10.2478/v10067-011-0007-3

ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA

VOL. LXV, 1 SECTIO C 2010

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Aquatic beetles (Coleoptera) of carbonate habitats in the vicinities of Chełm (eastern Poland)

Chrząszcze wodne (Coleoptera) siedlisk węglanowych w okolicach Chełma (Polska wschodnia)

SUMMARY

In the years 2008–2009 aquatic beetles (Coleoptera: Adephaga, Hydrophiloidea, Dryopoidea) of carbonate habitats were studied in the vicinity of Chełm. It is one of the most valuable natural areas of Poland, refugium of many rare species of plants and animals of xerothermophilic and aquatic habitats (mainly fens).

109 species of beetles were recorded (38% of Polish fauna among the studied families). In the research area *Berosus geminus* has the only site known in Poland which outlines the northern border of the whole species distribution area. On the edges of dense parts of their distribution areas there are also recorded sites of: *Gyrinus suffriani*, *Haliplus furcatus*, *Spercheus emarginatus*, *Hydrophilus aterrimus* and *Dryops anglicanus*. There were recorded 12 rare species occurring in Poland and five from the Polish Red List, as well as several rare and endangered species in the Lublin province.

Analysis of faunistic and ecological indicators proved that in the relatively habitat-homogenous research area, the most important for forming assemblages of beetles is the spatial structure of the water body. No correlation was displayed in the distance between the sites and their faunistic similarity, which indirectly indicates a low level of beetle migration.

Unmeliorated fens were characterized by the most natural fauna. With partial melioration it was deeply disturbed and very impoverished with stenotopic species. On completely meliorated fens fauna was again natural to a large extent, however, fen species occurred exclusively in ditches and canals, being very dependent on their form and human water management. Water fauna on carbonate habitats can be assessed as quite typical of fens in general – except for clearly evident presence of argilophilic species, which could result from a higher water reaction and larger fertility connected with a big amount of dissolved in water lime compounds.

Very interesting from ecological perspective and valuable for beetle protection turned out to be small water-courses of the research area, also those strongly transformed by human and even artificial ones. Their long sections have a structure which is favourable for species diversity and occurrence of valuable beetles.

The research area proved to be high quality refugium for aquatic beetles associated with dystrophic water bodies and small running waters.

STRESZCZENIE

W latach 2008–2009 badano chrząszcze wodne (Coleoptera: Adephaga, Hydrophiloidea, Dryopoidea) siedlisk węglanowych w okolicach Chełma. Jest to jeden z najcenniejszych przyrodniczo obszarów Polski, ostoja wielu rzadkich gatunków roślin i zwierząt siedlisk kserotermicznych i wodnych (głównie torfowiskowych).

Wykazano 109 gatunków chrząszczy (38% fauny krajowej badanych rodzin). *Berosus geminus* ma na terenie badań jedyne stanowisko znane w Polsce, które wyznacza granicę północną całego areału gatunku. Na skrajach zwartych części ich zasięgów leżą też stwierdzone stanowiska: *Gyrinus suffriani*, *Haliplus furcatus*, *Spercheus emarginatus*, *Hydrophilus aterrimus* i *Dryops anglicanus*. Stwierdzono 12 gatunków rzadkich w Polsce i pięć z krajowej Czerwonej listy oraz liczne gatunki rzadkie i zagrożone w skali województwa lubelskiego.

Analiza wskaźników faunistycznych i ekologicznych wykazała, że na stosunkowo jednorodnym siedliskowo obszarze badań najważniejsza dla kształtowania się zgrupowań chrząszczy jest struktura przestrzenna zbiornika. Nie wykazano korelacji między odległością liniową między stanowiskami a ich podobieństwem faunistycznym, co wskazuje pośrednio na niski poziom migracji chrząszczy.

Torfowiska niezmeliorowane cechowały się fauną najnaturalniejszą. Na torfowiskach zmeliorowanych częściowo fauna była silnie zaburzona i mocno uboższa w gatunki stenotopowe. Na torfowiskach zmeliorowanych całkowicie fauna była znów w dużym stopniu naturalna, jednak gatunki torfowiskowe występowały wyłącznie w rowach i kanałach, będąc silnie zależnymi od ich ukształtowania i od gospodarki wodnej człowieka. Faunę wód na torfowiskach węglanowych można ocenić jako dość typową dla torfowisk w ogóle. Wyjątkiem była obecność gatunków argilofilnych, mogąca wynikać z wyższego odczynu wody i większej żyzności związanej z dużą ilością rozpuszczonych w wodzie związków wapnia.

Bardzo interesujące ekologicznie i wartościowe dla ochrony chrząszczy okazały się drobne cieki terenu badań, także te silnie przekształcone przez człowieka a nawet sztuczne. Ich długie odcinki mają strukturę korzystną dla różnorodności gatunkowej i występowania interesujących chrząszczy.

Teren badań okazał się wysokiej rangi ostoją chrząszczy wodnych związanych ze zbiornikami dystroficznymi i z drobnymi wodami bieżącymi.

Key words: aquatic beetles, Coleoptera, assemblages, Poland, carbonate fen, protection, habitat degradation.

INTRODUCTION

The vicinities of Chełm are classified as the most valuable natural parts of Poland. There occur carbonate fens which are very rare in Poland, as well as refugia for many dying species of plants and animals (10). It is e.g.: habitat of about 25% of domestic vacuole population *Acrocephalus paludicola* (Vieill.) (26), one of two contemporary places in Poland where False Ringlets (*Coenonympha*

oedippus) occur (Fabr.) (21) and important refugium of *Cladium mariscus* (L.) Pohl. (9). Equally valuable are carbonate xerothermic habitats (35).

In comparison with the knowledge of flora, vertebrates or even land invertebrates, data about aquatic invertebrates are surprisingly scant. More detailed studies have been conducted only in case of water mites (31). There have also appeared initial data about dragonflies (15). Hence there are enormous research needs. We do not know composition and assemblage structure of particular groups of animals and their specificity towards other habitats and areas. We do not know for which species the waters in the vicinity of Chełm are important refugium in the range of the region, Poland or even Central Europe. And finally – how anthropogenic changes of habitats influence this state of affairs.

In the following study we present data about aquatic beetles from the discussed area. The studies were carried out mainly to answer the above questions. Because the research sites are located in a relatively small, flat and open area, there was also made an attempt to assess, to what extent the distance (indirectly – migration) influences the composition of beetle fauna. It was also checked whether sozological value of the sites is connected with selected measures of biological diversity.

STUDY AREA

The research area is situated in Volhynian Polesie (Polesie Wołyńskie). Its characteristic are ascending humps among plains, built from chalk marls and sandstones (30).

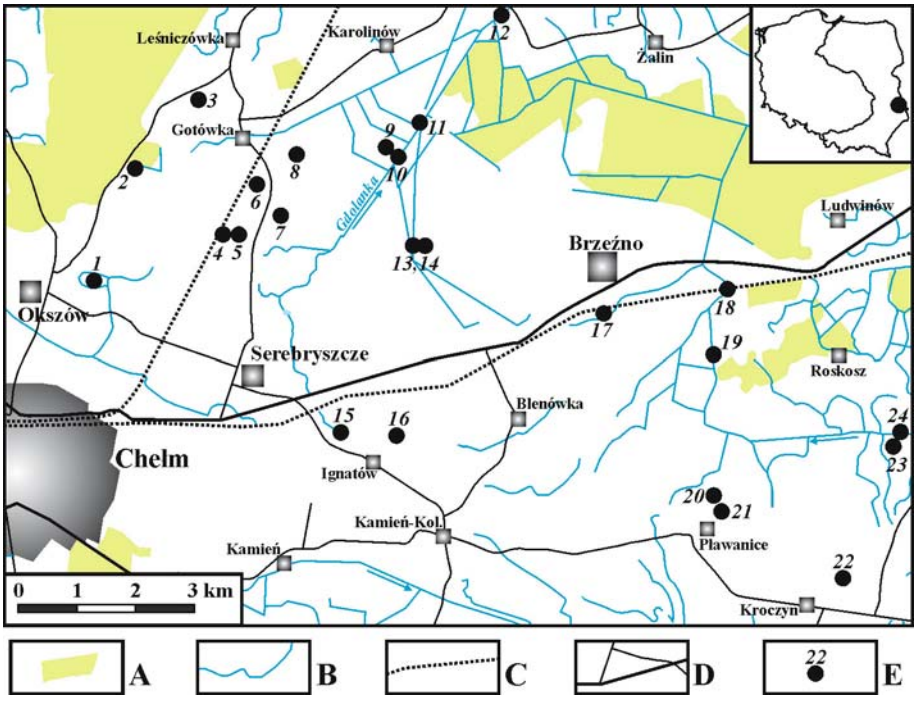

Fig. 1. Study area. A – forests; B – rivers, canals and drainage ditches; C – railways; D – main roads; E – study sites

The examined sites are located within the area of two mesoregions: Chełm Hills (Pagóry Chełmskie) (sites no 1–8) and Dubienka Depression (Obniżenie Dubienki) (the rest). Chełm Hills refers more to the Lublin Upland (Wyżyna Lubelska), however, hills forming it, built from upper cretaceous layers covered with sandstones have a monadnock character and do not form a dense upland, and depressions between them are filled with sands and marsh. Dubienka Depression is a continuation of Polesie Lowlands of Ukraine and Belarus, with several sandy and marshy depressions between small forms of the lay of the land connected with chalk ground (30).

The studied sites are situated in the above mentioned depressions between chalk humps or smaller forms of the lay of the land of the same origin. These depressions are filled with carbonate fens of various degree of conservation: from natural, usually under protection (nature reserves such as: "Bagno Serebryskie", "Brzeźno", "Gotówka"), through partly meliorated, to completely dried. Dominating here forms of area use are harvestable meadow and extensive pasture. In smaller area depressions or on the edges of fens complexes there are plentiful small water bodies: usually dystrophic, seldom eutrophic. Here and there small fish ponds are dug. Areas located higher, on cretaceous hills, are dominated by cultivable fields, mainly for cereals, potatoes, sugar beets and tobacco.

The whole research area is situated in the Bug basin. Its northern part is dewatered by Gdolanka, a tributary of the Uherka. Ditches and canals from the eastern part flow off to the Świerżowski Canal, feeding into Uherka, near its mouth to Bug; and from the southern part – to the Kacap stream, a tributary of the Udal River.

