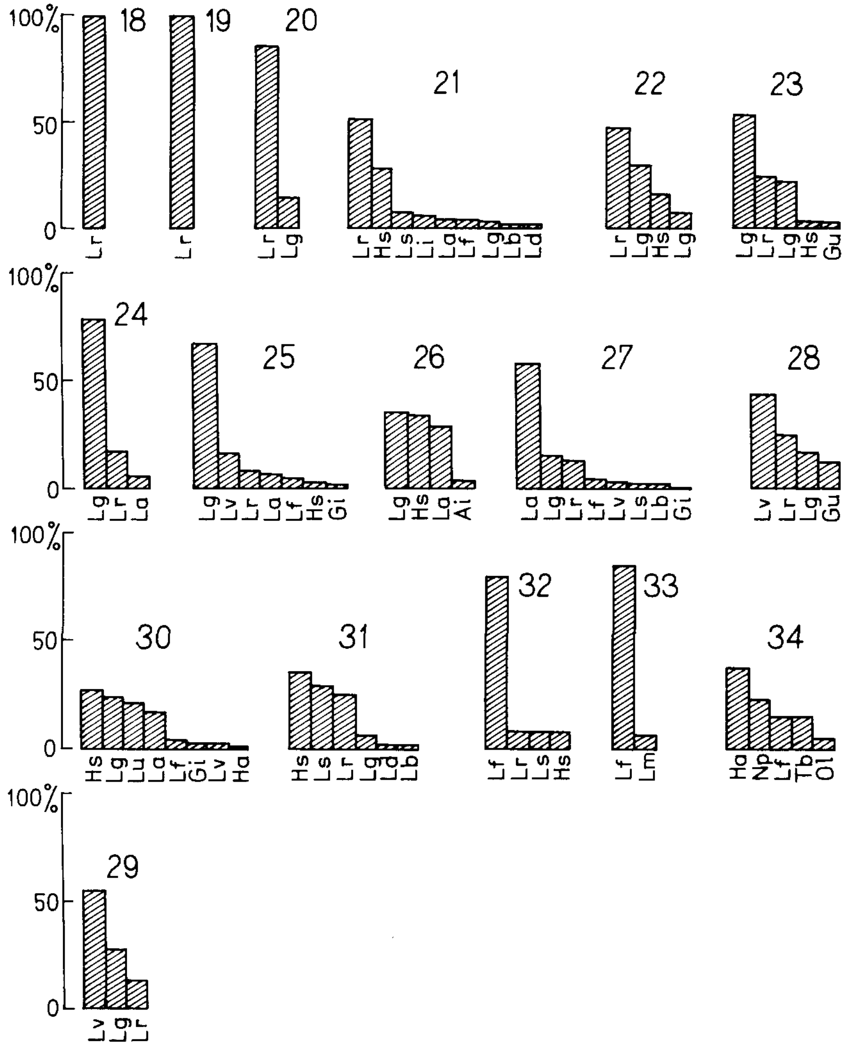

Fig. 3C. The dominance structure of caddis larvae in the water bodies (100% – total number of caddis larvae in one water body or aggregated group), abbreviations as Fig. 3A

instar (this situation resembles the bodies from group I). This water body is a permanent dystrophic body without aquatic or bog vegetation.

Group III A. Bodies with a marked dominance of *Trichostegia minor* and with the presence of *Grammotaulius nitidus* and *Limnephilus sparsus* (water bodies Nos. 40, 42). These are temporary water bodies occurring among alders (*Alnetum*).

Group III B. Water body 5 with a domination of *Limnephilus* sp. juv., *L. stigma, L. flavicornis, Glyphotaelius pellucidus* and with the occurrence of *Oligotricha striata, Trichostegia minor, Anabolia brevipennis* and *Limnephilus marmoratus*. This is a very shallow (about 10 cm deep) water body with moulding leaves, overgrown by grass and *Carex*.

Group IV. A large group of small water bodies with a domination of *Grammotaulius nitidus, Limnephilus flavicornis, L. stigma, L. griseus, L. vittatus, L. auricula* and *L. sparsus*. These are open field water bodies, mostly periodical, and fens. With regard to different dominating species, several subgroups can be distinguished in which gradual changes in the numbers of dominating species are conspicuous.

IV A. Bodies with dominance of *Limnephilus rhombicus*: water bodies 6, 18, 19, 20, 21 as well as eutrophic ponds in the Karkonosze Mountains (45) and 22. Apart from *L. rhombicus* other species can be numerous, such as *Limnephilus vittatus, L. griseus, L. flavicornis, Holocentropus stagnalis* or *Grammotaulius nitidus*. This subgroup contains a semi-permanent field pool (the Olsztyn area), a field pond and woodland ponds (the Mikołajki area).

