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In Memoriam Prof. István Andrássy

(1927–2012)

István Andrássy the world renowned Nematode taxonomist, founder and life-long editor of Opuscula Zoologica, Budapest, gently passed away on 4th August, 2012 at the age of 85. He will be remembered for his outstanding contribution to the evolutionary classification and taxonomy of nematodes and not least for his enormous influence on nematode ecology.

István Andrássy was born on 05 May, 1927 in Szolnok, Hungary. He graduated from the Ciszterci Szent Imre High School, Budapest in 1946 and continued his studies at the Pázmány Péter (later Eötvös Loránd) University, Budapest graduating as a "licensed museologist" in 1950.

He got his first job at the Hungarian Natural History Museum, Budapest but in 1952, by invitation of Endre Du

Apart from his scientific research Dr. Andrássy was an adjunct university teacher as well. He actively participated in the teaching of systematic zoology courses at ELTE University and supervised several MSc and PhD theses. Recognising these teaching activities he was granted an honorary full professorship by the Eötvös Loránd University in 1974.

The Hungarian zoologists hugely appreciated their internationally renowned colleague István Andrássy. In the university department where he worked for some 60 years, he has had a cordial collegial relationship with everyone. He helped anyone who needed it and his moderate opinions were always welcomed in shaping the educational or scientific goals of the department.

Prof. Andrássy's research was focused on evolutionary systematics, taxonomy, and the ecology of terrestrial Nematodes. He was one of the most influential nematode systematists and founder of the widely used evolutionary classification of the order Dorylaimida. However, he was also an enthusiastic taxonomist; he authored some 660 Nematoda taxa including 56 families and higher groups and 126 genera of which the last descriptions (more than 10 species new to science) were published in 2012.

During his long scientific career Prof. Andrássy has authored more than 230 publications including several keystone books such as "*Evolution as a Basis for the Systematization of Nematodes*" (1976) and "*Klasse Nematoda (Ordnungen Monhysterida, Desmoscolecida, Araeolaimida, Chromadorida, Rhabditida)*" (1984). However, the coronation of his lifelong work was the publishing of the three volume, 1622 pages book on the Hungarian free-living nematodes (*Free-living nematodes of Hungary (Nematoda errantia I-III*) between 2005–2009.

Although Prof. Andrássy was reserved by nature he held several scholarly positions. He was the Editor-in-chief of the Hungarian scientific journal "Állattani Közlemények" for 40 years and between 1987 and 1993 he was one of the editors of the Acta Zoologica Academiae Scientiarum Hungaricae as well. He was one of the founders and lifelong editor of Opuscula Zoologica, Budpaest. However, he not only edited the scientific journal of the Department of Systematic Zoology and Ecology of ELTE University but was also a prolific author publishing here 70 taxonomic and faunistic papers. Moreover, Prof. Andrássy described in the *Opuscula Zoologica* 222 new species group taxa and 47 new genus group taxa making this journal an excellent source of nematode taxonomy.

The impressive scientific opus of Prof. Andrássy has been recognised by many awards, such as the Skrjabin Medal by the Soviet Union Academy of Sciences in 1983, the Hungarian Academy Prize and the Huzella Prize by the Hungarian Biological Society in 1987, the Gelei Prize of the Hungarian Biological Society in 1998 and the Honorary Membership of the Society of Nematologists in 2007. His international recognition is also demonstrated by more than 60 taxa being named in honour of him.

Certainly, Prof. István Andrássy will sadly be missed by his students, colleagues, and friends both in Hungary and abroad.

