ZESZYTY NAUKOWE UNIWERSYTETU SZCZECIŃSKIEGO

NR 791 ACTA BIOLOGICA 20 2013

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WATER MITES (HYDRACHNIDIA) OF KETTLE HOLES IN ROSTOCK SURROUNDINGS (NORTHERN GERMANY)

Abstract

Small water bodies are very diversified environmentally, and also characterized by a considerable variation range of environmental parameters. These two features are responsible for the fact that the fauna of water mites is characterized by a considerable species diversity and that eurytopic species are prevalent. Due to the eurytopic character of the species it is very difficult to define the rules governing their environmental distribution, which probably often has a local character. The present study is an attempt at analyzing this problem, focusing on water mite fauna of kettle holes in Rostock surroundings (Germany). The main factor diversifying the fauna of studied reservoirs is their trophism. Correspondence analysis distinguished three separate groups among the reservoirs. The isolation of the reservoirs was an important factor diversifying the water mite fauna.

Keywords: small water bodies, temporary waters, ecological islands, distribution

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Introduction

Small water bodies are not only very diversified environmentally, but also characterized by a considerable variation range of environmental parameters. These two features are responsible for the fact that the fauna of water mites is characterized by a considerable species diversity and that eurytopic species, well-adjusted to a wide range of environmental changes, are prevalent. Due to the eurytopic character of the species and the considerable volatility of the zoocenoses made up by them, it is very difficult to define the rules governing their environmental distribution, which probably often has a local character. Furthermore, small water bodies can be treated as islands featured in MacArthur and Wilson's theory (1967), according to which the specific character of fauna encountered on an island depends on the size of an island and the degree of its isolation. Species diversity is also influenced by: the degree of a reservoir's astaticity, vegetation cover, and the presence of fish. The size of a reservoir and its astaticity remain the most important factors (Camacho, Valdecasas 1988; Collinson et al. 1995; Williams 1996; Rundle et al. 2002; Sanderson et al. 2005; Scheffer at al. 2006; Dąbkowski, Biesiadka 2011). However, in many cases their influence may not be explicit; many factors may become either stronger or weaker (Scheffer at al. 2006), or have a reverse effect and then, as a result, in seasonal reservoirs the species diversity may be higher than in permanent ones (Dąbkowski, Biesiadka 2011). Local habitat diversification in a reservoir is also important, as it significantly influences the level of species diversity (Scheffer at al. 2006). The present work is an attempt at analysing the distribution of water mite fauna in small water bodies depending on environmental conditions found in a water body, as well as its size and degree of isolation, on the basis of water mite fauna of kettle ponds in the surroundings of Rostock (Germany).

Material and methods

The material was collected in 15 localities (i.e. reservoirs) (Fig. 1) mostly in July, 2003, additional samples were collected in May, August and October. The water mite fauna was sampled with a hydrobiological sweep net with a triangular frame; each side of the triangle measured 30 cm. In each locality there were performed 20 sweeps, each covering the area of c. 1 m^2. Water mites were collec-

