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New data to the knowledge on the Harpacticoida (Crustacea, Copepoda) fauna in Poland

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Abstract: Harpacticoida is the least known group of Copepoda in freshwater habitats in Poland, although they are very common and very abundant in the continental waters. The last detailed taxonomic studies of Harpacticoida in Polish inland waters were carried out about 100 years ago. A faunistic and ecological review of 12 harpacticoid species from north-eastern Poland is presented herein for the first time. Two species new to the Polish fauna were recorded: *Elaphoidella elaphoides* (Chappuis, 1923) and *Bryocamptus (Rheocamptus) spinulosus* (Borutzky, 1934). *Bryocamptus spinulosus* is morphologically close to *B. zschokkei* (Schmeil, 1893). The latter species is considered to be widely distributed in Poland, yet many records of *B. zschokkei* might in fact refer to *B. spinulosus*. Distinguishing features of these species were described in detail.

Key words: freshwater Harpacticoida, ecology, distribution, lowlands, *Elaphoidella elaphoides*, *Bryocamptus spinulosus*

INTRODUCTION

Harpacticoid copepods are meiobenthic crustaceans that are common and occasionally very abundant in both marine and freshwater environments (Błędzki 2004). Harpacticoida is one of the least known animal groups in Poland (Drzycimski 1985). The last taxonomic studies of Harpacticoida in Polish inland waters were carried out about 100 years ago, among others by Wierzejski (1883), Demel (1922), Minkiewicz (1924). Moreover, except for Wigry Lake and its neighbourhood (Drzycimski 1985), there is no information about Harpacticoida from north-eastern Poland. We know much more about the group in the coastal waters of the Baltic Sea (Drzycimski 1991; Drzycimski 1993; Drzycimski 1997). The fauna of Poland and Southern Baltic includes 80 species, but only 28 species have so far been recorded from freshwater habitats. In the last century very little research has been done on the harpacticoids in the country (Błędzki 2004). The aim of my investigations was to explore the harpacticoid fauna and its peculiarities in different types of freshwater habitats in north-eastern Poland.

MATERIALS AND METHODS

Harpacticoids were collected in north-eastern Poland between 2010–2014. A total of 141 samples were collected from the different freshwater habitats (lakes, river, springs, underground water) and microhabitats (aquatic plants, peat bog, on the surface of freshwater bivalves) (Table 1). The samples were obtained by different water samplers, depending on the habitat (Karpowicz 2017).The water was filtered through a plankton net with mesh size of 50 µm and fixed with 4% formaline. Harpacticoids were sorted out from the samples under a stereo microscope in the laboratory. Microscope slides were prepared using Hoyer's mounting medium, as it immediately makes the embedded specimen transparent, which is helpful in fast species diagnostics. Also, it allows to store the slides for a relatively long time (Cielecka et al.

2009). Voucher specimens of the identified species are deposited in the Department of Hydrobiology, University of Bialystok. List of deposited species (slides) with their localization and habitat type are given in Table 1.

Table 1. List of deposited harpacticoid species with their localization and habitat type.

No.	Species	Habitat type	Location	GPS coordinates
1.	*Elaphoidella elaphoides*	groundwater/wells	Ciasne village	N 53°10'12; E 23°17'18
			Ogrodniczki village	N 53°11'06; E 23°16'12
2.	*Elaphoidella gracilis*	peatbogs	Lake Suchar I	N 54°05'06; E 23°00'51
			Lake Suchar II	N 54°05'16; E 23°00'58
			Lake Sączek	N 53°43'41; E 21°32'55
3.	*Moraria brevipes*	peatbogs	Suchar Wielki	N 54°01'33; E 23°03'28
			Lake Gorbacz	N 53°00'19; E 23°41'54
4.	*Attheyella trispinosa*	aquatic vegetation	Lake Bełdany	N 53°44'00; E 21°33'09
5.	*Pesceus schmeili*	*Dreissena*	Lake Boczne	N 53°57'37; E 21°44'16
6.	*Bryocamptus minutus*	aquatic vegetation	Lake Bełdany	N 53°44'00; E 21°33'09
		springs	Łaźnie	N 53°13'42; E 23°28'20
7.	*Bryocamptus spinulosus*	springs	Pólko	N 53°13'16; E 23°18'02
			Krzemianka	N 53°16'42; E 23°07'12
8.	*Bryocamptus pygmaeus*	peatbog	Suchar I	N 54°05'06; E 23°00'51
		springs	near Lake Jaczno	N 54°16'47; E 22°52'09
			Jałówka	N 53°14'05; E 23°20'09
9.	*Bryocamptus echinatus*	springs	Łaźnie	N 53°13'42; E 23°28'20
			Krzemianka	N 53°16'42; E 23°7'12
10.	*Nitokra hibernica*	*Dreissena*	Lake Mikołajki	N 53°47'15; E 21°34'58
11.	*Nitokra divaricata*	aquatic vegetation	Lake Tyrkło	N 53°49'10; E 21°52'19
12.	*Parastenocaris brevipes*	peatbog	Suchar Wielki	N 54°01'33; E 23°03'28

