MUSEUM & INSTITUTE OF ZOOLOGY
POLISH ACADEMY OF SCIENCES

FRAGMENTA FAUNISTICA

Fragm. faun.	Warsaw, 30.12.1999	**42**	8	71–93

Joanna PAKULNICKA*, Wojciech BARTNIK**

Changes in the fauna of aquatic beetles (*Coleoptera aquatica*) in Lake Luterskie (Olsztyn Lake District) in 1981–1993

Abstract. Ninety-five species of aquatic beetles were observed in the weakly eutrophic Lake Luterskie. The dominants were: *Noterus crassicornis*, *Haliplus flavicollis* and *H. immaculatus*. Over 13 years there was a decrease in the community abundance of aquatic beetles. Changes took place also with respect to the occurrence of the species, domination structure (a decrease in the abundance of *Haliplidae*, and an increase in the abundance of *Dytiscidae* communities) and synecological grouping (a decrease in the number of lake-river elements, and an increase of small water-body species). These changes clearly indicate progressing eutrophication of the lake under study.

Key words: lake, aquatic beetles, eutrophication

Authors' addresses: *Department of Ecology and Environmental Protection, Warmia and Masurian University, Żołnierska 14, 10-561 Olsztyn, POLAND
**Primary School in Lutry, 11-332, Lutry, POLAND

1. INTRODUCTION

The beetle fauna of Polish lakes is relatively little known. Studies have been performed on the beetles in Lake Kierskie (KRACH 1932), lakes of the Międzychód-Sieraków Lake District (BIESIADKA 1971), Sosnowice Lakes in the Łęczyna-Włodawa Lake District (KOWALIK 1968), lakes in the environs of Konin (BIESIADKA 1977a) and Lake Zbęchy in the Great Poland region (BIESIADKA 1980). Most of these papers are faunistical and ecological studies, where materials were exclusively collected using qualitative methods. The study by BIESIADKA (1980) has been the only one to be based on quantitative data and the first paper to evaluate absolute numbers of beetles in Lake Zbęchy and the selected habitats.

The objective of this study was to present data on aquatic beetles in Lake Luterskie, with special attention paid to changes which have taken place in the beetle fauna of this lake during 13 years. Although there are papers devoted to long-term changes occurring in the macrobenthic fauna (e.g. the paper by NALEPA (1987) on Lake Michigan) no similar studies of coleopteran fauna have ever been performed in Poland.

2. MATERIAL AND METHODS

Beetle fauna of Lake Luterskie was studied in two periods: from April to November 1981, and from May to October 1993. Samples were collected at monthly intervals. In all 13 series of catches were performed at ten selected stations. During a catch a hydrobiological sampler was used to collect five quantitative samples at each station, from an area enclosed within a 0.5 m × 0.5 m metal frame. Hence, each monthly series consisted of 50 samples. A total of 650 samples were collected in the course of the study.

Studies were carried out in the littoral zone, which extends along the entire length of the lake's shore. Ten stations were selected, taking into account the environmental diversity of this area. The following habitats were selected: a non-sandy bottom rich in organic debris, accumulated matter in the shallowest littoral, sedge growths, reed communities and rush and bulrush communities. The sampling stations were located in the eulittoral, at a depth of 10 cm, and in the supralittoral, at a depth of 30–50 cm. The stations had to be moved a little in the annual cycle due to changes in the water level.

Faunistic material was collected with a hydrobiological sampler. In 1981 it consisted of 5298 individuals belonging to 68 species, and in the last period of studies, of 1650 individuals belonging to 66 species. In all the materials consisted of 6948 individuals representing 95 species. As the numbers of beetle larvae were very low, they were excluded from the analyses. Imagines were classified using the keys of GALEWSKI and TRANDA (1978), GALEWSKI (1971a) and FRIDAY (1988). The taxonomic classification of *Hydradephaga* was adopted from GALEWSKI and TRANDA (1978), and of *Polyphaga*, from FRIDAY (1988).

3. STUDY AREA

3.1. Description of Lake Luterskie

Lake Luterskie is located in the north-east part of the Olsztyn Lake District. It is a young glacial lake, formed as a result of erosive and accumulative activity of the Scandinavian glacier.

The shape of Lake Luterskie enables its division into a "big basin", adjoined by the villages of Kikity, Wągsty and Żardeniki, and a "small basin", adjoined by the village of Lutry. The two basins are connected by means of a rather wide and deep isthmus.

The lake receives the waters of the Łyna-Symsarna River, the initial stretch of which had been regulated with the resulting decrease of the lake surface level by some 60 cm. The lake is also connected with Lake Bierdawy, and there are many drainage ditches reaching the lake. The south-west shore of the "big basin", between the villages of Kikity and Jeziorany, has a mixed forest growing. Northward there is an island of 0.7 ha in area called Wyspa Ptasia. Lake Luterskie is surrounded by recreation sites, housing estates, agrocenoses and pasture lands which are the main sources of anthropopression and are responsible for eutrophication of the lake.

The lake has an area of 691 ha, a maximum length of 5160 m, a width of 2620, and a maximum depth of 20.7 m (average depth 7.2 m). The shore-line is 19,050 m long. Emergent aquatic vegetation covers about 80.4% of the shore length, occupying an area of 59 ha, i.e. 8.5% of the lake's area. These data have been excerpted from the bathimetric tables of the Inland Fisheries Institute in Olsztyn.

The shores of Lake Luterskie are mostly covered with *Phragmites australis* and, to a lesser extent, with other bulrush-zone vegetation (*Juncus sp., Typha sp., Acorus calamus, Glyceria aquatica* and *Schoenoplectus lacustris*). There are well-developed sedge communities in the rush zone, where coleopteran fauna is fairly abundant. Assuming that aquatic beetles occupy the littoral belt between the isobaths 0.0–1.0 m, the area inhabited by these organisms in Lake Luterskie would be 52 ha, i.e. 7.6% of the lake area.

3.2. Description of the sampling stations

3.2.1. Habitats with a non-sandy bottom

These habitats comprise about 10% of the lake shore-line. They adjoin pasture lands and wetlands where cattle and horses graze, so that animal manure is a source of pollution. Three stations were selected in these habitats:

Station 3. Located at the south-west shore of Lake Luterskie. Shore is flat here, bottom shallow with a thick layer of mud and many old leaves from the nearby trees (*Alnus glutinosa, Salix sp.*). Water surface is covered with *Lemna minor* and *Lemna trisulca*. Small sedge communities occur in the eulittoral zone, with bulrushes growing a little deeper (20–50 cm). Bulrush communities dominated by *Phragmites australis*, accompanied by *Acorus calamus* and *Sparganium ramosum*. This station changes considerably during the year; water level is subject to periodic variations, and during the 13 years of the study the station has been progressively overgrown by vegetation.

Station 9. Located at the north shore of Lake Luterskie. Shore flat, wet. Lake bottom with a thick layer of mud, detritus, tree roots, and some scattered stones. *Phragmites australis* grows sparsely a few metres from the shore in the littoral zone at a depth of 30–50 cm. This station is also being progressively overgrown with vegetation. There is a typical putrid smell here.

Station 10. Located at the north shore of the lake. The shore is steep, the bottom with a thick layer of mud and numerous stones. The eulittoral zone

has grasses growing and large tufts of sedge, with sparse bulrush vegetation (*Phragmites australis, Juncus sp.*) in the deeper littoral (up to 1 m).

3.2.2. Accumulated matter in the shallowest littoral.

These habitats occupy approximately 7% of the shore-line. Two stations were selected:

Station 1. Located at the south-west shore of the lake. The shore is flat, the bottom sandy, with some mud and dead leaves from nearby trees. The eulittoral zone covered with grasses and *Glyceria aquatica*. Deeper littoral zone with *Juncus sp., Phragmites australis* and *Acorus calamus* forming rush communities. Water level changes periodically. Waves bring in fragments of aquatic plants: *Elodea canadensis, Ceratophyllum sp., Vaucheria sp., Spirogyra sp.* and *Charophyta*. These elements enrich the local debris, composed mainly of thick fragments of submerged plants.

Station 5. Located at south shore, near the fishermen's place. Shore is flat here, bottom sandy, poor in grasses but rich in detritus. There is no rush belt in the eulittoral. Deeper littoral, at the depth of 20 cm, is full of elongated fragments of dead reed. This station, like station 1, is weakly isolated from the lake basin, and is subject to periodic variations of water level.

3.2.3. Sedge stands of the shallowest littoral

Sedge habitats represent a small part of the littoral, occupying about 10% of the shore line. One station was selected.