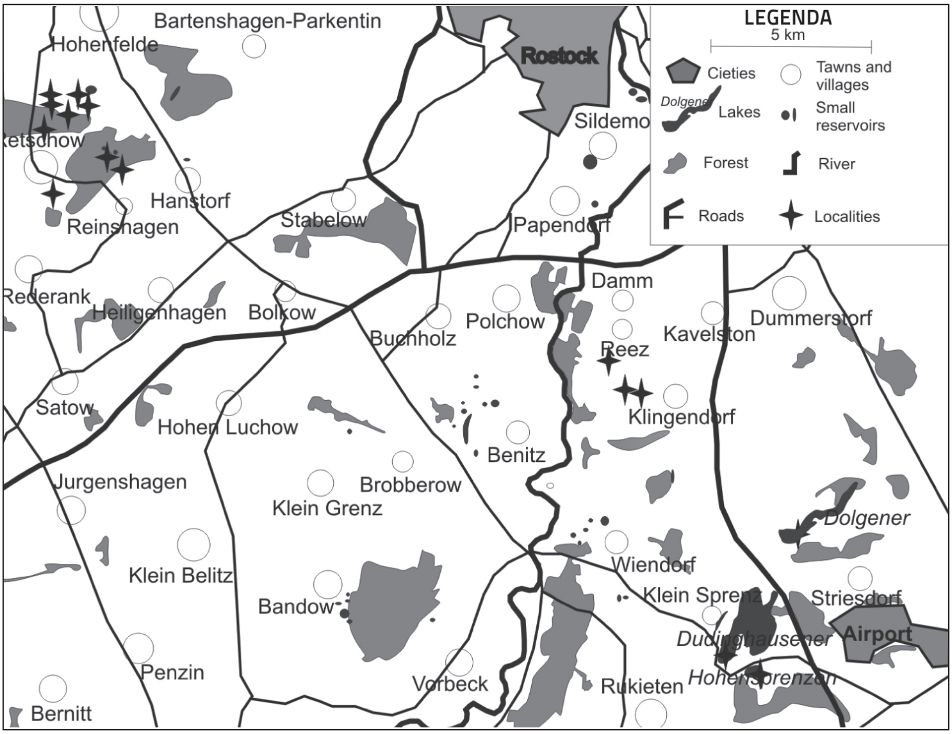

Fig. 1. Study area

ted alive and preserved in Koenike's fluid (Rey at al. 2004). All individuals were collected from every sample. Water reaction, temperature, electrolytic conductivity and dissolved oxygen content were measured with Elmetron CX–401 multiparametric sampling probe; the remaining parameters with the use of Slandi LF205 photometer.

In the case of some reservoirs there were available physical and chemical data (Tab. 1) indicating their eutrophic character. However, the general appearance of the reservoirs and the structure of vegetation growing in them facilitated their categorization. Due to the structure of vegetation and the presence of *Sphagnum* sp., *Utricularia* sp. and *Carex lasiocarpa*, two reservoirs (R28, R33) were considered dystrophic. One reservoir (R35), due to an almost total lack of vegetation and a large content of organic matter was identified as a hypertrophic one, while still another reservoir (R51), due to the presence of diversified vegetation and considerable water transparency was classified as a border case between mesotrophy and eutrophy. The two remaining reservoirs (V81, V86) were eutrophic ones. As for the other group of reservoirs, for which physical and chemical data were not available, three (L1, L2, L3) were small post-glacial lakes, one (R41/42) was a dystrophic reservoir, and the remaining ones (R15, R57, R65, R71, V52) were small eutrophic reservoirs. In summary, there were three lakes, three dystrophic reservoirs, one small reservoir representing a border case between mesotrophy and eutrophy and seven small eutrophic reservoirs.

Statistical analysis of the material was based on Spearman's rank correlation and correspondence analysis.

Table 1. Physico-chemical characteristics of some reservoirs

Parameter/Reservoir	R28	R33	R35	R51	V81	V86	R57	R65	R71
Width	104	37	15	30	15	67	—	127	66
Carbonate hardnes	1.2	1.8	5.6	3.1	2.9	2.0	1.5	6.1	5.7
Chlorophyll-a	108.4	9.0	41.4	43.2	0.8	269.4	—	—	—
Total N	1.7	1.4	10.5	1.5	1.1	1.3	—	—	—
Total P	88.4	158.0	401.6	81.1	152.5	191.5	—	—	—
Total hardnes	1.8	1.8	12.5	2.7	2.7	2.5	2.5	9.3	7.5
Conductivity	71.7	97.6	537.4	139.1	106.5	153.5	107.3	413.6	391.3
NH4	9.5	1.4	2.4	1.5	0.7	1.4	—	—	—
NO3	74.4	17.7	10131.1	156.1	4.6	5.5	—	—	—
NO2	4.9	3.7	64.7	12.0	5.5	4.0	—	—	—
Org. Mat. in Sediment	74	6	20	3	4	15	—	—	—
PO4	7.7	23.9	4.7	5.6	13.6	27.3	—	—	—
pH min	6.3	5.9	6.0	6.3	5.9	6.6	6.9	6.9	7.2
pH max	8.2	8.1	7.5	8.7	8.6	9.7	10.1	8.0	7.5
O2 (%) min	93.9	20.6	8.2	49.8	74.2	68.5	—	—	—
O2 (%) max	127.3	136.7	192.5	133.2	193.0	164.0	—	—	—
Seston	11.7	5.0	133.8	6.5		51.8	—	—	—
Depth	400	160	70	250	30	90	—	—	—
Foliage	100	50	0	40	0	80	—	—	—
Presence of water	perm	perm	period	perm	episod	perm	—	—	—

Results

In total, 904 water mite individuals were collected, including 499 females, 296 males and 109 deutonymphs. They belonged to 35 species. The most abundant species were *Hydrodroma despiciens* (23.3%), *Limnesia undulata* (13.3%) and *Unionicola crassipes* (10.0%). As for the species most frequently encountered in the studied localities, they included: *Hydrachna globosa* and *Hydrodroma despiciens* (frequency: 43.8%), *Limnochares aquatica*, *Limnesia fulgida*, *Unionicola crassipes* (frequency: 25.0%) and *Limnesia maculata*, *Piona conglobata*, *Mideopsis orbicularis* (frequency: 18.8%) (Tab. 2).