Abbreviations used in the text: P1–P5: thoracic legs numbers; exp: exopodite; enp: endopodite

RESULTS AND DISCUSSION

Harpacticoida had the highest frequency of occurrence in moss and peat bogs around humic lakes (84%) and in *Stratiotetum aloides* vegetation (83%). In these habitats harpacticoids occurred also in high numbers (Table 2). The highest abundance was found in the *Stratiotetum aloides* association in Lake Bełdany (160 indiv. l^{-1}) and in mosses near humic lakes (90 indiv. l^{-1}). These habitats were usually dominated by one or two highly abundant species. Despite their low abundance, harpacticoids constituted the most important component of crustacean zooplankton in in springs and groundwater.

Table 2. The occurrence of Harpacticoida in various types of aquatic habitats in NE Poland.

Habitat types		Frequency [%]	Abundance min-max [indiv. l^{-1}]	Average abundance [indiv. l^{-1}]	Number of samples [n]
Groundwater (wells)		44	0–0.25	0.1	9
Lowland springs		66	0–3.7	0.67	29
Moss and peat bogs (humic lakes)		84	0–90	15.4	19
Lakes		24	0–1.1	0.25	23
Streams and rivers		42	0.05–1.5	0.57	12
Type of vegetation	*Elodeetum canadensis*	67	0–7.25	2.3	6
	Stratiotetum aloides	83	0–160.5	37.4	12
	Ceratophylletum demersi	10	0–1.75	1.75	10
	Spirodeletum polyrhizae	67	0–10.5	3.6	9
Freshwater bivalves		50	–	–	12

Twelve harpacticoid species belonging to three families (Canthocamptidae, Ameiridae, Parastenocarididae) were found in NE Poland. Two species new to the Polish fauna were recorded: *Elaphoidella elaphoides* (Chappuis, 1923) and *Bryocamptus (Rheocamptus) spinulosus* (Borutzky, 1934). *Bryocamptus spinulosus* is closely related to *B. zschokkei* which is widespread and very common in Holarctic (Ishida 1987; Błędzki 2004). I speculate that many records of *B. zschokkei* in Poland might actually refer to *B. spinulosus.*

Brief information on the geographic distribution, biology, ecology as well as the distinguishing features of the species recorded in north-eastern Poland is presented below.

Family Parastenocarididae Chappuis, 1940

Parastenocaris brevipes Kessler, 1913
(Figs 1–3)

Location, ecology. *Parastenocaris brevipes* was usually found in peatbogs surrounding dystrophic lakes in Wigry National Park, i.e. Suchar II, Suchar Wielki. The species has so far been known only from the Masurian Lakeland in Poland (Drzycimski 1985).

General distribution and biology. Whole Europe. Geographic distribution of *P. brevipes* is likely influenced by the distribution of sphagnous peat bogs, the preferred habitat of the species (Borutzky 1952).

Distinguishing features. Length without caudal setae 0.4–0.5 mm. Body vermiform, all somites with almost equal width (Fig. 1). Caudal rami narrow (Fig. 3), nearly as long as anal somite (Fig. 1). Antennule seven-segmented, long second segment with three parallel setae (Fig. 2). Swimming legs very short with slender joints (Borutzky 1952).

Family Ameiridae Monard, 1927

Nitokra hibernica (Brady, 1880)
(Figs 4–7)

Location, ecology. *Nitokra hibernica* was common found on the surface of zebra mussel (*Dreissena polymorpha*) from Lake Mikołajki in the Masurian Lakeland. Both females (some with egg sacs) and males were observed.

General distribution and biology. Widespread in Europe and Asia, mainly in large lakes and rivers. Chappuis (1927) observed *N. hibernica* in the gill cavity of the common crayfish. Jakubisiak (1929) found the species in the water system of Poznan city. Those specimens slightly differed from the typical form and were named by Jakubisiak (1929) as *Nitocra hibernica* var. *hyalina* (see also Borutzky 1952).