IV B. Bodies with dominance of *Limnephilus vittatus* and *Limnephilus auricula*: 8, 9, 13 (Fig. 3A) and 28, 29 (Fig. 3C). *Limnephilus griseus, L. rhombicus, L. flavicornis* and *L. stigma* are also numerous. This group contains intermittent field pools and temporary autumnal field pools.

IV C. Water bodies with dominance of *Limnephilus auricula* and *L. griseus*: 15, 43, 36, 16 and 23, 24, 25, 26. Species characteristic of the other subgroup also occurrs in large numbers. This group contains: fens, astatic forest bodies (the Olsztyn area), fens (the Nowogard area), temporary pools of the Narew River valley, temporary fens (the Mikołajki area).

IV D. Water bodies with dominance of *Limnephilus sparsus* and numerous *L. auricula* and *L. griseus* – 41. These are astatic field pools from the Nowogard area.

IV E. Water bodies with dominance of *Limnephilus flavicornis*: 31, 32 and 17, 7, 14 (Fig. 3A–C). Species characteristic of group V also occurred. These were the permanent natural ponds.

IV F. Water bodies with dominance of *Holocentropus dubius* (water body No. 3) or *H. stagnalis*: water bodies No. 30 and 31. This subgroup contains dystrophic woodland and intermittent pools.

In group IV there is a series of species that can replace each other: *Limnephilus rhombicus, L. vittatus, L. auricula, L. griseus*. Resembling (analogical) gradual changes between other species in all groups are less apparent.

Group V. Water bodies with many species that develop from eggs in late summer or autumn and over winter in the larval and early instars form. These species are characteristic of permanent standing water bodies.

V A. Ponds with dominance of *Triaenodes bicolor* and *Athripsodes aterrimus*: 37, 35, 12, 10. This subgroup contains a pool on peat-bog, oxbow pools (the Łomża area), semi-permanent and permanent field ponds (the Olsztyn area).

V B. Permanent waters with dominance of *Halesus* sp., *Nemotaulius punctatolineatus* and many species from the subgroup V A – 34. This water body is a natural eutrophic field pond (the Mikołajki area).

Group VI. Water bodies with dominance or occurrence of species from running waters; their numbers increase at higher elevations (46, 47 – Fig. 3B). This group contains natural valley ponds (alt. 400 – 500 m) and mountain ponds (alt. 1120 – 1240m) in the Karkonosze Mountains.

The similarities between various types of standing waters reported in papers by Krey (1938) and Kreuzer (1940) are also estimated and presented in the form of the shortest dendrite (Figs. 4A, B). The groups of standing waters distinguished by Krey arrange themselves in the continuum: a) – ditches with partial or complete flow (pH 6.3–7.0); d) – habitats with typical tyrphophilic species (pH 3.6–4.0); c) – typical peat-bogs (pH 3.9–4.9); b) – eutrophic waters on peat-bogs (pH 4.6–7.1). The similarities between these groups of waters are small and range from 25 to 30%. In the types of standing waters distinguished by Kreuzer, the central position in the diagram is formed by waters of B type (small forest water bodies) and the greatest similarity with the type A is displayed by small waters on meadows and arable land. A considerably smaller faunistic similarity is for the water bodies of type C, consisting of waters on peat-bogs (18%) and the bodies of type D, i.e. brackish waters (14%) (Fig. 4B).

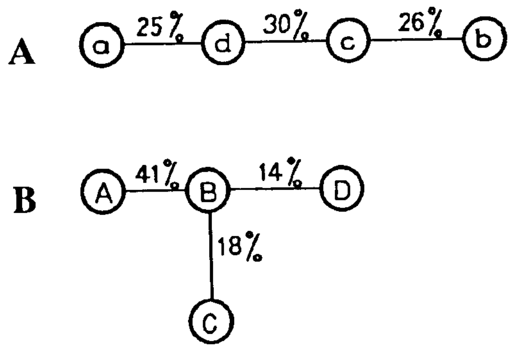

Fig. 4A – the shortest dendrite of faunistic similarity between various types of standing waters reported in the paper by Krey (1938)
a – ditches, b – eutrophic water bodies on peat-bogs, c – bogs, d – a habitat with typical tyrphophilic species
4B – the shortest dendrite of faunistic similarity between various types of standing waters repoeted by Kreuzer (1940), A – small field waters, B – small forest waters, C – bogs, D – brackish waters

4. DISCUSSION

4.1. TYPES OF STANDING WATER BODIES

The distinguished six groups of water bodies (Figs. 3A–C) should be considered as some simplification and approximation. Further studies should allow to separate ecological requirements of species with regard to habitat, trophy, astatibility and phenology.

