Polyhumic dystrophic rivers - an unique habitat for water mites (Acari, Hydrachnidia)?

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Abstract

Polyhumic dystrophic rivers are very rare in Poland and polyhumic rivers (both poly- and dystrophic) are weakly researched in general. The aim of the study was to present a detailed faunistic and ecological analysis of the water mites of polyhumic dystrophic rivers from Janów Forests Landscape Park (central-eastern Poland) and to compare the Hydrachnidia communities of those rivers with the Hydrachnidia of non-polyhumic rivers of this area. In small, fully polyhumic rivers Hydrachnidia fauna was poor in species and individuals, the populations of most species were very small and the characteristic feature of these rivers was very low species diversity. Therefore, the pronounced dystrophy of small polyhumic rivers should be considered a factor restricting the development of larger Hydrachnidia populations. In partially polyhumic rivers the water mite fauna was more diverse than in fully polyhumic rivers. The greater diversity of fauna resulted from the migration of species and individuals from the upper reaches of the river (non-polyhumic) and from greater habitat diversity.

As a general conclusion we can say that in the fauna of polyhumic dystrophic rivers it is impossible to indicate species that could be considered characteristic of these habitats and that distinguish the Hydrachnidia communities of polyhumic rivers from those of non-polyhumic rivers. The Hydrachnidia communities of polyhumic rivers differ from those of non-polyhumic rivers in terms of population size. Quantitative impoverishment of fauna is observed in polyhumic rivers (especially small, fully polyhumic ones). More research should be done to determine specificity of water mite fauna of polyhumic rivers.

Key words: dystrophy, species diversity, faunistic similarities, specificity, impoverishment of fauna.

Introduction

The term ‘polyhumic rivers’ is new. In 2014, the typology of rivers in Poland was revised so that two previously distinguished types of watercourses, ‘stream or brook in an area affected by peat-forming processes’ and ‘small or medium river in an area affected by peat-forming processes’ were combined into one category: ‘streams and rivers in valleys with a large share of peatlands’ (Updated list of JCWP and SCWP ... 2014). According to Górnia (2016), these types of watercourses should correctly be referred to as polyhumic rivers.

A characteristic feature of polyhumic rivers is the large share of dissolved organic matter (DOM) and partial organic matter (POM), which gives the water a permanent or periodic brown-rust colour (Górnia
The increased presence of organic matter in the water and bottom sediments of polyhumic rivers determines their biotic structure. Previous research indicates that polyhumic rivers contain invertebrates from a wide ecological spectrum: from calciphilic to acidophilic organisms and from filtrators to typical detritivores utilizing coarse detritus. The reason for such a wide diversity of fauna is the heterogeneity and origin of organic matter transported by rivers. The predominant peatlands in Poland are low peatbogs, from which moderately or heavily transformed organic matter reaches the rivers, usually in the form of humic acids. Calcium concentrations in these waters are above 40-50 mg/l, and bicarbonates predominate among anions. The pH is neutral, and electrolytic conductivity exceeds 150 μS/cm (Górniak 2016). The microbiological decomposition of organic matter and the breakdown of humic substances under the influence of UV radiation ensure sufficient amounts of available phosphorus and nitrogen for the development of algae. These are the conditions found in a fertile harmonic system, i.e., eutrophy. Rivers supplied with water from raised and transitional peat bogs with increased content of organic matter are hydrochemically similar to water of disharmonic systems, and thus should be referred to as dystrophic rivers. Their hydrochemical dystrophy index is greater than 50. Electrolytic conductivity in such watercourses is usually less than 150 μS/cm, the water is slightly acidic or neutral (pH < 7), and calcium and bicarbonate levels are low. This leads to the formation of a distinct microplankton structure, impoverishment of macrophytes, and a specific invertebrate community (Górniak 2016). According to Górniak (2016), due to the characteristic features of polyhumic rivers (eutrophic and dystrophic), they should be distinguished as a separate type in the ecological classification of Polish rivers. This is confirmed by regional studies of individual ecological and systematic groups of organisms inhabiting polyhumic rivers.