Station 2. Located in the south-west part of the lake. Shore here is flat, wet, bottom sandy. Zonation of the aquatic vegetation is well developed. Rush belt composed of large areas of *Carex sp.* At a depth of 30–50 cm, in the reed zone, there are stands of *Phragmites australis*, accompanied by *Typha sp.* and *Acorus calamus*. *Vaucheria sp.* and *Spirogyra sp.* were also observed here at times. This station is isolated from the open lake. As a result, its environment is less stable, subject to considerable variations of water temperature and level.

3.2.4. Community with Phragmites australis

This type of habitat was the major component of the littoral, occupying 70% of the shore line. Two stations were selected:

Station 7. Located at the south-east shore of the lake. Shore is flat and wet here, bottom sandy with many dead leaves of *Salix sp.* growing nearby. Accumulated matter in the eulittoral area. Littoral with reed communities markedly dominated by *Phragmites australis* at a depth of 40–50 cm. Algae occur periodically.

Station 8. Located at the north shore of the lake. It adjoins a bathing area in Lutry village. Shore flat, covered with grass and *Carex sp.* Large stand of *Phragmites australis* accompanied by *Typha sp.* and *Acorus calamus* occurs below the depth of 20 cm. The bathing area is the only place free of reed.

3.2.5. Communities with rush and bulrush.

This habitat is characteristic of the least eutrophic part of the lake, but it represents only a small part of the littoral, occupying about 3% of the shore length. Two stations were selected in this habitat:

Station 4. Located at the south shore of the lake (adjoining the bathing area). Shore is steep here, bottom sandy, with gravel, stones and detritus. Communities of *Juncus sp.* and *Helochares sp.* form patches, occupying about 2–5 m^2 on the sandy bottom, at a depth of up to 40 cm. Numerous small lagoons forming at the shore are the result of differences in the intensity of erosion processes.

Station 6. Located at the south shore of the lake. Shore is flat here, bottom sandy, with gravel and stones, a lot of accumulated matter, and a thick layer of detritus. In the supralittoral, at a depth of 50 cm, there is a rush belt dominated by *Schoenoplectus lacustris*, accompanied by scarce *Phragmites australis* growing over a thick layer of detritus.

4. RESULTS

4.1. General description of aquatic beetle communities in Lake Luterskie

The material comprised 95 species (Tab. I), with nearly a half (47 species) belonging to the family *Dytiscidae*. *Hydrophilidae* were represented by 29 species, *Haliplidae* by 10, *Hydraenidae* by 5, *Gyrinidae* by 2, and *Limnidae* and *Spercheidae* by one species each. The abundance structure of the entire community was quite different: *Haliplidae* was the most numerous family (47%), *Dytyscidae* were less numerous (42.8%) and were followed by *Hydrophilidae* (9.5%), *Hydraenidae* (0.2%) and *Grynidae* (0.4%). The remaining two families were present at very low numbers.

In 1981 only 68 species were found belonging to 5 families. Community structure was dominated by *Dytiscidae* (35 species), followed by *Hydrophilidae* (20) and *Haliplidae* (10). Two species belonged to *Hydraenidae*, and one to *Spercheidae*. As regards abundance, species belonging to *Haliplidae* dominated (52.2%) over *Dytiscidae* (38.8%) and *Hydrophilidae* (8.9%). Other families were present at very low numbers.

The 1993 catches yielded 66 species of aquatic beetles belonging to 6 families. Their grouping was similar as in 1981. 32 species belonged to *Dytiscidae*, 18 to *Hydrophilidae*, 8 to *Haliplidae*, 5 to *Hydraenidae*, 2 to *Gyrinidae* and 1 to *Limnidae*. The quantitative composition of the beetle fauna had changed in relation to 1981. First of all, numbers of *Haliplidae* had decreased, so that this family now represented 30.4% of the community. *Dytiscidae* constituted 55.7%, and *Hydrophilidae*, 11.6%. Members of the other families were present in low numbers.

Three species dominated in the beetle fauna: *Noterus crassicornis*, *Haliplus immaculatus* and *H. flavicollis*; together they accounted for 61.9% of all the beetles. *Hygrotus versicolor*, *Laccobius minutus*, *Hyphydrus ovatus*, *Hygrotus*

Table I. Statistical presentation of the materials. N – number of individuals, D – domination (%), S – number of sampling stations, P – number of samples, F – frequency (%).

Gatunek	1981					1993				
	N	D	S	P	F	N	D	S	P	F
1	2	3	4	5	6	7	8	9	10	11
GYRINIDAE										
Gyrinus distinctus AUBÉ						21	1.27	1	2	0.67
Gyrinus payculli OCHS.						4	0.24	2	2	0.67
HALIPLIDAE										
Haliplus confinis STEPH.	46	0.87	9	28	8.0	10	0.60	6	9	3.0
Haliplus obliquus (FABR.)	2	0.04	1	2	0.57					
Haliplus flavicollis STURM	1054	19.88	10	179	51.14	306	18.52	10	87	29.0
Haliplus fulvus (FABR.)	16	0.30	3	7	2.0					
Haliplus lineatocollis (MARSH.)	2	0.04	2	2	0.57	1	0.06	1	1	0.33
Haliplus fluviatilis AUBÉ	84	1.58	9	37	10.57	50	3.03	7	23	6.58
Haliplus heydeni WEHNCKE	53	1.0	7	25	7.14	5	0.30	3	3	0.86
Haliplus immaculatus GERH.	1335	25.18	10	193	55.14	111	6.72	9	31	10.33
Haliplus ruficollis (DEG.)	162	3.05	10	59	16.85	17	1.03	1	13	4.33
Haliplus wehnckei GERH.	14	0.26	5	8	2.28	1	0.06	1	1	0.33
DYTISCIDAE										
Noterus clavicornis (DEG.)	85	1.6	10	39	11.14	29	1.76	5	11	3.67
Noterus crassicornis (O. F. MÜLL.)	1071	20.2	10	161	46.0	424	25.70	10	63	21.0
Hydroporus angustatus STURM	1	0.02	1	1	0.28	12	0.73	2	3	0.86
Hydroporus dorsalis (FABR.)	3	0.06	1	1	0.28					
Hydroporus erythrocephalus (L.)	3	0.06	3	3	0.86					
Hydroporus incognitus SHARP						1	0.06	1	1	0.33
Hydroporus melanocephalus (MARSH.)	1	0.02	1	1	0.28					
Hydroporus neglectus SHAUM						1	0.06	1	1	0.33
Hydroporus palustris (L.)	58	1.09	10	44	12.57	16	0.97	4	10	3.33

1	2	3	4	5	6	7	8	9	10	11
Hydroporus planus (FABR)	5	0.09	3	4	1.14					
Hydroporus striola (GYLL)						2	0.12	2	2	0.67
Laccornis oblongus (STEPH)	3	0.06	3	3	0.86					
Graptodytes pictus (FABR)	3	0.06	3	3	0.86	5	0.30	2	4	1.33
Porhydrus lineatus (FABR)	41	0.77	6	21	6.0	13	0.78	6	12	4.0
Coelambus impressopunctatus (SHALL)	57	1.07	9	29	0.28					
Hygrotus decoratus (GYLL)	9	0.17	5	6	1.71	15	0.09	3	4	1.33
Hygrotus inaequalis (FABR)	182	3.43	10	69	19.71	61	3.69	9	27	9.0
Hygrotus versicolor (SCHALL)	240	4.53	10	81	23.14	101	6.11	8	42	14.0
Scarodytes halensis (FABR)	4	0.07	1	4	1.14	2	0.12	2	2	0.67
Potamonectes depressus (FABR)						2	0.12	1	2	0.67
Hyphydrus ovatus (L.)	195	3.68	9	89	25.42	94	5.69	8	39	13.0
Laccophilus hyalinus (L.)	6	0.11	5	6	1.71	33	1.99	4	16	5.33
Laccophilus minutus (L.)	37	0.70	8	25	7.14	1	0.06	1	1	0.33
Platambus maculatus (L.)	9	0.17	5	7	2.0	1	0.06	1	1	0.33
Agabus bipustulatus (L.)	2	0.04	1	2	0.57	1	0.06	1	1	0.33
Agabus congener (THUNB)	2	0.04	1	1	0.28					
Agabus guttatus (PAYK)	1	0.02	1	1	0.28					
Agabus neglectus ER.	2	0.04	1	1	0.28					
Agabus fuscipennis (PAYK)	1	0.02	1	1	0.28					
Agabus unguicularis (THOMS)						4	0.24	2	2	0.67
Agabus sturmii (GYLL)						50	3.02	2	6	2.0
Agabus undulatus (SCHRANK)	2	0.04	1	1	0.28	12	0.73	3	5	1.67
Ilybius fenestratus (FABR)						9	0.54	2	5	1.67
Ilybius fuliginosus (FABR)	1	0.02	1	1	0.28					
Ilybius quadriguttatus (LACORD)	2	0.04	1	2	0.57					
Rhantus exsoletus (FORST)						6	0.36	3	6	2.0
Rhantus incognitus (SCHOLZ)						1	0.06	1	1	0.33
Rhantus latitans SHARP	1	0.02	1	1	0.28	1	0.06	1	1	0.33

Table I. cont.