Physical and chemical properties of some water bodies on carbonate fens were examined by Radwan and Stępień (53) and Radwan et al. (54). They were characterized by: big fluctuations of temperature and oxygenation during vegetative season, neutral and alkaline reaction (pH 7.3–8.0), high concentrations of lime compounds (53.4–103.8 $mg \cdot dm^{-3}$), mean hardness (2.9–5.7 $mval \cdot dm^{-3}$), and high and very high electrolytic conductivity (476–1250 $\mu S \cdot cm^{-1}$). Despite high mineralization, the trophy of the water bodies was low (amount of general suspension: 0.0–3.5 $mg \cdot dm^{-3}$).

The research area is covered by the temperate transitory climatic zone with clearly evident influence of continental climate. Average yearly air temperature is about 7.4 °C, average temperature of July: 18.9 °C, January: 4.6 °C. Vegetative period lasts about 210 days, and its mean air temperature is 14.7 °C (61).

STUDY SITES

The examined 24 sites were selected in such a way as to take into account well-maintained and variously meliorated carbonate fens and watercourses dewatering them. In the research area other important habitats for beetles were taken into account as well. The sites were located at the height ranging from 152 to 188 meters above sea level (average: 169 m).

Below there are given brief descriptions of the sites, their location is shown in Figure 1:

1. Okszów, meliorated fen (51°09'50.7" N, 23°29'58.7" E) (Fig. 2). Open, with moist ground in spring only, gradually covering with meadow and ruderal flora. Water remains longer only in drainage ditches, although it dries up here in the 2nd half of summer. It is brown, clear and the bottom is covered with tyrphopel. Ditches are covered with aquatic and marsh flora with domination of *Carex appropinquata* Schum., here and there grow clusters of bushy willows.
2. Nowiny, small dystrophic water body (51°10'31.6" N, 23°31'27.2" E). Surrounded by strips of willows and alders. Size: 80x40 m, depth: to 60 cm, brown water, muddy bottom. Flora dominated by high, tufty sedges, coming from Magnocaricion with admixture of

Fig. 2. Drained carbonate fen in Okszów (locality no. 1) (July 2007)

Comarum palustre L., and with partially appearing *Phragmites australis* (Cav.) Trin. ex Steudel. Profusely occurring *Lemna trisulca* L. can indicate a progressing eutrophication.

3. Leśniczówka, water bodies in sandpit (51°11'33.5" N, 23°31'45.0" E). The pit with dimensions 110x50 m, situated in the open area but from one side it is enclosed by a strip of willows. On its bottom there are water bodies with depth to 0.5-1.0 m, from which some dry up in summer. In the used part water bodies are devoid of flora, the rest is covered by: rare rush – *Typha angustifolia* L. and tufts of *Juncus* sp. Water is yellowish, clear; bottom is sandy or sand and muddy. There occur small blooms of Zygnematophyceae.
4. Gotówka, unmeliorated fen (51°10'14.5" N, 23°32'05.9" E). Open, with clusters of bushy willows. Mossy ground, quite variable water level but the site does not dry. Flora is dominated by field rush *Carex* sp., partially occurs *Phragmites australis*.
5. Gotówka, a fish pond on the edge of farmlands and fen (51°10'14.8" N, 23°32'14.0" E) (Fig. 3). Dimensions: 80x20 m, depth: about 1.5 m, muddy bottom, clear and brownish water. Bank with field rush *Carex* sp. and low *Phragmites australis*. Bottom and the pelagic zone with *Myriophyllum* sp. and *Elodea canadensis* Michx (ex Rich.).
6. Gotówka, small dystrophic water body (51°10'53.2" N, 23°31'46.1" E). In depression among meadows, shaded by a strip of alders and willows. Dimensions: 50x10 m, depth: 1 m, muddy bottom, with leaves and branches, brown and clear water. It almost completely dries up in summer. The edge with a narrow strip of low *Carex* sp.
7. Gotówka, small dystrophic water body (51°10'15.9" N, 23°33'32.3" E). On the edge of an old orchard and peaty meadows there are ligneous willows. Dimensions:

Fig. 3. Fish pond in Gotówka (locality no. 5) (July 2007)

70x20 m, depth: 1 m, brown water, sandy and muddy bottom, with tree leaves. The edge with discontinuous strip of *Carex* sp. and flooded grass, on the water surface – *Lemna* spp.

8. Gotówka, small dystrophic water body (51°10’56.2” N, 23°33’17.6” E). A part of old, renaturalized small peat excavation on peaty meadow. Dimensions: 90x10 m, depth: to 1 m, brownish and clear water, muddy bottom covered with *Chara* sp. The edge with tufty rush *Carex* sp. with admixture of peat bog flora, on the water surface – not very profuse *Potamogeton natans* L. The water body surrounded by a strip of alders and willows.
9. Karolinów, meliorated fen (51°10’58.6” N, 23°34’46.5” E). Open, covered with meadow flora. In water-filled, shallow depressions there is dense field of *Molinia caerulea* (L.) Moench. with moist mossy ground. It dries up in summer.
10. Karolinów, main canal draining fen (51°10’57.6” N, 23°34’46.3” E). In the open area, width about 4 m, very slow current, greenish and murky water, muddy bottom. The edge with *Carex* sp., *Juncus* sp. and flooded grasses. The water surface with profuse *Lemna trisulca*.
11. Karolinów, fire water body – water uptake station on crossing of two canals (51°11’18.1” N, 23°35’05.5” E). Dimensions: 50x30 m, green and murky water, with the smell of methane, sandy and muddy bottom. The edge with flooded grasses, *Carex* sp., *Juncus* sp., here and there with bushy willows. The water surface covered with *Lemna trisulca*.
12. Gdola, the Gdolanka stream (51°12’50.9” N, 23°37’26.5” E) (Fig. 4). In the open area, among meliorated peaty meadows. Regulated, width about 5 m, depth to 1 m, slow current, brown and slightly muddy water, muddy bottom. The edge with a strip of flooded grasses, with admixture of rush flora and *Lemna trisulca*.

Fig. 4. Stream Gdolanka in Gdola (locality no. 12) (May 2009)

13. Kolonia Kępa, the Gdolanka stream in the Serebryskie Marsh (Bagno Serebryskie) (51°10'05.6" N, 23°34'57.7" E). Open area (fen). Regulated watercourse, width: 1–2 m, depth: to 0.4 m, brown and clear water, very slow current, bottom with tyrphopel. The whole channel covered with rare peat bog flora.
14. Kolonia Kępa, fen – Serebryskie Marsh (Bagno Serebryskie) (51°10'07.8" N, 23°34'52.7" E). Unmeliorated, with high, stable water level. Among flora dominates *Carex* sp. (field rush) with admixture of *Phragmites australis*, here and there patches of bushy willows.
15. Ignatów, eutrophic water body in sink hole (51°08'20.1" N, 23°34'46.2" E) (Fig. 5). Surrounded with a cornfield. Dimensions: 80x60 m, loamy and muddy bottom, with the smell of methane, water-slightly brown and murky. The edge with rush – *Typha* spp. with admixtures of *Carex* sp. and *Juncus* sp., here and there with bushy willows. The pelagic zone and water surface with profuse *Lemna trisulca* and *L. minor* L. In some places – patches of *Nuphar lutea* (L.) Sibth. et Sm.
16. Kolonia Ignatów, canal (51°08'51.6" N, 23°36'56.4" E) (Fig. 6). Among meliorated peaty meadows, partially covered with bushy willows. Width: about 2 m, depth: to 0.7 m, sandy and muddy bottom, colourless and clear water. Slow current, stable water level. Flora: *Phragmites australis*, *Typha* sp., *Juncus* sp., flooded grasses, *Lemna* spp.
17. Kolonia Brzeźno, fen (51°08'57.8" N, 23°37'46.9" E). Unmeliorated, in depression of the area surrounded by a narrow strip of willows. Dominating flora: tufty, high rush *Carex* sp. with occurring *Phragmites australis* and with admixtures of peaty plants (*Comarum palustre*, *Calla palustris* L. etc.). Water level – high, little variable.

Fig. 5. Eutrophic water body in a carbonate depression in Ignatów (locality no. 15) (May 2009)

Fig. 6. Canal in Kolonia Ignatów (locality no. 16), the most important study site for the protection of aquatic beetles (April 2008)

Fig. 7. Not meliorated carbonate fen in Pławanice (locality no. 20) (July 2007)

18. Kolonia Roskosz, canal draining the reserve "Roskosz" (51°09'46.1" N, 23°39'42.9" E). Flowing out from dystrophic dam before railway line, flowing in the open area. Width: 1–2 m, depth: 0.2–0.7 m, water – brown and clear, slow current, sandy bottom. The edge with flooded grasses and tufts of *Juncus* sp.
19. Kolonia Roskosz, drainage ditch (51°09'20.5" N, 23°40'31.3" E). Between dried fen and farm land, in the open area. Width: 2 m, depth: 0,4 m, slow current, brown and clear water, sandy and muddy bottom, with tree leaves. The ditch slope with bushy willows, the edge and centre with profuse flora (such as flooded grasses, *Carex* sp., *Juncus* sp., *Lemna* spp.). Water level – very variable, in summer the ditch completely dries up.
20. Pławanice, fen (51°08'12.4" N, 23°40'18.4" E) (Fig. 7). Unmeliorated. Open area, with patches of bushy willows. Part of fen with high, field rush *Carex* sp. on mossy ground, part with rush *Cladium mariscus* with admixture of *Phragmites australis*, with the ground of *Chara* sp. Water level – high and stable.
21. Pławanice, small dystrophic water body (51°07'43.3" N, 23°40'19.2" E) (Fig. 8). Open area, on the edge of farmlands and fens. Dimensions: 35x8 m, depth: 0.2–0.8 m, brown and clear water, muddy bottom. The water body covered with dense rush, with domination of *Heleocharis palustris* (L.) Roem. et Sch. (shallow edge) and *Typha latofilia* L. (deeper central part).
22. Kroczyn, fen (51°08'13.8" N, 23°42'53.1" E). Meliorated but not completely dried up. For most of the year the ground is moist, ruderal plants do not appear yet although there is a clear expansion of reed. Water remains in drainage ditch which is 2 m wide and 0.6 m deep, with muddy bottom. The ditch edges are covered with bushy willows, here and there

Fig. 8. Natural dystrophic small water body between fens and agricultural fields in Pławanice (locality no. 21), the second most important study site for the protection of aquatic beetles (July 2007)

growing also in the central part. In places without willows there remains typical fenny flora, with admixture of *Lemna trisulca*.