Table 2. Quantitative comparison of water mites

No.	Species	Females	Males	Deuto-nymphs	Total	Percentage	Frequency	Eutrophic		Dystrophic	
								l.o.	%	l.o.	%
1	Hydrachna globosa (Geer)	3	1	6	10	1.1	43.8	7	1.2	3	1.0
2	Hydrachna cruenta (O.F. Müll.)	1	1	—	2	0.2	6.3	2	0.3	—	—
3	Hydrachna uniscutata Thor	1	2	—	3	0.3	6.3	3	0.5	—	—
4	Limnochares aquatica (L.)	—	—	—	41	4.5	25.0	25	4.2	16	5.1
5	Eylais muelleri Koen.	—	1	—	1	0.1	6.3	1	0.2	—	—
6	Eylais infundibulifera Koen.	1	—	—	1	0.1	6.3	1	0.2	—	—
	Eylais sp.	—	—	19	19	2.1	18.8	18	3.1	1	0.3
7	Hydrodroma despiciens (O.F. Müll.)	112	65	33	210	23.2	43.8	73	12.4	137	43.6
8	Oxus ovalis (O.F. Müll.)	1	—	—	1	0.1	6.3	—	—	1	0.3
9	Frontioda musculus (O.F. Müll.)	36	25	1	62	6.9	6.3	62	10.5	—	—
10	Limnesia undulata (O.F. Müll.)	36	84	—	120	13.3	12.5	111	18.8	9	2.9
11	Limnesia fulgida Koch	6	10	2	18	2.0	25.0	11	1.9	7	2.2
12	Limnesia maculata (O.F. Müll.)	2	5	—	7	0.8	18.8	7	1.2	—	—
13	Hygrobates longipalpis Herm.	1	—	—	1	0.1	6.3	1	0.2	—	—
14	Unionicola gracilipalpis (Viets)	1	—	—	1	0.1	6.3	—	—	1	0.3
15	Unionicola crassipes (O.F. Müll.)	76	14	—	90	10.0	25.0	70	11.9	20	6.4

No.	Species	Females	Males	Deuto-nymphs	Total	Percentage	Frequency	Eutrophic		Dystrophic	
								l.o.	%	l.o.	%
16	Neumania deltoides (Piers.)	12	—	—	12	1.3	12.5	3	0.5	9	2.9
17	Neumania vernalis (O.F. Müll.)	18	1	—	19	2.1	12.5	—	—	19	6.1
18	Piona carnea (Koch)	4	3	—	7	0.8	12.5	7	1.2	—	—
19	Piona conglobata (Koch)	8	2	—	10	1.1	18.8	2	0.3	8	2.5
20	Piona longipalpis (Krend.)	—	1	—	1	0.1	6.3	1	0.2	—	—
21	Piona stjoerdalensis (Thor)	15	20	—	35	3.9	12.5	1	0.2	34	10.8
22	Piona variabilis (Koch)	16	3	—	19	2.1	12.5	17	2.9	2	0.6
	Piona sp.	—	—	41	41	4.5	18.8	2	0.3	39	12.4
23	Tiphys ensifer (Koen.)	9	—	—	9	1.0	6.3	9	1.5	—	—
24	Forelia liliacea (O.F. Müll.)	17	14	1	32	3.5	6.3	32	5.4	—	—
25	Brachypoda versicolor (O.F. Müll.)	57	1	3	61	6.7	12.5	59	10.0	2	0.6
26	Axanopsis complanata (O.F. Müll.)	1	—	—	1	0.1	6.3	1	0.2	—	—
27	Midea orbiculata (O.F. Müll.)	1	—	—	1	0.1	6.3	1	0.2	—	—
28	Mideopsis orbicularis (O.F. Müll.)	4	1	—	5	0.6	18.8	2	0.3	3	1.0
29	Arrenurus affinis Koen.	1	—	—	1	0.1	6.3	1	0.2	—	—
30	Arrenurus albator (O.F. Müll.)	15	18	—	33	3.7	12.5	32	5.4	1	0.3
31	Arrenurus cuspidator (O.F. Müll.)	—	1	—	1	0.1	6.3	1	0.2	—	—
32	Arrenurus bicuspidator Berl.	2	—	—	2	0.2	6.3	2	0.3	—	—
33	Arrenurus globator (O.F. Müll.)	17	—	—	17	1.9	12.5	15	2.5	2	0.6
34	Arrenurus crassicaudatus Kram.	1	2	—	3	0.3	6.3	3	0.5	—	—
35	Arrenurus sinuator (O.F. Müll.)	3	1	—	4	0.4	6.3	4	0.7	—	—
	Arrenurus sp.	—	—	3	3	0.3	6.3	3	0.5	—	—
	TOTAL	478	276	109	904			590		314	

From eutrophic reservoirs 590 water mite individuals were collected, which belonged to 32 species. The most abundant species included: *Limnesia undulata* (18.8%), *Hydrodroma despiciens* (12.4%), *Unionicola crassipes* (11.9%), *Frontipoda musculus* (10.5%) and *Brachypoda versicolor* (10.0%) (Tab. 2).