There are very few papers with the term ‘polyhumic’ in the title or keywords. The rare use of the word is probably due to the fact that polyhumic waters are only present in some parts of the world. The few studies on invertebrates inhabiting polyhumic waters deal with standing water bodies and focus mainly on zooplankton (e.g., Kankaala & Eloranta 1987; Kankaala 1988; Ojala et al. 1995; Ojala & Salonen 2011; Górniak & Karpowicz 2014). Far fewer publications concern other ecological formations (Koskenniemi 1992, 1994).

The world literature contains no studies on the Hydrachnidia of polyhumic dystrophic rivers or on the water mites of polyhumic rivers in general. The present study is the first dealing with this subject. In Poland, polyhumic eutrophic rivers predominate, while polyhumic dystrophic rivers are rare. In eastern Poland only a few polyhumic dystrophic rivers can be found: the Łukawica, the Czartosowa and the lower reaches of the Bukowa in Janów Forests (Górniak 2016). The aim of the study was to present a detailed faunistical and ecological analysis of the water mites of polyhumic dystrophic rivers from Janów Forests Landscape Park (central-eastern Poland) and to compare the Hydrachnidia communities of those rivers with the Hydrachnidia of non-polyhumic rivers of this area. The following research hypothesis was put forward: due to differences in abiotic factors between polyhumic rivers and non-polyhumic rivers, the Hydrachnidia communities of polyhumic rivers are different from those of non-polyhumic rivers in species composition as well as numbers of individuals.

**Study area and sites**

The research was conducted in the Janów Forests Landscape Park (central-eastern Poland). A general description of that area and its riverine system can be found in Stryjecki et al. (2018). Two polyhumic rivers (Czartosowa and Łukawica) and the polyhumic section of the River Bukowa were included in the study. The Czartosowa is a small lowland river, about 10 km long. The river flows through densely forested areas throughout its course. It flows out of a marshy, boggy area. The source of the river (50°38'55.8"N; 22°27'12.5"E) is located at 209.5 m above sea level (Geoportal 2019). The Czartosowa is a right-bank tributary of the park’s largest river, the Bukowa. It flows into the Bukowa in its middle course (50°36'56.5"N; 22°19'55.1"E). The estuary of the Czartosowa is located at 175.2 m above sea level (Geoportal 2019). The difference in altitude between the source of the river and its mouth is about 34 m, for an average drop of 3.4%. Sandy sediments predominate in the river. Aquatic vegetation is very poor. A distinctive feature is the tea-coloured water.

The Łukawica is a typical lowland river, about 34 km in length. From the 4th to the 26th kilometre of its course, it flows through densely forested areas. The source of the river is in the village of Stupie (50°45'09.8"N; 22°19'00.6"E) at an altitude of 211.0 m above sea level (Geoportal 2019). The Łukawica is a right-bank tributary of the River San. It flows into the San near the village of Wola Rzeczycka (50°39'26.7"N; 21°59'52.5"E). The mouth of the Łukawica is located at 146.2 m above sea level (Geoportal
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2019). The difference in altitude between the source of the river and its mouth is about 65 m, for an average drop of 1.9‰. The river feeds two large complexes of fish ponds. Water from the ponds is periodically drained into the river.

The following four polyhumic sites were selected for the research.

**Site 1** – on the River Czartosowa in the village of Szklarnia (50°38’30.4"N; 22°23’46.4"E)

A site located about 5 km from the source, in a dense pine forest; the water table is shaded. The river bed lies fairly deep below the ground surface, meandering slightly, with a width of 2.5 m to 3.5 m at the bends. The depth varies from 0.1 m at the banks to 0.4 m in the central part of the river. The water has a high content of humic compounds and is brown in colour. During the study period there were significant fluctuations in the water level and associated fluctuations in current velocity. Sediments were sandy and slightly silty by the banks. Vegetation was very sparse, with sporadic *Sparganium emersum* Rehmann, 1871 and *Fontinalis* sp.