23. Kroczyn, fen (51°08'21.9" N, 23°42'10.3" E) (Fig. 9). Meliorated, although not completely dried up. Open, covered with meadow vegetation. Water-filled shallow depressions are covered with dense field of *Carex nigra* (L.) Reihard. with admixture of *C. flava* L. and *C. hirta* L. For most of the year those little basins remain at least partly filled with water and even if they dry up, there are fragments with moist mossy ground left.
24. Kroczyn, main canal in fen (51°08'21.8" N, 23°42'14.1" E). In the open area, surrounded by a strip of bushy willows. Width: 2 m, depth: 1 m, slow current, brown and clear water, sandy and muddy bottom. The edge with tufts of *Carex* sp. and *Juncus* sp. and with flooded grasses. Before culvert under road the canal is dammed, with water surface covered thickly with *Lemna trisulca*. Below culvert there is a fragment with clear flow and exposed mineral bottom (sand).

The examined sites are situated in three squares of the UTM grid: FB77 (no 1–9), FB87 (no 10–19), FB86 (no 20–24).

MATERIAL AND METHODS

The material was collected in the years 2008–2009, from April to October. There were collected semiquantitative samples with the use of hydrobiological scoop; 5 samples were collected from each site. The material was sorted out in the same place, beetles were preserved in 70%–ethanol and other

Fig. 9. Temporary drying out water body in a partially drained carbonate fen in Kroczyn (locality no. 23) (June 2009)

animals were set free to water. 120 samples were collected, beetles were founded in 105 of them. The analysed material consists of 52 larvae and 2,433 imagines.

The site location was defined by device Garmin GPSMap 60CS. In determining sizes of the examined water bodies, satellite pictures of the programme Google Earth were used.

Indexes used in the statistical analysis of the material are: domination, frequency in samples, quality and quantity similarity (formulae of Jaccarda and of Biesiadka), PIE (Probability of Interspecific Encounters), linear correlation of Pearson (8, 33, 36, 58). Correlations were calculated by the programme Statistica 9.0. Domination and frequency categories were accepted according to Trojan (59), with addition of a class of eudominants (>10%). Similarity values were arranged with the use of the method of Wrocław dendrite (28

In significance assessment of the sites and research area for protection of aquatic beetles, index of sozological importance (20) was used.

RESULTS

In the collected material 109 species of aquatic beetles were found. Its small part, mainly larvae of younger stages, was defined only as genus or subfamily (Tab. 1).

Tab. 1. Aquatic beetles recorded in carbonate habitats in the vicinity of Chełm in the years 2008–2009. NS – number of samples [Σ=120], Img – number of imagines [Σ=2433], Lrv – number of larvae [Σ=52], Σ – total number of specimens collected, D – dominance [%]. Habitat distribution – numbers of specimens collected in various habitats: A – well preserved fens, B – partially meliorated fens, C – drainage ditches in fully meliorated fens, D – main canals, E – streams, F – dystrophic water bodies, G – eutrophic water bodies, H – artificial habitats (fish pond, sand pit, fire-fighting water basin)

No.	Species	Material collected					Localities no.	Habitat distribution							
		NS	Img	Lrv	Σ	D		A	B	C	D	E	F	G	H
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gyrinidae															
1.	*Gyrinus marinus* Gyll.	3	48	–	48	1.93	3, 5	–	–	–	–	–	–	–	48
2.	*G. minutus* Fabr.	1	1	–	1	0.04	13	–	–	–	–	1	–	–	–
3.	*G. natator* (L.)	9	42	–	42	1.69	5, 13, 14, 16, 18, 24	3	–	2	21	15	–	–	1
4.	*G. paykulli* Ochs	1	4	–	4	0.16	16	–	–	–	4	–	–	–	–
5.	*G. substriatus* Steph.	12	34	–	34	1.37	3, 5, 12-14, 18, 24	1	–	6	18	5	–	–	4
6.	*G. suffriani* Scriba	2	66	–	66	2.66	5, 16	–	–	–	63	–	–	–	3
–.	*Gyrinus* sp.	1	–	2	2	0.08	5	–	–	–	–	–	–	–	2
Haliplidae															
7.	*Haliplus flavicollis* Sturm	1	4	–	4	0.16	5	–	–	–	–	–	–	–	4
8.	*H. fluviatilis* Aubé	3	3	–	3	0.12	2, 5, 19	–	–	1	–	–	1	–	1
9.	*H. fulvicollis* Er.	1	1	–	1	0.04	21	–	–	–	–	–	1	–	–
10.	*H. furcatus* Seidl.	6	8	–	8	0.32	2, 7, 16, 19, 21	–	–	1	2	–	5	–	–
11.	*H. immaculatus* Gerh.	3	4	–	4	0.16	10-12	–	–	–	1	1	–	–	2
12.	*H. laminatus* (Schall.)	1	1	–	1	0.04	18	–	–	1	–	–	–	–	–
13.	*H. obliquus* (Fabr.)	6	11	–	11	0.44	5, 8, 11, 16	–	–	–	2	–	7	–	2
14.	*H. ruficollis* (De G.)	46	157	–	157	6.32	6-17, 19, 21, 22, 24	11	2	9	52	13	55	5	10
15.	*H. sibiricus* Motsch.	4	7	–	7	0.28	5, 7, 11, 12	–	–	–	–	1	1	–	5
16.	*H. variegatus* Sturm	2	2	–	2	0.08	16, 24	–	–	–	2	–	–	–	–
17.	*Peltodytes caesus* (Duftschm.)	1	1	–	1	0.04	17	1	–	–	–	–	–	–	–
Noteridae															
18.	*Noterus clavicornis* (De G.)	2	3	–	3	0.12	16	–	–	–	3	–	–	–	–

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
19.	*N. crassicornis* (O.F. Müll.)	35	117	–	117	4.71	2, 4, 5, 8-17, 21, 22	42	2	2	19	6	40	3	3
Dytiscidae															
20.	*Agabus bipustulatus* (L.)	1	1	–	1	0.04	17	1	–	–	–	–	–	–	–
21.	*A. clypealis* (Thoms.)	1	2	–	2	0.08	16	–	–	–	2	–	–	–	–
22.	*A. labiatus* (Brahm.)	1	3	–	3	0.12	22	–	–	3	–	–	–	–	–
23.	*A. paludosus* (Fabr.)	1	1	–	1	0.04	1	–	–	1	–	–	–	–	–
24.	*A. pseudoclypealis* Scholz	1	3	–	3	0.12	16	–	–	–	3	–	–	–	–
25.	*A. undulatus* (Schrank)	12	33	–	33	1.33	6-8, 10, 17, 19, 21	2	–	5	1	–	25	–	–
26.	*A. unguicularis* (Thoms.)	4	5	–	5	0.20	4, 17, 22	4	–	1	–	–	–	–	–
–.	*Agabus* sp.	1	–	1	1	0.04	22	–	–	1	–	–	–	–	–
27.	*Ilybius ater* (De G.)	6	6	–	6	0.24	8, 16, 22, 24	–	–	1	3	–	2	–	–
28.	*I. fenestratus* (Fabr.)	7	10	–	10	0.40	8, 10-12, 15, 24	–	–	–	4	2	1	1	2
29.	*I. quadriguttatus* (Lacord.)	7	11	–	11	0.44	4, 6, 12, 14, 16, 22	3	–	2	1	4	1	–	–
30.	*I. subtilis* (Er.)	1	1	–	1	0.04	19	–	–	1	–	–	–	–	–
–.	*Ilybius* sp.	3	–	5	5	0.20	4, 19, 21	3	–	1	–	–	1	–	–
31.	*Colymbetes fuscus* (L.)	1	1	–	1	0.04	15	–	–	–	–	–	–	1	–
32.	*C. striatus* (L.)	7	7	–	7	0.04	5, 8, 9, 12, 17	1	1	–	–	2	2	–	1
–.	*Colymbetes* sp.	1	–	1	1	0.28	12	–	–	–	–	1	–	–	–
33.	*Rhantus exsoletus* (Forst.)	5	5	–	5	0.20	5, 12, 23, 24	–	1	–	1	2	–	–	1
34.	*R. frontalis* (Marsh.)	4	5	–	5	0.20	8, 15, 23	–	2	–	–	–	1	2	
35.	*R. grapii* (Bergstr.)	4	5	–	5	0.20	9, 11, 13, 19	–	1	3	–	1	–	–	1
36.	*R. suturalis* (Mac. L.)	2	2	–	2	0.08	5, 15	–	–	–	–	–	–	1	1
–.	*Rhantus* sp.	1	–	1	1	0.04	12	–	–	–	–	1	–	–	–
–.	*Colymbetinae* n.det.	3	–	4	4	0.16	3, 12, 23	–	–	–	–	1	–	–	3
37.	*Liopterus haemorrhoidalis* (Fabr.)	7	8	–	8	0.32	4, 6, 8-10, 22	2	1	1	1	–	3	–	–
38.	*Acilius canaliculatus* (Nic.)	8	9	–	9	0.36	7, 8, 11, 13, 14, 16, 24	1	–	–	2	2	3	–	1
39.	*A. sulcatus* (L.)	8	9	–	9	0.36	3, 5, 7, 11, 18	–	–	1	–	–	2	–	6
40.	*Graphoderus cinereus* (L.)	1	2	–	2	0.08	10		–	–	2	–	–	–	–
41.	*Cybister lateralimarginalis* (De G.)	2	–	4	4	0.16	3	–	–	–	–	–	–	–	4
42.	*Dytiscus circumcinctus* Ahr.	3	–	8	8	0.32	7, 8, 23	–	1	–	–	–	7	–	–