The groups in question (mainly I – V) arrange themselves according to two main axes: dystrophy – eutrophy and astatism – stability (Fig. 2, Czachorowski and Szczepańska 1991). However, standing water bodies in high-mountains contain also rheophilic species (group VI). This is in accordance with other data (Decamps 1968). Most probably it is associated with temperature and oxygen factors. That is why a third dimension should be added, to the proposed model i. e. "rheophilness" (oxystenothermobility – oxyeurythermobility). The higher the altitude and latitude, the more rheophilic species (oxyphiles and stenothermophiles) can be expected in small standing waters. In mountains the rhithron species will penetrate into small bodies of standing waters and in the North the species from small water bodies may penetrate into lakes and *vice versa*.

It has also been noticed that in oxbow pools of the Łomża area (water bodies number 21) and some ponds (17, 7, 14), species characteristic of lakes are occurring (e.g. *Halesus* sp., *Anabolia laevis*, *Phryganea bipunctata*, *Oecetis furva*, *O. lacustris*, *Cyrnus crenaticornis*). Also in other small standing water bodies, species typical for lakes may occur (Higler 1968, Claassen 1984). Considering that lakes are characterized by a still higher stability of habitat conditions, "lakeability" can be placed at the prolongation of stability. This is confirmed by studies on benthos in lakes used for hydroenergetic goals; daily water fluctuations increase the astaticity of the littoral of such lakes and results in an increase of the number of species characteristic of small ponds and astatic pools (Mastrantuono 1987).

Based on the proposed typology, the peat-bogs in the area of the Lake Kierskie (Western Poland) (Jakubisiakowa 1933) can be recognized as natural ponds of group V. Eutrophic late-glacial bodies in Holland may also belong to this group (Claassen 1984).

Kreuzer (1940) distinguished four types of waters: field and forest water bodies, fens and brackish waters, and listed caddisflies living there (Holstein, Germany). With respect to species composition and the frequency of occurring, the first two groups (permanent field and forest ponds) approximate group V. (Species that require small and permanent water bodies are dominating). Fens resemble the waters from group IV and particularly groups IV E and IV F. Brackish bodies on the other hand were dominated by lake species (typical of large water bodies).

4.2. THE PROBLEM OF CONTINUITY OF COMMUNITIES

The similarities between water bodies studied extensively arrange themselves in a certain continuum (Fig. 2, individual waters without integrated groups 16 and 17). Such a situation indicates gradual changes in the parameters of the habitats studied.

In case of faunistic similarities estimated on the basis of data published by Krey (1938) and Kreuzer (1940) (Fig. 4), the gradual character is less conspicuous because of the small number of systems compared. The greater the number of objects compared, the more conspicuous is the gradient character of the changes observed.

If few systems are compared, they are separated discretely. Thus, the method of analysis of material effects the observed character of communities and, more broadly, the observed character of ecological systems.

The same conclusion as to the gradient character of caddis larvae communities (and consequently to the continuity of habitat changes) can be drawn from the analysis of groups and subgroups distinguished, where the numbers of dominating species change gradually. In further investigations of small standing waters bodies, the groups I and II, will be probably less discernible. Therefore, there is no hope for discrete differences between different limnological types as well as between individual water bodies.

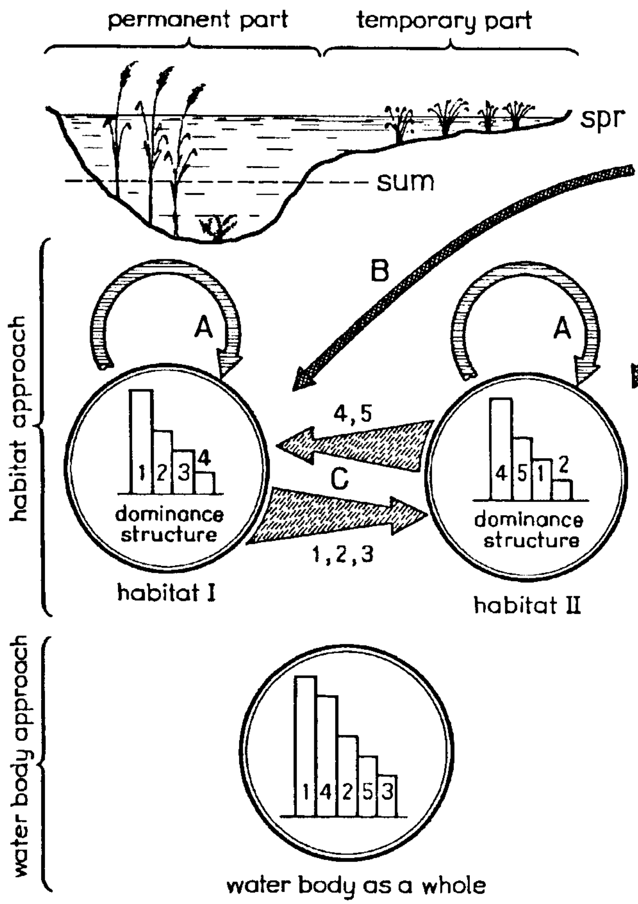

Fig. 5. Schematic diagram of habitat approach to research on small water bodies ("habitat island") SPR – water level in spring, SUM – water level in summer, A – fauna persisting from the previous season (adapted species), B – migrations from other waters by air, C – migrations from adjacent habitats, 1 – 5 – species

