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Water bugs (Heteroptera) in small water bodies located in Olsztyn

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Key words: water bugs (Heteroptera), urban water bodies, permanent and astatic water bodies, communities of water boatmen

Abstract

The study was conducted on 16 water bodies located in Olsztyn, most of them natural and dominated by astatic ones (dystrophic, eutrophic, and artificial with elevated mineralization levels). Heteroptera was identified to 32 species represented by five synecological groups, i.e., species typical of dystrophic water bodies (*Cymatia bonsdorffi*, *Hesperocorixa linnaei*, *H. moesta*, *H. sahlbergi*, *Gerris lateralis*, *G. sphagnetorum*, *Hebrus ruficeps*), lacustrine species (*Gerris argentatus*, *Aquarius paludum*), halophilous species (*Cymatia rogenhoferi*, *Paracorixa concinna*, *Gerris thoracicus*), psammophilous and argilophilous species (*Sigara lateralis*) and eurytopic species typical of small water bodies (18). It was found that the degree of permanency of astatic water bodies affects both the species diversity and abundance of the Heteroptera fauna. Migrations play a crucial role with respect to the colonization of newly-formed bodies of water and to the abandonment of those that are drying up.

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INTRODUCTION

Small water bodies are a typical component of the ecological landscape in northern Poland although their number has decreased considerably in recent decades (Paczuska and Paczuski 1996, Paczuski and Paczuska 1997). They can be classified based on origin, location, durability (degree of astatism), size and trophy (Chodorowski 1958, Klimowicz 1959, Paschalski 1959, Kajak 2001). The dynamics of changes taking place in small water bodies is so high that they cannot be directly compared to the relations observed in large, deep water bodies, such as lakes (Starmach et al. 1978, Mikulski 1982, Kajak 2001).

For many years, and particularly recently, thorough ecological research has been carried out in urban environments where aquatic zoocenoses are subjected to human pressure, including isolation, exposure to artificial light, and the impact of chemical pollutants (Caspers 1964, Kołodziejczyk 1976, Pieczyńska 1977). In cities an important role is also played by artificial reservoirs (water tanks for fire prevention and suppression, fountain reservoirs, excavation pits filled with water), which provide refuge for numerous species of aquatic insects whose natural habitats have already disappeared or will disappear in the nearest future (Bednarek 1980; Czachorowski, Pietrzak 2004).

To date, 63 species of water bugs have been identified in Poland, of these, at least 20 are considered to be rare or very rare (Wróblewski 1980). Since the rarity of some species is due to the disappearance of natural habitats, further studies should be conducted on artificial reservoirs that may serve as substitute habitats for these species. Among the publications and reports describing the water bugs of urban environments, particular attention should be paid to those by Biesiadka and Kasprzak (1977) and Bednarek (1980), which address water bodies in the city of Poznań, Biesiadka and Radek (1983) and Kurzątkowska (2005) on the lakes of Olsztyn, as well as to those by Biesiadka and Tabaka (1990) on the lakes of Szczytno.

The aim of the present study was to determine the faunal structure of water bugs (Heteroptera) living in various types of small urban bodies of water, taking into account the effect of their permanency on the species diversity and number of taxa. Synecological and trophic analyses as well as the analysis of faunal similarities among particular types of water bodies were performed to estimate the quality of the studied aquatic environments and the significance of migration, which is common in this group of insects.

MATERIALS AND METHODS

The study was conducted in 1999, 2002, and 2004 on 16 water bodies (sites) located in Olsztyn (Fig. 1). According to the degree of their permanency,