**Site 2** – in the River Łukawica in the village of Bania (50°41’54.6"N; 22°10’18.7"E)

A site located about 14 km from the source in a mixed forest, with a shaded water table. The bed was about 2.5 m wide and 0.3-0.5 m deep. Sediments were silty and thick, composed of sand and silt in places. Small amounts of *Potamogeton pusillus* L., 1753, *Hydrocharis morsus-ranae* L., 1753, *Elodea canadensis* Michaux, 1803 and *Sagittaria sagittifolia* L., 1753 grew by the banks. In the central part of the river there were no plants at all, but there were numerous branches and rotting tree trunks. The water flow was slow, and periodically the water was nearly stagnant.

Sites 3 and 4 – situated in a polyhumic stretch of the Bukowa River. For a description of those sites see Stryjecki *et al.* (2018, sites 4 and 5 in the paper).

**Methods and material**

**Field research**

The field research was conducted from April to November 1996 and from March to October 1997. Samples were taken once a month. Sampling was done with a hand net. The net had a round frame 0.25 m in diameter and 250 µm mesh size. A single sample was taken over a distance of about 10 m. A total of 128 samples were collected from polyhumic rivers. The material comprised a total of 1,163 individuals. The material collected in the field was transported to the laboratory and segregated on white cuvettes. The keys used to identify water mites were Gerecke (2003, 2009), Davids *et al.* (2007), Di Sabatino *et al.* (2010), and Gerecke *et al.* (2016). Species nomenclature and systematics were adopted according to Davids *et al.* (2007), Di Sabatino *et al.* (2010) and Gerecke *et al.* (2016). Species were classified as very rare and rare according to Biesiadka (2008).

During collection of hydrobiological samples, the basic physical and chemical indicators of the water were measured: temperature (°C), pH, electrolytic conductivity (µS/cm), dissolved oxygen (mg O₂/l), and water saturation with oxygen (%). The measurements were made using a Slandi kit (TM204 thermometer, PH204 pH meter and CM204 conductivity meter) and an Elmetron CX401 multifunction meter. The water current was determined by the floating object method, by measuring the object’s flow time over a distance of 10 m.

Data from three non-polyhumic rivers were used for comparative purposes. The following non-polyhumic rivers/sites were included: the River Bukowa (Stryjecki *et al.* 2018, sites 1-3), the River Branew (Stryjecki 2019 in press, 2 sites), and the River Rakowa (unpublished data, 2 sites). Non-polyhumic rivers were researched at the same time and in the same area as the polyhumic rivers in this study. The comparative material comprised a total of 224 samples and 6,940 individuals.

**Statistical analyses**

Descriptive statistics (sums, means, range, and standard deviation) were calculated using PAST ver. 3.16/2019 software (Hammer *et al.* 2001). The software was also used to calculate the Shannon-Wiener index (H’). Analyses of quantitative faunistic similarities based on the Bray–Curtis formula were carried out using BioDiveristy Pro ver. 2 software (McAleece *et al.* 1997). Similarity dendrograms were generated using BioDiveristy Pro software. Group Average was used to create clusters.

The normality of the data distribution was checked by the Shapiro–Wilk test. The data were tested for homogeneity of variance using Levene’s test. The t test was used to compare two independent samples when data had normal distribution and the variance was homogenous. The Mann-Whitney U test (Z) was
used to compare two independent samples when data did not have normal distribution. All tests were carried out in Statistica 13.1 software. The statistical significance level was set at $p = 0.05$.