Klára Dózsa-Farkas, Csaba Csuzdi
&
Árpád Berczik

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Hibernian reports of a new Franco-Iberian worm (Oligochaeta: Megadrilacea: Lumbricidae)

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Abstract. A continental European earthworm, *Kenleenus armadas* sp. nov., is newly described from an introduction to a farm in Dublin, Ireland. Previously recognized as Aquitainian *Prosellodrilus amplisetosus* Bouché, 1972, the morphology and molecular characteristics rather indicate it as a taxon new to science. Its description has required revision of all prosellodrilid genera including Algerian subgenus *Maghrebiella* Baha & Bera, 2001 that is a permanently invalid homonym, here replaced with *Cadanera* nom. nov. A revised checklist is appended that holds *Allolobophora festae* Rosa, 1892 as a *species incertae sedis* pending review of the *Cadanera* type. This report brings the total earthworms known from Britain & Ireland to 72 species, including a new record of cosmopolitan *Pithemera bicincta* (Perrier, 1875) (Megascolecidae) from Dublin's Botanic Gardens.

Keywords. Alien exotic earthworms, new species, Ireland, Europe, Mediterranean, DNA barcode.

INTRODUCTION

Melody & Schmidt (2012) recently reported *Prosellodrilus amplisetosus* Bouché, 1972 as an introduction to Ireland, supposedly from Aquitaine France, and attributed its increased range to global warming. Placement of these specimens sent to the author required revision of the Franco-Iberian genus *Prosellodrilus* Bouché 1972. Originally comprised of about a dozen species, Qiu & Bouché (1998c) proposed 16 new species or subspecies with a few others transferred to two newly erected subgenera that then raised the total to *ca.* 30 (sub)species. Baha & Berra (2001) described one further species and proffered: "splitting the genus *Prosellodrilus* Bouché 1972 into two subgenera: the nominal one, including the species living in southwestern France, and a new subgenus inhabiting Maghreb and Sardinia." Oblivious to previous subgenera, they proposed the name *Maghrebiella* but its type was not explicit, possibly *Prosellodrilus doumandjii* Baha & Berra, 2001 or the other species they provisionally included: "*P. (M.) festai*" (sic = *Allolobophora festae* Rosa, 1892).

Originally found in Tunisia (most likely by introduction) but soon recognized as abundant on Sardinia (Rosa 1893), this taxon was maintained as "*Helodrilus* (*Allolobophora*) *festae*" by Michaelsen (1900: 486). However, Zicsi (1985: 284) reviewed type material and excluded it from *Helodrilus* Hoffmeister, 1845 because of its U-shaped nephridial bladders [Cs. Csuzdi pers. comm. 21st Nov., 2012, although Csuzdi (2012: http://earthworm.uw.hu/ index.php) again has "*festai*" there]. In contrast, Qiu & Bouché (1998d: 196) maintained "*festai* (Rosa, 1892)" in *Helodrilus* whilst, according to Omodeo *et al.* (2003: 458) and Omodeo & Rota (2008: 72, fig. 5), "*festai*" and its four subspecies belong in *Prosellodrilus* (although I can find no report of its subspecies nor their "*Prosellodrilus* sp. n."). Most recently, Blakemore (2008a: 16) held it in its original state as: *Allolobophora festae* Rosa, 1892 *species inquirendum* (*cf.* Appendix 1).

Three other taxa Baha & Berra (2001) thought similar to *Maghrebiella* were already placed by Qiu & Bouché (1998b) in genus *Eumenescolex*. Recent accounts of these genera by Blakemore (2004, 2008a) questioned some of these inclusions and suggested that all *Prosellodrilus* subgenera required revision. Here all three subgenera are reviewed and elevated with some species redistributed. A checklist of revised taxa is appended (Appendix 1) along with mtDNA COI gene barcode for the new species (Appendix 2, plus http://blast.ncbi.nlm.nih.gov BLAST results).

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TAXONOMIC RESULTS

Maghrebiella Baha & Bera, 2001 is a permanently invalid junior homonym of *Maghrebiella* Lacourt 1988 (Hymenoptera) (see Nomenclator Zoologicus: http://uio.mbl.edu/NZ/) thus a replacement name is required. The name *Cadanera* nom. nov. (feminine) is newly provided based on a noun in apposition of a variety of orange (*Citrus sinensis* L.) cultivated in both Spain and Algeria (hence a possible route of its introduction and distribution). The type-species is here fixed as *Prosellodrilus doumandjii* Baha & Berra, 2001 since the authors merely state that "the same applies to *H. festai*".