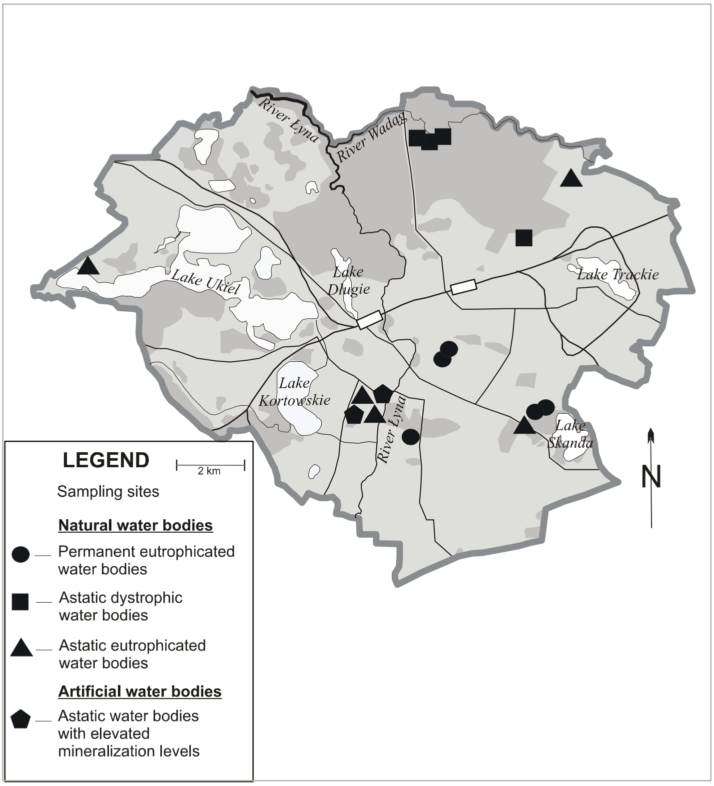

Fig. 1. Study area.

their character, as well as the character of their catchment areas, they were classified as:

1. Natural permanent eutrophic water bodies (five, of which three are situated in built-up areas). Their banks are often overgrown by willow shrubs and macrophytes (*Phragmites australis*, *Typha latifolia*, *T. angustifolia*, *Glyceria maxima*, *Carex* spp., *Juncus effusus*, and sometimes *Equisetum limosum*, *Eleocharis palustris*, *Polygonum amphibium*). *Myriophyllum spicatum*, *Elodea canadensis*, *Potamogeton natans*, *P. filiformis*, *Lemna trisulca*, and, rarely, *Stratiotes aloides*, occur in the water. The bottoms are usually slimy and sticky, rarely hard or sandy, and covered with a mud layer.
2. Natural astatic dystrophic water bodies (three located in forests and one in a sphagnum peatland area). The largest mid-forest body of water has no

vegetation, and its banks are marshy and swampy. The other two, which are much smaller and shallower, have banks overgrown with sedges and other grasses. Mid-forest water bodies are in places overgrown with peat moss, and their bottoms are covered with a thick layer of decomposing leaves. The water body in the peatland forms a system of channels that are gradually drying up among clusters of sedges. *Typha latifolia* and other vegetation typical of peatlands and wetlands (*Calla palustris*, *Comarum palustre*) occur. The unstable bed is composed of *Sphagnum* spp.

3. Natural, intermittent eutrophic water bodies that appear in the spring and summer, and then re-appear in the fall (five, of which two are situated in built-up areas). They are formed in a depression and are surrounded by willow shrubs, *Carex* spp*.*, *Typha latifolia*, *T. angustifolia,* and sparse stands of *Phragmites australis*. Their bottoms are overgrown with vegetation and covered by large amounts of decomposing organic matter.
4. Artificial astatic water bodies (former excavation pits), situated in built-up areas, with elevated mineralization levels. One of them, which is shallow and has no vegetation, developed on artificially leveled ground and has a water-impermeable clayey bed. The other water body, formed in a former sand extraction pit, is extensive, with a bottom of diversified character and a well-developed shoreline. The bed is slightly muddy or sandy-clayey and is overgrown with *Myriophyllum spicatum* and *Ceratophyllum demersum* in places. It seems that the deeper layers of this water body have existed for at least two to three years.

Among the permanent water bodies, two that are situated in the city center were analyzed in 1999, and three located on the city outskirts were studied in 2002. The astatic water bodies were examined in 2004, and samples were simultaneously taken from the permanent small ponds that had been studied previously, which confirmed their constant faunal structure, thus permitting an analysis of faunal similarities between all of these water bodies. The faunal materials analyzed in this study came from the same phenological period of each water body.

Semi-qualitative samples were taken at monthly intervals (every two or three weeks in astatic water bodies) with a scoop net (dragged through the water about 10 times to obtain a single sample). The collected faunal materials comprised 2791 individuals, including 1191 larvae (550 larvae were not identified to the species).

Faunal similarities between the tested water bodies were determined with the qualitative (Jaccard index) and quantitative (Bray-Curtis index) methods, using the BioDiversity program. The Shannon-Weaver biodiversity index and the Pielou uniformity index were calculated for the water bodies examined in the study (mean values and standard deviations (SD)).