Results

Abiotic environmental parameters
The water temperature in the investigated rivers during the study period ranged from 1.0 to 19.7°C (Table 1). The average water temperature was slightly higher in polyhumic rivers than in non-polyhumic ones, but the differences were not statistically significant ($t_{132} = 0.1590$, $p = 0.8738$). Water pH ranged from 5.80 to 8.59. The average value of this parameter was lower in polyhumic rivers (6.92) than in non-polyhumic rivers (7.38), and the differences were statistically significant ($t_{132} = -5.3537$, $p = 0.0001$). Electrolytic conductivity during the study ranged from 79 to 970 μS/cm. The average value of this parameter was markedly lower in polyhumic rivers (242) than in non-polyhumic ones (358). The differences were statistically significant ($Z = -4.9508$, $p = 0.000001$). It should be emphasized that this parameter was highly variable during the study in both polyhumic and non-polyhumic rivers ($±SD 155.30$ and $±SD 175.14$, respectively). Better oxygen conditions prevailed in non-polyhumic rivers (Table 1), with somewhat higher oxygen content (on average 8.50 mg O$_2$/l vs 8.13 mg O$_2$/l in polyhumic rivers) and higher oxygen saturation (80.9% vs 77.5% in polyhumic rivers). The differences in dissolved oxygen content and oxygen saturation were not statistically significant ($t_{95} = -0.9693$, $p = 0.3348$; $t_{23} = -1.3308$, $p = 0.1864$). Water current ranged from 0.11 to 1.00 m/s (Table 1). Statistically slower water flow was recorded in polyhumic rivers (on average 0.42 m/s vs 0.38 m/s in non-polyhumic rivers). The differences in water current between the two types of rivers were not statistically significant ($Z = 0.8963$, $p = 0.3700$). It should be emphasized that the water current was highly variable in the polyhumic rivers ($±SD 0.24$). In the small polyhumic rivers (Czartosowa and Łukawica), extremely slow water current was observed periodically.

Table 1. Values of analyzed environmental parameters (range; mean; $±SD$) in investigated polyhumic (P) and non-polyhumic (NP) rivers. a, b – the differences in the values were statistically significant. * – periodically almost stagnant water.

| Parameter                        | P                  | NP                  |
|----------------------------------|--------------------|---------------------|
| Temperature (°C)                 | 1.0-19.4;          | 2.2-19.7;           |
|                                  | 11.5; ±4.73        | 11.29; ±4.27        |
| pH                               | 5.80-8.01;         | 6.00-8.59;          |
|                                  | 6.92$^a$; ±0.47    | 7.38$^b$; ±0.51     |
| Electrolytic conductivity (μS/cm)| 79-980;            | 86-970;             |
|                                  | 242$^a$; ±155.30   | 358$^b$; ±175.14    |
| Dissolved oxygen (mg O$_2$/l)    | 4.50-11.78;        | 5.10-12.40;         |
|                                  | 8.13; ±1.82        | 8.50; ±1.88         |
| Water saturation with oxygen (%) | 47.0-115.7;        | 50.0-117.5;         |
|                                  | 77.5; ±14.86       | 80.9; ±14.92        |
| Water current (m/s)              | 0.11-1.00$^*$;     | 0.14-0.67;          |
|                                  | 0.42; ±0.24        | 0.38; ±0.12         |

Water mite fauna
There were 1,163 water mite specimens belonging to 47 species caught in the polyhumic rivers (Table 2). The species belonged to 24 genera and 14 families. Among the species caught in polyhumic rivers, four can be classified as very rare in Poland: Pseudohydryphantes parvulus, Nilotonia borneri, Parabrachypoda modesta and Atractides samsoni. Another six species were rare among Polish fauna: Hydrodroma torrenticola, Thyopsis cancellata, Teutonia cometes, Albia stationis, Nautarachna crassa and Mideopsis roztoczensis. Species found only in polyhumic rivers and not in non-polyhumic rivers were Eylais extendens.
**Table 2.** Qualitative and quantitative composition of water mite fauna found in polyhumic dystrophic rivers. Bu – polyhumic section of the Bukowa River, Cza – the Czartosowa River, Łuk – the Łukawica River