1	2	3	4	5	6	7	8	9	10	11
Rhantus notatus (FABR.)	1	0.02	1	1	0.28	1	0.06	1	1	0.33
Rhantus pulverosus (STEPH.)	6	0.11	4	5	1.43					
Colymbetes paykulli ER.						12	0.73	2	3	0.86
Colymbetes fuscus (L.)						1	0.06	1	1	0.33
Bidessus geminus (FABR.)	2	0.04	2	2	0.57	5	0.30	1	2	0.67
Colymbetes striatus (L.)	7	0.13	3	6	1.71					
Hydaticus seminiger (DEG.)	6	0.11	2	5	1.43					
Dytiscus dimidiatus BERGSTR						1	0.06	1	1	0.33
Acilius canaliculatus (NIC.)	6	0.11	5	6	1.71	2	0.12	1	2	0.67
HYDRAENIDAE										
Ochthebius minimus (FABR.)						1	0.06	1	1	0.28
Hydraena palustris ER.						1	0.06	1	1	0.33
Limnebius atomus (DUFT.)						2	0.12	1	1	0.33
Limnebius crinifer (REY)	1	0.02	1	1	0.28	1	0.06	1	1	0.33
Limnebius truncatulus (THOMS.)	2	0.04	2	2	0.57	7	0.42	4	6	2.0
SPERCHEIDAE										
Spercheus emarginatus (SCHALL.)	3	0.06	2	3	0.86					
HYDROPHILIDAE										
Hydrochus brevis (HERBST.)						3	0.18	3	3	0.86
Hydrochus carinatus (GERM.)						2	0.12	1	2	0.67
Hydrochus elongatus (SCHALL.)						1	0.06	1	1	0.33
Helophorus aquaticus (L.)	66	1.24	9	16	4.57	7	0.42	2	3	0.86
Helophorus aequalis (THOMS.)						2	0.12	1	1	0.33
Helophorus flavipes FABR.	6	0.11	4	4	1.14					
Helophorus granularis (L.)	5	0.09	2	3	0.86	1	0.06	1	1	0.33
Coelostoma orbiculare (FABR.)	2	0.04	2	2	0.57					
Sphaeridium scaraboides (L.)	1	0.02	1	1	0.28					
Cercyon tristis (ILL.)						1	0.06	1	1	0.33

1	2	3	4	5	6	7	8	9	10	11
Cercyon ustulatus (PREYSSL.)	4	0.07	2	4	1.43					
Cercyon haemorhoidalis (FABR.)	1	0.02	1	1	0.28					
Hydrobius fuscipes (L.)	17	0.32	5	13	3.71	8	0.48	5	7	2.33
Anacaena lutescens (FABR.)	18	0.34	6	13	3.71	1	0.06	1	1	0.33
Laccobius biguttatus GERH.	1	0.02	1	1	0.28					
Laccobius bipunctatus (FABR.)	29	0.55	8	10	2.86					
Laccobius minutus (L.)	205	3.87	10	82	23.43	69	4.17	7	21	7.0
Laccobius sinuatus MOTSCH.						1	0.06	1	1	0.33
Helochares griseus (FABR.)	60	1.13	10	37	10.57	39	2.36	4	4	2.0
Helochares punctatus (FORST.)						32	1.94	1	6	0.67
Enochrus coarctatus (GREDL.)						3	0.18	2	2	
Enochrus ochropterus (MARSH.)	3	0.06	3	3	0.86					
Enochrus quadripunctatus (HERBST)	4	0.07	3	3	0.86					
Enochrus affinis (THUNB.)	2	0.04	2	2	0.57					
Enochrus testaceus (FABR.)	30	0.57	9	24	6.86	13	0.78	6	8	2.67
Enochrus melanocephalus (OLIV.)	5	0.09	3	3	0.86					
Cymbiodyta marginella (FABR.)	2	0.04	1	1	0.28	7	0.42	5	7	2.33
Hydrophilus caraboides (L.)	8	0.15	3	4	1.14	1	0.06	1	1	0.33
Megasternum obscurum MARSCH.						1	0.06	1	1	0.33
LIMNIDAE										
Oulimnius tuberculatus (O. F. MÜLL.)						1	0.06	1	1	0.33

inaequalis, *Haliplus ruficollis*, and *H. fluviatilis* were also fairly numerous. All these species are also the most stable component of the coleopteran fauna of Lake Luterskie. The only exception is *Haliplus immaculatus*, which accounted for 25.2% of the community in 1981, and only 6.7% in 1993. The rest of the community was composed of migratory forms comprising 43 species which totally represented 1.3% of the community's abundance. This group comprised also beetles found in small polyhumic, eutrophic bodies of water and watercourses.

The water beetle fauna of Lake Luterskie is ecologically diversified. Four basic elements can be distinguished, associated with:

- lakes and rivers,
- small eutrophic water bodies,
- polyhumic waters,
- small watercourses and sources.

The lake-river element is characteristic of less eutrophic lakes; it was represented by 9 species, of which *Haliplus flavicollis*, *Hygrotus versicolor* and *Haliplus fluviatilis* were the most numerous. The total number of beetles belonging to this element accounted for 27.6% of the whole material. A major part of the fauna (75 species) was composed of beetles inhabiting small, eutrophic water bodies. They represented 72.2% of the community. Beetles characteristic of polyhumic waters comprised 9 species: *Hydroporus angustatus*, *H. incognitus*, *H. neglectus*, *H. melanocephalus*, *H. decoratus*, *Agabus unguicularis*, *Colymbetes paykulli*, *C. striatus*, *Laccornis oblongus* (0.9%). Two species: *Haliplus lineatocollis* and *Agapus guttatus* are related to small watercourses and sources.

4.2. Occurrence of the beetles in different habitats

4.2.1. Community with Phragmites australis

A total of 40 species of water beetles were collected in this habitat: 36 in 1981 and much fewer, 19 species in 1993. There were 16 species common for both study years. The most numerous species in the reed community were: *Haliplus immaculatus*, *H. flavicollis*, *Noterus crassicornis* and *Hygrotus versicolor*. In the catches carried out in 1993 these species were, however, far less abundant than in the earlier study period. The most pronounced changes were observed with respect to the numbers of *Haliplus immaculatus* (10-fold decrease), *Haliplus flavicollis* (4-fold decrease), *Noterus crassicornis* (2.5-fold decrease). The numbers of *Hygrotus versicolor* changed least of all (1.5-fold decrease). The mean number of aquatic beetles in this habitat was 40.1 individuals $\times m^{-2}$ in 1981, and the maximal number amounted to 87.6 ind. $\times m^{-2}$. In 1993 the respective figures were 18.9 ind. $\times m^{-2}$ and 42.8 ind. $\times m^{-2}$. In 1981 *Haliplidae* represented 74.5% of all beetles in this habitat, *Dytiscidae* – 18.8%, *Hydraenidae* – 0.8% and *Hydrophilidae* – 5.8%. By 1993 the share of *Haliplidae* had decreased to 37%, and that of *Hydraenidae*, to 0.3%, while that of *Dytiscidae* had increased to 52.6% and of *Hydrophilidae*, to 10.3%.

4.2.2. Community with sedge and underwater shore meadows

A total of 52 beetle species were collected in this habitat, with 43 species collected in 1981, 32 species in 1993; 21 species were common for the two periods. This habitat was dominated by the following species: *Noterus crassicornis*, *Haliplus immaculatus*, *H. flavicollis*, *Hygrotus inaequalis*, *Hyphydrus ovatus*, *Hygrotus versicolor*, *Haliplus fluviatilis*, *H. ruficollis* and *Helochares punctatus*. By 1993 there had been a decrease in the numbers of the following species compared to the earlier period: *Haliplus immaculatus* (3-fold), *H. flavicollis* (4-fold), *H. ruficollis* (3-fold), *Hygrotus inaequalis* (2.5-fold) and *Hyphydrus ovatus* (2-fold). On the other hand the numbers of *Hygrotus versicolor* had increased 9-fold. *Noterus crassicornis* appeared to be the most stable species. *Helochares punctatus* was observed in sedge communities only in 1993. In 1981 the mean number of water beetles in the sedge community was 78.2 ind. $\times$ m^{-2}, and the maximal number amounted to 160 individuals $\times$ m^{-2}. By 1993 beetle numbers had decreased 1.5-fold (mean – 61.1, maximal 236 individuals $\times$ m^{-2}). A quantitative breakdown in 1981 showed that the beetle fauna consisted of *Haliplidae*, representing 32.9% of the community, *Dytyscidae* – 60%, *Hydraenidae* – 1%, and *Hydrophilidae* – 6.1%. In 1993 the respective percentages changed to: 16.2%, 69.8%, 2.7% and 11.3%.