RESULTS

A total of 32 water bug species were identified in the small water bodies of Olsztyn (20 species of Nepomorpha, which live in deep waters, and 12 species of Gerromorpha, which live on the water surface; Table 1). One of the common and relatively abundant species was *Gerris lacustris* (15 sites). *Hesperocorixa sahlbergi* (10 sites), *Notonecta glauca* (8 sites) and *Gerris odontogaster* (10 sites) occurred in high numbers in over half of the analyzed water bodies. *G. argentatus* was less abundant (9 sites), whereas *Plea minutissima* and *Microvelia reticulata* were present in great numbers in some permanent water bodies only.

Five synecological groups were identified in the faunal material collected, i.e. species typical of dystrophic water bodies (*Cymatia bonsdorffi*, *Hesperocorixa linnaei*, *H. moesta*, *H. sahlbergi*, *Gerris lateralis*, *G. sphagnetorum*, *Hebrus ruficeps*; Wróblewski 1939, 1980; Štys 1961; Mielewczyk 1963; Midak 1965; Karg 1966; Krajewski 1969; Biesiadka 1977; Biesiadka and Radek 1983; Bednarek 1988; Biesiadka and Tabaka 1990; Kurzątkowska 1999; approximately 9.5% of the total abundance); lacustrine species (*Gerris argentatus*, *Aquarius paludum*; Wróblewski 1939, 1980; Karg 1966; Mielewczyk 1970b; Biesiadka 1977; Biesiadka and Tabaka 1990; approximately 3%); halophilous species (*Cymatia rogenhoferi*, *Paracorixa concinna*, *Gerris thoracicus*; Karg 1966; Mielewczyk 1970b; Savage 1971, 1985; Biesiadka 1977; Mielewczyk 1978; Wróblewski 1980; approximately 1.5%); psammophilous and argilophilous species (*Sigara lateralis*; Mielewczyk 1963, 1964, 1978; Karg 1966; Wróblewski 1980; approximately 4%), and eurytopic species typical of small water bodies (18, approximately 82%).

Twenty-four Heteroptera species were identified in permanent, eutrophic water bodies (Table 1) with the clear domination of *Plea minutissima* and *Microvelia reticulata* (almost 60% of the materials collected). With respect to abundance, *P. minutissima* dominated in deeper water bodies, while *M. reticulata* did so in a body of water overgrown with water soldier. *Notonecta glauca* (eudominant) as well as *Gerris odontogaster*, *Ilyocoris cimicoides*, *Hesperocorixa linnaei*, *G. argentatus*, and *H. sahlbergi* (subdominants) were also recorded frequently. The boatmen fauna was also relatively rich (12 species) in these water bodies. Eurytopic fauna typical of small water bodies dominated in synecological terms (18 species, 90.5% of the material examined). The mean values of the Shannon-Weaver biodiversity and the Pielou uniformity indexes calculated for these water bodies were 2.19 (SD = 0.64) and 0.58 (SD = 0.15), respectively.

Eight water bug species were noted in astatic dystrophic water bodies (Table 1). Gerromorpha species dominated in terms of quality, and the most

Table 1

Presentation of the faunal material collected during the study (N- number of specimens; D- domination; Ns- number of sites; F- frequency at sites; SD- standard deviations)

No.		Total materials collected				Natural water bodies						Artificial water bodies	
						Permanent eutrophic water bodies		Astatic dystrophic water bodies		Astatic eutrophic water bodies		Astatic water bodies with elevated mineralization levels	
		N	D (%)	Ns	F (%)	N	D (%)	N	D (%)	N	D (%)	N	D (%)
	Gerromorpha												
1.	*Cymatia bonsdorffi* Sahl.	1	0.04	1	6.25							1	0.13
2.	*Cymatia rogenhoferi* (Fieb.)	1	0.04	1	6.25							1	0.13
3.	*Callicorixa prausta* (Fieb.)	5	0.18	4	25.00	2	0.15			2	0.38	1	0.13
4.	*Corixa dentipes* (Thom.)	7	0.25	2	12.50	1	0.07					6	0.78
5.	*Corixa punctata* (Illig.)	48	1.72	5	31.25	3	0.22			1	0.19	44	5.71
6.	*Hesperocorixa linnaei* (Fieb.)	44	1.58	6	37.50	42	3.08			1	0.19	1	0.13
7.	*Hesperocorixa moesta* (Fieb.)	1	0.04	1	6.25	1	0.07						
8.	*Hesperocorixa sahlbergi* (Fieb.)	211	7.56	10	62.50	38	2.79	74	56.06	56	10.63	43	5.58
9.	*Paracorixa concinna* (Fieb.)	20	0.72	3	18.75	1	0.07					19	2.47
10.	*Sigara distincta* (Fieb.)	39	1.40	3	18.75	3	0.22					36	4.68
11.	*Sigara falleni* (Fieb.)	69	2.47	5	31.25	7	0.51					62	8.05
	Sigara falleni, S. distincta larvae	133	4.77	2	12.50	51	3.74					82	10.65
12.	*Sigara lateralis* (Leach)	110	3.94	2	12.50							110	14.29
13.	*Sigara limitata* (Fieb.)	63	2.26	2	12.50	4	0.29					59	7.66
14.	*Sigara semistriata* (Fieb.)	24	0.86	4	25.00	5	0.37					19	2.47
15.	*Sigara striata* (L.)	31	1.11	6	37.50	19	1.40			1	0.19	11	1.43