| No | Species                                | Bu | Cza | Łuk |
|----|----------------------------------------|----|-----|-----|
| 1  | Limnochares aquatica (Linnaeus, 1758)   | 111|     |     |
| 2  | Eylais extendens (Müller, 1776)         | 1  |     |     |
| 3  | Hydrodroma torrenticola (Walter, 1908)  | 2  | 1   | 3   |
| 4  | Thyopsis cancellata (Protz, 1896)       | 4  |     |     |
| 5  | Hydryphantes planus Thon, 1899          | 3  | 1   |     |
| 6  | Hydryphantes ruber (Geer, 1778)         |    | 2   |     |
|    | Hydryphantes sp. (deutonymphs)          | 2  | 1   |     |
| 7  | Pseudohydryphantes parvulus K. Viets, 1907 | 1   |     |     |
| 8  | Nilotonia borneri (Walter, 1922)         | 40 | 2   |     |
| 9  | Lebertia fimбриata Thor, 1899           | 28 | 5   |     |
| 10 | Lebertia oblonga Koenike, 1911           | 15 | 1   |     |
| 11 | Lebertia rivulorum K. Viets, 1933        | 1  |     |     |
| 12 | Lebertia dubia Thor, 1899               | 106| 2   | 5   |
| 13 | Lebertia inaequalis (Koch, 1837)        | 21 |     |     |
| 14 | Lebertia insignis Neuman, 1880          | 7  |     |     |
| 15 | Lebertia porosa Thor, 1900              | 15 | 1   |     |
|    | Lebertia sp. (deutonymphs)              |    |     |     |
| 16 | Sperchon clupeifer Piersig, 1896        | 86 | 1   |     |
| 17 | Sperchon papillosus Thor, 1901          | 1  |     |     |
| 18 | Sperchon setiger Thor, 1898             | 73 |     |     |
| 19 | Sperchonopsis verrucosa (Protz, 1896)   | 2  | 1   |     |
| 20 | Teutonia cometes (Koch, 1837)           | 15 | 1   |     |
| 21 | Torrenticola amplexa (Koenike, 1908)    | 7  |     |     |
| 22 | Albia stationis Thor, 1899              | 3  |     |     |
| 23 | Brachypoda versicolor (Müller, 1776)    | 7  |     |     |
| 24 | Ljania bipapillata Thor, 1898           | 1  |     |     |
| 25 | Parabrachypoda modesta (Koenike, 1911)  | 2  | 1   |     |
| 26 | Atractides distans (K. Viets, 1914)     | 5  |     |     |
| 27 | Atractides nodpalpis Thor, 1899         | 32 |     |     |
| 28 | Atractides samsoni (Sokolow, 1936)      | 1  |     |     |
| 29 | Atractides tener Thor, 1899             | 1  |     |     |
|    | Atractides sp. (deutonymphs)            | 1  |     |     |
| 30 | Hygrobates calliger Piersig, 1896       | 80 |     |     |
| 31 | Hygrobates flaviatilis (Ström, 1768)    | 10 | 1   |     |
| 32 | Hygrobates longipalpis (Hermann, 1804)  | 6  | 1   | 14  |
| 33 | Hygrobates setosus Besseling, 1942      | 67 | 73  |     |
|    | Hygrobates sp. (deutonymphs)            | 2  | 2   |     |
| 34 | Limnesia maculata (Müller, 1776)        | 2  |     |     |
| 35 | Forelia variegator (Koch, 1837)         | 73 | 2   | 30  |
| 36 | Nautarachna crassa (Koenike, 1908)      | 3  | 2   |     |
| 37 | Piona carnea (Koch, 1836)               | 1  | 1   |     |

..continued on the next page
The dominant species (dominance > 5%) in the material collected in the polyhumic rivers were *Hygrobes setosus* (12.3%), *Lebertia inaequalis* (9.9%), *Limnochares aquatica* (9.8%), *Forelia variegator* (9.2%), *Sperchon clupeifer* (7.7%), *Hygrobes calliger* (7.1%), *Sperchon setiger* (6.4%) and *Mideopsis crassipes* (6.1%).