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
43.	*D. dimidiatus* Bergstr.	10	8	5	13	0.52	2, 5, 7, 10-12, 16, 18	–	–	2	2	2	5	–	2
44.	*D. marginalis* L.	6	1	10	11	0.44	3, 5, 7, 17, 21	1	–	–	–	–	2	–	8
–.	*Dytiscus* sp.	2	–	7	7	0.28	12, 23	–	3	–	–	4	–	–	–
45.	*Hydaticus continentalis* Balf.-Br.	2	2	–	2	0.08	23, 24	–	1	–	1	–	–	–	–
46.	*H. seminiger* (De G.)	14	23	–	23	0.93	3, 4, 8, 9, 13, 16, 17, 20, 22, 23	10	4	3	2	1	1	–	1
47.	*H. transversalis* (Pontopp.)	10	12	–	12	0.48	7, 8, 12, 16, 21, 24	–	–	–	3	1	8	–	–
–.	*Hydaticus* sp.	1	–	1	1	0.04	12	–	–	–	–	1	–	–	–
48.	*Bidessus unistriatus* (Goeze)	3	4	–	4	0.16	10, 20, 21	1	–	–	2	–	1	–	–
49.	*Hydroglyphus geminus* (Fabr.)	6	8	–	8	0.32	5, 11, 12, 15, 24	–	–	–	1	3	–	1	3
50.	*Graptodytes bilineatus* (Sturm)	1	1	–	1	0.04	4	1	–	–	–	–	–	–	–
51.	*G. granularis* (L.)	23	77	–	77	3.10	1, 4-7, 10-12, 16-18, 20-22, 24	24	–	9	3	1	36	–	4
52.	*G. pictus* (Fabr.)	12	21	–	21	0.85	4, 10-12, 16, 18, 22	3	–	5	3	9	–	–	1
53.	*Hydroporus angustatus* (Sturm)	14	40	–	40	1.61	1, 4, 5, 8, 10, 11, 16, 17, 21, 22	21	–	4	7	–	5	–	3
54.	*H. erytrocephalus* (L.)	10	19	–	19	0.76	4, 7, 12, 17, 19, 24	5	–	1	1	4	8	–	–
55.	*H. fuscipennis* Schaum	3	3	–	3	0.12	7, 21	–	–	–	–	–	3	–	–
56.	*H. glabriusculus* Aubé	1	2	–	2	0.08	22	–	–	2	–	–	–	–	–
57.	*H. incognitus* Sharp	1	2	–	2	0.08	12	–	–	–	–	2	–	–	–
58.	*H. notatus* Sturm	6	10	–	10	0.40	4, 17, 22	7	–	3	–	–	–	–	–
59.	*H. palustris* (L.)	15	40	–	40	1.61	6, 7, 10-12, 16, 18, 19, 22	–	–	5	6	10	16	–	3
60.	*H. planus* (Fabr.)	4	4	–	4	0.16	6, 17, 22	2	–	1	–	–	1	–	–
61.	*H. rufifrons* (O.F. Müll.)	4	6	–	6	0.24	9, 15, 17, 19	3	1	1	–	–	–	1	–
62.	*H. striola* (Gyll.)	13	47	–	47	1.89	1, 4, 17, 19, 21, 22, 24	16	–	16	4	–	11	–	–
63.	*H. tristis* (Payk.)	5	11	–	11	0.44	1, 4, 22	5	–	6	–	–	–	–	–
64.	*H. umbrosus* (Gyll.)	14	45	–	45	1.81	4, 5, 11, 17, 21, 22	27	–	9	–	–	7	–	2
65.	*Porhydrus lineatus* (Fabr.)	22	75	–	75	3.02	2, 5-9, 10, 11, 13, 16, 21	–	–	–	6	1	24	–	44
66.	*Suphrodytes dorsalis* (Fabr.)	31	66	–	66	2.66	1, 2, 4, 6-8, 10, 14, 16, 17, 20-22, 24	18	–	6	19	23	–	–	–
67.	*Hygrotus decoratus* (Gyll.)	9	18	–	18	0.72	4, 12, 17, 21, 24	9	–	–	1	3	4	–	–
68.	*H. impressopunctatus* (Schall.)	11	23	–	23	0.93	9, 12, 14-17, 23, 24	7	6	–	2	6	–	3	–
69.	*H. inaequalis* (Fabr.)	22	39	–	39	1.57	3, 5-8, 10-13, 15, 16, 21, 22, 24	–	–	1	8	6	14	1	8

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
70.	*Hyphydrus ovatus* (L.)	31	139	–	139	5.59	5, 7, 10-14, 16-18, 22-24	4	1	4	66	32	16	–	16
–.	*Hydroporinae* n.det.	2	1	2	3	0.12	23	–	3	–	–	–	–	–	–
71.	*Laccornis oblongus* (Steph.)	2	2	–	2	0.08	7, 22	1	–	1	–	–	–	–	
72.	*Laccophilus hyalinus* (De G.)	3	6	–	6	0.24	5, 12	–	–	–	–	2	–	–	4
73.	*Laccophilus minutus* (L.)	6	15	–	15	0.60	3, 5, 11, 12, 15	–	–	–	–	1	–	1	13
74.	*Laccophilus poecilus* Klug	3	5	–	5	0.20	10, 15, 17	2	–	–	2	–	–	1	–
Helophoridae															
75.	*Helophorus aquaticus* (L.)	1	1	–	1	0.04	24	–	–	–	1	–	–	–	–
76.	*H. flavipes* Fabr.	2	3	–	3	0.12	12, 16	–	–	–	1	2	–	–	–
77.	*H. granularis* (L.)	15	43	–	43	1.73	3, 7, 10, 12, 14-17, 20, 21, 23, 24	3	2	–	20	7	6	3	2
78.	*H. minutus* (Fabr.)	4	4	–	4	0.16	3, 12, 23	–	1	–	–	2	–	–	1
Hydrochidae															
79.	*Hydrochus crenatus* (Fabr.)	6	12	–	12	0.48	12, 16, 17, 21	3	–	–	1	5	3	–	–
Spercheidae															
80.	*Spercheus emarginatus* (Schall.)	3	4	–	4	0.16	16, 21, 23	–	2	–	1	–	1	–	–
Hydrophilidae															
81.	*Anacaena limbata* (Fabr.)	46	311	–	311	12.52	1, 4, 5, 7-12, 15-17, 19-23	54	21	99	29	6	75	2	25
82.	*A. lutescens* (Steph.)	26	115	–	115	4.63	6, 6-12, 16, 17, 19, 21-24	7	7	11	10	67	13	–	2
83.	*Berosus geminus* Reich. Saulcy	1	2	–	2	0.08	7	–	–	–	–	–	2	–	–
84.	*B. luridus* (L.)	7	10	–	10	0.40	7, 11, 17, 21, 23, 24	2	2	–	1	–	4	–	1
85.	*Chaetarthria seminulum* (Herbst)	1	1	–	1	0.04	1	–	–	1	–	–	–	–	–
86.	*Cymbiodyta marginella* (Fabr.)	14	29	–	29	1.17	2, 4, 6, 12, 15, 17, 21	9	–	–	–	1	15	3	–
87.	*Enochrus affinis* (Thunb.)	11	22	–	22	0.89	3, 12, 15, 17, 20, 21, 23	8	5	–	–	2	4	2	1
88.	*E. coarctatus* (Gredl.)	31	107	–	107	4.31	1-5, 7, 9, 12, 15-17, 19-23	51	4	14	3	7	19	7	2
89.	*E. ochropterus* (Marsh.)	11	20	–	20	0.80	4, 8, 14, 15, 17, 21, 22	15	–	1	–	–	3	1	–
90.	*E. quadripunctatus* (Herbst)	2	2	–	2	0.08	21, 23	–	1	–	–	–	1	–	–
91.	*E. testaceus* (Fabr.)	9	11	–	11	0.44	2, 5, 10, 11, 13, 17, 21	1	–	–	1	1	6	–	2
92.	*Helochares obscurus* (O.F. Müll.)	25	61	–	61	2.45	4, 7-12, 14, 15, 17, 21, 23	11	6	–	2	2	30	6	4
93.	*Hydrobius fuscipes* (L.)	22	35	–	35	1.41	4, 6-9, 12, 15-17, 19, 21-23	3	4	6	1	1	19	1	–

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
94.	*Hydrochara caraboides* (L.)	13	22	–	22	0.89	2, 6-9, 11, 12, 15, 19, 21, 23	–	8	2	–	3	6	2	1
95.	*Hydrophilus aterrimus* Eschsch.	1	1	–	1	0.04	23	–	1	–	–	–	–	–	–
96.	*Laccobius bipunctatus* (Fabr.)	6	9	–	9	0.36	2, 12, 16, 17, 24	1	–	–	5	2	1	–	–
97.	*L. minutus* (L.)	19	26	–	26	1.05	3, 5, 8, 10-12, 14-17, 21, 22, 24	2	–	3	8	2	2	1	8
98.	*Coelostoma orbiculae* (Fabr.)	4	4	–	4	0.16	10, 15, 17	2	–	–	1	–	–	1	–
99.	*Cercyon convexiusculus* Steph.	2	2	–	2	0.08	15, 19	–	–	1	–	–	–	1	–
Hydraenidae															
100.	*Hydraena palustris* Er.	6	9	–	9	0.36	4, 12, 16, 18, 21	1	–	1	1	4	2	–	–
101.	*H. riparia* Kug.	3	4	–	4	0.16	16, 17, 22	1	–	1	2	–	–	–	–
102.	*Limnebius aluta* Bed.	8	11	–	11	0.44	4, 16, 17, 20-22	4	–	1	2	–	4	–	–
103.	*L. atomus* Duttschm.	6	29	–	29	1.17	3, 8, 12, 16, 23	–	4	–	1	20	1	–	3
104.	*L. crinifer* Rey	2	2	–	2	0.08	22	–	–	2	–	–	–	–	–
105.	*L. papposus* Muls.	1	1	–	1	0.04	12	–	–	–	–	1	–	–	–
106.	*L. parvulus* (Herbst)	20	74	–	74	2.98	4, 6, 8, 11, 12, 14, 16-23	22	3	10	5	–	9	–	1
107.	*Ochthebius minimus* (Fabr.)	11	17	–	17	0.68	6, 7, 12, 16, 17, 21, 22	3	–	4	1	2	7	–	–
Dryopidae															
108.	*Dryops anglicanus* Edw.	3	3	–	3	0.12	4, 17	3	–	–	–	–	–	–	–
109.	*D. auriculatus* Geoffr.	6	7	–	7	0.28	4, 5, 6, 8, 17	3	–	–	–	3	–	–	1

Below there are listed more specific observations concerning some species which are interesting because of their location, ecological requirements and legal protection. The sites numbers are given in square brackets:

- *Gyrinus suffriani* – [16] 21 X 2008, 63 exx. on the edge of current and littoral zone, together with one specimen of *Gyrinus paykulli*;
- *Haliplus fulvicollis* – [21] 28 VII 2008, 1 ex. in rush of *Heleocharis palustris*;
- *Haliplus furcatus* – [2] 23 VII 2008, 1 ex. in tuft of *Carex* sp.; [7] 29 IV 2008, 1 ex. among flooded grasses on the edge of water body; [16] 28 IV 2008, 1 ex. and 28 VII 2008, 1 ex.; [19] 28 VII 2008, 1 ex. among littoral tufts *Carex* sp.; [21] 28 VII 2008, 3 exx. in the rush of *Heleocharis palustris*;
- *Haliplus immaculatus* – [10] 29 IV 2008, 1 ♂; [11] 29 VII 2008, 2 exx.; [12] 21 V 200, 1 ex.;
- *Haliplus variegatus* – [16] 21 IX 2008, 1 ex. in coastal strip of flooded grasses; [24] 7 VIII 2009, 1 ex. among flooded grasses by the concrete culvert under the road;
- *Agabus clypealis* – [16] 28 IV 2008, 2♂♂ in coastal strip of flooded grasses, along with *A. pseudoclypealis*;
- *Agabus pseudoclypealis* – [16] 28 IV 2008, 2♂♂ 1♀ (vide *A. clypealis*);
- *Hydroporus incognitus* – [12] 21 V 2009, 2 exx.;
- *Spercheus emarginatus* – [16] 21 VIII 2008, 1 ex. in grass roots by the shore; [21] 21 X 2008, 1 ex. in the rush of *Heleocharis palustris*; [23] 7 VIII 2009, 1 ex. in the rush of *Carex nigra*;
- *Berosus geminus* – 29 IV 2008, 2♂♂ among *Lemna* spp. and stems of flooded grasses by the shore;
- *Hydrophilus aterrimus* – [23] 1 V 2009, 1 ex. in the rush of *Carex nigra*;
- *Limnebius aluta* – [4] 21 VIII 2008, 1 ex. in moist moss; [16] 27 VII 2008, 2 exx.; [17] 27 VII 2008, 1 ex., 21 VIII 2008, 1 ex. in the rush of *Carex* sp.; [20] 21 VIII 2008, 1 ex. in the rush of *Carex* sp.; [21] 27 VII 2008, 2 exx.; [17] 27 VII 2008, 2 exx. in the rush of *Heleocharis palustris*; [22] 21 VIII 2008, 1 ex. in the tuft of *Carex* sp. on the edge of the ditch;
- *Dryops anglicanus* – [4] 29 VII 2008, 1 ex. on very marshy mossy ground in the rush of *Carex* sp.; [17] 28 VII 2008 and 21 X 2008, by 1 ex. in flooded strip of alders on the edge of fen.

The only eudominant in the material collected was *Anacaena limbata* (12.5%). There were also found: two dominants (*Haliplus ruficollis* and *Hyphydrus ovatus*), 9 subdominants, 14 recedents and 84 subrecedents (Tab. 1).

In the biggest number of sites there were caught: *Haliplus ruficollis* and *Anacaena limbata* (16 of them) and *Noterus crassicornis* and *Suphrodytes dorsalis* (15 of them). In total there were 9 common species caught in more than half of the

examined sites. Most species were very rare, registered only in 1–2 sites (<10%) – as many as 37 (Table 1).

The most often caught species were: *Haliplus ruficollis* and *Anacaena limbata* (43.8% of samples) and *Noterus crassicornis* (33.3%). The value of frequency index of over 10% was achieved by 29 species altogether, in the range of 5.1–10.0% – 26 species, 2.1–5.0% – 21 species, 1.1–2.0 – 11 species and ≤1.0% – 22 (Table 1).

In particular sites there were caught 14–300 specimens (average 38) and 13–43 species (average 23). Within each of the distinguished types of water there were recorded both sites with fauna of a rich quality and quantity, as well as of poor. It indicates a bigger (at least in the examined area) significance of spatial structure of a given water body than by general kind of habitat.

Faunistic qualitative similarities between sites were fluctuated in the range of 0-58,8% (average 18.8%), quantitative ones: 0-26.9% (average 8.2%). The value 0% they took only once, for sites no 9 and 18. Similarities were not in accordance with water types and site arrangement in quality and quantity analysis was different. However, in both analyses, on the biggest levels of similarity were grouped the same sites: 4, 17, 22 and 21.

No correlation was stated between the sites' distance and faunistic qualitative similarity (r = -0.0211) or quantitative similarity (r = -0.0898) (Fig. 10). Both correlations were also statistically insignificant.

In particular water types there were noted 23–61 species of beetles. The smallest number was in a small eutrophic water body and the biggest – in canals and small dystrophic water bodies. Quite rich were also faunas: of unmeliorated fens, ditches in meliorated fens and anthropogenic lentic waters (Table 1).

Qualitative similarities between the studies water types fluctuated in the range 18.0–52.5% (average 34.8%), quantitative similarities: 5.3–26.1% (average 14.5%). In both analyses the lowest values were taken for ditches in meliorated fens and eutrophic water body.

The site structure in Wrocław dendrites (Fig. 11) was similar. In both dendrites the eutrophic water body has the biggest distinction, both are also characterized by the same habitat block covering all water types apart from partly meliorated fens and eutrophic water body. Also in both dendrites, the highest similarity values were the features of unmeliorated fens and small eutrophic water bodies.

As regards ecological requirements, in the collected material eurytopic species dominate: 61.5% of species and 68.9% of specimens. The second are tyrphophiles: 27.5% and 23.4%. Next places in this category have: hylophiles (adequately 4.6 and 3.9%), reophiles (4.6 and 3.2%), argilophiles (0.9 and 0.3%), psammophiles (0.9 and 0.2%) and halophiles (0.9 and <0.1%).

Two most profusely represented ecological elements had also the widest spectrum of occupied habitats – covering all the examined waters. Hylophiles

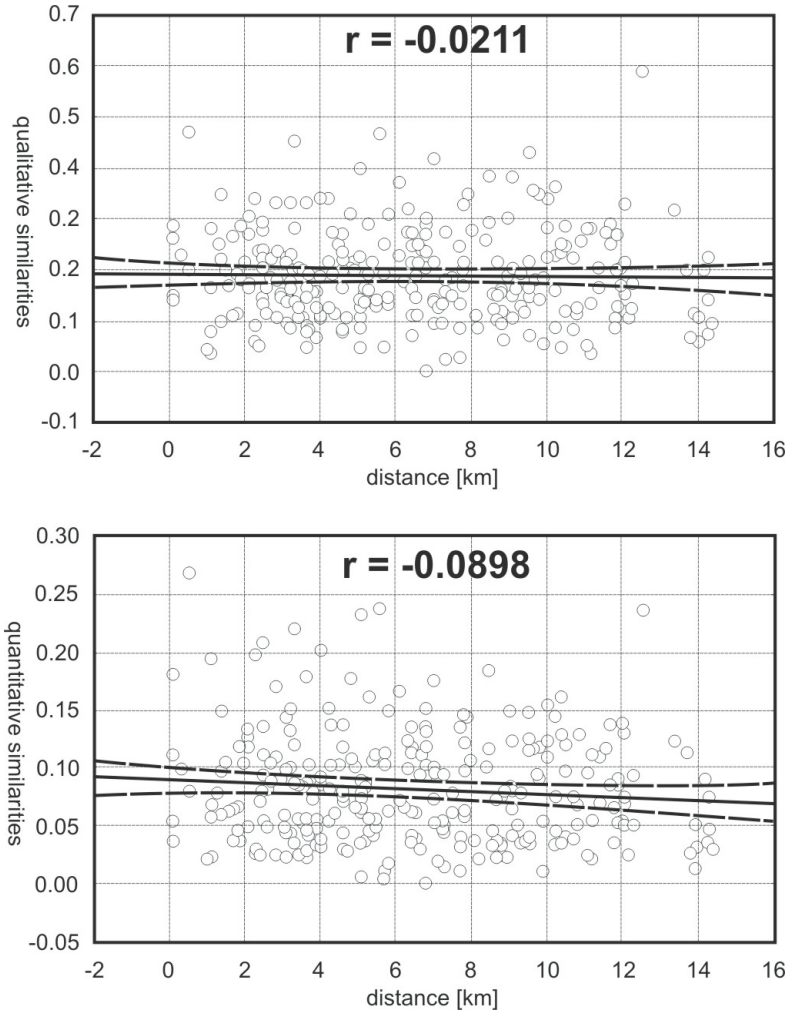

Fig. 10. Correlation between the distance between localities and the faunistic similarities: the qualitative ones (upper diagram) and the qualitative ones (lower diagram)

were noticed in 7 water types, reophiles in 6, argilophiles in 5, halophiles and psammophiles in 2 (Fig. 12).

The biggest domination of eurytopic species was preserved in anthropogenic lentic waters (87.3% of specimen collected) and partly meliorated fens (81.3%). However, the lowest was in unmeliorated fens (52.1%). Participation of tyrphophiles was the highest in unmeliorated fens (43.4%), the highest value was also achieved in streams (32.9%), while the lowest – in canals (only 9.9%) (Fig. 11). Between the size of these two elements a very strong negative and statistically insignificant correlation (r = -0.79) was found.

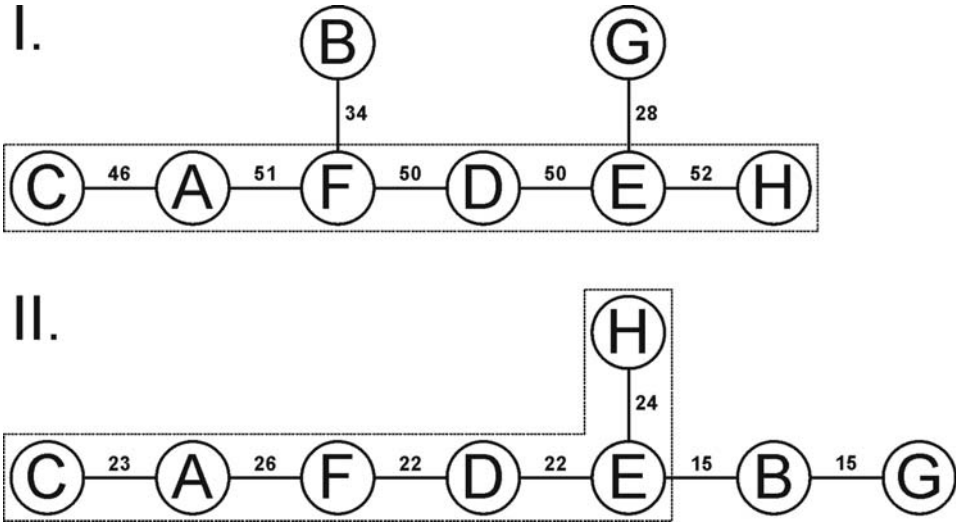

Fig. 11. Diagram of faunistic similarities between studies habitats (in %). Symbols of habitats like in Tab. 1

Reophiles occurred in large numbers only in canals (14.3%). All the other ecological elements always occurred in small or very small size (Fig. 12).