In dystrophic reservoirs there were identified 19 water mite species, represented by the total number of 314 individuals. The most abundant species included *Hydrodroma despiciens* (43.6%) and *Piona stjoerdalensis* (10.8%) (Tab. 2).

No statistically significant correlations were identified between general abundance of water mites and physicochemical parameters of water, which had the following values: carbonate hardness = –0.144943, chlorophyll-a = 0.550782, Total N = –0.115954, Total P = –0.405840, Total hardness = –0.144943, NH4 = –0.028989, NO3 = 0.057977, NO2 = –0.318874, Org. Mat. in Sediment = –0.405840, PO4 = 0.289886, pH min. = 0.405840, pH max. = 0.637748, O2 (%) min. = –0.028989, O2 (%) max. = –0.579771, Seston = –0.500000, Depth = 0.579771, Foliage = 0.470588. However, statistically significant correlations were discovered in the case of particular species: *Limnochares aquatica* – O2 (%) max (correlation = –0.84515), *Limnochares aquatica* – Depth (correlation = 0.84515), *Piona conglobta* – Seston (correlation = –0.894427), *Limnesia undulata* – PO4 (correlation = 0.845154), *Neumania deltoides* – NO2 (correlation = –0.84515), *Hydrachna globosa* – Total P (correlation = –0.84515), *Hydrodroma despiciens* – Total P (correlation = 0.84515).

The conducted correspondence analysis (Overall inertia = 5.6413; Chi^2 = 5082.8; df = 540; p = 0.0000) specified the characteristics of habitat preferences of the studied species with respect to particular water reservoirs. The high Chi^2 value indicated a very high diversification of habitat preferences and a very high diversity of species composition in particular localities. There could be distinguished two dimensions influencing species distribution. The first of these, i.e. coordinate axis X, accounted for ca. 16% of the diversity, while the second one, i.e. coordinate axis Y, accounted for ca. 15% (Fig. 2). A relatively low quality of these dimensions resulted from a low iterative input (inputs to chi-squares (Category 1) Input Table (rows*columns): 37 x 16). The localities R15, L1, L2, L3 and V86 had the highest participation in the creation of the dimensional factor space. The first dimension accounted especially for the distribution of such species as *Hydrachna cruenta*, *Eylais infundibulifera*, *Piona carnea* and *Limnesia undulata*. The second dimension accounted especially for the distribution of such species as *Limnesia maculata*, *Hydrachna uniscutata*, *Piona longipalis*, *Midea orbiculata* and *Limnesia undulata* (Fig. 2). The studied reservoirs constituted three groups of localities: 1st – L1, L2, L3; 2nd – R15; 3rd – the remaining ones (Fig. 2). Water mite species distribution in the studied reservoirs could be specified with reference to these three groups in the following way: 1st – *Limne-*

sia maculata, *Hydrachna uniscutata*, *Piona longipalpis*, *Midea orbiculata*; 2nd – *Eylais infundibulifera*, *Hydrachna cruenta*; 3rd – the remaining ones (Fig. 2).