4.2.3. Habitats with a non-sandy bottom

A total of 51 beetle species were collected in these habitats: 45 in 1981 and 36 in 1993. Only 19 species occurred in both years of study. The most numerous species were: *Haliplus immaculatus*, *H. flavicollis*, *Noterus crassicornis*, *Haliplus ruficollis*, *Hygrotus versicolor* and *Hyphydrus ovatus*. In 1993 these species were much less numerous. The highest decrease was observed with respect to *Haliplus immaculatus* (34-fold), *H. ruficollis* (21-fold), *H. flavicollis* and *Noterus crassicornis* (7-fold), while the smallest decrease was in the numbers of *Hygrotus versicolor* (3.5-fold) and *Hyphydrus ovatus* (1.5-fold). In 1981 the mean number of beetles was 73.4 ind. $\times$ m^{-2}, and the maximal value reached 121 ind. $\times$ m^{-2}. By 1993 beetle numbers had decreased over 6 times (mean – 16.3 ind. $\times$ m^{-2}, maximal 30.7 ind. $\times$ m^{-2}). In 1981 the family *Haliplidae* dominated as regards the beetle numbers; representing 64.1% of the community, it was followed by *Dytiscidae* – 30.3%, *Hydraenidae* – 5.3%. In 1993 *Haliplidae* represented 30.8%, *Dytiscidae* – 63.1%, *Hydrenidae* – 0.3%, and *Hydrophilidae* – 6.1% of the community.

4.2.4. Accumulated matter in the shallowest littoral

47 Coleoptera species were found in this environment, with 33 species registered in 1981 and 30 in 1993. There were 16 species common for the two periods. The most numerous species were: *Gyrinus distinctus*, *Haliplus flavicollis*, *H. immaculatus*, *H. ruficollis*, *Noterus crassicornis*, *Hygrotus inaequalis*, *H. versicolor*, *Laccobius minutus* and *Helocharis griseus*. The highest decrease in numbers between the two study years was observed in the case of *Haliplus*

ruficollis (14-fold decrease), *Noterus crassicornis* (4-fold), *Hygrotus inaequalis* (3-fold), *Haliplus flavicollis* and *H. immaculatus* (2.5-fold), *Helochares griseus* and *Hyphydrus ovatus* (2-fold). *Laccobius minutus* was found only in 1981, and *Gyrinus distinctus* – only in the later period. The abundance of *Hygrotus versicolor* did not change much. The mean number of the beetles in 1981 amounted to 46.6 ind. $\times m^{-2}$, maximal to 69.6 ind. $\times m^{-2}$. By 1993 mean number had decreased about 3–fold (mean – 18.4 ind. $\times m^{-2}$, maximal 53.2 ind. $\times m^{-2}$). The quantitative composition of coleopteran fauna was dominated in 1981 by the representatives of *Haliplidae* – 24.2%, *Dytiscidae* – 60.1%, *Hydrophilidae* – 13.8% and *Hydraenidae* – 1.9%. In the later period *Gyrinidae* represented 8.83% of the community, while the percentages of the other families had changed in relation to 1981, amounting respectively to 27.2%, 46.6%, 14.8% and 4.6%.

4.2.5. Communities with rush and bulrush

There were 46 beetle species found in these habitats: 38 in 1981 and 24 in 1992; 15 species were common for the two years. The most numerous species were: *Haliplus flavicollis*, *H. immaculatus*, *Noterus crassicornis* and *Laccobius minutus*. In 1993 these species were less numerous than in 1981. The most pronounced changes were observed as regards the numbers of *Haliplus immaculatus* (22-fold decrease) and *Noterus crassicornis* (5-fold decrease). The numbers of *Haliplus flavicollis* and *Laccobius minutus* did not change much between the two periods. The mean number of beetles in these communities was 43.7 ind. $\times m^{-2}$ in 1981, with a maximum of 57.6 ind. $\times m^{-2}$. By 1993 these values had changed about 3–fold (mean – 15 ind. $\times m^{-2}$, maximal 53.6 ind. $\times m^{-2}$). Quantitative composition in 1981 was as follows: *Haliplidae* – 39.8%, *Dytiscidae* – 41.9%, *Hydraenidae* – 6.8%, *Hydrophilidae* – 11.0% and *Spercheidae* – 0.4%. By 1993 these values had changed, amounting respectively to: 54.1%, 32.0%, 13.0%, 0.4% and *Limnidae* – 0.4%.

4.3. Occurrence profile of the most numerous species in Lake Luterskie

4.3.1. Noterus crassicornis

This species was the most numerous in the study material. A total of 1495 individuals were collected in the two years of study (1071 in 1981 and 424 in 1993), representing 21.5% of all beetles collected in Lake Luterskie. In 1981 *Noterus crassicornis* was most numerous in sedge stands (31.7 beetles $\times m^{-2}$). Inflow habitats of the shallowest littoral were a little less abundantly inhabited by this species (19.1 ind. $\times m^{-2}$), and were followed in this ranking by the non-sandy bottom habitats (11.4 ind. $\times m^{-2}$). The lowest numbers of this species were recorded in rush and bulrush communities (7.2 ind. $\times m^{-2}$) and in reed stands (4.3 ind. $\times m^{-2}$). In the later period of study, *Noterus crassicornis* was again most numerous in sedge stands (33.2 ind. $\times m^{-2}$), much less numerous in the inflow habitats of the shallowest littoral (4.8 ind. $\times m^{-2}$), in reed communities (1.8 ind. $\times m^{-2}$), in the non-sandy

bottom habitat (1.7 ind. × m^{-2}) and in the communities with rush and bulrush (1.4 ind. × m^{-2}). The mean number of *Noterus crassicornis* in all habitats of Lake Luterskie was 84.2 ind. × m^{-2} in 1981, and almost twice less in 1993 (45.7 ind. × m^{-2}) Changes in the abundance of this beetle in the two periods were very similar (Fig. 2). The wintering generation died in June, and a new generation appeared more numerously in August. In October and November the beetles dispersed due to their migration to wintering places. *Noterus crassicirnis* inhabits small water bodies and feeds on detritus. It is very popular in Poland, and is frequently caught. It lives in the offshore zone of stagnant or slowly flowing waters, overgrown with aquatic vegetation; it is also found in brackish waters. This species has been noted in coastal Baltic waters (KINEL 1924, WĘGRZECKI 1932, PODGÓRNIAK 1960, PAWŁOWSKI 1966), in Lake Kierskie and the nearby water bodies (KRACH 1932) in lakes of the Konin complex (BIESIADKA 1971), in Lake Zbęchy (BIESIADKA 1980), in the Międzychód-Sieraków lake district (BIESIADKA 1971), in the Great Poland region (SZULCZEWSKI 1922), in streams of the Kraków-Częstochowa highlands (KORDYLAS 1994), the Karkonosze Mountains (BIESIADKA 1993), the Pasłęka River in the Mazurian lake district (KORDYLAS 1990a). This species has a Euro-Siberian distribution. It has also been found in China and Caucasus, but not in north Finnish Scandinavia.

4.3.2. Haliplus flavicollis

A total of 1360 individuals of this species were found in Lake Luterskie (1054 in 1981 and 306 in 1993); this represented 19.6% of all beetles. *Haliplus flavicollis* was most numerous in the non-sandy bottom habitat (20.3 ind. × m^{-2}) and reed stands (19.4 ind. × m^{-2}). It was less numerous in the communities with rush and bulrush (7.4 ind. × m^{-2}), sedge stands (7.3 ind. × m^{-2}), and inflow habitats of the shallowest littoral (5.6 ind. × m^{-2}). In 1993 the highest numbers of *Haliplus flavicollis* were found in the community with rush and bulrush (7.4 ind. × m^{-2}). Reed stands were inhabited a little less numerously (5.0 ind. × m^{-2}), and this species was rather rare in the non-sandy bottom habitat (2.9 ind. × m^{-2}), in the accumulated matter and sedge stands of the shallowest littoral (1.8 ind. × m^{-2}). Patterns of annual change in this beetle's density differed between 1981 and 1993 (Fig. 2). Juveniles of the new generation probably appear from July till September, and in November the beetles move to deeper littoral, to their wintering places. *Haliplus flavicollis* is a riverine-lake species. It can be found in lakes and slowly flowing, weakly eutrophic, watercourses but overgrown with vegetation. It is very popular in Poland and widely distributed. It prefers oligotrophic environments, so its numbers in Lake Luterskie decreased during 13 years due to the eutrophication of the lake. This species was noted in Lake Kierskie (KRACH 1932), in Sosnowickie lakes and the Łęczna-Włodawa Lake District (KOWALIK 1968), the Międzychód-Sieraków Lake District (BIESIADKA 1971), lakes of the Konin complex (BIESIADKA 1977a), Lake Zbęchy (BIESIADKA 1980), as well as in valley and mountain ponds in the Karkonosze Mountains (BIESIADKA 1993). It has a

Euro-Siberian distribution, and has also been found east of Caucasus, in Kazakhstan, Egypt and Morocco.