There were recorded: 6 species from the national Red list (44), 16 from the regional Red list (32), one species protected by law, one umbrella species (23) (Table 2). Those species occurred in 15 sites in total. Most scores in environmental science classification were obtained by the sites no: 16 (33 pt.) and 21 (21 pt.) (Table 3).

Index of sozological importance correlated fairly positively with the number of specimen caught in a particular site (r = 0.55647) and with the number of species (r = 0.52779) (Fig. 13). Both correlations were statistically significant. Other correlations were lower and statistically insignificant. Correlation with species diversity measured with the use of PIE indicator, was weak positive (r = 0.33). There was also found weak negative correlation of index of sozological importance with the quantity participation of eurytopic species (r = -0,27), and regarding the number of eurytopic species there was no correlation at all (r = -0.03).

Fens with various degree of naturalness had very similar values of index of sozological importance. Their mean is: 4.0 (unmeliorated sites), 5.0 (partly dried up) and 4.75 (completely dried up, only with ditches as beetle habitat). Qualitative and quantitative share of tyrphophiles in their fauna was very large in natural sites, low in partly dried up sites and large in ditches in completely dried sites. Perhaps regression in the central phase of changes resulted from its distinctive hydrological

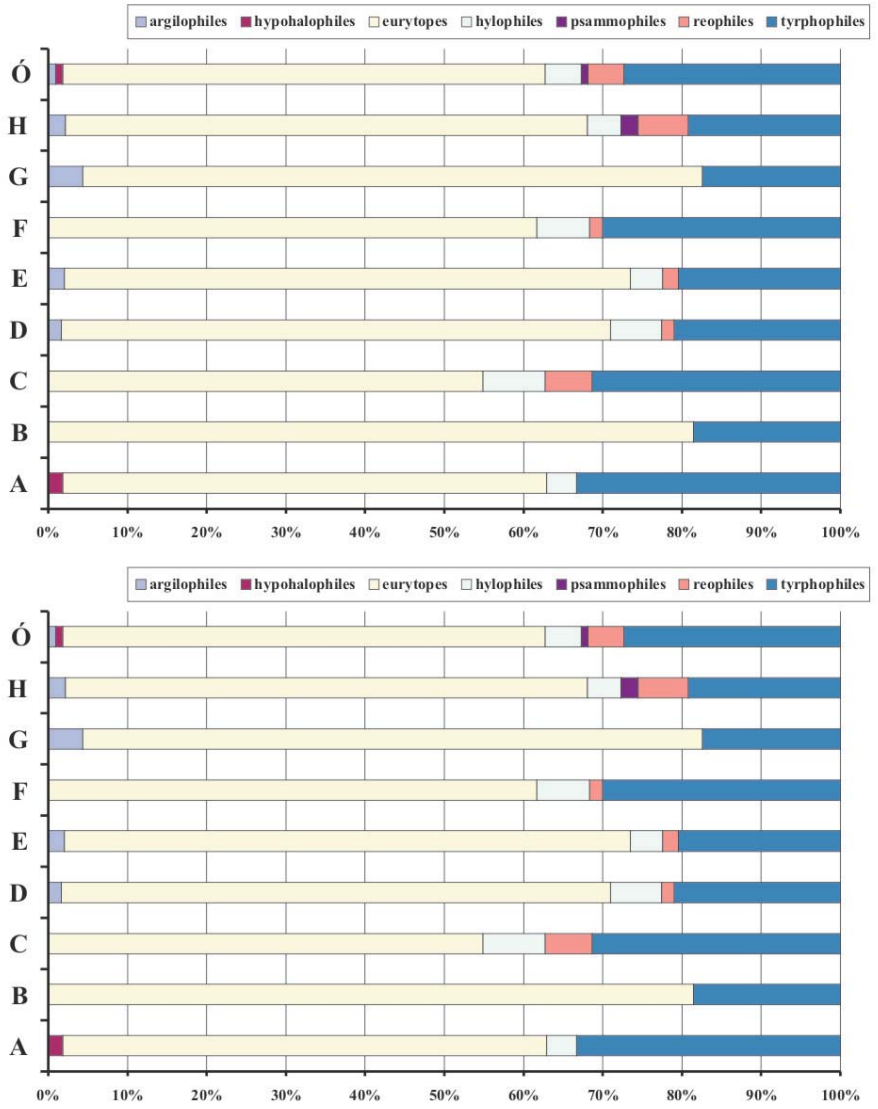

Fig. 12. Percentage share of ecological elements in faunas of particular habitats (A–H) and in the whole material collected (Σ). Upper diagram – qualitative data, lower diagram – quantitative data. Symbols of habitats like in Tab. 1

instability of beetle habitats. As for fauna composition, except for species poverty of partly dried fens, we cannot see large distinctions. Even when participation of some stenotopic species was decreasing or when they did not appear in ditches in completely dried peat bogs – like some species from *Hydroporus* Clairv. – they were occurring in different water types anyway.

Table 2. Beetle species of species care and indicator species recorded in the study area

Species	Red List (Poland)	Red List (Lublin distr.)	Protection by law	Umbrella species
Gyrinus paykulli		NT		
G. suffriani		DD		
Haliplus fluviatilis		VU		
H. fulvicollis	VU	VU		
H. furcatus	VU	VU		
H. laminatus		NT		
H. variegatus	NT	VU		
Agabus clypealis	VU			
A. labiatus		DD		
A. pseudoclypealis		CR		
Graptodytes bilineatus		NT		x
Hydroporus fuscipennis		NT		
Laccornis oblongus		VU		
Laccophilus poecilus		VU		
Spercheus emarginatus	CR	NT		
Hydrophiolus aterrimus	VU	NT	x	
Limnebius aluta		DD		

Table 3. Sozological importance of particular localities

Number of points	Localities no.
33	16
21	21
10	17, 23
9	7
8	19
7	22
5	2
4	4, 18, 24
3	10, 15
2	5, 20
0	other 9 localities

DISCUSSION

Taking into account species connected with water environment belonging to the examined families (some of their representatives settle organic remains and excrement in animal land environment), 109 species is about 38% of the country fauna of the examined families (45, 47, 48, 49). As a result of similar studies regarding territorial range and intensity, conducted currently in various regions of Poland, there were registered 100–113 species of aquatic beetles (8, 20, 16, 19).

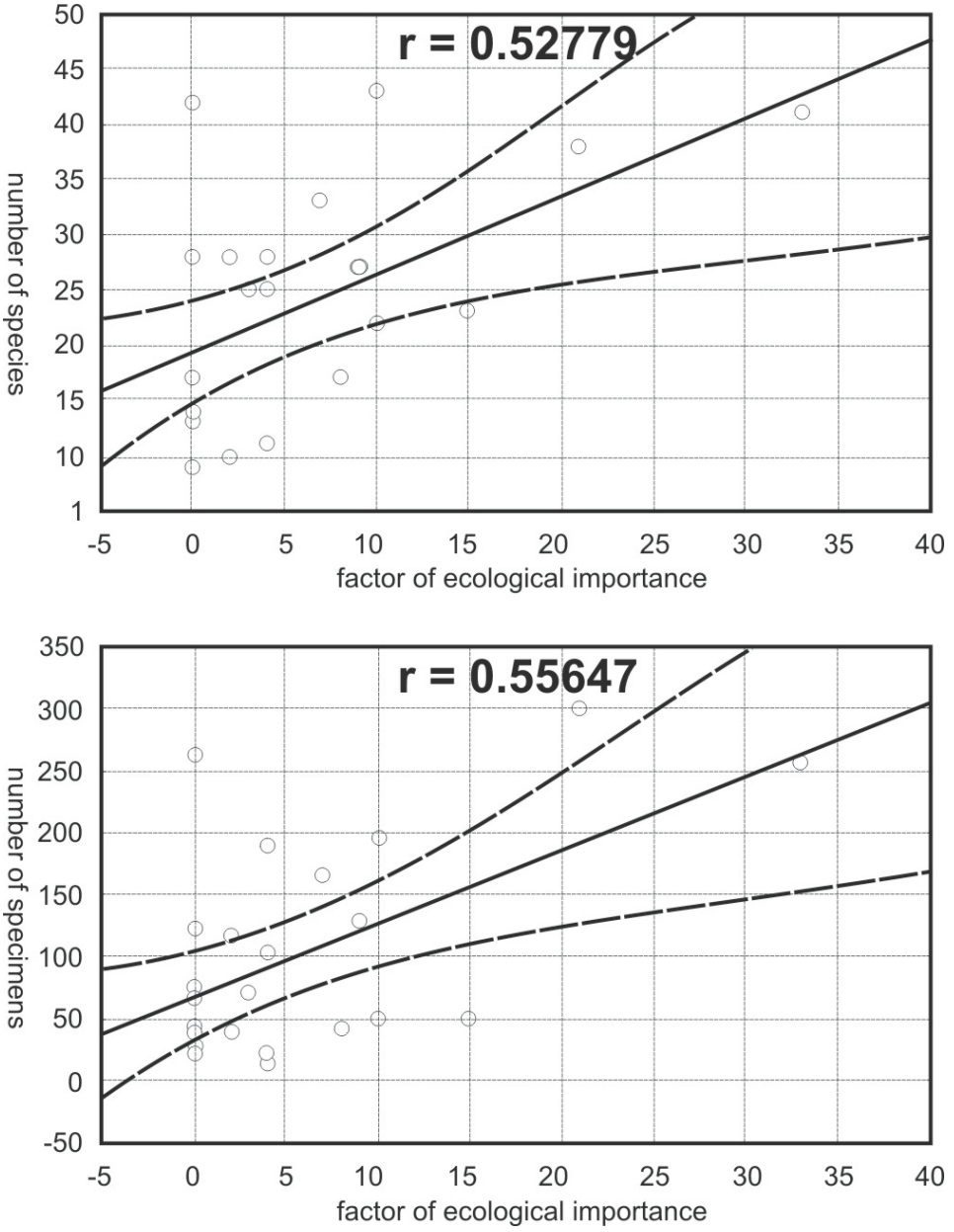

Fig. 13. Correlation between the factor of ecological importance and the richness of beetle fauna: the qualitative one (upper diagram) and the qualitative one (lower diagram)

Considering that diversity of aquatic habitats in the research area is small despite their large number and total area, 109 found species is plenty.

