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Ecology of *Hydrozetes* Berlese, 1902 (Acari, Oribatida) at various water bodies near Bydgoszcz (northern Poland)

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Abstract: Mites of the genus *Hydrozetes* Berlese, 1902 are abundant and important in wet habitats and can be useful in palaeoecological studies and bioindication. However, due to problems with their identification, there is still a limited knowledge on their ecology. In this study, 5 *Hydrozetes* species have been investigated. The most abundant was *H. lemnae* (about 121 000 ind./m²), which constituted 76% of the total Oribatida at a pond shore in the Botanical Garden in Myślęcinek in Bydgoszcz. Its population density was lower in duckweed and filamentous algae on the water surface of the same pond. This species was found also in several other bodies of water, varying in water quality, but it preferred neutral pH. *Hydrozetes thienemanni* had a narrower ecological tolerance and was restricted only to a forest pond with neutral pH in Pruszcz, where it dominated among the Oribatida. Three other species – *H. lacustris*, *H. octosetosus*, and *H. longisetosus* – were found only in acid water. The last mentioned species was absent from the peat pond in Bagno Chlebowo Nature Reserve, with a high concentration of sulphur and worse oxygen conditions, but that site was suitable for *H. lacustris*.

Keywords: *Hydrozetes*, Acari, Oribatida, bog, *Sphagnum*, ecology

INTRODUCTION

The family Hydrozetidae Grandjean, 1954, includes one genus, *Hydrozetes* Berlese, 1902, with 30 species. They have a cosmopolitan distribution, except the Antarctic (Subías 2004). In Europe and Poland, 7 species have recently been recorded (Seniczak et al. 2007, 2009; Seniczak & Seniczak 2008), including a new one to science (Seniczak & Seniczak 2009). All the species are aquatic, i.e. all their developmental stages live in water or at its margins (Schatz & Behan-Pelletier 2008), up to several meters under the water line (Buford 1976). This is possible due to many interesting adaptations of the species to aquatic life, like respiration through the plastron (Krantz & Baker 1982), orientation about the water depth thanks to a light-sensitive structure, the lenticulus (Alberti & Fernandez 1988), and levitation (Newell 1945) that is known only in the adults (Behan-Pelletier & Eamer 2007).

All European species occur in lakes, ponds, and slowly flowing water (Weigmann 2006; Weigmann & Deichsel 2006), where they can achieve high abundances (e.g. Seniczak et al. 2006; Seniczak 2011). *Hydrozetes* specimens have been found in many fossil samples and can be important in reconstruction of palaeoclimates (Erickson 1988; Krivolutsky et al. 1990; Solhøy & Solhøy 2000; Solhøy 2001; Erickson & Platt 2007). An increase in their density is correlated with water temperature, depth, and availability of nutrients in the aquatic ecosystem, while its low abundance or absence suggests a cold climate, with reduced nutrient cycling or prolonged dry conditions (Erickson & Platt 2007 and references therein). However, the poor knowledge of the ecology of *Hydrozetes* species limits their importance in both palaeoecological and bioindication studies.

This study aimed to compare the occurrence of *Hydrozetes* in selected bodies of water near Bydgoszcz and analyse ecological preferences of individual species.

MATERIAL AND METHODS

Study area

Samples were taken from the shores of 5 bodies of water: My = a pond in the Botanical Garden in Myślęcinek in Bydgoszcz (53°10'19" N, 18°02'48" E, 83 m a.s.l.); Pr = a forest pond in Pruszcz-Bagienica (53°26'08" N, 17°53'09" E, 90 m a.s.l.); Du = a pond in Dury Nature Reserve (53°38'20" N, 18° 21'22" E, 99 m a.s.l.); Ma = Lake Martwe in Martwe Nature Reserve (53°37'05"N, 18°12'07" E, 118 m a.s.l.); and Ba = a peat pond in Bagno Chlebowo Nature Reserve (53°44'17" N, 16°45'26" E, 65 m a.s.l.).

Pond My is under anthropogenic pressure (influence of the city, visitors, regular mowing of the lawn, and cutting of the shore plants). At its shore, the moss *Cratoneuron filicinum* Spruce dominated, and on the water surface, green filamentous algae and duckweed (mainly *Lemna gibba* L.) were present during the study. By contrast, all the other bodies of water are located in woodlands. At the shore of pond Pr there were mosses *Pleurozium schreberi* (Brid.) Mitt., *Hylocomium splendens* (Hedw.) and *Pseudoscleropodium purum* (Hedw.), while edges of the other ponds and the lake were dominated by *Sphagnum* mosses, mostly *S. fallax* (Klinggr.).

Water analyses

For the water analyses, 3 dm^3 of water were taken from each body of water at a distance of 2 m from the shore. The water was analysed in the Laboratory of Environmental Protection (Naftobazy Baza Paliw no. 2) in Nowa Wieś Wielka. The measured parameters and used methods are given in Table 1.