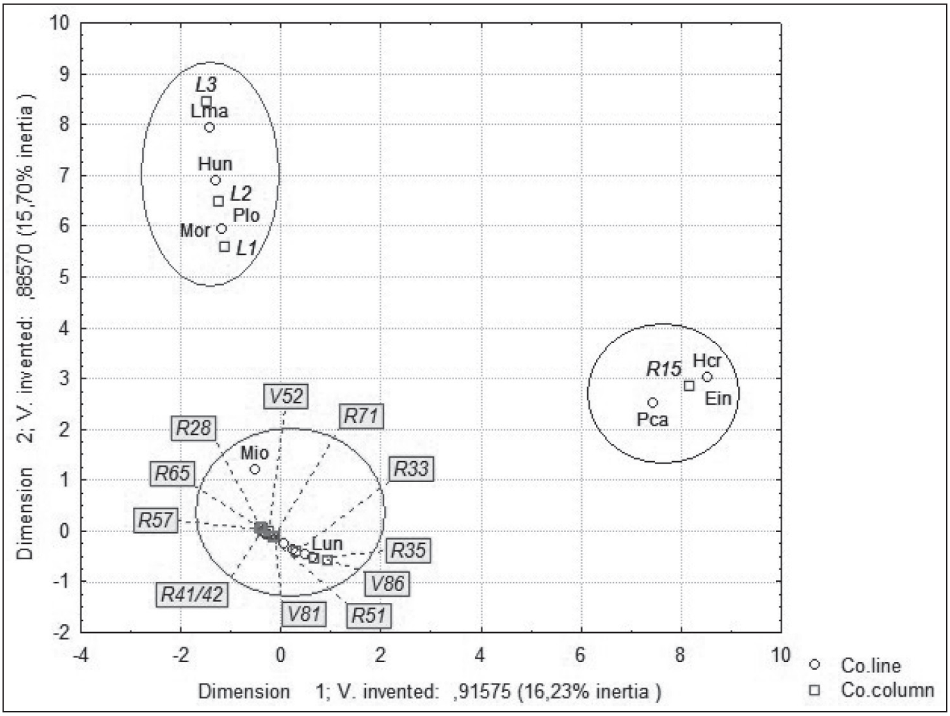

Fig. 2. Correspondence analysis – characteristics of the studied species with respect to particular water reservoirs (R15…R71, V52…V86 – small reservoirs; L1-L3 – lakes; Ein – *Eylais infundibulifera*, Hcr – *Hydrachna cruenta*, .Hun – *H. uniscutata*, Lma – *Limnesia maculata*, Lun – *L. undulata*, Pca – *Piona carnea*, Plo – *P. longipalpis*, Mor – *Midea orbiculata*, Mio – *Mideopsis orbicularis*; explanations about coordinate axes in text)

Discussion

Species richness of a particular area to some extent reflects its size and habitat diversity. From the point of view of these factors, the diversity of water mite fauna inhabiting small water bodies in Rostock surroundings is not particularly high. Earlier studies featuring data showed either similar (Schieferdecker 1966; Stryjecki 2010), a lower (Camacho, Valdecasas 1988; Stryjecki 2006b; Zawal

2006) or a higher species diversity (Kreuzer 1940; Biesiadka 1972; Cichocka 1998; Stryjecki 2006a, 2007). The analysis of subject literature allows for a conclusion that a higher level of species diversity is correlated with a larger size and a more permanent character of water bodies (Biesiadka 1972; Cichocka 1998; Stryjecki 2006a, 2007, 2010). The level of species diversity is clearly lower in water bodies existing only temporarily (Biesiadka 1972; Camacho, Valdecasas 1988; Stryjecki 2006b). Scheffer at al. (2006) point out that the presence of fish is a factor clearly reducing the biodiversity of invertebrates in permanent water bodies of larger sizes, which are not covered with vegetation. However, it refers to water mites to a lesser degree than to other invertebrates, as fish are rather unwilling to feed on water mites and thus they are present in large numbers in fish ponds (Puncochàr 1971; Proctor, Garga 2004; Stryjecki 2007), with fish affecting the size of their population only indirectly, by reducing the number of hydrobionts which serve as hosts for their larval stages (Zawal 2003).

Water mites can be encountered in very diversified aquatic environments but the presence of most species, as well as their high abundance, are associated with aquatic plants. Due to the fact that a majority of studied water bodies were permanent ones, rich in aquatic plants, the number of water mite species inhabiting those reservoirs should have been considerably higher. Such a low number of recorded species could be the result of a small number of collected samples which probably did not allow for detection of a number of species, especially those encountered in spring. Thus, species diversity of water mite fauna in the studied area was certainly higher than detected.

Water mite fauna of the area encompassed elements characteristic of small water bodies and a considerable share of lake species, surprisingly high for that type of water bodies and including the following: *Oxus ovalis*, *Frontipoda musculus*, *Hygrobates longipalpis*, *Unionicola gracilipalpis*, *U. crassipes*, *Piona stjoerdalensis*, *Brachypoda versicolor*, *Axanopss complanata*, *Mideopsis orbicularis*, *Arrenurus albator*, *A. crassicaudatus*.. As for the share of species associated with astatic spring waters it could not be estimated since no samples were collected in spring. The species typical of small water bodies recorded in the studied localities had been previously encountered in small reservoirs in Germany (Zacharias 1887; Viets 1914, 1918, 1936; Schmidt 1933; Kreuzer 1940; Schieferdecker 1966), the Netherlands (En Groen 1993) and Poland (Biesiadka 1972; Cichocka 1998; Stryjecki 2006a, b, 2007, 2010; Zawal at al. 2004; Zawal 2006, 2010). As for the lake species, they had previously been encountered almost solely in lakes

(Zacharias 1887; Viets 1914, 1918, 1936; Schmidt 1933; Schieferdecker 1966; Biesiadka 1972). Within the studied area these species inhabited mostly several larger reservoirs characterized by considerable water transparency and sandy bottoms covered with lush submergent vegetation, which was a combination of factors resembling the conditions typically found in lakes.