4.3.3. Haliplus immaculatus

In the two periods of study a total of 1446 individuals of this species were collected (1335 in 1981 and 111 in 1993), this being 20.8% of all beetles collected in Lake Luterskie. In 1981 this species was most numerous in the non-sandy bottom habitat (29.3 ind. × m^{-2}), less so in the communities with reed (16.0 ind. × m^{-2}) and in sedge stands (12.9 ind. × m^{-2}), and it was least numerous in the communities with rush and bulrush (7.1 ind. × m^{-2}), and in accumulated matter in the shallowest littoral (4.7 ind. × m^{-2}). In 1993 this species was most numerous in sedge communities (4.4 ind. × m^{-2}), while in other habitats its numbers were much lower. Mean numbers of these beetles in the lake's entire littoral zone amounted to 70.3 ind. × m^{-2} in 1981 and 9.0 ind. × m^{-2} in 1993. Phenological analysis for 1981 revealed an abundance peak in September (Fig. 2). The juveniles of a new generation probably appear in August and September. A November drop in abundance is related to migration to wintering places. The materials collected in 1993 were too scarce to perform a phenological analysis. *Haliplus immaculatus* is a phytophilic species inhabiting small and stagnant water bodies. According to ZAJČEV (1953) it is a halophilic species. It has been found in the waters of Wolin Island (HORION 1941, PODGÓRNIAK 1960), in the complex of Konin lakes (BIESIADKA 1977a), Lake Zbęchy (BIESIADKA 1980), Sosnowickie lakes (KOWALIK 1968), in the region of Great Poland (SZULCZEWSKI 1922), Międzychód-Sieraków Lake District (BIESIADKA 1971), as well as in anthropogenic waters near Konin (BIESIADKA 1977b), in lakes, ponds, streams and in peatbogs of the Karkonosze Mountains (BIESIADKA 1993). It has also been found in the Pasłęka River, Mazurian Lake District (KORDYLAS 1990a). Its distribution range is defined as Mid-European. It is especially common in the middle and east Europe, and in southern part of Fennoskandia, extending westwards to north-east France. It has also been observed in Siberia.

4.3.4. Hygrotus versicolor

In the two periods of study, 341 beetles belonging to this species were found in total (240 in 1981 and 101 in 1993), representing 4.9% of the entire faunistic material collected from Lake Luterskie. This species was present in all habitats, bust it was most numerous in reed stands. Mean abundance of *Hygrotus versicolor* amounted to 11.3 ind. × m^{-2} in 1981, and was almost twice lower in 1993 (6.8 ind. × m^{-2}) *Hygrotus versicolor* is a lake beetle. It occurs in lakes, ponds, old river beds, canals, sandbars, drainage ditches and slowly flowing watercourses. It prefers water bodies of moderate size, weakly eutrophic, with a sandy bottom nurturing lush aquatic vegetation (Biesiadka 1971). In Poland, it is relatively common and fairly numerous. It has been found along the Baltic coast (PODGÓRNIAK 1960), in West Pomerania (KINEL 1948), the Great Poland region (SZULCZEWSKI 1922), Lake Kierskie (KRACH

1932), the complex of Konin lakes (BIESIADKA 1977b), Lake Zbęchy (BIESIADKA 1980), lakes Bialskie and Czarne (KOWALIK 1968) in the Podlasie region, in the Międzychód-Sieraków Lake District (BIESIADKA 1971), in disused water-filled gravel pits near Konin (BIESIADKA 1977b). Also found in the Pieniny (GALEWSKI 1979) and Bieszczady (GALEWSKI 1971b) mountains, in the Blue Springs – Niebieskie Źródła – (TRANDA 1972), Pasłęka River (KORDYLAS 1990a), Łyna River (KORDYLAS 1994) and Gizela River (CZACHOROWSKI et al. 1993). *Hygrotus versicolor* has a Euro-Siberian distribution range, occurring nearly all over Europe, except the south. It has also been found in Siberia, the Caucasus and eastwards of it.

4.3.5. Hyphydrus ovatus

A total of 289 beetles belonging to this species were found, 195 in 1981 and 94 in 1993, this accounting for 4.1% of the entire coleopteran fauna collected in lake Luterskie. *Hyphydrus ovatus* was present in all habitats as a permanent component of the associated beetle communities, although its numbers were low. The mean numbers of *Hyphydrus ovatus* in the upper littoral amounted to 10.6 ind. $\times$ m^{-2} in 1981, and were twice less in 1993 (5.5 ind. $\times$ m^{-2}). This species was most abundantly caught in April and May, and then from July to September. *Hyphydrus ovatus* is characteristic of small water bodies. It is a phytophilic beetle, occurring in permanent or late-drying water bodies, amongst aquatic vegetation in lakes, ponds, old river beds, sandbars, ditches. It is very popular in Poland, and has been found along the Baltic coast (PODGÓRNIAK 1960), in the Great Poland region (SZULCZEWSKI 1922, KRACH 1932, BIESIADKA 1971), in Lake Bialskie in Podlasie Region (KOWALIK 1968), lakes and disused water-filled gravel pits in the vicinity of Konin (BIESIADKA 1977b), Lake Zbęchy (BIESIADKA 1980), Niebieskie Źródła (Blue Springs) (TRANDA 1972), the rivers Pasłęka (KORDYLAS 1990a), Gizela (CZACHOROWSKI et al. 1993) and Łyna (KORDYLAS 1994) in the Mazurian lake district. It is also known in the Bieszczady (GALEWSKI 1971b) and Karkonosze (BIESIADKA 1993) Mountains. It is an Euro-Siberian species, reaching northward beyond the Arctic circle in Fennoscandia.

4.3.6. Laccobius minutus

205 individuals of this species were found in 1981, and only 69 in 1993. The total abundance of this species for both periods of study were 274 beetles i.e. 3.9% of all beetles collected in Lake Luterskie. This species was present mostly in the shallowest littoral, especially in accumulated matter and in the rush and bulrush communities. Numbers of *Laccobius minutus* in the entire supralittoral during the two periods of studies were 11.1 ind. $\times$ m^{-2} in 1981 and 6.2 ind. $\times$ m^{-2} in 1993. In 1981 this beetle was most abundantly caught in June and July, and in 1993 – in May. In October or November they abandoned water bodies and migrated to wintering places. *Lacobius minutus* beetles inhabit small water bodies; are detritophilous. These beetles can be usually found in water bodies overgrown with vegetation: ponds,

pools, marshes, ditches, shallow water areas, while they are rare in flowing waters. The species is fairly widespread in Poland, and probably occurs in the whole country. It has been recorded in the Wielkopolska-Kujawy Lowlands (SZULCZEWSKI 1922), in Lake Kierskie and the adjacent peat bog pools (KRACH 1932), in lakes Bialskie, Czarne and Białe in the Podlasie region (KOWALIK 1968), in Konin lakes (BIESIADKA 1977b), small water bodies in the opencast lignite mine near Konin (BIESIADKA 1977b), Lake Zbęchy (BIESIADKA 1980), in the water bodies of Międzychód-Sieraków Lake District (BIESIADKA 1971), in the Bieszczady Mountains (GALEWSKI 1971b), the Pieniny Mountains (GALEWSKI 1979) and the Karkonosze Mountains (BIESIADKA 1993), in water sources of the Małopolska (Little Poland) Uplands (TRANDA 1972), the Pasłęka (KORDYLAS 1990a) and Gizela (CZACHOROWSKI et al. 1993) rivers, and the Łyna River (KORDYLAS 1994). It is a widely distributed Euro-Siberian species.

4.3.7. Hygrotus inaequalis

205 *Hygrotus inaequalis* beetles found in 1981, compared with 61 in 1993. The total number of beetles belonging to this species collected in the two years of study was 243, this being 3.5% of all beetles collected in Lake Luterskie. *Hygrotus inaequlais* was most numerous in the communities with sedge, in the accumulated matter of the shallowest littoral, and in the non-sandy bottom habitat, and least numerous in the communities with rush and bulrush and in reed stands. The mean abundance of *Hygrotus inaequalis* in the upper littoral of Lake Luterskie was 11.7 ind. $\times$ m^{-2} in 1981, and 4.3 ind. $\times$ m^{-2} in 1993. This species inhabits small water bodies. It is detritophilous, lives in permanent water bodies with an abundance of aquatic and marsh plants, sometimes in calm areas of slowly flowing waters. It is common all over Poland, and is very numerous. It has been found in every place where coleopteran fauna has been analysed.