Revision of Genera
(chronological)

Prosellodrilus Bouché, 1972 *sensu stricto*

Diagnosis. (Following Qiu & Bouché, 1998c *cf.* Baha & Berra, 2001: 90, tab. 1). Lumbricidae. Small to large size (48–232 mm). Unpigmented (mostly). First dorsal pore 4/5–9/10(12/13). Setae closely paired (*cf.* wide in *Kenleenus*). Clitellum in some of 19–32. TP in some of 21–28. Spermathecae paired or multiple in 12/13–13/14 or 13/14–14/15. Calciferous glands in 11–14 with dilations in 11 and sometimes in 13 too (*cf.* in 10–14 with diverticula in 10 in *Cadanera* and *Eumenescolex*). Nephridial vesicles vary: J- or U-shaped often (but not always, despite Qiu & Bouché's claim which differs from their figures!) with a proximal bulb, at least after anterior; never digitoid (as in *Pyrenodrilus*). (Seminal vesicles in 11 & 12). Typhlosole bifid or trifid/multiple.

Pyrenodrilus Qiu & Bouché, 1998 stat. nov.

Diagnosis. As for *Prosellodrilus* (size 35–335 mm; setae closely paired; dorsal pores from 4/5–9/10; calciferous glands 11–14 with dilations in 11), but nephridial vesicles (except in anterior segments) digitoid or sometimes ocarina-like with meatus opening ventrally (or in *bidasoanus*, mesially) into basal bulb. Typhlosole bifid or trifid/multiple.

Kenleenus Qiu & Bouché, 1998 stat. nov.

Diagnosis. As for *Prosellodrilus* but small <100 mm and setae separate (or 'loosely' paired). Prostomium prolobous to tanylobous. Dorsal pores from 4/5(6/7) (or newly 7/8 in *Ke. armadas* sp. nov.). Clitellum some of 19–29(30). TP some of 19–23. Spermathecae paired in (12/13) 13/14–14/15. Calciferous glands variable, absent or in some or all of ½10, 11,12–14 with dilations in 10 or 11 (or sometimes in 13 in type and *Ke. armadas*). Nephridial vesicles U-shaped sharply curved and reclining almost their whole length (hairpin-like) without bulbs (as in some *Prosellodrilus*). Typhlosole bifid.

Eumenescolex Qiu & Bouché, 1998 stat. nov.

Diagnosis. Lumbricidae. Size 37–112 mm. Setae closely paired. Dorsal pores from 10/11–13/14 (cf. *Cadanera*). Clitellum some of (21)22–36. TP in some of (23)25–33. Spermathecae paired in 11/12–13/14, 12/13/14 or just 13/14. Calciferous glands in 10–14 with diverticula in 10 (as in *Cadanera*, *cf. Prosellodrilus*). Nephridial vesicles fish-hook or J-shaped (longest arm proximal without bulb *cf. Prosellodrilus*). Typhlosole pinnate ("laminated" in *proclitellatus*; unclear in *simplex*).

Cadanera gen. nov.

Nom. nov. pro *Maghrebiella* Baha & Bera, 2001 (non Lacourt 1988, Hymenoptera); *genus inquirendum.*

Diagnosis. As for *Prosellodrilus* [setae closely paired (*cf. Kenleenus*), dorsal pores from 4/5/6, spermathecae paired in 13/14/15 (cf. 12/13/14 in *Eumenescolex* and *festae*), but small (<55 mm) and calciferous glands in 10–14 with diverticula in 10 (as in *Eumenescolex cf.* 11–14 in *Prosellodrilus* and in *festae*)]. Clitellum 23,24–33. TP 29–31. Nephridial vesicle form unreported (hence *inquirendum*). Typhlosole bifid (or trifid or sometimes absent? *cf.* cylindrical in *festae*). (Seminal vesicles four pairs, *cf.* two in *festae*).