Many of the found beetle species are very interesting because of zoogeographic and faunistic reasons.

Berosus geminus was found near Chełm for the first time in Poland. Its site in Gotówka is also interesting since it is situated about 350 km north of the nearest known sites in Hungary and about 800 km east of the nearest site in Germany. Therefore it extends the known range of species in the Central Europe and outlines the northern border of the whole distribution area (50).

Haliplus furcatus is a species of a small distribution area, whose dense part covers only Central Europe and the southern part of Scandinavia (6, 29, 40). The sites near Chełm are located at the eastern border of this part of the range. On the eastern edge of dense parts of these species ranges there are also situated sites discovered here by us: *Gyrinus suffriani*, *Spercheus emarginatus*, *Hydrophilus aterrimus* and *Dryops anglicanus* (1–4, 18), whereas on the western edge – *Agabus pseudoclypealis* (5, 51).

Data concerning at least 12 species are valuable for the knowledge of their distribution in Poland, in terms of their rare recording or occurrence (45, 47, 48, 49). *Spercheus emarginatus* and *Limnebius aluta* are very rare in the country scale. Another 9 species are considered rare: *Gyrinus suffriani*, *Haliplus fulvicollis*, *H. furcatus*, *H. immaculatus*, *H. variegatus*, *Hydroporus incognitus*, *Agabus clypealis*, *A. pseudoclypealis* and *Dryops anglicanus* (although considering *H. incognitus* in this category raises doubts of the authors). *Hydrophilus aterrimus* occurs locally in Poland. So 'faunistic rarities' make 11–12% of the found species.

It is also worth mentioning the species from the Red list of Polish animals, from categories: CR (Critically Endangered) – *Spercheus emarginatus*; VU (Vulnerable) – *Haliplus fulvicollis*, *H. furcatus, Agabus clypealis* and *Hydrophilus aterrimus*; NT (Near Threatened) – *Haliplus variegatus* (44). *Hydrophilus aterrimus* is also provided with legal protection.

Most of the distinguished here species are tyrphophiles (*Haliplus fulvicollis*, *Hydroporus incognitus*, *Agabus clypealis*, *Limnebius aluta* and *Dryops anglicanus*), or reophiles (*Gyrinus suffriani* and *Agabus pseudoclypealis*) (18, 51). It indicates significance of the research area as refugium of beetles of dystrophic and flowing waters. It is obvious for extensive and well preserved fens, however surprisingly valuable turned out to be also some small water courses of the research area, even very much transformed or typically anthropogenic like the canal in Kolonia Ignatów.

Interesting is also a regional measure of our results. Data about *Gyrinus suffriani* and *Agabus clypealis* are long expected confirmation of their contemporary occurrence in Middle-Eastern Poland (17). As many as 9 species were found for the first time in the Lublin Upland (in a division used in the *The Catalogue of*

Polish fauna). These are: *Gyrinus suffriani*, *Agabus clypealis*, *A. pseudoclypealis*, *Hydroporus glabriusculus*, *H. umbrosus*, *Berosus geminus*, *Limnebius aluta* and *Dryops anglicanus* (17). Moreover, a substantial number of the recorded species – 16 in total – is included in *The Red List of the Lublin Province* (32). So the research area favourably stands out even when compared with an area considered so much valuable for species protection and preservation of biological diversity of aquatic beetles, which is Middle-Eastern Poland (17).

Assemblages of dystrophic water bodies in the vicinity of Chełm seem typical in comparison with similar habitats in different regions of Poland (8, 12, 51), they also refer to data from Belarusian part of Polesie (38, 39). Different is only clearly evident presence of argilophiles which may result from specificity of carbonate area waters – bigger reaction and fertility connected with a large amount of dissolved in water lime compounds.

Anthropogenic lentic water bodies turned out to be important for beetles, which is proved by other authors' comments about forming species-rich assemblages, valuable from the sozological perspective (13, 41, 42, 43). It also concerns other groups of aquatic invertebrates such as dragonflies (14, 37, 46, 60), caddisflies (11) or water mites (57).

However, the most interesting material from anthropogenic habitats was collected in very much transformed or completely artificial running waters. Ditches, canals and regulated rivulets draining fens harboured many valuable species connected with peat bogs and small watercourses, and their sozological importance was high. It may seem surprising but similar results were already obtained in e.g. ditches and canals in fens in the Drömling Natural Park in Germany (34). Of course, for fens' preservation it would be better if they were not drained. However, in case when ditch and canal systems were made long time ago and when they are still working, one can only take care of their structure to make it possible to maintain possibly good conditions for aquatic invertebrates. Watercourses of Chełm carbonate fens – although without intentional human action – have such a structure in long segments. Their features include: surroundings (unrotten fens), little water depth, diverse bottoms, suitable edge structure, diverse flora structure and its unmoving (27, 34).

A high level of faunistic individualism of the examined sites, which can indirectly indicate a little migration level between water bodies, is surprising. Numerous aquatic beetles are well-known for their strong tendencies to migration, some of them make mass wanderings (22, 25, 56). For instance, according to Czachorowski et al. (24), they were the most important group integrating faunistic water bodies in the valley of the Gizela River (North-Eastern Poland). However, research conducted into Dytiscidae showed that inclination to migrations is very diverse even in the range of a particular family. For example, for *Dytiscus marginalis* and *Acilius sulcatus* it is significant but

for *Colymbetes fuscus* decreases clearly, whereas for *Agabus bipustulatus* it is simply slight, even influenced by as drastic factor as complete drying up of a settled body (25). It points to one of possible explanations of low migration level: perhaps only some species migrate which are too sparse to have an influence on values of such general index as faunistic similarity. We can also put forward a hypothesis that opportunistic and eurytopic species migrate most often, and they occur in many water bodies in a particular area so their moving between bodies is not visible without individual marking. And species which are very specialized and stenotopic are more deeply connected with a settled water body. However, data on this subject are not complete and the problem requires further research. They would make it possible to plan active protection of aquatic beetles in a better way, e.g. through making systems favourable for particular species or assemblage of secondary habitat.

REFERENCES

1. Alonzo-Zaranzaga M.A., Hansen M. 2004. Hydrophilidae. [In:] Fauna Europaea version 2.1. Internet: http://www.faunaeur.org
2. Alonzo-Zaranzaga M.A., Hansen M. 2004. Spercheidae. [In:] Fauna Europaea version 2.1. Internet: http://www.faunaeur.org
3. Alonzo-Zaranzaga M.A., Jaech M. 2004. Dryopidae. [In:] Fauna Europaea version 2.1. Internet: http://www.faunaeur.org
4. Audisio P., Mazzoldi P. 2004. Gyrinidae. [In:] Fauna Europaea version 2.1. Internet: http://www.faunaeur.org
5. Audisio P., Nilsson A. 2004. Dytiscidae. [In:] Fauna Europaea version 2.1. Internet: http://www.faunaeur.org
6. Audisio P., Rocchi S. 2004. Haliplidae. [In:] Fauna Europaea version 2.1. Internet: http://www.faunaeur.org
7. Biesiadka E. 1978. Coleoptera. [In:] Bottom fauna of the heated Konin lakes. A. Wróblewski (ed.), Monogr. Fauny Polski, 7, 259–280.
8. Biesiadka E., Pakulnicka J. 2004; Chrząszcze wodne (Coleoptera) Łomżyńskiego Parku Krajobrazowego Doliny Narwi. Parki Nar. Rez. Przyr., 23 (3), 427–447.
9. Buczek A. 2006. Monitoring of saw sedge *Cladium mariscus* (L.) Pohl. in the conditions of carbonate fens near Chełm. Pol. J. Environ. Stud., 15 (5d), 149–154.
10. Buczek T., Buczek A. 1993. Torfowiska węglanowe w okolicach Chełma – walory przyrodnicze, zagrożenia, ochrona. Chrońmy Przyr. Ojcz. 49 (3), 76–89.
11. Buczyńska E. 2006. Influence of hydrotechnical works on caddisflies (Trichoptera) as exemplified by 'Echo' ponds in the Roztoczanski National Park. Acta Agroph., 7 (2): 303–307.
12. Buczyńska E., Buczyński P. 2006. Aquatic insects (Odonata, Coleoptera, Trichoptera) of the central part of the "Krowie Bagno" marsh: the state before restoration. Annales Univ. M. Curie-Skłodowska, Sec. C, 61, 71–88.
13. Buczyńska E., Buczyński P., Lechowski L., Stryjecki R. 2007. Fish pond complexes as refugia of aquatic invertebrates (Odonata, Coleoptera, Heteroptera, Trichoptera, Hydrachnidia): A case study of the pond complex in Zalesie Kańskie (Central-East Poland). Nat. Cons., 64, 39–55.