Distinguishing features. Body length without caudal setae about 0.65 mm. Caudal rami as long as wide (Fig. 4). Antennule eight-segmented with second segment bolded (Fig. 5). Anal plate semicircular and armed with spinules (Fig. 6). Both rami of P1 – P4 three-segmented. Inner lobe of basal segment of P5 triangular-shaped, distal segment large and ovate with 6 setae and bearing several spinules on both medial and lateral margins (Fig. 7).

Nitokra divaricata Chappuis, 1923

Location, ecology. Single female was found in *Stratiotes aloides* vegetation of Lake Tyrkło in the Masurian Lakeland, however, the species is known as a commensal of common crayfish (Janetzky et al. 1996).

General distribution and biology. *Nitokra divaricata* is known from the Russian Federation, Romania, Germany and Poland. It lives in the gill cavity and on the body surface of common crayfish, and its species range likely overlaps with the range of these decapods (Borutzky 1952).

Distinguishing features. *Nitokra divaricata* is closely related to *N. hibernica*, and these species exhibit great similarity in the structure of the swimming legs. The two species can be distinguished by the morphology of P1 and P5. Proximal segment of endopodite of P1 reaching middle of distal segment of exopodite in *N. diverciata*.

Family Canthocamptidae Brady, 1880

***Moraria brevipes* (Sars, 1863)**
(Figs 10–11)

Location, ecology. *Moraria brevipes* was found in peatbog surrounding dystrophic lakes in Wigry National Park (Suchar I, Suchar Wielki) and in a peatbog near Lake Gorbacz (Grodek -Michalowo Basin). Males and females occurred in relatively high abundances.

General distribution and biology. Widespread in Poland (Błędzki 2004), and occurs almost throughout Europe. Associated mainly with sphagnous swamps. The species has been encountered in the littoral of stagnant water bodies with silty bottoms and in springs where it often shows developmental aberrancies. Absent from the tundra zone (Borutzky 1952).

Distinguishing features. Length without caudal setae 0.55 – 0.63 mm. Caudal rami elongate, tapering terminally (Fig. 8). Dorsal surface of caudal rami with longitudinal ridge (Fig. 9). First and second segment of exopodites of P1 − P4 without seta on inner margin.

***Attheyella (Brehmiella) trispinosa* (Brady, 1880)**
(Figs 10–11)

Location, ecology. The species was found among aquatic vegetation in lakes and rivers. High numbers of *A. trispinosa* up to 160 indiv. l^{-1} were recorded in *Stratiotes aloides* habitats in Lake Tyrkło and Bełdany in the Masurian Lakeland (Karpowicz et al. 2016). Many male-female tandems were observed (Fig. 11). In the pre-copulatory (phase preceding mating) the male harpacticoid grasps the caudal rami of the female with its first antenna (Glatzel 1988).

General distribution and biology. Lowland water bodies of Europe, North Africa and Asia (Borutzky 1952). Widespread in Poland (Błędzki 2004). The range of the subgenus *Brehmiella* is mostly restricted to the Holarctic region (Borutzky 1952).

Distinguishing features. Relatively large species, length of female without caudal setae 0.72–0.84 mm. Caudal rami short, slightly tapering distally. Endopodite and exopodite of P1 three-segmented (Fig. 10). First segment of P1 endopodite as long as whole exopodite of P1 (Fig. 10). Diagnostic features of the species include also structure of P5 in both sexes.

***Pesceus schmeili* (Mrázek, 1893)**

Location, ecology. Only females were found on the surface of zebra mussel (*Dreissena polymorpha*) from Lake Boczne in the Masurian Lakeland.

General distribution and biology. Palaearctic, inhabits various types of water bodies, from large lakes where it is common in benthos and reaches considerable depths, to lowland swamps and springs (Borutzky 1952). *Pesceus schmeili* s. str. occurs throughout

Europe up to and including Ural region. Widespread in Poland (Drzycimski 1985). Polycyclic (Sarvala 1990; Fefilova 2007) and oligosaprobic (Sarkka 1995).

Distinguishing features. Caudal rami widely divergent, almost three times as long as wide, with slightly narrowed and pointed tips. Outer and inner margins of caudal rami hairy.

Elaphoidella gracilis (Sars, 1863)
(Figs 12–13)

Location, ecology. In peatbogs surrounding dystrophic lakes in Wigry National Park (Suchar I, Suchar II) and Lake Sęczek in Masurian Lakeland. Both males and females occurred in relatively high abundances. Some females carried egg sacks (Fig. 12).

General distribution and biology. Widespread in Poland (Błędzki 2004) and occurs almost throughout Europe (Borutzky 1952). *Elaphoidella gracilis* inhabits various types of water bodies, yet it prefers sphagnous peat swamp and it is particularly abundant in small pools (Borutzky 1952).

