Water mites (Acari: Hydrachnidia) of the „Golczewskie Uroczysko” nature reserve

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Abstract
The „Golczewskie Uroczysko” nature reserve was established on 5 May 2004 to protect the raised peat bog and the dystrophic Lake Żabie with its surrounding transitional bog and adjacent forest complexes containing valuable plants. In May, July and October 2006 the research of water mite (Hydrachnidia) fauna has been conducted. A total of 557 water mite specimens belonging to 41 species were collected and among these 382 specimens belonging to 31 species were collected in Lake Żabie, 83 specimens belonging to 21 species were collected in ditches in the forest, 70 specimens belonging to 15 species in a ditch on the beatboog and 22 specimens belonging to 10 species in flooded alder forest. In a ditch in the peat bog, ditches in the forest and Lake Żabie tyrphobiontic and tyrphophilous species were dominant, with a substantial part of small water body species in Lake Żabie and with similar part of small water body species and vernal astatic water body species in a ditch in the peat bog and ditches in the forest. In flooded alder forest vernal astatic water body species were dominants.

Key words: water mites, Hydrachnidia, synecological groups, peat bog, NW Poland.

Introduction
In Europe, there is a large number of studies on water mites inhabiting bogs (e.g. Viets, 1938; Biesiadka & Kowalik, 1991; Cichocka, 1996a, 1998; Smit & Van der Hammen, 2000; Wiecek et al., 2013a), including Atlantic raised bogs in north-western Germany (Wiecek et al., 2013a). However, most studies refer to bogs degraded by human activities (draining, peat extraction), where water mites can be used for monitoring purposes (Wiecek et al., 2013b). There are only few studies on raised bogs in more natural conditions (Cichocka, 1996a, b, 1998; Stolbov et al., 2018). Many of these studies pointed to the low specificity of the water mite fauna of peatlands, where eurytopic species predominated (Kleiber, 1911; Harnisch, 1924; Viets, 1938; Schieferdecker 1966; Lundblad, 1968). Different results were presented in the papers of Protz (1906) and Ciochocka (1996b, 1998), where the water mite fauna of the peatlands was characterized by a high specificity, with many acidophilic and sphagnoophilic species. Interestingly, for water mites the peatland vegetation is more important than water chemistry (Wiecek et al., 2013a). Many water mites lay eggs and...
transform from one stage to another among aquatic mosses and macrophytes (Smith et al., 2009). Microhabitats created by vegetation also offer suitable conditions for hosts thus playing a large role in the dispersion and colonization of new habitats by water mites (Martin, 2008).

The aim of this study was to investigate the Hydrachnidia of the „Golczewskie Uroczysko” natural reserve, to determine the condition of the reserve based on characteristic of water mite communities and assessment of the impact of the reserve form of protection on the fauna of water-mites.

Material and methods

The research was conducted three times during the year: in May, July and October 2006. The samples were collected using a hydro-biological hand net with a triangular hoop: side length 30 cm, mesh size 200 μm. The sampling method involved 20 sweeps performed directly above the surface of the bottom over an area of about 1 m².

Characterization of water mite fauna was based on the dominance structure and the Shannon-Wiener biodiversity index. The water mites caught in the Golczewskie Uroczysko Reserve were assigned to three synecological groups (after Cichocka, 1998): small water body species, vernal astatic water body species, and tyrphobiontic and tyrphophilous species.

The ordering of the waters based on faunistic data was conducted using nonmetric multidimensional scaling (NMDS). PAST version 3.16 software (Hammer et al. 2001) was used to perform the NMDS analysis: these were done using the Bray-Curtis formula.