numerous and most common among them was *Gerris lacustris*, accompanied by the much less frequent *G. lateralis* and *Hebrus ruficeps*, which are typical of dystrophic waters. The Nepomorpha group was represented by a large population of the tyrphophil *Hesperocorixa sahlbergi* (56% of total abundance) and were noted only in the oldest, mid-forest water body. In this group of water bodies the mean values of the Shannon-Weaver biodiversity and the Pielou uniformity indexes were 0.88 (SD = 0.64) and 0.44 (SD= 0.32), respectively.

Of the Heteroptera species reported in intermittently strongly eutrophic water bodies, nine (approximately 64% of the materials collected) belonged to Nepomorpha (Table 1). The most abundant and most common species were *Gerris odontogaster*, *G. lacustris*, *Hesperocorixa sahlbergi* (eudominants), *Notonecta glauca* (dominant), and *G. argentatus* (subdominant). The small proportion of detritivorous boatmen (5 species, approximately 15% of the total abundance) should be emphasized. Eurytopic species typical of small water bodies accounted for over 85% of the materials collected in these water bodies (10 species). Peatland fauna was represented by four species (approximately 11% of the total abundance). The mean values of the Shannon-Weaver biodiversity and the Pielou uniformity indexes were 1.72 (SD = 1.11) and 0.60 (SD = 0.35), respectively.

Twenty-two Heteroptera species were recorded in two water bodies with elevated mineralization levels (Table 1). One of them, artificially drained and devoid of vegetation, was occupied only by migratory boatmen (5 species) dominated by the psammophilous and argilophilous species *Sigara lateralis*, which are typical of such waters, and the halophilous species *Paracorixa concinna* (approximately 88% of the total abundance). In this body of water the Shannon-Weaver biodiversity index was 1.19 and the Pielou uniformity index was 0.51. In the other water body, formed as a result of sand extraction, the water bug fauna was composed primarily of members of the family Corixidae (14 species, approximately 60% of the materials collected there). The most common dominant species were *Sigara limitata*, *Corixa punctata*, *Hesperocorixa sahlbergi*, *S. lateralis*, and *S. distincta,* accompanied by *Paracorixa concinna* and *Cymatia rogenhoferi*, which are quite rare and very rare in Poland. As for surface water bugs (Gerromorpha), only members of the family Gerridae were identified, of which particular attention should be paid to the halophilous species *Gerris thoracicus*. In this body of water the Shannon-Weaver biodiversity index was 3.76 and the Pielou uniformity index was 0.84. The mean values of the Shannon-Weaver biodiversity and the Pielou uniformity indexes, calculated for both bodies of water, were 2.47 (SD = 1.82) and 0.68 (SD = 0.23), respectively. In both of these water bodies the typical fauna was represented by three halophils (3.8% of the materials) and one psammophilous and argilophilous species (over 14%).

The qualitative analysis of faunal similarities between the studied water bodies did not permit their classification into the three types above. Permanent water bodies showed the highest degree of faunal similarity (on average about 45%), especially when located in close proximity of each other (52% and 80%). In the other types of water bodies faunal similarity ranged from 20 to 25%. Quantitative analysis revealed the highest degree of similarity (almost 30%) between astatic, dystrophic water bodies. Permanent water bodies, characterized by a stable faunal structure, were found to be similar in about 20% (50 and 70% in the case of neighboring ones). The analysis of two categories of water bodies, i.e., permanent and intermittent, revealed a high level of faunal similarity with respect to species composition (approximately 70%) and a low level of faunal similarity in terms of domination structure (approximately 25%). The analysis of the four groups of water bodies included in the present study indicated the highest faunal distinctness between dystrophic water bodies (about 28% in comparison with more than 52% in the other groups; Fig. 2). As regards species domination, the greatest differences were observed between permanent water