Distinguishing features. Female relatively large (Fig. 12), total body length without caudal setae 0.70−0.77 mm. Caudal rami 3 times as long as maximum width (Fig. 13), with outer margin bearing two lateral setae.

Elaphoidella elaphoides (Chappuis, 1923)
(Figs 14–20)

Location, ecology. Dominant species in groundwater (wells) of Ogrodniczki and Ciasne villages near Białystok city. Only females and copepodites were found.

General distribution and biology. The species is new to the Polish fauna. *Elaphoidella elaphoides* is considered to be a stygophilic species that recently invaded the subterranean waters (cave, hyporheic and phreatic waters). Widespread in epigean and underground waters of Europe, i.e. Greece, Italy, Turkey (Pesce 1985), Balkan Penisula, Germany (Borutzky 1952), Austria, Czech Republic (Janetzky et al. 1996).

Distinguishing features. Antennule eight-segmented (Fig. 15). Antennal exopodite one-segmented with 4 setae (Fig. 16). Caudal rami short, as long as wide; inner margin convex with row of short hairs (Fig. 17). Two lateral setae inserted midway on outer margin of caudal rami and dorsal seta inserted near posterolateral angle of the ramus (Fig. 17). Exopodite and endopodite of P1 three-segmented with seta formula 0/1/0.2.2 for exopodite (Fig. 18) and 1/1/1.1.1 for endopodite (Fig. 19). Inner lobe of proximal segment of P5 short with 4 setae; distal segment of P5 rounded and as long as wide (Fig. 20).

Bryocamptus (Rheocamptus) spinulosus Borutzky, 1934
(Figs 21–25)

Location, ecology. *Bryocamptus spinulosus* was commonly found in many springs of the Knyszyn Primeval Forest Landscape Park (i.e. Pólko, Krzemianka, Dworzysk, Łaźnie) and in the rivers of Wigry National Park. Both female and male were detected.

Remarks. New species to the Polish fauna. *Bryocamptus spinulosus* is morphologically close to *B. zschokkei* (Schmeil, 1893). The latter species is considered to be widely distributed in Poland, yet many records of *B. zschokkei* might in fact refer to *B. spinulosus*.

General distribution and biology. The *B. zschokkei* group is widespread in Holarctic. The typical form of *B. zschokkei* is a cold-water stenothermal form, found in the littoral of alpine lakes or in cold springs and brooks. In lowland regions it is confined to cold

springs, very close to their issue, where moist moss is its favorite habitat (Borutzky 1952). *Bryocamptus spinulosus* has been reported from Slovakia, Czech Republic (Sterba 1968), mountain brooks and springs in the North Caucasus (Borutzky 1952), Albania and Bulgaria (Apostolov 2004) and caves in NE Romania (Meleg et al. 2011).

Distinguishing features. *Bryocamptus spinulosus* is morphologically very close to *B. zschokkei*. The *Bryocamptus zschokkei* group is highly variable. Differences from the typical form have been described by Schmeil, and relate to the armature of the body segments, limbs and even the number of leg segments. In *B. spinulosus* the swimming legs have the same segmentation pattern as what is observed in *B. zschokkei* group. The setal formula of leg 1−4 in the *B. zschokkei* group is as follows (according to Janetzky et al. 1996):

	Exp	Enp
P1:	0/1/0.2.2	1/2(1).1.1
P2:	0/1/1.2.3	1/2.2.1 or 1/1/1.2.1
P3:	0/1/2.2.3	1/3.2.1 or 1/1/2.2.1
P4:	0/1/2.2.3	1/2.2.1

In the springs of Knyszyn Primaeval Forest *B. spinulosus* shows two-segmented endopodites in P2 and P3 (Fig. 23). The setal formula of leg 1−4 is as follows:

	Exp	Enp
P1:	0/1/0.2.2	1/1.1.1
P2:	0/1/1.2.3	1/2.2.1
P3:	0/1/2.2.3	1/3.2.1
P4:	0/1/2.2.3	1/2.2.1

Basiendopodite and exopodite of P5 with 6 and 5 setae, respectively (Fig. 25). The structure of the inner apical caudal seta (Fig. 22) and P5 (Fig. 25) of the female are distinguish *B. spinulosus* from *B. zschokkei*. The inner apical caudal seta of *B. spinulosus* is serpentine-like with much widened base (Borutzky, 1934), which is very characteristics feature of this species. Caudal rami almost as long as wide (Fig. 22). Anal operculum with 4 large denticles (Fig. 22), which differs from the state (5 denticles) mentioned in the original description (Borutzky 1934). Antennule eight-segmented (Fig. 24).