4.3.8. Haliplus fluviatilis

A total of 134 beetles were found (84 in 1981 and 50 in 1993) i.e. 1.9% of all beetles collected. This species was most numerous in reed stands and in the non-sandy bottom habitat. The mean numbers of *Haliplus fluviatilis* were 6.2 ind. $\times$ m^{-2} in 1981, and 4.2 ind. $\times$ m^{-2} in the later period. These beetles inhabit lakes and rivers, they are fairly numerous amongst vegetation in stagnant and slowly flowing waters, less so in lakes, ponds, old river beds and sandbars. They are quite common in Poland, and have been recorded in the Wielkopolska-Kujawy Lowlands (SZULCZEWSKI 1922, KRACH 1932, ŁĘGOSZ-OWSIANNA 1955, BIESIADKA 1971), in Konin lakes (BIESIADKA 1977a), Lake Zbęchy (BIESIADKA 1980), the Karkonosze Mountains (BIESIADKA 1993). The species is a Euro-Siberian element distributed throughout Europe, with the exception of extreme north and south regions. Also noted in Siberia and east of the Caucasus.

4.3.9. Noterus clavicornis

The total number of these beetles in the two periods of studies was 114 individuals (85 in 1981 and 29 in 1993), this being 1.6% of the whole material collected from the lake. *Noterus clavicornis* was most numerous in the communities with rush and bulrush. Its mean numbers in the upper littoral amounted to 5.1 ind. $\times$ m^{-2} in 1981 and 2.2 ind. $\times$ m^{-2} in 1993. This detritophilous species occurs in small water bodies, mostly in stagnant and slowly flowing waters, overgrown with water and marsh vegetation. It has never been found in higher mountains. It is very common in Poland and has been recorded in the lakes of the Great Poland region (SZULCZEWSKI 1922), Lake Kierskie (KRACH 1932), the Międzychód-Sieraków Lake District (BIESIADKA 1971), Konin lakes (BIESIADKA 1977a), Lake Zbęchy (BIESIADKA 1980). It has also been caught in the Bieszczady (GALEWSKI 1971b) and Pieniny (1979) Mountains, but not in Karkonosze Mountains (BIESIADKA 1993). Found in rivers of the Mazurian lake district (KORDYLAS 1990a, CZACHOROWSKI et al. 1993). A widely distributed Euro-Siberian element, recorded also in Asia Minor, the Caucasus and west Asia.

4.5. General assessment of the numbers and domination structure of aquatic beetles in the littoral zone of Lake Luterskie

The profiles of water beetles in lakes based on the total material collected in different habitats are incapable of reflecting the actual composition of the beetle fauna because particular habitats occupy areas of different sizes in the littoral. Thus it seems worthwhile to interpret the results so as to be able to obtain a realistic picture of the quantitative relations in the beetle fauna inhabiting the supralittoral of Lake Luterskie. Mean beetle numbers in particular habitats were adjusted for habitat area size (weighted averages). Occupying the largest area in the lake, reed stands weighed most heavily on the structure of coleopteran fauna in the lake.

In 1981 the average number of beetles in the lake's upper littoral zone amounted to 52.0 ind. $\times$ m^{-2}, and in 1993 it was twice lower, amounting to 23.3 ind. $\times$ m^{-2}.

Even greater changes took place in the overall domination structure of water beetles in the upper littoral (Fig. 1). In 1981 three species: *Haliplus flavicollis*, *H. immaculatus* and *Noterus crassicornis* accounted for 80% of all beetles in Lake Luterskie. The remaining 65 species made up less than 20% of the abundance. In 1993 *Haliplus flavicollis*, *H. immaculatus* and *Noterus crassicornis* made up on 48% of all beetle communities in Lake Luterskie. Relations between the most numerous species changed radically (Fig. 2).

5. DISCUSSION

A total of 95 species of *Coleoptera* were found in Lake Luterskie (68 species in 1981 and 66 in 1993). This can be compared to 83 species found in the eutrophic Lake Kierskie and the adjacent marsh water pools (KRACH 1932).

One mesotrophic lake of Wolin island was inhabited by only 13 species (PODGÓRNIAK 1960). 57 species were found in three lakes of the Łęczna-Włodawa Lake District (KOWALIK 1968), 46 in Lake Bialskie, which is eutrophic but still has some oligotrophic features, 34 in the eutrophic-dystrophic Lake Czarne, and 18 in the strongly eutrophic Lake Białe. In the Międzychód-Sieraków Lake District, 31 lakes (mostly eutrophic) were inhabited by 43 species of *Coleoptera* belonging to *Adephaga* (BIESIADKA 1971). A total of 97 species were recorded in eutrophic lakes of the Konin complex (BIESIADKA 1977a). The number of species in individual lakes ranged from 44 in Lake Licheńskie to 61 in Lake Ślesińskie. The beetles of the strongly eutrophic Lake Zbęchy, the Leszno Lake District, were represented by 64 species (BIESIADKA 1980), while 52 species of water beetles were recorded in the α-mesotrophic Lake Krzemno (KORDYLAS 1990b).

These data reveal considerable differences as to the number of beetle species in different Polish lakes. In view of this, the question arises what factors determine the number of species found by different authors in individual lakes? It is obvious that this number may depend on the intensity and duration of the investigations. This may be the reason behind the finding of small species diversity of coleopteran fauna in the lakes of Wolin island (PODGÓRNIAK 1960) and the Międzychód-Sieraków Lake District (BIESIADKA 1971), where much less attention was given to lakes than to other waters. Compared to the lakes in which intensive investigations were carried out over a few years, the number of beetle species found in Lake Luterskie seems to be very high. This high species differentiate is probably due to high diversity of habitats occupied by water beetles.

In Lake Luterskie the *Dytiscidae* family was represented by 47 species (almost a half of all beetles collected), *Hydrophilidae* by 29 species, *Haliplidae* by 10, *Hydraenidae* by 5, *Hyrinidae* by 2, and the families *Limnidae* and *Spercheidae* by 1 species each. In Lake Kierskie and the nearby marsh pools (Krach 1932) the family *Dytiscidae* was represented by 46 species, *Hydrophilidae* by 23, *Haliplidae* by 8, *Gyrinidae* by 4. In Sosnowice lakes (KOWALIK 1968) the share of *Dytiscidae* was 27 species, *Hydrophilidae* – 18, *Haliplidae* – 6 and *Gyrinidae* – 6 species. In the lakes of the Konin complex (BIESIADKA 1977a) the family *Dytiscidae* was represented by 47 species, *Hydrophilidae* by 21, *Haliplidae* by 9, *Gyrinidae* by 5, *Sphaeridae* by 6, and *Spercheidae* by 1 species. The respective data for lake Zbęchy (BIESIADKA 1980) were: *Dytiscidae* – 24 species, *Hydrophilidae* – 22, *Gyrinidae* – 3, *Spercheidae* – 1 species. In Lake Krzemno (KORDYLAS 1990b) the family *Dytiscidae* was represented by 24 species, *Hydrophilidae* by 15 species, *Haliplidae* by 5, *Hydraenidae* by 3, *Gyrinidae* by 2, and *Lamnidae* by 1 species. These data reveal a similarity of percentages of species from individual families in all lakes, with the families *Dytiscidae* and *Hydrophilidae* represented by the highest number of species.

The following species dominated in Lake Luterskie: *Noterus crassicornis*, *Haliplus flavicollis*, *Haliplus immaculatus*, *Hygrotus versicolor* and *H. inaequalis*. In Lake Kierskie and the nearby peat waters (KRACH 1932) the most numerous species were: *Haliplus flavicollis*, *Hygrotus inaequalis*, *Hygrotus*