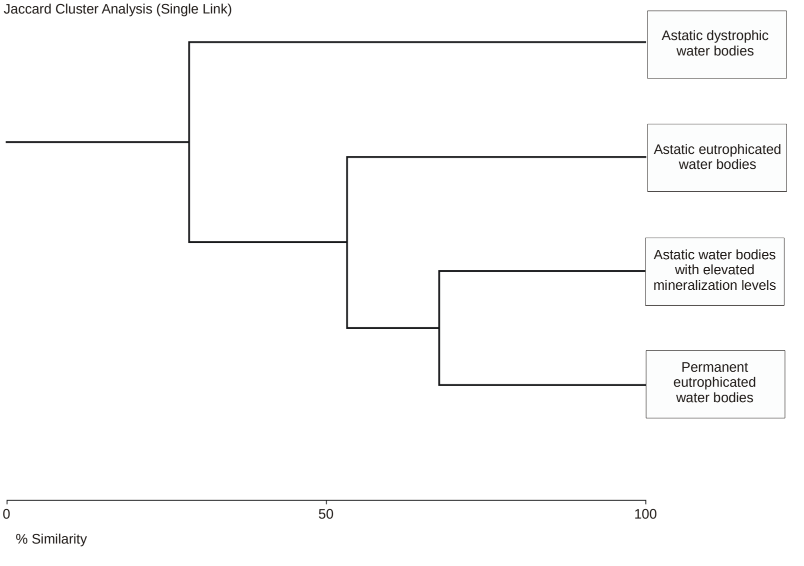

Fig. 2. Cluster of faunal similarities between the types of water bodies distinguished in the study (Jaccard index).

bodies (about 23% in comparison with more than 33% in the other groups; Fig. 3). The species common to all four types of water bodies were: *Hesperocorixa sahlbergi*, *Notonecta glauca*, *Gerris lacustris*, and *G. odontogaster*. *Hesperocorixa moesta*, *Mesovelia furcata*, and *Microvelia reticulata* occurred exclusively in permanent water bodies. *Hebrus ruficeps* and *Aquarius paludum* occurred in dystrophic ones. *Gerris sphagnetorum* was noted in astatic eutrophic water bodies, while *Cymatia bonsdorfii*, *C. rogenhoferi*, and *Sigara lateralis* were noted in astatic ones with elevated mineralization levels.

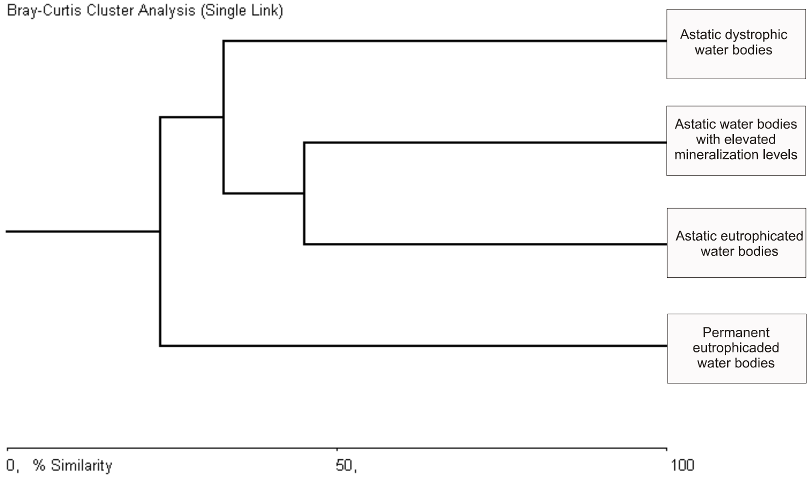

Fig. 3. Cluster of faunal similarities between the types of water bodies distinguished in the study (Bray-Curtis index).

DISCUSSION

The faunal structure of water bugs is affected by the physiographical features of the area, especially the hydrographical network, which in Olsztyn is widely diversified and comprised of many lakes and running waters as well as hundreds of natural, permanent and astatic small water bodies. The species abundance of 32 observed in the study is comparable with the data gathered on urban water bodies in the city of Poznań (36 species, Bednarek 1980).

Stable faunal structures develop in permanent water bodies where potential changes are related to natural succession processes or human pressure.