Mite analyses

From each shore, 10 samples of moss (each 100 cm^2 in area and 5 cm deep) were taken in the summer of 2005 (My) or 2006 (Du, Ma, Ba) or in the autumn of 2005 (Pr). Additionally, from pond My, 10 samples (500 cm^3) of green algae and 10 samples (500 cm^3) of duckweed were collected from the water surface at a distance of 2 m from the shore.

Table 1. Physicochemical parameters of the studied water bodies in northern Poland: My = urban pond in Myślęcinek; Pr = forest pond in Pruszcz-Bagienica; Du = pond in Dury Nature Reserve; Ma = Lake Martwe in Martwe Nature Reserve; Ba = peat pond in Bagno Chlebowo Nature Reserve

Parameter	Method of analysis	Unit	Body of water				
			My	Pr	Du	Ma	Ba
pH	PH meter PN-90 C-04540.01	-	7.2	7.8	5.8	5.7	5.2
Conductivity	PN-EN 27888:1999	µs/cm	684	348	23	22	153
COD	PN-74/C-04578.03	mgO_2/dm^3	92	33	30	25	86
BOD5	PN-EN 1899-1:2002 PN-EN 1899-2:2002	mgO_2/dm^3	4.1	2.5	2.4	1.2	33
Chlorides	PN-751C-04617.02 PN ISO 9297:1994	mg/dm^3	65	27	37	33	46
Sulphates	PN-74/C-04566.09	mg/dm^3	91	35	3	1.8	12
Total phosphorus	PN-88/C-04537/04 PN EN 1189:2000	mg/dm^3	0.09	0.13	0.02	<0.004	0.03

The mites were extracted using a modified Tullgren funnel. All *Hydrozetes* specimens were identified, including the juvenile stages, following Seniczak et al. (2009). The populations were characterized with the abundance (*A*), dominance (*D*) and constancy (*C*) indices, while the oribatid communities were characterized with the number of species (*S*) and Shannon index (*H*'). The basic statistical analyses included the mean values, range, and standard deviation. For other statistical analyses, the values were log-transformed LN (x+1) (Berthet & Gerard 1965; McDonald 2009; Łomnicki 2010). The normality of the distribution was tested with the Kolmogorov-Smirnov test, while the equality of variance in different samples, with the Levene test. When the assumption of normality or equality of variance was not met, the non-parametric Kruskal-Wallis test was used, followed by the Mann-Whitney *U* test. The statistical calculations were carried out with STATISTICA 8.0 software.

RESULTS

Ponds My and Pr had a neutral pH, high conductivity, and high phosphorus content, which indicate their eutrophication (Table 1). In contrast, pond Du and lake Ma were acidic and dystrophic, while peat pond Ba was acidic but had a high conductivity, and relatively high sulphur content.

The highest density of *Hydrozetes* was found in moss at the shore of pond My, but only *H. lemnae* (Coggi, 1897) was present there. Its density was about 121 000 ind. per m^2. Because of sample size ($100\ cm^2 \times 5\ cm$), this corresponds to 1210 ind. per 500 cm^3. *H. lemnae* made up 76% of the total Oribatida at that site (Table 2). This

Table 2. Abundance (*A*, in 10^3 ind./m²), constancy (*C,* in %), and dominance (*D,* in %) indices, number of species of Oribatida (*S*) and Shannon species diversity index (*H'*) at the edges of water bodies in northern Poland: My = urban pond in Myślęcinek; Pr = forest pond in Pruszcz-Bagienica; Du = pond in Dury Nature Reserve; Ma = Lake Martwe in Martwe Nature Reserve; Ba = peat pond in Bagno Chlebowo Nature Reserve; SD = standard deviation. Superscripts denote significant differences ($P \leq 0.05$) between means: (a) My-algae vs My-duckweed, My-moss, Pr, Du, Ma, Ba; (b) My-duckweed vs My-moss, Pr, Du, Ma, Ba; (c) My-moss vs Pr, Du, Ma, Ba; (d) Pr vs Du, Ma, Ba; (e) Du vs Ma, Ba; (f) Ma vs Ba