Study area

The „Golczewskie Uroczysko” nature reserve was established on 5 May 2004 to protect the raised peat bog and the dystrophic Lake Żabie with its surrounding transitional bog and adjacent forest complexes containing valuable plants. It is located on the Gryfice Plain, in a moraine upland area in the Kamięń Pomorski anticline (north-western Poland), and occupies two shallow depressions in the ground moraine landscape, separated by a small hill, and a flat moraine plain in the northern part of the reserve, with a moraine kame at 40 m a.s.l. situated on the north-western border of the reserve (Kondracki, 2011). The southern depression is occupied by Lake Żabie, a small dystrophic lake located in a transitional, topogenous peat bog (sites 5-14) (Fig. 1). The lake is firmly muddy (maximum depth about 1 m, water surface area 1.3 ha, water with a brown color and the Secchi disc visibility of 70 cm, pH 4.2). It has a narrow zone of Typhetum angustifoliiæ and Typhetum latifoliæ, which penetrate the farthest into the lake. Among the rush species, elements of the moss vegetation gradually overgrowing the water penetrate, and at the edge of the chow there are small, fragmented patches of Caricetum rostratae, Caricetum appropinquatae, Caricetum paniculatae, and Caricetum elatae. The largest area of the reservoir is covered by the Nymphaeetum candidae community, which is composed mainly of northern waterlilies (Nymphaea candida) and the accompanying white waterlilies (N. alba). At the edge of the water surface there are patches of the floating knotweed - Potametum natantis community, in small bays among rush communities, sparse small-surface patches of the Hydrocharitetum morsus-ranae association with the predominance of frogscent have developed. There were small communities of Lemnetum trisulcaæ on the water surface. The clusters of small duckweed Lemna minor are accompanied by a less numerous three-leaf duckweed – Lemna trisulca, which forms the second layer of the community under the water surface. Lemno-Utricularietum vulgaris has also been found. Lemna minor forms a loose layer on the water surface, while the underwater layer is Utricularia vulgaris, often with Lemna trisulca. The lake is also home to the Utricularietum neglectae complex, with Utricularia australis – yellow bladderswort being the dominant feature. The depression occupying the central part of the reserve is entirely filled with peat. In the eastern part it is a transitional, topogenous bog, while in the western part it is a raised, ombrogenous bog. There are also waters in the form of small depressions and ditches in the northern peat bog (sites 2 and 3), drainage ditches crossing forest complexes (site 1) and astatic waters in alder forest (site 4) (Fig. 1). They are also brown in color and acidic (pH 3.6 - 5.0).
Figure 1. Map with the locality of samples in „Golczewskie Uroczysko” nature reserve.
Results

A total of 557 water mite specimens (123 males, 250 females, 166 deutonymphs and 1 larva) belonging to 41 species were collected (Table 1). Among the water mites collected 382 specimens belonging to 31 species were collected in Lake Żabie, 83 specimens belonging to 21 species were collected in ditches in the forest, 70 specimens belonging to 15 species in a ditch in the beat bog and 22 specimens belonging to 10 species in flooded alder forest (Table 1). The differences in the number of specimens collected in each water were statistically significant: $H(3, N=85)=14.39362$ ($p=0.0024$). The most abundant species were *Hydrodroma despiciens* (10.1%), followed by: *Piona conglobata* (7.6%), *P. nodata* (6.1%), *P. carnea* (6.0%) and *P. alpicola* (5.1%). The combined species diversity of the Hydrachnidia of the Golczewskie Uroczysko Reserve was high $H=3.1721$.

The NMDS (stress=1.589, axis1=0.5585, axis2=0.3062) ordering (Fig. 2) shows two groups of sites: 1 – permanent, connected with low pH values (Lake Żabie and ditches on peat bog), with small water bodies species and tyrphophilous and tyrphobiontic species; 2 – sites from ditches in the forest and alder forest partially drying out, with mainly vernal astatic water body species. One species *Piersigia intermedia* is connected in samples from ditches on peat bog (Table 1, Fig. 2). Coordinate 1 illustrates the gradient of decreasingly astatic conditions, from astatic to permanent waters. Coordinate 2 illustrates the gradient of the decreasing impact of low pH, from dystrophic Lake Żabie and peat boog, to sites in alder forest.

![Figure 2. Non-metric multidimensional scaling of faunistic assemblages of the „Golczewskie Uroczysko“.

The most numerous group in the fauna of the Reserve were small water body species – the contribution of the 15 species from this synecological group was 37% of the material collected, and 172 specimens contribute 41% (Fig. 3).
### Table 1. Quantitative overview of water mites in the "Golczewskie Uroczysko" nature reserve, swbs: small water body species, vawbs: vernal astatic water body species, tts: tyrphophilous and tyrphobiont species.