Among the most abundant species, the first two (*Hydrodroma despiciens* and *Limnesia undulata*) are characteristic of small water bodies, and the third one (*Unionicola crassipes*) is a lake species (Tab. 2). *Unionicola crassipes*, even though it is a species preferring lakes, has also been encountered in small permanent reservoirs (Biesiadka 1972; Cichocka 1998; Zawal at al. 2004; Stryjecki 2006a; Zawal 2006). In order to go through the complete developmental cycle it needs the presence of sponges, in which it lays eggs. In the studied area it was found in the largest numbers in the reservoir which were the least eutrophized (R51). Among the most frequent species, those characteristic of small water bodies were prevalent, but there were also two lake species (*U. crassipes* and *Mideopsis orbicularis*). These species clearly avoided the most heavily eutrophized reservoirs, and their presence confirmed that a reservoir was in a good condition. In this faunistic set of the most abundant and most frequent species, *Hydrodroma despiciens* and *Limnesia undulata* are the species found, frequently and in large numbers, in the littoral of lakes and in permanent reservoirs (Biesiadka 1972; Cichocka 1998), while *Unionicola crassipes* and *Mideopsis orbicularis* are mainly found in lakes and their presence in small water reservoirs is associated with a good condition of the reservoir and, in the case of *Mideopsis orbicularis*, also with the presence of a sandy bottom (Biesiadka 1972; Stryjecki 2006a).

In eutrophic reservoirs there was recorded a definitely larger number of species than in dystrophic ones. On the one hand it resulted from a larger number of eutrophic reservoirs in the area, and on the other, from the restrictions put on the water mite fauna by low pH, which is typically responsible for the disappearance of a number of species (Cichocka 1998).

In eutrophic reservoirs there prevailed the species characteristic of small water bodies, with the admixture of two lake species (*Unionicola crassipes* and *Brachypoda versicolor*), which were present almost exclusively in the cleanest reservoir (R51). Their presence was associated with a good condition of the reservoir, while the presence of *B. veriscolor* indicated a considerable area of a sandy bottom, i.e. a characteristic habitat of this species (Biesiadka 1972).

In dystrophic reservoirs, among the most abundant species was *Hydrodroma despiciens*, an eurytopic species characteristic of small water bodies and often reaching the superdominant status in acidic waters (Cichocka 1998; Zawal 2007). Another numerous species in this reservoir type was *Piona stjoerdalensis*, a typical lake species found in the deep littoral and sublittoral (Biesiadka 1972), whose presence, in large numbers, in the dystrophic reservoir R33 was a proof of good oxygen conditions near the bottom of that reservoir.

Because of a comparatively small number of samples, obtained correlation values (even those which are statistically significant) should be treated with caution. Bearing that in mind it can be pointed out that such species as *Hydrodroma despiciens*, *Limnesia undulata* and *Piona conglobata* prefer water bodies characterized by a higher trophic level, contrary to *Hydrachna globosa* and *Neumania deltoids* which prefer reservoirs with parameters indicating a lower trophic level. As for *Limnochares aquatica*, it is associated with slightly deeper reservoirs that have bottoms covered with organic matter responsible for deoxidation of these reservoirs.

Small water bodies can be treated as islands featured in MacArthur and Wilson's theory (1967), according to which the endemic character of species encountered on an island depends on the size of an island and the degree of its isolation. Apart from these two factors, species diversity is also influenced by: the degree of a reservoir's astaticity, the degree to which it is covered with vegetation, and the presence of fish (Camacho, Valdecasas 1988; Collinson et al. 1995; Williams 1995; Rundle et al. 2002; Sanderson et al. 2005; Scheffer at al. 2006; Dąbkowski, Biesiadka 2011). The above authors point out that the size of a reservoir and its astaticity are the most important factors. However, in many cases their influence may not be explicit; many factors may become either stronger or weaker (Scheffer at al. 2006), or have a reverse effect and then, as a result, in seasonal reservoirs the species diversity may be higher than in permanent ones (Dąbkowski, Biesiadka 2011). Local habitat diversification in a reservoir is also important, as it significantly influences the level of species diversity (Scheffer at al. 2006). This was clearly seen in the present study, where this factor was responsible for a large participation of lake species. However, a major factor influencing the diversity of species composition in particular reservoirs was their isolation. Correspondence analysis distinguished three separate groups among the reservoirs. The first and the second group included reservoirs isolated from other studied reservoirs. Furthermore, the first group included lake reservoirs, and the second one was composed of a single reservoir characterized by the presence of *Potamogeton acutiformis*, *P. natans* and *Lemna trisulca*. The latter reservoir was distinguished by the presence of two exclusive species, i.e. *Hydrachna cruenta* and *Eylais infundibulifera*, typically preferring reservoirs with lush submergent vegetation and inhabited by water bugs (the Heteroptera), which are the hosts of the water mite species (Biesiadka, Cichocka 1994). The lake reservoirs, apart from their sizes, differed also with respect to the presence of *Ceratophyllum demersum*, *Potamogeton lucens* and *Phragmites australis*, and were distinguished by four exclusive species: *Limnesia maculata*, *Hydrachna uniscutata*, *Piona longipalpis* and *Midea orbiculata*. These species, apart from being ecological opportunists, do not have any autoecological characteristics in common, which might differentiate them from other, eurytopic water mite species. As for the third group, it included all the remaining reservoirs, indicating the eurytopic character of the water mite fauna inhabiting them.