Bryocamptus zschokkei zschokkei var. *tatrensis*, described by Minkiewicz (1916) from water bodies in the Tatra mountains and subsequently found in Lake Wigry and other parts of Poland, differ from *B. spinulosus* in few features only, i.e. differences in leg armature, row of spinules on the body segments (Walter 2015).

***Bryocamptus (Echinocamptus) echinatus* (Mrázek, 1893)**

(Fig. 26)

Location, ecology. *Bryocamptus echinatus* was commonly found in springs of the Knyszyn Primaeval Forest Landscape Park, i.e. Dworzysk, Krzemianka, Łaźnie, Jałówka. Both females and males were detected.

General distribution and biology. Cold-water, European species, most frequently found in highland water bodies, rarely in cold spring in lowland regions (Borutzky 1952). It has been recorded from lowland springs and rivers in Poland (Drzycimski 1985) and Estonia (Fefilova 2010).

Distinguishing features. Caudal rami slightly longer than wide, tapering posteriorly. Oblique row of spinules present above bases of apical setae. Exopodites of P1 − P4 and

endopodite of P1 three-segmented, endopodites of P2 – P4 two-segmented (Borutzky 1952). P5 large and massive. Inner lobe of proximal segment of P5 markedly produced posteriorly with 5 setae of unequal length. Distal segment of P5 nearly oval-shaped with 5 setae (Fig. 26).

Bryocamptus (Rheocamptus) pygmaeus (Sars, 1863)
(Fig. 27)

Location, ecology. Springs in the Knyszyn Primaeval Forest Landscape Park, vauclusian springs nearby Jaczno Lake (Suwalki Landscape Park) and in peatbogs surrounding dystrophic lakes in Wigry National Park. Some authors however suggest that this species apparently avoids typically highland sphagnous swamps of higher acidity (Borutzky 1952). Both females and males were observed.

General distribution and biology. Widespread in Europe and North America, except the tundra zone. Also known from North Africa. It inhabits different types of surface waterbodies and groundwater too (Fefilova 2010). It was most often found in moist moss cushions in swamps of lowland or transitional type, with avoidance of higher acidity swamps (Borutzky 1952).

Distinguishing features. Body length without caudal setae about 0.45 mm. Caudal rami square-shaped, outer margin bearing 3 lateral setae with several spinules near their bases, inner margin bearing several spinules above apical setae. Antennule short, eight-segmented (Borutzky 1952). Inner lobe of proximal segment of P5 well developed, with 5 pinnate setae of unequal size (Fig. 27). Distal segment of P5 subrotund with 5 setae – middle one slender, nonpinnate (Fig. 27).

Bryocamptus (Bryocamptus) minutus (Claus, 1863)
(Figs 28–29)

Location, ecology. From among aquatic vegetation in the Masurian lakes (Lake Tyrkło and Lake Bełdany), and in springs of the Knyszyn Primeval Forest Landscape Park. Both females and males were observed.

General distribution and biology. Holarctic species (Borutzky 1952; Rundle et al. 2000), widely distributed in Poland (Drzycimski 1985). It inhabits large water bodies and small pools, and is most frequently encountered among aquatic vegetation (Borutzky 1952).

Distinguishing features. Caudal rami short and tapering backward (Fig. 29). Exopodites of P1 − P4 and endopodites of P1 − P3 three-segmented. In male, basiendopodite and exopodite of P5 with 6 and 5 setae, respectively (Fig. 28). The very characteristic features of this species are the large bifurcate denticles on outer margin of anal plate (Fig. 29).