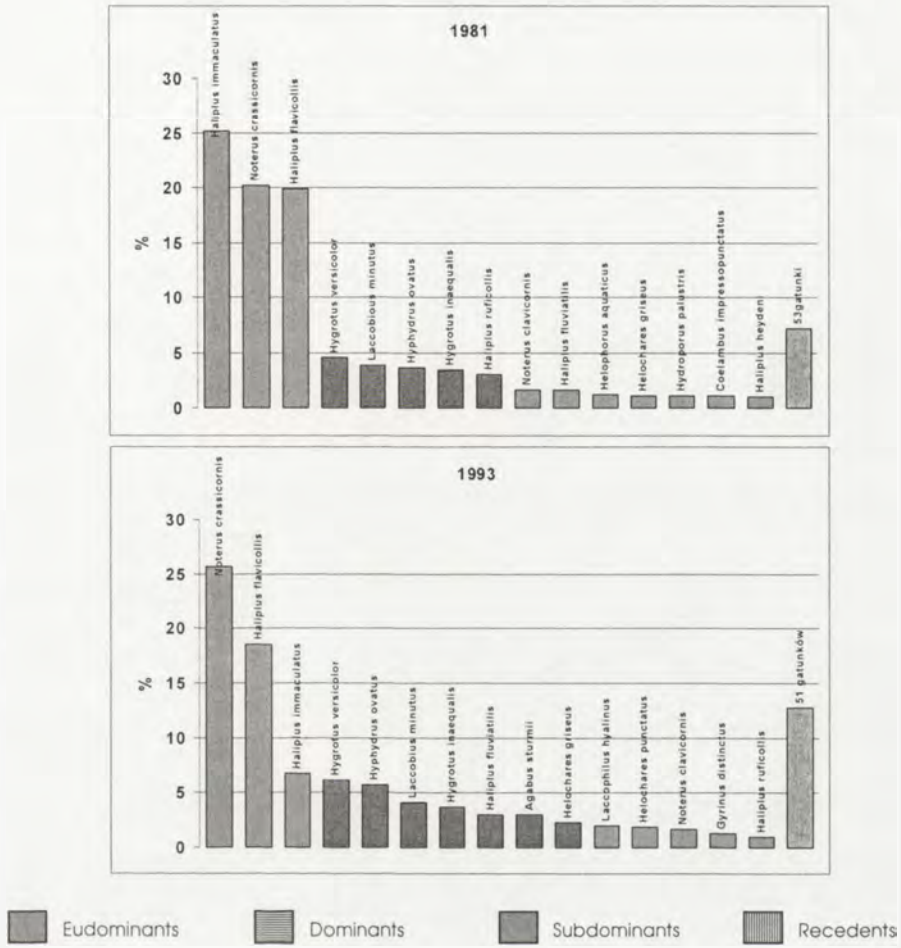

Fig. 1. Domination structure of water beetles in the upper littoral of Luterskie Lake

versicolor, *Laccobius minutus*, whereas in Sosnowice lakes (KOWALIK 1968) the most numerous species were: *Noterus crassicornis*, *Haliplus confinis*, *Potamonectus depressus*, *Ilybius fenestratus*, and *Anacaena limbata*. In the Konin lakes (BIESIADKA 1980) the following species appeared to be the most numerous: *Noterus crassicornis*, *Noterus clavicornis*, *Laccophilus hyalinus*, *Laccobius minutus* and *Hydrovatus cuspidatus*. The beetle fauna of Lake Zbęchy (BIESIADKA 1980) was most numerously represented by *Noterus crassicornis*, *Hydrobius fuscipes* and *Haliplus flavicollis*.

Comparisons of species composition in individual lakes reveal that usually the same species are dominants.

The most characteristic component of beetle fauna in lakes is usually lake-riverine species. These species represented 27.6% of all materials in Lake Luterskie. In the α-mesotrophic, Lobelia-type Lake Krzemno, the lake-riverine

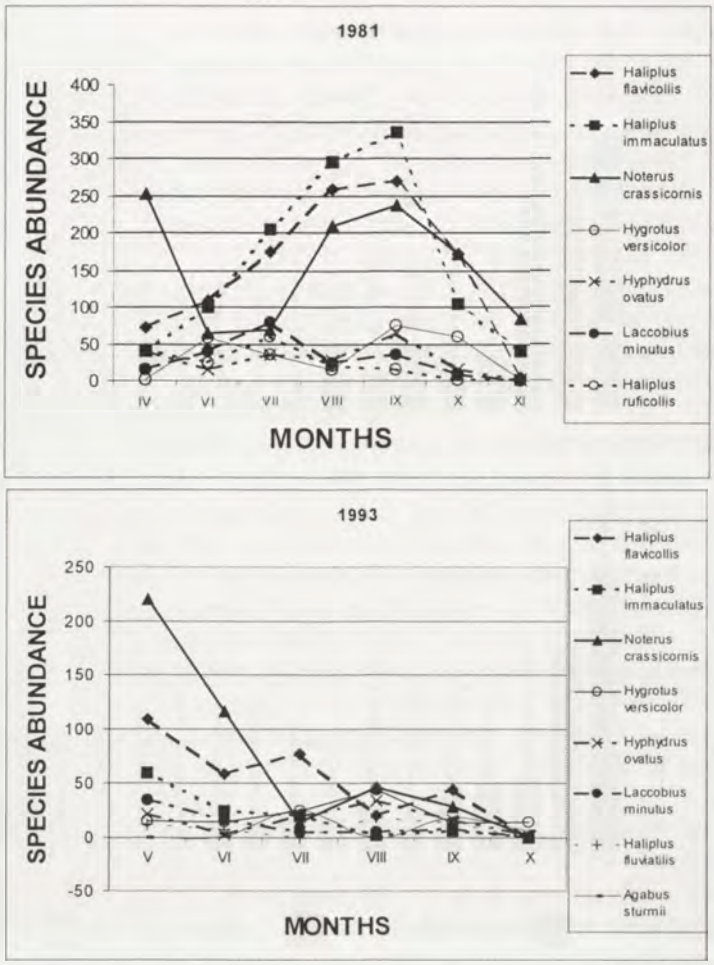

Fig. 2. Analysis of the differentiation in time of the abundance of species dominating in Luterskie Lake

element was even more numerous (KORDYLAS 1990b). Lake Zbęchy presents a different picture – its lake-riverine element represented only 12% of the collected material (BIESIADKA 1980).

Compared to the other lakes, Lake Luterskie may be regarded as relatively weakly eutrophic, although the eutrophication process progressed over the 13 years, as was reflected by changes in species composition, domination structure and synecological grouping. There was a noticeable decrease in the abundance of *Haliplidae*, and an increase in *Dytiscidae*, indicative of some degradation of the lake's fauna. There was also a decrease in the typical lake-associated element, i.e. the species which are usually common and very numerous in lakes, but also in other lake-specific beetles, irrespective of how abundant they had been before. Over the 13 years this element changed con-

siderably in a manner consistent with progressive eutrophication of the lake. At the same time, there was a noticeable increase in the numbers of species connected with eutrophic waters, polyhumic and small water bodies, and sources. These species are very diversified from an ecological point of view, but on the other hand they represent a migrating element in lake fauna, characterised by high dispersal. Their presence in the lake under study suggests intensive exchange between Lake Luterskie and other nearby waters. The species composition of this element changes in a fluctuating "undirected" manner. However, changes in the species composition of the lake-riverine element, which was the major component of the beetle lake fauna, were generally related to progressing eutrophication and degradation of this fauna. The presence of such species as *Laccophilus hyalinus*, *Platambus maculatus*, *Potamonectes depressus* and most of all – *Oulimnius tuberculatus* may be regarded as an indicator of environment quality, suggesting that ecological condition of the lake under study is still fairly good.

BIBLIOGRAPHY

BIESIADKA E. 1971. Chrząszcze wodne z podrzędu *Adephaga* Pojezierza Międzychodzko-Sierakowskiego. Bad. fizjograf. Pol. zach., B, Poznań, 34: 9–33.

BIESIADKA E. 1977a. *Coleoptera* (A. Wróblewski (ed.) In Bottom fauna of the heated Konin lakes). Monogr. Fauny Polski, Kraków, 7: 259–280.

BIESIADKA E. 1977b. Materials for a study on *Heteroptera*, *Coleoptera* and *Hydracarina* of small water bodies situated in the lignite opencast mine near Konin. Acta hydrobiol., Kraków, 19: 439–449.

BIESIADKA E. 1980. Water beetles (*Coleoptera*) of the eutrophic lake Zbęchy (Leszno voiv.). Pol. ecol. Stud. Warszawa, 6: 263–275.

BIESIADKA E. 1993. Środowiskowe rozmieszczenie chrząszczy (*Coleoptera*) wodnych w Karkonoszach. Wydawnictwo Uniwersytetu Wrocławskiego, Wrocław, p. 263–273.

CZACHOROWSKI S., LEWANDOWSKI K., WASILEWSKA A. 1993. The importance of aquatic insects for landscape integration in the catchment area of the River Gizela (Masurian Lake District, notheastern Poland). Acta hydrobiol., Kraków, 35: 49–64.

FRIDAY L. 1988. A key to the adults of British water beetles. Field Studies 7, 1–151

GALEWSKI K. 1971a. Chrząszcze – *Coleoptera*. Pływakowate – *Dytiscidae*. Klucze do ozn. Owad. Pol., Warszawa, 19: 1–122.

GALEWSKI K. 1971b. Pływakowate (*Coleoptera*, *Dytiscidae*) Bieszczadów. Fragm. faun., Warszawa, 17: 179–211

GALEWSKI K. 1979. Chrząszcze wodne (*Haliplidae*, *Dytiscidae*, *Gyrinidae* i *Hydrophilidae*) Pienin. Fragm. faun., Warszawa, 24: 227–281

GALEWSKI K., TRANDA E. 1978. Chrząszcze – *Coleoptera*. Fauna słodkowodna Polski. Warszawa, 10: 7–396

HILDT L. 1914. Krajowe owady wodne (*Hydrocanthares*) Pam. fizjograf., Warszawa, 22: 1–131.