Remarks. *Allolobophora festae* Rosa, 1892 is now held *incertae sedis* (Appendix 1), whereas

Prosellodrilus (*Kenleenus*) *occidentalis* Qiu & Bouché, 1998 (?= *Pr. amplisetosus* sensu Souto *et al*., 1991) is possibly congenic, despite its wide setae, by virtue of calciferous diverticula in 10 – these placements dependent upon determination of the type-species' nephridial state (see Tab. 1).

Distribution of Genera

Genus *Eumenescolex* is from Provence (Maures, France), Corsica, Sardinia, Campania (Italy) and Valencia (Spain); Qiu & Bouché's other genera are mainly from Aquitaine region of SW France, the Pyrenees and the Basque region into northern Spain with a few Mediterranean records [e.g. southern Italy and, according to Omodeo & Rota (2008: 72), Catalonia – although I cannot find this latter report, there is one from adjacent Valencia]. Genus *Cadanera* is from Algeria (imported?) (*cf. festae* in Tunisia and Sardinia). Souto *et al.* (1991) found "*Prosellodrilus amplisetosus*" as a human-mediated introduction to La Coruña (Galicia, Spain) – this same material (really?) later described as *Pr. occidentalis* Qiu & Bouché, 1998 extending the generic range past the Cantabrian Cordillera (although likely introduced to Spain too), and Krough *et al.* (2007) reported *Pr. amplisetosus* from Dijon in central France.

Table 1. Contingency table of 'Prosellodrilid' genera having spermathecal pores ca. 11/12-14/15

Genus	Setae	Nephridial vesicles	Ca Glands	Typhlosole
Prosellodrilus	Close	J- or U-shaped (bulb)	11-14 dilated 11 (& 13)	Bifid-trifid/multi
Pyrenodrilus	Close	Digitoid/ocarina	11-14 dilated 11 (& 13)	Bifid-trifid/multi
Kenleenus	Wide	U-shaped (no bulb)	Variable (10,11-13,14) dilated in 11 (& 13)	Bifid
Eumenescolex	Close	J-shaped (no bulb)	10-14 diverticula in 10	Pinnate (always?)
Cadanera	Close?	?	10-14 diverticula in 10	Bifid (always?)

Description of a New Species

***Kenleenus armadas* sp. nov.**

(Figures 1–2)

Prosellodrilus amplisetosus: Souto *et al.* 1991: 79, fig. 1?, Keith & Schmidt 2012; Melody & Schmidt 2012 – identifications revised herein.

Material examined. *H*, holotype (Natural History Museum London NHMUK 2012.96), figured (Fig. 1) and dissected plus DNA sampled (Appendix); *P1* (NIBR INV0000261271) figured (Fig. 2) and bisected; *P2* (NHMUK 2012.97); *P3–P5*, paratypes in formalin inspected (NIBR INV 0000261272). Specimens mainly matures, in two batches sent by O. Schmidt from Dublin 22nd Oct., 2012: one set of three (#1) ethanol preserved, the other (#2) fixed in formalin. Earlier specimens (topotypes) as *"Pr. amplisetosus*" sent by Olaf Schmidt to Emma Sherlock in NHMUK London. First found from near Dunleer, County Louth, a single specimen sampled 3rd October 2006 in the National Museum of Ireland (Dublin NHM) (O. Schmidt pers. comm. 10th April, 2010). The current specimens were reported as common on urban "Airfield farm" Dundrum in County Dublin (53º14'N, 6º 14'W, 75 m elevation).

Etymology. Noun in apposition, alluding to Spanish and French Armadas of 1588 and 1779 having slight historical connection of these countries (whence the species is presumed to originate) with Britain & Ireland, albeit introduction of this worm is presumably more recent.