14. Buczyński P. 1999. Dragonflies (Odonata) of sand pits in south-eastern Poland. Acta hydrobiol., 41 (3/4), 219–230.
15. Buczyński P. 2008. Wstępne badania ważek (Odonata) chełmskich torfowisk węglanowych. Odonatrix, 4 (1), 21–25.
16. Buczyński P., Przewoźny M. 2002. Wodne chrząszcze (Coleoptera) Krzczonowskiego Parku Krajobrazowego. Parki Nar. Rez. Przyr., 21 (3), 283–297.
17. Buczyński P., Przewoźny M. 2006. Stan poznania chrząszczy wodnych (Coleoptera: Adephaga, Hydrophiloidea, Byrrhoidea) Polski środkowo-wschodniej. Wiad. Entomol., 25 (3), 133–155.
18. Buczyński P., Przewoźny M. 2008. New data on the occurrence of *Dryops anglicanus* Edwards, 1909 in Poland (Coleoptera: Dryopidae). Nat. J., 41, 53–57.
19. Buczyński P., Przewoźny M. 2009. Aquatic beetles (Coleoptera) of Wdzydze Landscape Park (Tuchola Forests, N Poland). Nat. J., 42, 67–85.
20. Buczyński P., Przewoźny M., Guz M. 2007. Chrząszcze wodne (Coleoptera: Hydradephaga, Hydrophiloidea, Staphylinoidea, Byrrhoidea) Kozłowieckiego Parku Krajobrazowego. Parki Nar. Rez. Przyr., 26 (2), 93–111.
21. Buszko J. 2004. *Coenonympha oedippus* (Fabricius, 1787), Strzępotek edypus. [In:] Polska czerwona księga zwierząt, Bezkręgowce. Z. Głowaciński, J. Nowacki (eds), Instytut Ochrony Przyrody PAN, Akademia Rolnicza im. A. Cieszkowskiego, Kraków–Poznań, 260–261.
22. Csabai Z., Boda P. 2005. Effect of the wind speed on the migration activity of aquatic insects (Coleoptera, Heteroptera). Acta Biol. Debr. Oecol. Hung. 13, 37–42.
23. Czachorowski S., Buczyński P., Walczak U., Pakulnicka J. 2000. Gatunki osłonowe (parasolowe) w ochronie owadów. Przegl. Przyr. 11 (2-3), 139–148.
24. Czachorowski S., Lewandowski K., Wasilewska A. 1993. The importance of aquatic insects for the landscape integration in the catchment area of the River Gizela (Masurian Lake District, northeastern Poland). Acta Hydrobiol., 35 (1), 49–64.
25. Davy-Bowker J. 2002. A mark and recapture study of water beetles (Coleoptera: Dytiscidae) in a group of semi-permanent and temporary ponds. Aqu. Ecol., 36, 435–44Dyrcz A., Maniakowski M. 2004. *Acrocephalus paludicola* (Vieill., 1817), Wodniczka. [In:] Poradniki ochrony siedlisk i gatunków Natura 2000 – podręcznik metodyczny. Tom 7. Ptaki (część I), M. Gromadzki (ed.), Ministerstwo Środowiska, Warszawa, 325–329.
26. Dyrcz A., Maniakowski M. 2004. *Acrocephalus paludicola* (Vieill., 1817), Wodniczka. [In:] Poradnik ochrony siedlisk i gatunków Natura 2000 – podręcznik metodyczny. Tom 7. Ptaki (część I), M. Gromadzki (ed.), Ministerstwo Środowiska, Warszawa, 325–329.
27. Harrison S.S.C., Harris I.T. 2002. The effects of bankside management on chalk stream invertebrate communities. Freshw. Biol., 47 (11), 2233–2245.
28. Kasprzak W., Niedbała K. 1981. Wskaźniki biocenotyczne stosowane przy porządkowaniu danych w badaniach ilościowych. [In:] Metody stosowane w zoologii gleby. M. Górny, L. Grüm (eds), PWN, Warszawa, 377–409.
29. Klausnitzer B. 1996. Käfer im und am Wasser. Die Neue Brehm-Bücherei, Bd. 567. Westarp Wissenschaften, Magdeburg.
30. Kondracki J. 2002. Geografia regionalna Polski. PWN, Warszawa.
31. Kowalik W., Stryjecki R. 1981. Invertebrate macrofauna of carbonate peat pits of the Chełm Landscape Park with special emphasis on water mites (Hydracarina). [In:] Walory przyrodnicze Chełmskiego Parku Krajobrazowego i jego najbliższych okolic. J. Łętowski (ed.), Wydawnictwo UMCS, Lublin, 165–176.
32. Kucharczyk M., Buczyński P., Chobotow J., Gosik R., Kucharczyk H., Staniec B. (in press). Czerwona lista roślin i zwierząt województwa lubelskiego. Wydawnictwo UMCS, Lublin.
33. Lampert W., Sommer U. 1995. Ekologia wód śródlądowych. PWN, Warszawa.

34. Langheinrich U., Tischew S., Gersberg R.M., Lüuderitz V. 2004. Ditches and canals in management of fens: opportunity or risk? A case study in the Drömling Natural Park, Germany. Wetl. Ecol. Manag., 12, 429–445.
35. Łętowski J. (ed.) 2000. Walory przyrodnicze Chełmskiego Parku Krajobrazowego i jego najbliższych okolic. Wydawnictwo UMCS, Lublin.
36. Łomnicki A. 1995. Wprowadzenie do statystyki dla przyrodników. PWN, Warszawa.
37. Meier C., Zucchi H. 2000. Zur Bedeutung von Regenwasserrückhaltebecken für Libellen (Odonata) – ein Beitrag zum urbanen Artenschutz. Osnabrücker Natwiss. Mitt., 26, 153–166.
38. Moroz M., Czachorowski S., Lewandowski K. 2003. Wstępne badania nad wodnymi owadami rezerwatu „Prostyr" (Białoruś). Parki Nar. Rez. Przyr., 22 (1), 117–124.
39. Moroz M.D., Maksymenkov M.V., Czachorowski S., Buczynski P. 2002. Predvaritelnyje rezultaty issledovaniya vodnyh nasekomyh (Insecta: Collembola, Ephemeroptera, Odonata, Trichoptera, Heteroptera, Coleoptera) biologicheskogo zakaznika „Sporovskiy". Prir. Res., 2, 88–94.
40. Nilsson A.N. 1996. Coleoptera Haliplidae, Crawling Water Beatles. [In:] Aquatic insects of North Europe, A Taxonomic Handbook. Vol. 1. Apollo Books, Stenstrup, 131–138.
41. Pakulnicka J. 2003. Wstępne dane na temat chrząszczy wodnych (Coleoptera) zasiedlających zbiorniki powyrobiskowe Pojezierza Olsztyńskiego. Przegl. przyr., 14 (1-2), 85–94.
42. Pakulnicka J. 2008. The formation of water beetle fauna in anthropogenic water bodies. Oceanol. Hydrobiol. St., 37 (1), 31-42.
43. Pakulnicka J., Zawal A. 2007. Chrząszcze wodne (Coleoptera) rezerwatu "Jezioro Szare" i zbiorników usytuowanych w jego sąsiedztwie. Parki Nar. Rez. Przyr., 25 (4), 121–133.
44. Pawłowski J., Kubisz D., Mazur M. 2002. Coleoptera Chrząszcze. [In:] Czerwona lista zwierząt ginących i zagrożonych w Polsce. Z. Głowaciński (ed.), Wydawnictwo Instytutu Ochrony Przyrody PAN, Kraków, 88–110.
45. Petryszak B. 2004. Chrząszcze drapieżne (Adephaga). [In:[Fauna Polski, Charakterystyka i wykaz gatunków – Fauna of Poland, Characteristics and checklist of species. W. Bogdanowicz, E. Chudzicka, I. Filipiuk, E. Skibińska (eds), Muzeum i Instytut Zoologii PAN, Warszawa, 28–44.
46. Piksa K., Wachowicz B., Kwarcińska M. 2006. Dragonflies (Odonata) of some small anthropogenic water bodies in Cracow City. Fragm. Faun., 49 (2), 81–89.
47. Przewoźny 2004a. Byrrhoidea. [In:] Fauna Polski, Charakterystyka i wykaz gatunków – Fauna of Poland, Characteristics and checklist of species. W. Bogdanowicz, E. Chudzicka, I. Filipiuk, E. Skibińska (eds), Muzeum i Instytut Zoologii PAN, Warszawa, 118–124.
48. Przewoźny M. 2004b. Kałużnicowate (Hydrophiloidea). [In:] Fauna Polski, Charakterystyka i wykaz gatunków – Fauna of Poland, Characteristics and checklist of species. W. Bogdanowicz, E. Chudzicka, I. Filipiuk, E. Skibińska (eds), Muzeum i Instytut Zoologii PAN, Warszawa, 149–151.
49. Przewoźny M. 2004c. Hydraenidae. [In:] Fauna Polski, Charakterystyka i wykaz gatunków – Fauna of Poland, Characteristics and checklist of species. W. Bogdanowicz, E. Chudzicka, I. Filipiuk, E. Skibińska (eds), Muzeum i Instytut Zoologii PAN, Warszawa, 151–153.
50. Przewoźny M., Buczyński P. 2008. *Berosus* (*Berosus*) *geminus* Reiche et Saulcy, 1856 recorded in Poland, and a key to Polish species of the genus *Berosus* Leach, 1817 (Coleoptera, Hydrophilidae). Pol. J. Ent., 77 (4), 309–320.
51. Przewoźny M., Buczyński P., Mielewczyk S. 2006. Chrząszcze wodne (Coleoptera: Adephaga, Hydrophiloidea, Byrrhoidea) doliny Bugu w województwie lubelskim (południowo-wschodnia Polska). Nowy Pam. Fizj., 4 (1-2), 23–54.
52. Rozporządzenie Ministra Środowiska z dnia 28 września 2004 r. w sprawie gatunków dziko występujących zwierząt objętych ochroną. Dz. U. nr 220, poz. 227.

53. Radwan S., Stępień B. 1994. Chemizm torfianek Poleskiego Parku Narodowego i Chełmskiego Parku Krajobrazowego. [In:] XVI Zjazd Hydrobiologów Polskich. Streszczenia komunikatów, Wrocław, 120.
54. Radwan S., Stępień B., Koproń J. 1996. Status ekologiczny torfianek kwaśnych i węglanowych Poleskiego Parku Narodowego i Chełmskiego Parku Krajobrazowego. [In:] Funkcjonowanie ekosystemów wodno-błotnych w obszarach chronionych Polesia. S. Radwan (ed.), Wydawnictwo UMCS, Lublin, 141–142.
55. Staniec B., Buczyński P., Gosik R., Przewoźny M. (in press). Chrząszcze (Coleoptera). [In:] Czerwona lista roślin i zwierząt województwa lubelskiego. M. Kucharczyk (ed.), Wydawnictwo UMCS, Lublin.
56. Stevens L.E., Polhemus J.T., Durfee R.S., Olson C.A. 2007. Large mixed-species dispersal flights of predatory and scavenging aquatic Heteroptera and Coleoptera, Northern Arizona, USA. West. N. Am. Naturalist, 67 (4), 587–592.
57. Stryjecki R. 2007. The role of fish ponds as important habitats for water mites (Hydrachnidia, Acari). Oceanol. Hydrobiol. St., 36 (Supl. 4), 73–79.
58. Szujecki A. 1983. Ekologia owadów leśnych. PWN, Warszawa.
59. Trojan P. 1980. Ekologia ogólna. PWN, Warszawa.
60. Willigalla C., Fartmann T. 2009. Die Libellenfauna der Regenrückhaltebecken der Stadt Mainz (Odonata). Libellula, 28 (3/4), 117–137.
61. ZPKP [Zespół Parków Krajobrazowych Polesia] 2010. Charakterystyka ChPK. Internet: http://zchpk.w4u.pl/index.php?option=com_content&task=view&id=64&Itemid=60