HORION A. 1941. Faunistik der deutschen Käfer. I. *Adephaga* – *Caraboidea* – Krefeld, 464 pp.

KINEL J. 1924. Flisakowate i pływakowate z wycieczki Muzeum im. Dzieduszyńskich na Pomorze w r. 1922. Rozpr. Wiad. Muz. Dzieduszyńskich, Lwów, 9, 11pp.

KINEL J. 1948. *Hydradephaga* Polski i sąsiednich krain. Pol. Pismo ent., Wrocław, 18: 337–446.

KONDRACKI J. 1952. Uwagi o ewolucji morfologicznej Pojezierza Mazurskiego. Z badań czwartorzędu w Polsce. Biul. Pol. Inst. Geolog. , Warszawa, 65.

KORDYLAS A. 1990a. Water Beetles in the Pasłęka River, North-East Poland. The Balfour-Brown Club Newsletter, 46: 16–21.

KORDYLAS A. 1990b. Chrząszcze wodne (*Coleoptera*) lobeliowego jeziora Krzemno. Fragm. faun., Warszawa, 33: 71–81
KORDYLASA. 1994. An investigation of the water beetles of Polish springs. Latissimus 4: 9–11
KOWALIK W. 1968. Chrząszcze wodne (*Coleoptera aquatica*) jezior sosnowickich na Pojezierzu Łęczyńsko-Włodawskim. Ann. UMSC, Lublin, 18: 283–300.
KRACH W. 1932. Materiały do fauny chrząszczy (*Coleoptera*) wodnych Jeziora Kierskiego i wód przyległych. Pr. Kom. mat. przyr. Pozn. TPN, Poznań, B, 3: 2–20
ŁĘGOSZ-OWSIANNA D. 1955. Chrząszcze drobnych zbiorników okolic Poznania. Pr. Kom. mat – przyr. Pozn. TPN, Poznań, 16: 1–19
NALEPA T. 1987. Long-term changes in the macrobenthos of southern lake Michigan. Can. J. Fish. Aquat. Sci. Ottawa, 44: 515–524
PAWŁOWSKI I. 1966. Chrząszcze (*Coleoptera*) zebrane na plaży w okolicach Pobierowa na Pomorzu Zachodnim. Acta. Zool. Cracov., Kraków, 11: 387–396
PODGÓRNIAKR. 1960. Chrząszcze wodne wyspy Wolin. Bad. fzjogr. Pol.zach., Poznań, 6: 51–67
SZULCZEWSKI J. W. 1922. Chrząszcze Wielkopolski.Pr. Kom. mat-przyr. Pozn.TPN, ser. B, Poznań, 1: 183–243
TRANDA E. 1969. Krętakowate – *Gyrinidae*. Klucze do ozn. owad. Pol., Chrząszcze – *Coleoptera*, Warszawa, 8–19
TRANDA E. 1972. Fauna Niebieskich Źródeł. Chrząszcze wodne (*Coleoptera*). Zeszyt Nauk. U. Ł., Łódź, 2 (46): 65–73
WĘGRZECKI M. 1932. Dotychczasowe wyniki badań nad chrząszczami Helu. Fragm. Faun. Mus. Zool.Pol., Warszawa, 1: 465–505
ZAJČEV F. 1953. Nasiekomyje żestkokryłyje. Plavunčovyje i viertiački. Fauna SSSR. Moskva – Leningrad, 4: 1–377

STRESZCZENIE

[Tytuł: Zmiany w faunie chrząszczy wodnych (*Coleoptera aquatica*) Jeziora Luterskiego (Pojezierze Olsztyńskie) w latach 1981–1993.]

Badania nad fauną chrząszczy Jeziora Luterskiego położonego w północnej części Pojezierza Olsztyńskiego prowadzono w dwu okresach: – w roku 1981 – od kwietnia do listopada i w roku 1993 – od maja do października. Badania prowadzono w pasie górnego litoralu, rozciągniętym wzdłuż całej linii brzegowej jeziora, gdzie wyznaczono 10 stanowisk, uwzględniając następujące środowiska: dno niepiaszczyste bogate w złoża szczątków organicznych, napływki najpłytszego litoralu, turzycowiska, zbiorowiska z trzciną oraz zbiorowiska z sitem i sitowiem.

Zebrany materiał obejmuje łącznie 95 gatunków chrząszczy wodnych, należących do 7 rodzin: *Dytiscidae, Hydrophilidae, Haliplidae, Hydraenidae, Gyrinidae, Limnidae* oraz *Spercheidae*. W strukturze gatunkowej rodzin wyraźnie dominuje *Dytiscidae* (47 gatunków) a następnie *Hydrophilidae* (29 gatunków) i *Haliplidae* (10 gatunków). Odmiennie przedstawia się struktura liczebności całego zebranego materiału faunistycznego. Najliczniejsza jest rodzina *Haliplidae* (47% liczebności). Mniejszą liczebnością odznaczyły się rodziny *Dytiscidae* (42,8%) oraz *Hydrophilidae* (9,5%). Pozostałe rodziny charakteryzowały się małym zróżnicowaniem gatunkowym oraz bardzo niską liczebnością.

W strukturze gatunkowej na przestrzeni 13 lat nie obserwowano większych zmian. W obu okresach badań przeważały *Dytiscidae*, a następnie *Hydrophili-*

dae i *Haliplidae*. Zaszły natomiast poważne zmiany w strukturze ilościowej. Przede wszystkim zmniejszyła się liczebność *Haliplidae* z 52,2% w roku 1981 do 30,4% w późniejszym okresie badań. Równocześnie nastąpił poważny wzrost liczebności rodziny *Dytiscidae*. Zmiany te mieściły się w przedziale 38,8% – 55,7% materiału.

Gatunkami najliczniejszymi w Jeziorze Luterskim są: *Noterus crassicornis*, *Haliplus flavicollis* oraz *H. immaculatus*. Łącznie stanowią one 61,9% całości materiału. Dość powszechnie występują tu także *Hygrotus versicolor*, *Laccobius minutus*, *Hyphydrus ovatus Hygrotus inaequalis*, *Haliplus ruficollis* oraz *H. fluviatilis*.

W faunie chrząszczy wodnych badanego jeziora można wyróżnić 4 podstawowe elementy synekologiczne. Elementem najbardziej stabilnym w jeziorze jest element jeziorno – rzeczny, szczególnie typowy dla jezior słabo zeutrofizowanych. Jest on reprezentowany przez 9 gatunków, z których najliczniej występują: *Haliplus flavicollis*, *H. immaculatus* oraz *Hygrotus versicolor*. Drugim elementem, stanowiącym główną część fauny (76 gatunków), są chrząszcze związane z drobnymi wodami eutroficznymi. Jest to zarazem grupa tworząca element migracyjny, najbardziej labilny w faunie chrząszczy jeziora. Należy tu także zaliczyć 9 gatunków związanych z drobnymi wodami polihumusowymi oraz *Haliplus lineatocollis* i *Agabus guttatus* – gatunki charakterystyczne dla drobnych wód bieżących i źródeł.

W strukturze dominacji chrząszczy zasiedlającyc badane środowiska litoralowe, środowiskiem najliczniej zasiedlonym przez koleopterofaunę, były turzycowiska, w których zebrano łącznie w obu okresach badań 52 gatunki chrząszczy, z dominującym *Noterus crassicornis*. Średnie liczebności w obu okresach badań wyniosły tu 78,24 osobnika × m^{-2} – 61,1 osobnika × m^{-2}. Najuboższa fauna zasiedlała zbiorowiska z trzciną, gdzie dominował *Haliplus immaculatus*. Zmiany średnich liczebności mieściły się w przedziale 40,1 osobnika × m^{-2} – 18,91 osobnika × m^{-2}. Ponieważ środowiska te zajmują największą powierzchnię litoralu (70%), to one w największym stopniu decydują o obliczu faunistycznym fauny chrząszczy górnego litoralu Jeziora Luterskiego.

Cechą charakterystyczną Jeziora Luterskiego, podobnie jak i innych zbadanych jezior o tym samym charakterze, jest wysoka liczebność gatunków eurytopowych, związanych z wodami drobnozbiornikowymi. Znaczny wzrost tych gatunków na przestrzeni 13 lat, wskazuje na postępującą eutrofizację jeziora. Obecność jednak *Oulimnius tuberculatus* – gatunku uznawanego w Polsce za rzadki i typowy dla wód czystych, pozwala zaklasyfikować Jezioro Luterskie do słabo zeutrofizowanych.