Taxon		My-algae	My-duckweed	My-moss	Pr	Du	Ma	Ba
Hydrozetes lacustris (Michael, 1882)	*A*	0.0	0.0	0.0	0.0	0.2 0.0-1.2 SD=0.38	<0.1 0.0-0.1 SD=0.03	1.2^{abcdef} 0.0-2.9 SD=0.91
	C					50	10	90
	D					<1.0	<1.0	2.3
H. lemnae (Coggi, 1897)	*A*	2.0* 0.7-3.2 SD=0.91	26.7^{a}* 8.2-61.3 SD=15.80	121.2^{ab} 1.4-259.6 SD=105.46	1.3^{abc} 0.0-3.1 SD=1.37	0.0^{abcd}	0.0^{abcd}	0.6^{abcef} 0.0-1.7 SD=0.63
	C	100	100	100	80			70
	D	99.5	99.9	76.4	6.0			1.1
H. longisetosus S. Seniczak & A. Seniczak, 2009	*A*	0.0	0.0	0.0	0.0	1.6^{abcd} 0.0-4.8 SD=1.62	0.1^{abcde} 0.0-0.4 SD=0.13	0.0^{ef}
	C					90	60	
	D					<1.0	<1.0	
H. octosetosus Willmann, 1932	*A*	0.0	0.0	0.0	0.0	0.5^{abcd} 0.0-1.6 SD=0.59	1.9^{abcde} 0.1-5.8 SD=1.64	<0.1^{ef} 0.0-0.3 SD=0.10
	C					80	100	20
	D					<1.0	<1.0	<1.0
H. thienemanni Strenzke, 1943	*A*	0.0	0.0	0.0	11.2^{abc} 0.4-71.1 SD=21.29	0.0^{d}	0.0^{d}	0.0^{d}
	C				100			
	D				50.0			
Oribatida	*A*	2.0*	26.8^{a}*	158.7^{ab}	22.4^{ac}	304.8^{abd}	203.2^{abd}	53.2^{acef}
Acari	*A*	10.6*	27.5^{a}*	162.8^{ab}	24.8^{ac}	306.8^{abd}	204.4^{abd}	55.4^{acef}
Number of species	*S*	2	2	4	30	25	22	31
Shannon index	*H'*	0.03	0.01	0.55	1.85	0.42	1.09	1.85

* The density in 50 000 cm³

species was also present but less common on the water surface, where it was over 10-fold more abundant in duckweed than in green algae. *H. lemnae* also occurred in pond Pr and in peat pond Ba, but in far lower densities.

The second most abundant among *Hydrozetes* species was *H. thienemanni* Strenzke, 1943. It was present only in pond Pr, with the density of about 11 000 ind. per m^2 (corresponding to 110 ind. per 500 cm^3). At the acidic pond Du and lake Ma, *H. lacustris* (Michael, 1882), *H. longisetosus* S. Seniczak & A. Seniczak, 2009, and *H. octosetosus* Willmann, 1932 were present. However, at the former water body, the most abundant was *H. longisetosus*, while at the latter one, *H. octosetosus*. At peat pond BC, only *H. lacustris* and *H. octosetosus* were found, and the first one dominated there.

DISCUSSION

Oribatid mites are abundant in aquatic and semi-aquatic habitats, including bogs, margins of lakes, and ponds (e.g. Belanger 1976; Fernandez & Athias-Binche 1986; Seniczak et al. 2006; Seniczak 2011), where they decompose organic matter (Kuriki 2008). For example, *H. lemnae* on duckweed in Argentina had a mean population density of 1600 per 200 cm^3 of water (Fernandez & Athias-Binche 1986), which corresponds to 4000 per 500 cm^3. In this study, the species achieved in the moss at pond My a 3-fold lower abundance, while on duckweed, its density was about 15-fold lower than in Argentina. In filamentous algae its abundance was 200-fold lower than in Argentina.

In the aquatic and semi-aquatic habitats, the species richness of Oribatida is lower than in soils (Schatz & Behan-Pelletier 2008), but the Oribatida remains the most diverse group of mites (Gerecke et al. 2009).

Hydrozetes lemnae lives mainly in eutrophic water bodies (Strenzke 1952), like lakes, ponds, and slowly flowing water, on submerged vegetation and on detritus (Weigmann & Deichsel 2006). It was also found in a flooded pasture (Haarlov 1957), an oasis in Central Sahara (Hammer 1975), aquariums with neutral pH (Fain et al. 1988) and on the gills and throat epithelium of fish and other aquatic animals (Grandjean 1948; Fain et al. 1988), but it was not a parasite (Grandjean 1949). Its feeding preferences and biology have been investigated by Athias-Binche & Fernandez (1986), Fernandez & Athias-Binche (1986) and Ermilov (2006).

Hydrozetes thienemanni has a similar ecology like *H. lemnae* and lives in eutrophic water bodies (Strenzke 1952), but has a narrower ecological amplitude. In the present study this species was found exclusively in the forest pond Pr with neutral pH, while *H. lemnae* occurred both at neutral and low pH, but was more abundant at neutral pH.

In contrast, *H. lacustris* was found only in acidic waters. Popp (1962) considered this species extremely euryionic, but other authors announced its preference for strongly acidic water (Walgram 1976; Weigmann 2006; Weigmann & Deichsel 2006; Mistrzak et al. 2011), which is confirmed in this study. Similarly, *H. octosetosus* and *H. longisetosus* were found only in the bodies of water with low pH, but *H. longisetosus* was absent in the peat pond Ba, possibly due to the higher concentration of sulphur and worse oxygen conditions, in comparison to other water bodies. However, these conditions were favourable for *H. lacustris*, which achieved its highest density there, being accompanied by *H. octosetosus*.

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