The fragmentary character of data does not allow to draw more general conclusions, however, the separate character of water mite communities may be connected with the strategy of parasitizing and dispersion (Zawal 2003) as well as the peculiar type of a reservoir (lake). A connection between the dispersion strategy of water mites and their ways of surviving the period when the reservoirs they inhabit dry out and the character of fauna inhabiting small water bodies was pointed out by Camacho & Valdecasas (1988), however, in that case the factor taken into account while creating groupings was the degree of a reservoir's astaticity. On the other hand, in the studies by Bohonak (1999) and Bohonak et al. (2004) it was observed that the genetic structure of populations of several *Arrenurus* species depended on their dispersion capacity and confirmed the theory developed by MacArtur and Wilson (1967), according to which the endemic character of fauna was connected with the degree of a locality's isolation. The present study confirms this conclusion.

References

Biesiadka E. 1972. Water mites (Hydracarina) of the Wielkopolski National Park. *Prace monograficzne nad przyrodą Wielkopolskiego Parku Narodowego*, 5: 1–102.

Biesiadka E., Cichocka M. 1994. Water mites (Hydracarina) – parasites of water bungs of the group Nepomorpha. *Pol. Pis. Entomol.*, 63: 357–368.

Bohonak A.J. 1999. Effect of insect-mediated dispersal on the genetic structure of postglacial water mite populations. *Heredity*, 82: 451–461.

Bohonak A.J., Smith B.P., Thornton M. 2004. Distributional, morphological and genetic consequences of dispersal for temporary pond water mites. *Freshwater Biol*., 49: 170–180.

Camacho A.I., Valdecasas A.G. 1988. Spatial and biocenotic trends in the water-mite fauna of small ponds. *Hydrobiologia*, 160: 207–217.

Cichocka M. 1998. *Wodopójki (Hydracarina) torfowisk Pojezierza Mazurskiego. Studium faunistyczno-ekologiczne*. Studies and Materials of WSP Olsztyn, Olsztyn.

Collinson N.H., Biggs J., Corfield M.J., Hodson D., Walkert D., Whitfield M., Williams P.J. 1995. Temporary and permanent ponds: an assessment of the effects of drying out on the conservation value of aquatic macroinvertebrate communities. *Biol. Cons*., 74: 125–133.

Dąbkowski P., Biesiadka E. 2011. Water beetles (Coleoptera) of small reservoirs in the neighborhood of Świnoujście (NW Poland). *Acta Biologica*, 18: 101–118.

En Groen D.R. 1993. *Macrofauna – atlas van Noord-Holland*. Verspreidingskaarten en responsies op, ilieufactoren van ongewervelde waterdieren. Basisinformatie 7.

Kreuzer R. 1940. Limnologisch-ökologische Untersuchungen an holsteinischen Kleingewässern. *Archiv f. Hydrobiologie. Suppl.-Bd*., 10: 359–572.

MacArtur R., Wilson E.O. 1967. *The theory of island biogeography*. Princeton N. J., Princeton University Press.

Proctor H.C., Garga N. 2004. Red, distasteful water mites: did fish make them that way? *Exp. Appl. Acarol*., 34: 127–147.

Puncohàr P. 1971. On the occurrence of water mites (Hydrachnellae) in the submerged vegetation of a carp pond. *Proc. 3rd Internat. Congr. Acarology Prague 1971*: 173–176.

Rey I., Dorda B.A., Valdecasas A.G. 2004. Traditional water mite fixatives and their compatibility with later DNA studies**.** *Exp. Appl. Acarol*., 34: 59–65.

Rundle S.D., Foggo A., Choiseul V., Bilton D.T. 2002. Are distribution patterns linked to dispersal mechanism? An investigation using pond invertebrate assemblages. *Freshwater Biol*., 47: 1571–1581.

Sanderson R.A., Eyre M.D., Rushton S.P. 2005. Distribution of selected macroinvertebrates in mosaic of temporary and permanent freshwater ponds as explained by autologistic models. *Ecography*, 28: 355–362.

Scheffer M., van Geest G.J., Zimmer K., Jeppensen E., Søndergaard M., Butler M.G., Hanson M.A., Declerk S., De Meester L. 2006. Small habitat size and isolation can promote species richness: second-order effects on biodiversity in shallow lakes and ponds. *Oikos*, 112: 227–231.

Schieferdecker H. 1966. Die Hydrachnellae des Naturschutzgebietes ‚Ostufer der Merrfe' in Mecklenburg. (Eine öine Meckle Untersuchung) (Acari: Hydrachnellae). *Beitr. Ent*., 16(5/6): 721–758, 8 Textfig.

Schmidt U. 1933. Erster Beitrag zu einer Hydracarinenfauna Mecklenburgs. *Arch. Ver. Freunde Naturg. Mecklenburg, Rostock (N.F:)*, 7, 1932 (1933): 61–80.