The highest mean number of individuals per sample in the polyhumic rivers was recorded in the River Bukowa (12.9 ind./sample), and the lowest in the Czartosowa (4.4 ind./sample). In the non-polyhumic rivers, the mean numbers of specimens were much higher (Table 3). When all rivers of each category are considered together, the number of individuals per sample in the polyhumic rivers is much lower than in the non-polyhumic rivers (9.1 and 31.0, respectively) – Table 3.

The dendrogram of faunistic similarities shows a clear grouping of the non-polyhumic rivers Branew and Rakowa (59.8% similarity) and another grouping of the polyhumic section of the Bukowa River with the non-polyhumic stretch of that river (49.5% similarity; Figure 1). The fauna of the polyhumic River Czartosowa was most similar to the Hydrachnidia communities of the polyhumic section of the Bukowa (22.9% similarity). The fauna of the polyhumic Łukawica was quite distinct: it was only 12.3% similar to the Hydrachnidia communities of the non-polyhumic section of the Bukowa, 11.5% similar to the fauna of the polyhumic Czartosowa, and 11.0% similar to the fauna of the polyhumic section of the Bukowa (Figure 1). In the River Łukawica, as many as six species were caught that were not caught in any other river in the

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**Table 2.**

| 38. | *Piona obturbans* (Piersig, 1896) | 1 |
| 39. | *Piona pusilla* (Neuman, 1875) | 1 |
|      | *Piona* sp. (deutonymphs) | 3 |
| 40. | *Arrenurus crassicaudatus* Kramer, 1875 | 16 |
| 41. | *Arrenurus cuspidator* (Müller, 1776) | 2 |
| 42. | *Arrenurus neumani* Piersig, 1895 | 2 |
| 43. | *Arrenurus cylindratus* Piersig, 1896 | 2 |
| 44. | *Arrenurus mediorotundatus* Thor, 1898 | 2 |
| 45. | *Mideopsis crassipes* Soar, 1904 | 21 37 11 |
| 46. | *Mideopsis orbicularis* (Müller, 1776) | 1 |
| 47. | *Mideopsis roztoczensis* Biesiadka & Kowalik, 1979 | 37 |
|      | *Mideopsis* sp. (deutonymphs) | 1 |

| Total individuals | 828 141 194 |
| Total species | 35 19 15 |

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*Figures 1.* Faunistic similarities between polyhumic and non-polyhumic rivers. For abbreviations see Table 3.
park, either polyhumic or non-polyhumic. These were *Eylais extendens, Pseudohydrphantes parvulus, Brachypoda versicolor, Piona obturbans, Arrenurus cuspidator* and *A. neumani*.

**Table 3.** Average number of individuals per sample in polyhumic and non-polyhumic rivers. Bu-P – polyhumic section of the Bukowa River, Cza – the Czartosowa River, Łuk – the Łukawica River, P-total - polyhumic rivers together, Bu-NP – non-polyhumic section of the Bukowa River, Bra – the Branew River, Rak – the Rakowa River, NP-total – non-polyhumic rivers together

|                | Polyhumic rivers | Non-polyhumic rivers |
|----------------|------------------|----------------------|
| Bu-P           | 12.9             | 4.4                  |
| Cza            | 6.1              |                      |
| Łuk            | 9.1              |                      |
| P-total        | 20.4             | 43.5                 |
| Bu-NP          | 20.4             | 43.5                 |
| Bra            | 43.5             | 34.2                 |
| Rak            | 34.2             | 31.0                 |
| NP-total       | 31.0             |                      |

Higher species diversity was found in the polyhumic rivers (H’ = 2.96) than in the non-polyhumic rivers (H’ = 2.79). However, in some polyhumic rivers (Czartosowa and Łukawica) species diversity was very low – much lower than in the non-polyhumic rivers (Figure 2).