Description. In life, a rosy, pinkish colour due to sub-cutaneous capillaries. Preserved, an unpigmented pale yellow, dorsal vessel intermittently visible; clitellum white. First and last segments are slightly striated. Length *H* 35 mm, *Ps ca.* 40–65 (all appear somewhat contracted). Segments *H* 165, *P1* 154. Prostomium small, closed epilobous. Setae widely paired, some slightly irregular in anterior and after clitellum. First dorsal pore 7/8. Nephropores not readily visible (possibly in b lines from internal inspection). Spermathecae 13/14/15 in *d* lines. Female pore indistinct as slits lateral of *b* setae on 14. Male pores in 15/16 la-

teral of *b* lines within tumid lips. Genital tumescences around *ab* on 11 and 13 (*H*) or just on 13 (*Ps* plus unilateral on 11lhs in one and 14rhs in another). Clitellum ½19–28,½29. Tubercula pubertates (TP) flared, mostly in 20–21 but slight lateral bands extend into 19 and/or 22. Segment 22 is slightly expanded ventrally in two paratypes.

Internally (*H, P1*), septa stronger to 8/9/10. Hearts 7,8–11. Testis free and iridescent in 10 & 11. Seminal vesicles small and difficult to see, apparently weak anteriorly in 11 & 12 in *H*, possibly also in 10 in *P1*. Ovaries as long eggstring in 13, small ovisacs seen anteriorly in 14. Nephridial bladders difficult to discern in anterior, possibly sausage-shaped, after about segment 10 they are tightly U-shaped (almost like blunt hairpin) without pronounced terminal bulb. Calciferous glands in 11–13, less dilated in 12, with some incursion into 10 and 14 (so range within 10–14). Oesophagus dilates in 15 to crop in 16 and muscular gizzard in 17–18 (septum 17/18 to its midriff). Typhlosole bifid (like an inverted T-shape) from around 21. Gut contains mainly colloidal mucus (specimens stored and starved before preservation?). No obvious parasites. DNA in Appendix.

Remarks. *Prosellodrilus*-like species known to have clitella in 19–29 (or 20–28) are: *Prosellodrilus biserialis* and *Pr. proporus* or *Kenleenus amplisetosus* and *Ke. ticalus*, possibly also *Ca. occidentalis*. Of these, those with TP in or near 20–21 are: *Pr. proporus*, *Ke. amplisetosus* and *Ca. occidentalis*. However, *Pr. proporus* in Qiu & Bouché (1998c: 42, fig. 5, tabs. 1, 2) differs from *Ke. armadas* in having a prolobous prostomium; female pores anteriorly on 14 in setal *a* lines (hence its specific epithet); clitellum in 20–29,30; TP in 20–22 inclusive; spermathecae in 13/14/15 in *c–d* (described) or *d* and above (figured) that are simple or doubled or sometimes tripled, and also by virtue of characteristics of its nephridial bladders. Both *Ke. amplisetosus* and *Ca. occidentalis* differ according to their prostomia, dorsal pore commencement and apparently on genital papillae and tubercula pubertates. Nephridial bladder and calciferous gland details appear variable in these two taxa despite being critical even for generic placement (see Tab. 2). Subspecies, *Ke. am. hexathecosus* Bouché, 1972 was for the first time formally described and distinguished from its nominal subspecies by Qiu & Bouché (1998c: 40, fig. 3, tab. 4) on its epilobic prostomium, first dorsal pore in 4/5, spermathecal pores simple in *c* (described) or in mid *c–d* lines (figured), clitellum in 19–27 and TP in 19–21 with genital papillae in 14 & 20. Despite its name, rather than six only four spermathecae occur in this subspecies from Qiu & Bouché (1998c) with six possible in *Pr. am. amplisetosus*.

Possibly the current taxon only merits subspecific status too, nevertheless morphological differences presumably exclude additions by Souto *et al.* (1991) that perhaps came closer to *Ke. armadas* albeit these same specimens ("Ce taxon a été initialement identifié comme *Prosellodrilus amplisetosus amplisetosus* (Souto *et al.*, 1991) [sic]" – Qiu & Bouché 1998c: 45) were apparently redescribed as *Pr. occidentalis* Qiu & Bouché, 1998 that "differs by the position of the dorsal pore, absence of longitudinal striations on peristomium, the form of the clitellum, the well developed male pores and the calciferous glands with diverticula in 10. The last character is exceptional in the genus [*Prosellodrilus*]" (translation of Qiu & Bouché 1998c: 46). Data and discrepancies are summarized in Table 2.