According to Mielewczyk (1963), Biesiadka (1969, 1977) and Bednarek (1988), small water bodies situated in the open country are dominated by the herbivorous-detritivorous Corixidae, which is an indication of high trophic levels. Twelve boatmen species were identified in permanent water bodies located in Olsztyn; however, their populations were not too numerous (at a domination level of about 13.5%). The low contribution of *Sigara falleni*, which prefers beds with no or sparse vegetation (Biesiadka 1969; Biesiadka, Szczepaniak 1987; Biesiadka, Tabaka 1990), the more common occurrence of *S. striata* as well as the high contribution of *Hesperocorixa sahlbergi* and *H. linnaei*, typically found in polyhumus and mid-forest waters (Mielewczyk 1970a, Midak 1965, Biesiadka 1969, Bednarek 1988, Wróblewski 1980, Kurzątkowska 1999), indicate that the water bodies examined in the study are overgrown with vegetation and associated with a high level of woodiness in the city and its vcinity, as well as with the presence of peatlands and swamps.

A certain phenological specificity of the Heteroptera fauna observed in astatic water bodies was noted. In the early spring, immediately after ice melting, natural bodies of water are colonized by members of the family Gerridae, which overwinter in the vicinity. Migratory boatmen usually come from other water bodies in mid April, when thermal conditions are more favorable. However, they do not colonize very shallow water bodies which, in most cases, dry up by mid July. The maximum densities of their larvae are observed in August. In subsequent months, this results in the occurrence of high numbers of imagines that soon have to abandon water bodies that are drying up. This phenomenon was also described by Bednarek (1980) in studies of fountain reservoirs in Poznań. An interesting phenological situation was encountered in artificial reservoirs with elevated mineralization levels. A newly-formed and short-lasting (refilled) water body was colonized by boatmen, typical dwellers of such waters. The absence of members of the family Gerridae can be explained by the fact that none of them overwintered nearby since this water body had not existed previously. Boatmen prefer water bodies that survive over longer periods of time (about two to three years) as they do not have to leave them for the winter provided it is not too severe.

Anthropogenic water bodies, characterized by elevated mineralization levels, contribute considerably to increasing the species diversity of water bugs in the urban environment. In this study such water bodies were occupied primarily by Nepomorpha species, which were dominated by the family Corixidae (14 species, approximately 65%) with the typical components (*Sigara lateralis*, *Paracorixa concinna*, *Cymatia rogenhoferi*) accounting for about 17% of the total abundance. Doubtless, particular attention should be paid to the previously-mentioned species *Cymatia rogenhoferi,* which is very rare in Poland, and large populations of this species have only been reported by Karg

(1966) in clay-pit ponds with elevated salinity levels, situated near Gliwice and Rybnik. The new locality in Olsztyn is currently the most northward site within its entire range of occurrence. Interesting communities of boatmen were also recorded in these water bodies, i.e., an assemblage typical of clay-pit ponds with high salinity levels (*Cymatia rogenhoferi*, *Sigara lateralis*, *Paracorixa concinna*; Karg 1966), an assemblage associated with clayey-loamy beds (*Corixa punctata*, *Sigara semistriata*, *S. limitata*, *S. lateralis*; Wróblewski 1939, Midak 1965) as well as a more common assemblage typical of sandy-slimy beds (*Sigara falleni*, *S. striata*; Wróblewski 1939, Mielewczyk 1963, Karg 1966). The most common community of boatmen in the small water bodies of Olsztyn was a single-species assemblage characteristic of dystrophic waters, with *Hesperocorixa sahlbergi* (also described by Midak 1965), which sometimes co-existed with the less abundant and less common *H. linnaei* (a two-species assemblage typically found in dystrophic waters; Mielewczyk 1963, 1970a).

Particular attention should be paid to the widespread occurrence, also in astatic water bodies, of the lacustrine *Gerris argentatus*. Due to its flying ability, it can colonize aquatic environments generally considered untypical of this species, and its migratory activity is observed mainly in the second half of April and in May (Wróblewski 1980).

It was found that the degree of permanency of astatic water bodies affects both the species diversity and abundance of the Heteroptera fauna. The constant increase in the number of taxa (peaking in July and August) with no species replacement was observed in the water bodies that existed for a longer period of time, e.g., until the fall.

Migrations play a crucial role with respect to the colonization of newly-formed bodies of water and to the abandonment of those that are drying up. Due to the presence of wetlands in Olsztyn, the faunal structure of small water bodies and lakes can be enriched with the peatland and lacustrine component, respectively. The significance of migrations for the colonization of intermittent, astatic water bodies was reflected by their faunal similarities and confirmed by high numerical values.

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