Stryjecki R. 2006a. Water mites (Acari: Hydrachnidia) of the Echo Ponds in the Roztoczański National Park before hydrotechnical restructuring. *Acta Agrophysica*, 7: 487–493.

Stryjecki R. 2006b. Roadside temporary water pool as a habitat for water mites (Acari: Hydrachnidia). *Teka Komisji Ochrony Kształtowania Środowiska Przyrodniczego*, 3: 181–186.

Stryjecki R. 2007. The role of fish ponds as important habitats for water mites (Hydrachnidia, Acari). *Oceanol. Hydrobiol. St. 36* (suppl.), 73–79.

Stryjecki R. 2010. Water mites (Acari: Hydrachnidia) of water bodies in the carbonate peat bog Bagno Bubnów in Polski National Park. Direction and dynamics of changes. *Teka Komisji Ochrony Kształtowania Środowiska Przyrodniczego*, 7: 382–388.

Viets K. 1914. Zur Kenntnis der Hydracarinen-Fauna von Ost- und Westpreußen und Brandenburg. 1. Mitteilung. *Schr. phys.-ökon. Ges. Königsberg* 1913, 54 (2): 225–229.

Viets K. 1918. Zur Kenntnis der Hydracarinen-Fauna von Ost- und Westpreußen und Brandenburg. 3. Mitteilung. *Schr. phys.-ökon. Ges. Königsberg*, 58, 1917: 14–19.

Viets K. 1936. Wassermilben oder Hydracarina (Hydrachnellae und Halacaridae). In: *Tierwelt Deutschlands*, F. Dahl (ed.) 31, (pp. 10+1–288), 32, (pp. 289–574), *Jena (G. Fischer).*

Williams D.D. 1996. Environmental constraints in temporary fresh waters and their consequences for the insect fauna. *Jour. North Amer. Benthol. Soc.*, 15: 634–650.

Zacharias E.O. 1887. Faunistische Studien in westpreußischen Seen. Beiträge zur Kenntnis der Seenfauna in Norddeutschland. *Schr. naturf. Ges. Danzig (N.F.)*, 6 (4): 43–72, (Sep. 30S.)

Zawal A. 2003. The role of insects in the dispersion of water mites. *Acta Biologica Universitatis Daugavpiliensis*, 3: 9–14.

Zawal A. 2006. Materiały do znajomości wodopójek (Acari: Hydrachnidia) okolic Złocieńca (Północno-Zachodnia Polska. *Acta Biologica*, 13: 163–169.

Zawal A. 2007. Wodopójki (*Hydrachnidia*) rezerwatu „Jezioro Szare" i jego otuliny. *Parki Narodowe i Rezerwaty Przyrody*, 26: 57–78.

Zawal A. 2010. Water mites (Hydrachnidia) of the small reservoir in the neighbourhood of Świnoujście (NW Poland). *Natura Montenegrina*, 9: 441–449.

Zawal A., Buczyński P., Pietrzak L. 2004. Aquatic invertebrates of the lowland peatbog Krępskie Bagno (Northwestern Poland). In: *The future of Polish mire*. L. Wołejko, J. Jasnowska (eds.). Agriculture University of Szczecin, pp. 199–204.

WODOPÓJKI (HYDRACHNIDIA) ZBIORNIKÓW WYTOPISKOWYCH OKOLIC ROSTOKU (PÓŁNOCNE NIEMCY)

Streszczenie

Drobne zbiorniki wodne są z jednej strony bardzo zróżnicowane środowiskowo, a z drugiej – charakteryzują się dużą skalą zmienności parametrów środowiskowych. Te dwie cechy powodują, że zasiedlająca je fauna wodopójek jest zróżnicowana gatunkowo, oraz że przeważają tu gatunki eurytopowe, przystosowane do szerokiej skali zmian środowiskowych. Ze względu na eurytopowość tych gatunków i dużą zmienność tworzonych przez nie zoocenoz, bardzo trudno jest wskazać powody ich środowiskowego rozmieszczenia, które prawdopodobnie mają często charakter lokalny. Niniejszy artykuł jest próbą podjęcia takiej analizy na podstawie fauny wodopójek zbiorników wytopiskowych z okolic Rostoku (Niemcy). Głównym czynnikiem różnicującym faunę badanych zbiorników była ich trofia. Analiza korespondencjna wyróżniła trzy odrębne grupy zbiorników. Izolacja zbiorników była najistotniejszym czynnikiem różnicującym faunę wodopójek.

Słowa kluczowe: drobne zbiorniki wodne, wody okresowe, wyspy ekologiczne, rozmieszczenie

Cite this article as: Zawal A., Kłosowska M., Pitsch T., Karlowski U., Bańkowska A. 2013**.** Water mites (Hydrachnidia) of kettle holes in Rostock surroundings (northern Germany). Acta Biologica, 20: 89–103.