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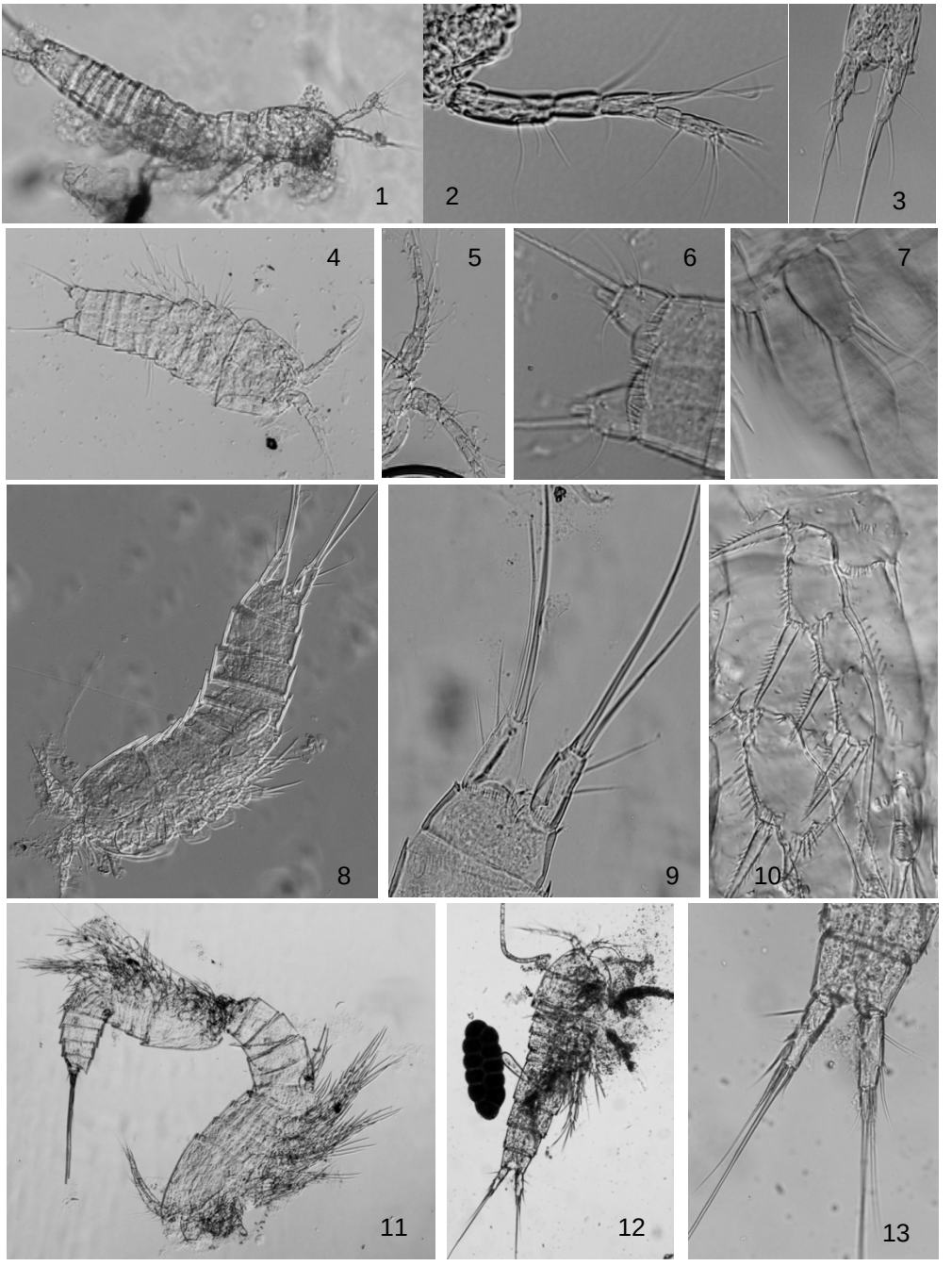