| No. | Species | females | males | deutonymphs | larvae | total | domination | Zabie Lake ditches in the forest | ditch on the peat bog | flooded alder forest | synecological group |
|-----|---------|---------|-------|-------------|--------|-------|------------|---------------------|---------------------|---------------------|---------------------|
| 1   | *Hydrachna globosa* (Geer) | 2       | 1     | 1           | 3      | 3     | 0.5%       | 1                    | 1                   | 2                   | swbs                |
| 2   | *Hydrachna geographic* (O. F. Müll.) | 1       | 1     | 1           | 3      | 3     | 0.5%       | 1                    | 1                   | swbs                |
| 3   | *Hydrachna cruenta* (O. F. Müll.) | 1       | 1     | 1           | 2      | 3     | 0.2%       | 1                    | 1                   | swbs                |
| 4   | *Limnochaera aquatica* (L.) | 17      | 18    | 17          | 17     | 17    | 3.1%       | 7                    | 7                   | 3                   | tts                 |
| 5   | *Eylais extendens* (O. F. Müll.) | 1       | 1     | 1           | 2      | 2     | 0.2%       | 1                    | 1                   | swbs                |
| 6   | *Piersigia intermedia* Williams. | 2       | 2     | 1           | 1      | 2     | 0.4%       | 2                    | 2                   | vawbs               |
| 7   | *Hydryphantes hellichi* Thon. | 1       | 1     | 1           | 1      | 2     | 0.2%       | 1                    | 1                   | swbs                |
| 8   | *Hydryphantes planus* Thon. | 2       | 2     | 1           | 1      | 2     | 0.4%       | 2                    | 2                   | vawbs               |
| 9   | *Hydryphantes ruber* (Geer) | 17      | 17    | 17          | 17     | 17    | 3.1%       | 7                    | 7                   | 3                   | tts                 |
| 10  | *Limnesia connata* Koen. | 7       | 4     | 1           | 6      | 12    | 2.0%       | 6                    | 1                   | 4                   | tts                 |
| 11  | *Limnesia maculata* (O. F. Müll.) | 3       | 2     | 1           | 6      | 10    | 1.1%       | 6                    | 1                   | swbs                |
| 12  | *Piona alpicola* (Neum.) | 17      | 17    | 17          | 17     | 17    | 5.1%       | 16                   | 5                   | 7                   | tts                 |
| 13  | *Piona carnea* (Koch) | 23      | 7     | 3           | 33     | 36    | 6.0%       | 17                   | 11                  | 5                   | tts                 |
| 14  | *Piona coccinea* (Koch) | 3       | 1     | 4           | 4      | 8     | 0.7%       | 4                    | 2                   | swbs                |
| 15  | *Piona conglobata* (Koch) | 33      | 9     | 4           | 42     | 46    | 7.6%       | 42                   | 2                   | swbs                |
| 16  | *Piona nodata* (O. F. Müll.) | 21      | 9     | 4           | 34     | 38    | 6.1%       | 29                   | 5                   | vawbs               |
| 17  | *Piona rotundoides* (Thor) | 2       | 2     | 1           | 2      | 4     | 0.4%       | 2                    | 1                   | swbs                |
| 18  | *Piona variabilis* (Koch) | 7       | 6     | 13          | 57     | 57    | 2.3%       | 5                    | 5                   | 3                   | swbs                |
| 19  | *Piona sp.* | 57      | 57    | 57          | 57     | 57    | 10.3%      | 45                   | 7                   | 5                   | swbs                |
| 20  | *Pionidae* | 64      | 64    | 64          | 64     | 64    | 11.6%      | 50                   | 6                   | 6                   | 2                   |
| 21  | *Tiphys latipes* (O. F. Müll.) | 4       | 1     | 5           | 5      | 5     | 0.9%       | 2                    | 3                   | vawbs               |
| 22  | *Tiphys ensifer* (Koen.) | 5       | 1     | 6           | 6      | 6     | 1.1%       | 1                    | 1                   | 5                   | vawbs               |
| 23  | *Arrenurus affinis* Koen. | 12      | 5     | 17          | 15     | 15    | 3.1%       | 15                   | 2                   | swbs                |
| 24  | *Arrenurus claviger* Koen. | 1       | 1     | 2           | 2      | 2     | 0.4%       | 2                    | 2                   | swbs                |
| 25  | *Arrenurus caspidator* (O. F. Müll.) | 6       | 1     | 7           | 13     | 13    | 1.3%       | 6                    | 1                   | swbs                |
| 26  | *Arrenurus maculatus* (O. F. Müll.) | 3       | 1     | 4           | 4      | 4     | 0.7%       | 4                    | 4                   | swbs                |
| 27  | *Arrenurus neumanni* Piers. | 13      | 9     | 22          | 22     | 22    | 4.0%       | 18                   | 2                   | 2                   | tts                 |
| 28  | *Arrenurus fimбриatus* Koen. | 1       | 1     | 2           | 2      | 2     | 0.2%       | 2                    | 2                   | tts                 |

..continued on the next page
Table 1.

| Species                              | Individuals | Species | Individuals |
|--------------------------------------|-------------|---------|-------------|
| Arrenurus tetracyphus Piers.          | 2           | 4       | 2           |
| Arrenurus buccinator (O. F. Müll.)   | 8           | 16      | 2           |
| Arrenurus globator (O. F. Müll.)     | 13          | 7       | 3           |
| Arrenurus tubulatus (O. F. Müll.)    | 5           | 3       | 8           |
| Arrenurus bifidicodulus Piers.       | 1           | 2       | 3           |
| Arrenurus forpicatus Neum.           | 1           | 1       | 0,2         |
| Arrenurus inexploratus Viets         | 3           | 2       | 0,5         |
| Arrenurus stecki Koen.               | 2           | 1       | 0,4         |
| Arrenurus truncatellus (O. F. Müll.) | 1           | 6       | 0,2         |
| Arrenurus bisulcicodulus Piers.      | 6           |         |             |
| **Total**                            | 250         | 123     | 166         |