DISCUSSION

Of 23,000 Annelida with 10,000 Oligochaeta and 6,000 Megadrilacea, the Family Lumbricidae from a total of about 1,130 names (~17% of megadriles) has about 670 valid species with another 55 or so uncertain shared amongst 63 genera (see Blakemore 2008a). Justification of lumbricid genera on their nephridial vesicles has precedent from, for example, *Eisenia* Malm, 1877 and *Eiseniella* Michaelsen, 1900 that are usually described with sausage-shaped bladders while *Eisenoides* Gates, 1969 from North American has U-shaped bladders – this being all that morphologically separates *Eisenoides carolinensis* Michaelsen, 1903 from *Eisenia koreana* (Zicsi, 1972) and similar new species in Korea (see Blakemore & Park 2012).

Table 2. *Kenleenus* and *Prosellodrilus* species after Qiu & Bouché (1998c) and pers. obs.

Character	***Ke. armadas* sp. nov.**	***Pr. proporus***	***Ke. a. amplisetosus****
Length (mm)	35–65	58–95	40–60
Segments	154–165	112–236 (or 262?)	142–173
Prostomium	Epilobic, closed	Prolobic	Prolobic (or open epilobic*)
Setae	Widely paired (= separate)	Closely paired	Separate
Ratio aa:ab	4:1	3:1	2:1 (or 4:1*)
1st dorsal pore	7/8	7/8	(5/6*)6/7
Female pores	Lateral of *b* on 14	Anterior of *a*	(Anterior of *b**)
Spermathecal pores	13/14/15 in *d*	13/14/15 in *cd*, simple or double	(12/13)13/14/15 in *d* lines, simple or double
Papillae in ab	10(11 lhs) and/or 13(14 rhs)	13, 14 &15	(13, 14, 20 & 22*)
Clitellum	19,½19–28,½29	20-29,30	19-28 (or 19-28,29*)
TP	(½19)20–22 (mostly20–21)	20–22	19–½22 (or ½19–22*)
Nephridial bladders	U-shaped (indistinct in anterior) without bulb	J-shaped often with bulb at base	U-shaped (or J-shaped*) without bulb
Spermathecae	Round in 14 and 15, paired	Pyriform, simple or double (triple)	Simple pair (or variable, double sometimes extra in 13*)
Seminal vesicles	(10) 11 & 12 weakly developed	11 & 12	11 & 12 (racemose*)
Ovisacs in 14	Weak	Well developed	Small or absent
Ca Glands	10,11-13,14 dilated in 11 & 13	11-14 dilated in 11 & 13	Variable, absent or in (10),(11), 12–14 with dilation in 13 (or 11–13 with dilation in 11*)
Gizzard	17-18	17-18	17-18
Typhlosole	Bifid or T-shaped from 21	Bifid from 21/22	Bifid from 21/22

*Additional information from Souto *et al.* (1991) – but see Discussion on *Ca. occidentalis*.