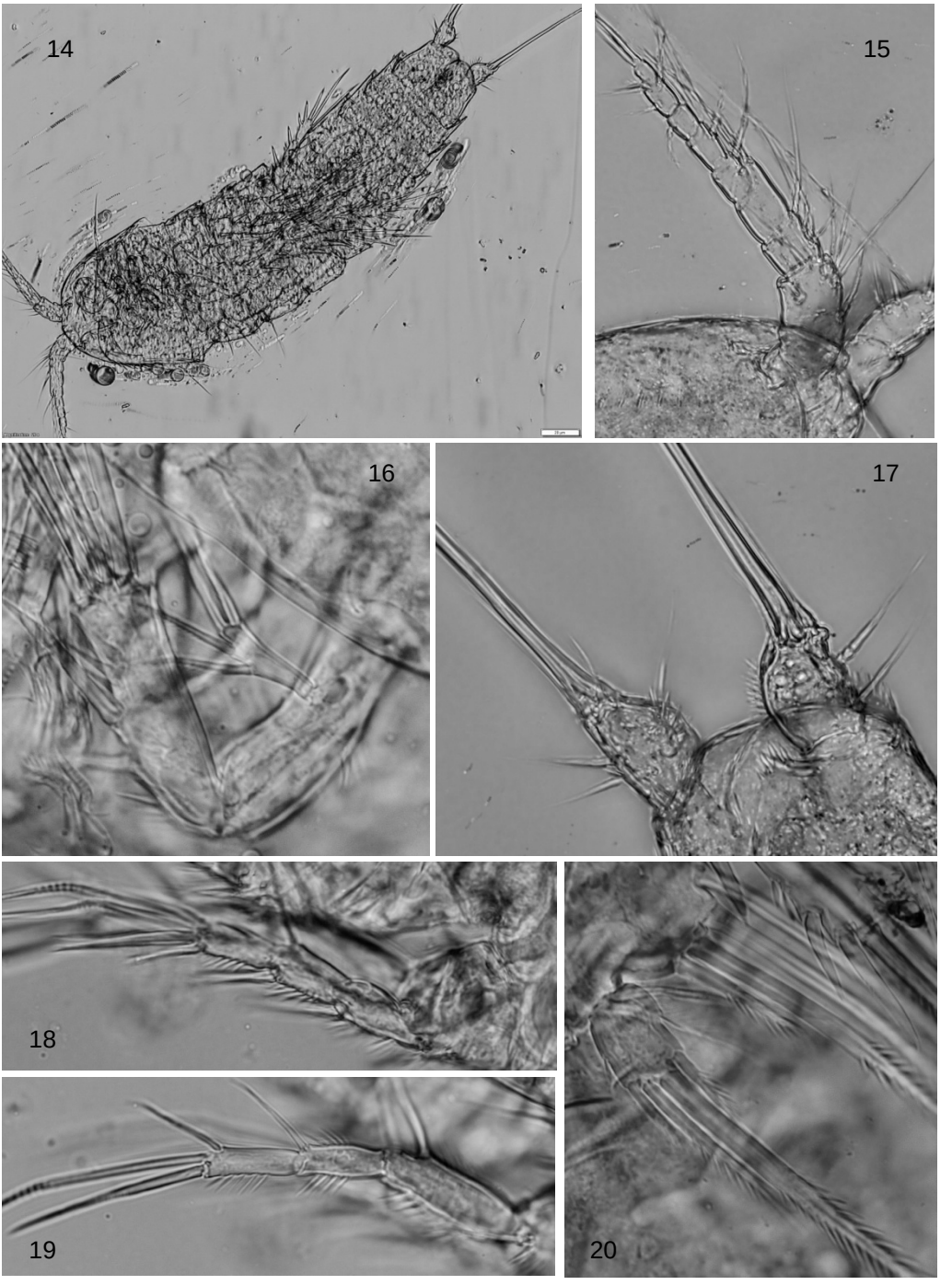
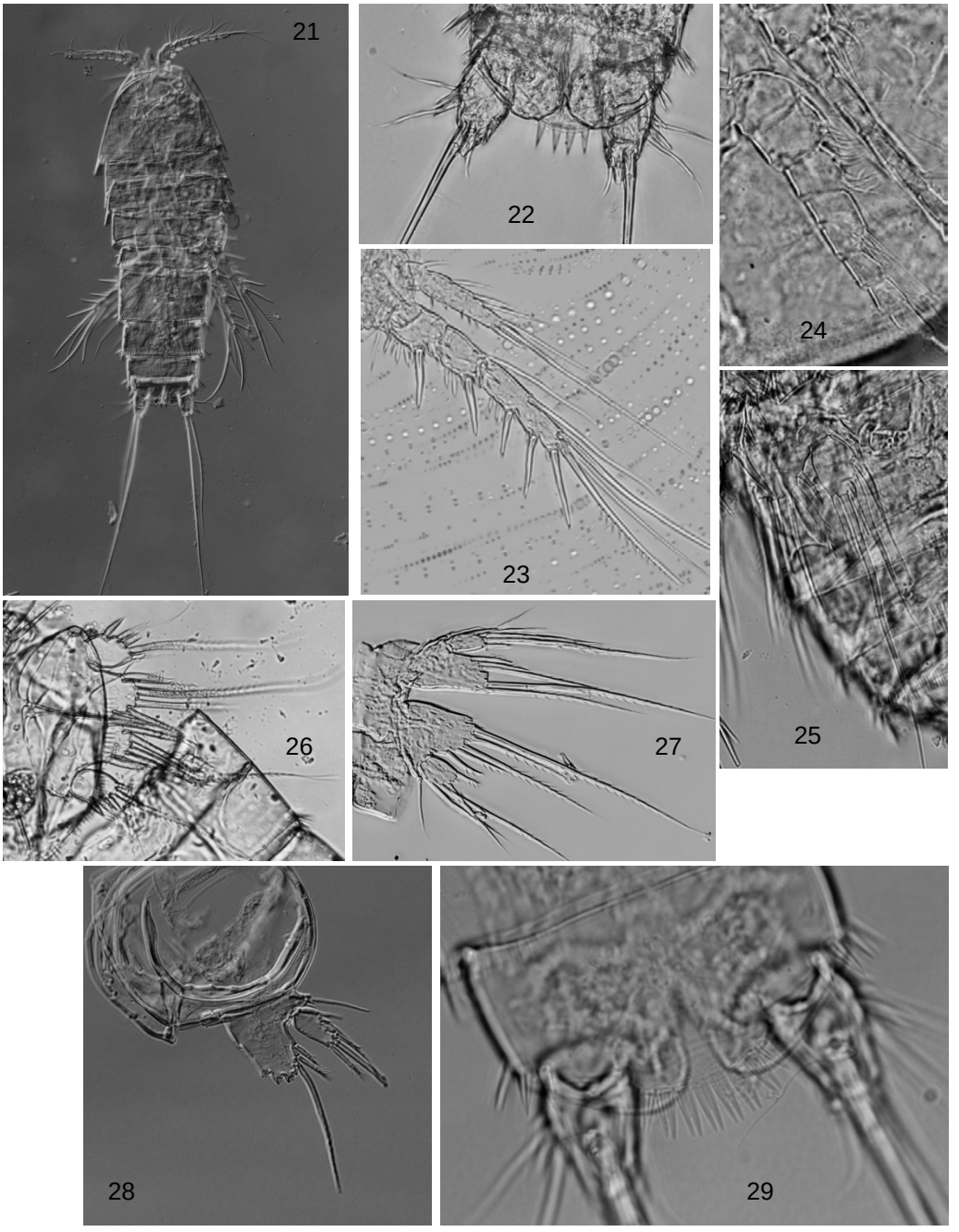