**Figure 2.** Shannon-Wiener index values in polyhumic and non-polyhumic rivers. For abbreviations see Table 3

**Discussion**

Analysis of the Hydrachnidia fauna of the polyhumic rivers of the Janów Forests Landscape Park indicates that the rivers should be divided into two subcategories: fully polyhumic rivers (the Czartosowa and Łukawica) and partly polyhumic rivers, i.e. those in which only certain parts of the course of the river are polyhumic (the Bukowa). In fully polyhumic rivers, the water mite fauna was both quantitatively and qualitatively poor; many more individuals and species were caught in the non-polyhumic rivers of the park (Stryjecki et al. 2018; Stryjecki 2019). Many more individuals and species have also been found in other lowland rivers of Poland than in the fully polyhumic rivers in the present study (Kowalik 1981; Kowalik & Biesiada 1981; Cichocka 1996, 2006; Zawal & Kowalik 2013; Zawal et al. 2017). The fully polyhumic rivers had significantly lower, slightly acidic pH and lower electrolytic conductivity than the non-polyhumic rivers. According to Górnia (2016), low values for pH and electrolytic conductivity in polyhumic dystrophic rivers, as well as low concentrations of calcium and bicarbonates, contribute to the depletion of important elements of food webs, i.e. algae and macrophytes, as well as to the formation of distinctive
invertebrate communities in which certain groups are absent (e.g. molluscs). The impoverishment of producers in dystrophic rivers results in the impoverishment of subsequent links in the food chain, including predators such as water mites. The pronounced dystrophy of the park’s small polyhumic rivers should be considered a factor limiting the development of larger Hydrachnidia populations. The Czartosowa and Łukawica are small watercourses running through forests and are much less diversified in terms of habitat than the non-polyhumic rivers of the park. Both rivers were shallow, with low abundance of aquatic vegetation, bottom sediments with little variation, and practically no differentiation into lotic and lentic habitats in the transverse profile. The low habitat diversity of small polyhumic rivers can be considered another reason for the impoverishment of their fauna.

The fauna of the lower Bukowa was much richer in species and individuals than that of the small, fully polyhumic rivers, but poorer than in the upper, non-polyhumic section of the Bukowa and the non-polyhumic rivers of the park (Stryjecki et al. 2018; Stryjecki 2019). The markedly greater diversity of the Hydrachnidia communities of the polyhumic section of the Bukowa was due to the migration of many species in the longitudinal profile of the river (Stryjecki et al. 2018). Differences in the physicochemical parameters of the water between the upper and lower course of the Bukowa were not significant (Stryjecki et al. 2018), so species inhabiting the non-polyhumic section of the river could also live in the polyhumic part. The Bukowa is a much larger river than the Czartosowa or the Łukawica, with much greater habitat diversity. The presence of numerous meso-habitats, including well-developed lotic and lentic zones, has translated into a greater diversity of fauna than in small polyhumic rivers.

Four very rare species and six rare species for Poland were found in the polyhumic rivers. Two of the four very rare species (Pseudohydrophantes parvulus and Atractides samsoni) were found only in the small, fully polyhumic rivers, and a third (Nilotonia borneri) was found only in the polyhumic section of the Bukowa. The fourth species (Parabrachypoda modesta) was also present in non-polyhumic rivers. Of the six rare species for Polish fauna, one (Albia stationis) was found only in polyhumic rivers, and the population of another (Thyopsis cancellata) was larger in the polyhumic rivers than in the non-polyhumic rivers. This analysis indicates that polyhumic dystrophic rivers, including small, fully polyhumic rivers, are habitats whose fauna raises the faunistic value of the area.