Species diversity was highest in Lake Żabie (H=2.8978), following by a ditch in the peat bog (H=2.8284), ditches in the forest (H=2.6987) and lowest in alder forest, where the Shannon index was 2.2604 (Table 1). Differences of the species diversity were statistically significant (p<0.05) only between alder forest and other waters.

![Diagram](image)

**Figure 3.** Participation of particular synecological groups of the water mite fauna of "Golczewskie Uroczysko" nature reserve; the inner ring – a number of individuals, the outer ring – the number of species.

In a ditch in the peat bog, ditches in the forest and Lake Żabie tyrphobiontic and tyrphophilous species were dominants, with a substantial part of small water body species in Lake Żabie and with a similar part of small water body species and vernal astatic water body species in a ditch in the peat bog and ditches in the forest. In alder forest vernal astatic water body species dominated (Fig. 4)
**Discussion**

Earlier studies showed that the fauna of water mites in peat bogs and dystrophic reservoirs is relatively poor, which was attributed to the low pH of the water, which limited the occurrence of many species. However, this research and the data contained in the study by Cichocka (1998) resulted in a different view on this subject, where high species diversity depends on high habitats diversity. The presence of 41 species of water mites in Golczewskie Uroczysko and the high value of the Shannon-Wiener Index indicate a relatively high species richness and diversity, which is confirmed by previous data from transitional topogenous peat bogs with relatively large waters (Cichocka, 1998) and dystrophic lakes (Zawal, 2007). Such a high species diversity is due to the high habitat diversity of Lake Żabie, which confirms the earlier thesis that the high species diversity of water mites is mainly due to the richness of the vegetation found in the peat pond (Więcek et al., 2013a). It seems that, as in the case of regular lakes, where species diversity is very different and the range of differences reaches 24-71 species (Kowalik, 1973; Biesiadka, 2003), in the case of raised and transitional peat bogs with dystrophic reservoirs, species diversity is different and depends on the habitat diversity of reservoirs (Cichocka, 1998; Zawal, 2003; Więcek et al., 2013a).

Among the dominant species, two (*Hydrodroma despiciens* and *Piona conglobata*) are small water body species, two other (*P. alpicola* and *P. carnea*) are tyrphophilous species, and one (*P. nodata*) is species characteristic for astatic waters. The situation that small water body species dominate the water mite fauna is appropriate for many lakes (Pieczyński, 1963; Biesiadka, 1972; Kowalik, 1973; Zawal, 1992) and dystrophic waters in peat bogs (Biesiadka, 1972; Cichocka, 1998; Zawal, 2007). This is especially true for *Hydrodroma despiciens*, which is a dominant species both in dystrophic waters (Cichocka, 1998; Zawal, 2007) and lakes (Biesiadka & Cichocka, 1997; Zawal, 2007; Stryjecki et al., 2017). In the case of the latter species, the reasons may be twofold. The first reason is a taxonomic reason, where *H. pilosa*, which seems to be a species with a preference for lakes, was often mistaken with *H. despiciens*, which is a small water body species, at
the same time very numerous in dystrophic reservoirs (Zawal, 2007). The second reason is of an ecological nature, where due to low competition from other water mites in dystrophic waters, the number of *H. despiciens* dominates (Zawal, 2007). *Piona conglobata*, on the other hand, is a species with a wide ecological amplitude and is often recorded in high numbers in dystrophic reservoirs in peat bogs (Cichocka, 1998; Zawal, 2007; Więcek *et al.*, 2013a). On the other hand, *P. nodata* is a species characteristic of astatic waters, tolerating low pH, hence its numerous records in shallow waters of a dystrophic nature (Biesiadka, 1972; Zawal, 2007).

The water mite fauna of „Golczewskie Uroczysko” is divided into two groups of species: one associated with Lake Żabie and a ditch in a raised peat bog, and the other associated with ditches in the forest and flooded alder forest. The common element of these two groups were tyrpho-biontic and typhophilous species. The first group was characterized by a large part of small water body species, and the second group was characterized by a large share of vernal astatic water body species. Such an arrangement of species confirms previous observations (Cichocka, 1998; Zawal, 2007; Więcek *et al.*, 2013a).

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