Figs 1–3. ***Parastenocaris brevipes*****:** 1 – dorsal view, female; 2 – antennules, female; 3 – caudal rami, female. **Figs 4–7.** ***Nitokra hibernica*****:** 4 – dorsal view, female; 5 – antennules, female; 6 – caudal rami, female; 7 – fifth leg, female. **Figs 8–9.** ***Moraria brevipes*****:** 8 – dorsal view, male; 9 – caudal rami, male. **Figs 10–11.** ***Attheyella (Brehmiella) trispinosa*****:** 10 – endopodit and exopodit of first leg, female;11 – female and male form a tandem. **Figs 12–13.** ***Elaphoidella gracilis*****:** 12 – habitus, dorsal view, female; 13 – caudal rami, female.



Figs 14–20. ***Elaphoidella elaphoides*****:** 14 – habitus, dorsal view, female; 15 – antennulae, female; 16 – antenna with one-segmented exopodite; 17 – caudal rami, female; 18 – exopodite of first leg; 19 – endopodite of first leg; 20 – fifth leg, female.



Figs 21–25. ***Bryocamptus (Rheocamptus) spinulosus*****:** 21 – habitus dorsal view, female; 22 – caudal rami, female; 23 – third leg: endopodit and exopodit, female; 24 – antennules, female; 25 – fifth leg, female. **Fig. 26.** ***Bryocamptus (Echinocamptus) echinatus*****:** fifth leg, female. **Fig 27.** ***Bryocamptus (Rheocamptus) pygmaeus*****:** fifth leg, female. **Figs 28–29.** ***Bryocamptus (Bryocamptus) minutus*****:** 28 – fifth leg, female;. 29 – caudal rami, female.

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STRESZCZENIE

[**Nowe dane dotyczące fauny Harpacticoida (Crustacea, Copepoda) w Polsce**]

Harpacticoida są najsłabiej poznaną grupą zooplanktonu w Polsce, mimo iż organizmy te są bardzo powszechne i występują obficie w różnych typach siedlisk wodnych. Ostatnie kompleksowe, taksonomiczne badania tej grupy zwierząt w Polsce były prowadzone prawie 100 lat temu. Celem moich badań było uzyskanie szerszych danych na temat występowania Harpacticoida w wodach północno-wschodniej Polski, a także opis głównych, charakterystycznych cech diagnostycznych stwierdzonych gatunków. Ogólnie stwierdzono i opisano 12 gatunków Harpacticoida, w tym dwa gatunki nowe dla fauny Polski: *Elaphoidella elaphoides* (Chappuis, 1923) i *Bryocamptus (Rheocamptus) spinulosus* Borutzky, 1934. *B. spinulosus* jest bardzo blisko spokrewniony z *Bryocamptus (Rheocamptus) zschokkei* (Schmeil, 1893), który został wykazany na terenie całej Polski. Prawdopodobnie większość stwierdzeń gatunku *B. zschokkei* w Polsce dotyczy *B. spinulosus*. Cechy wyróżniające oba gatunki zostały szczegółowo opisane.

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