There were 14 species found in the polyhumic rivers that were not caught in non-polyhumic rivers. Of these, as many as 8 were found only in small, fully polyhumic rivers. Despite this large number of exclusive species, it is difficult to identify taxa preferring polyhumic rivers. Most of the species exclusive to the polyhumic rivers were caught in small numbers, often as single specimens, so they cannot be considered characteristic of these environments. The species exclusive to the polyhumic rivers included stagnobiontic species that should be considered accidental elements rather than characteristic of polyhumic rivers. A particularly high share of stagnobiontic and stagnophilic species was found in the River Łukawica. They were caught there in very small numbers, but are common in other types of water bodies of the park: fish ponds (Stryjecki 2004a; Stryjecki et al. 2015), small permanent water pools and astatic pools (Stryjecki 2004b) and transitional water bodies (Stryjecki 2003). Stagnobionts and stagnophiles found in the Łukawica may have been an indigenous component of the fauna (slow water flow in the river), but may also have been an exogenous element. Water from the fish ponds was periodically drained into the river, so that species from fish ponds could make their way into the river together with the pond water.

_Limnochares aquatica_ was the only species whose presence in the Łukawica can be considered a response to environmental conditions (stagnant, slightly acidic water). The Łukawica had the largest population of _Limnochares aquatica_ of all rivers of the park. The presence of a large population of this species in a river with lower water pH, a dark silty bottom and numerous decaying tree trunks confirms literatures reports of this species’ preference for riparian sediments of permanent stagnant waters or pools in streams, often in decaying wood, roots and leaf litter (Biesiadka 1972; Davids et al. 2007). _Limnochares aquatica_ is sometimes referred to as an acidophilic species (Biesiadka 2008). The fact that many _Limnochares aquatica_ individuals were caught in the River Łukawica confirms this species’ preference for water with a lower pH (Davids et al. 2007; Biesiadka 2008). Apart from the Łukawica, _Limnochares aquatica_ has been found in large numbers in the dystrophic pond Imielty Ług (Stryjecki 2004a), in transitional waters at sites with a lower pH (Stryjecki 2003), and in the River Bukowa only at a site with a lower pH (Stryjecki et al. 2018). _Limnochares aquatica_ is found in large numbers in dystrophic lakes (Cichocka 2005; Zawal 2007). Analysis of the habitat distribution of _Limnochares aquatica_ in various waters of the Janów Forests Landscape Park and literature data indicate that this species is characteristic not for dystrophic rivers in particular but for dystrophic waters in general.
In the dendrogram of faunistic similarities, we can see a grouping of non-polyhumic rivers (the Branew and Rakowa) and a grouping of the polyhumic section of the Bukowa with its non-polyhumic section. Together, the Branew, Rakowa and Bukowa form a cluster comprising the larger rivers of the park, with diversified habitats, flowing through open areas or in certain sections through wooded areas. Small, fully polyhumic rivers are not grouped into a separate cluster, which indicates the absence of a group of species that could be identified as the core of the fauna characteristic of polyhumic dystrophic rivers. Apart from species caught in single numbers, mainly characteristic of standing water bodies, the taxa caught in somewhat higher numbers, characteristic of flowing water bodies, indicate that generally the same species that were found in non-polyhumic rivers were found in small, polyhumic dystrophic rivers. The basic difference between the two types of river was that much smaller populations of individual species were found in polyhumic rivers than in non-polyhumic rivers.

Conclusions

In small, fully polyhumic rivers:
1. Hydrachnidia fauna is poor in species and individuals. The populations of most species are very small. The characteristic feature of these rivers is very low species diversity.
2. The pronounced dystrophy of small polyhumic rivers should be considered a factor restricting the development of larger Hydrachnidia populations.

In partially polyhumic rivers:
1. The water mite fauna is more diverse than in fully polyhumic rivers. The greater diversity of fauna results from the migration of species and individuals from the upper reaches of the river (non-polyhumic) and from greater habitat diversity.

General conclusion – verification of the research hypothesis:
1. In the fauna of polyhumic rivers it is impossible to indicate species that could be considered characteristic of these habitats and that distinguish the Hydrachnidia communities of polyhumic rivers from those of non-polyhumic rivers.
2. The Hydrachnidia communities of polyhumic rivers differ from those of non-polyhumic rivers in terms of population size. Quantitative impoverishment of fauna is observed in polyhumic rivers (especially small, fully polyhumic ones).

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