The great individuality of particular water bodies and the gradient of fauna changes between limnological types are easy to interpret if the water bodies are not treated as uniform systems but as an integrated aggregate (system) of various habitats (as in the lake – Czachorowski 1992). It is possible to conclude then that larger number of species occur in more differentiated water bodies (with regard to habitat). This is confirmed by data from permanent water bodies with astatic flood zones (Czachorowski and Szczepańska 1991), data concerning aggregate groups and oxbow pools (Fig. 3A–C).

Investigations of small stagnant water bodies as the integrated systems of various habitats are necessary to learn more about the distribution of caddis larvae in these waters. Investigations of caddis larvae distribution in lakes has provided good results (Czachorowski 1992).

A model of small water bodies as an integrated system of habitats explains the highly individual character of species composition and also the gradual changes between communities (Fig. 5). This is a model of habitat islands (Minshall and Petersen 1985, Czachorowski and Szczepańska 1991) analogous to the colonization model of oceanic islands (MacArthur and Wilson 1963, 1967).

Highly individual species composition of various water bodies is a result of isolation and is also a result of the migration of fauna by water (habitats and "fenological periods" adjoining one water body, adjoining e.g. running waters) and by air from adjacent waters (ecological landscape). Waters far apart are less likely to have the same fauna composition because the connection by water or air is not easy. This explains the frequent occurrence of rheophilic species and their greater abundance in stagnant mountain waters as compared with stagnant lowland waters due to migrations (by adults) from a great many of running waters in the mountain landscape.

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5. SUMMARY

The investigations cover small standing water bodies in the following areas: Nowogard district (north-western Poland), Olsztyn district, Mikołajki district, Łomża district (northern Poland) and the Karkonosze Mountains (southern Poland) (Fig. 1). All types of small water bodies were surveyed: temporary pools, permanent natural ponds, field and forest water bodies, eutrophic and dystrophic water bodies, fens and bogs.

On the basis of Trichoptera fauna (Table 1), faunistic similarities among particular water bodies (Fig. 2) and similarities among different types of standing waters on the basis of data from two other papers (Fig. 4) are specified. The dominance structure of all water bodies analysed (Fig. 3) is compared and according to it six groups and several subgroups of water bodies are distinguished.

Changes in the trichopteran fauna among various types of standing waters have a continuous and gradual character. The water bodies and caddis larvae communities living there are grouped according to three main factors: statism – astatism (water level fluctuation), eutrophy – dystrophy and temperature-oxygen. Finally, a model of small water bodies as an integrated system of habitats has been proposed (Fig. 5). This model explains the highly individual character of species composition in small water bodies.

6. POLISH SUMMARY

Badaniami objęto małe zbiorniki wód stojących okolic Nowogardu (północno-zachodnia Polska), Olsztyna, Mikołajek, Łomży (płn. Polska) oraz Karkonoszy (płd. Polska) (rys. 1). Badano wszystkie typy drobnych zbiorników: zbiorniki okresowe, trwałe stawy naturalne, zbiorniki śródleśne i śródpolne, eutroficzne i dystroficzne, torfowiska niskie i wysokie.

Na podstawie fauny Trichoptera (tab. 1) wyliczono podobieństwa faunistyczne pomiędzy poszczególnymi zbiornikami wodnymi (rys. 2) oraz podobieństwa faunistyczne pomiędzy różnymi typami zbiorników wodnych opierając się na danych z dwu innych prac (rys. 4). Porównano strukturę dominacji wszystkich badanych zbiorników wodnych (rys. 3) i na podstawie struktury dominacji wyróżniono sześć grup i kilka podgrup zbiorników wodnych.

Zmiany fauny chruścików pomiędzy różnymi typami wód stojących miały charakter ciągły i gradientowy. Zbiorniki wodne i zgrupowania larw chruścików w nich żyjące układały się zgodnie z głównymi czynikami: stabilność–niestabilność, eutrofia–dystrofia i wzdłuż czynnika temperaturowo--tlenowego. Zaproponowano model małego zbiornika jako zintegrowanego systemu różnych siedlisk (rys. 5). Model ten tłumaczy duży indywidualizm faunistyczny poszczególnych zbiorników wodnych.

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