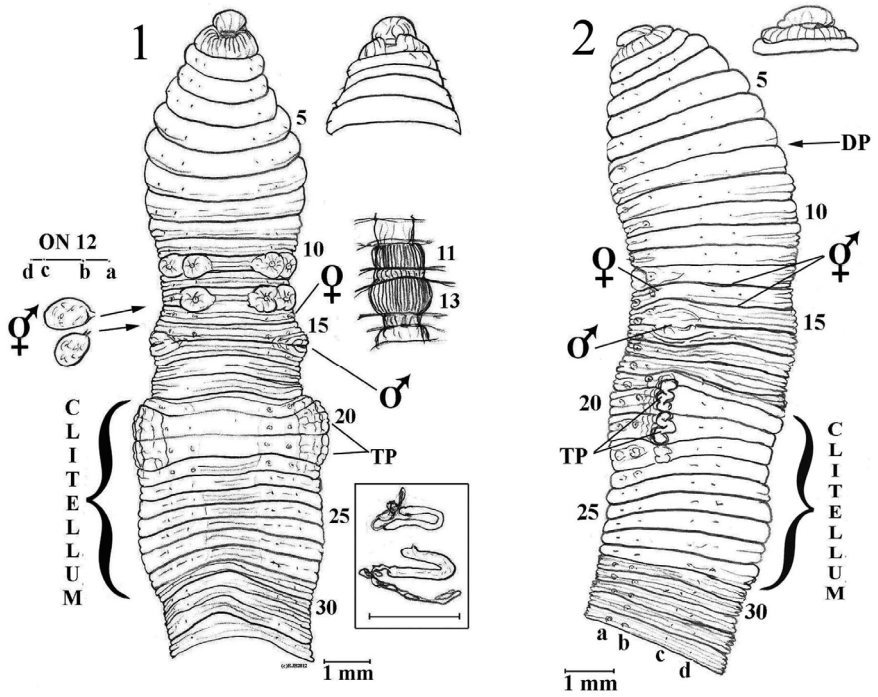

Figure 1-2. 1 = *Kenleenus armadas* sp. nov. Holotype, ventral view of body and dorsal view of prostomium; spermathecae and calciferous glands *in situ*; actual setal ratios on segment 12. [Boxed is X2 enlargement of nephridia in 19rhs and ca. 40rhs]. 2 = *Ke. armadas* P1, lateral view of body and dorsal view of prostomium. DP – dorsal pores; TP – tubercula pubertates.

It was noted that athecal worms in genus *Bimastos* Moore, 1893 in America when preserved may superficially resemble *Prosellodrilus* during description of another similar but athecal lumbricid, *Eisenia anzac* Blakemore, 2011 from Japan (see Blakemore & Grygier 2011). As already noted, *Helodrilus* Hoffmeister, 1845 was characterized by lack of nephridial bladders, but these were intermittent in *Helodrilus hachiojii* Blakemore, 2007 also from Japan, with the extent of reduction of bladders probably no less subjective than cut-off for whether setae are closely or widely paired, despite this being a key character for lumbricids.

The new Franco-Iberian species (*Ke. armadas*) introduced directly or indirectly to Ireland raises the total of earthworm species from Britain and Ireland to *ca.* 72 taxa (Blakemore 2008b), including cosmopolitan megascolecids *Amynthas corticis* (Kin berg, 1867) and *Pithemera bicincta* (Perrier, 1875) from Dublin Botanic Gardens (material in Tokyo National Museum sent by Dr Olaf Schmidt of University College Dublin to the author for identification in 2011). Also kindly sent by Dr Olaf Schmidt were an unidentified "monster" specimen from grassland in Dublin Airport (courtesy of Alice D'Arcy, University College Cork, NHMUK 2012.98) with clitellum 49–65 having two sets of female pores, displaced male pores and asymmetrical markings; plus three specimens (NIBR INV0000261273) from Tomnafinnogue Wood, from Waterford and Dublin's Botanic Gardens of *Dendrobaena attemsi* (Michaelsen, 1903) that was also recently discovered in New Zealand (Blakemore 2012).

Type specimens of *Cadanera doumandjii* (Baha & Bara, 2001) were found "in an orange plantation on hydromorphic soil" possibly with soil moisture due to drainage or irrigation. Previously, Baha (1997) had recorded other species from the same site, but collected at different times with different methods to those used in Baha & Berra (2001). They said *P. doumandjii* specimens numbered 500 – a large population and coincidentally the same number as identified by Baha (1997: 252) from the whole of Algeria – and they gave a segmental range of 60 adults but only listed six types and no other species. Claimed earlier from the same site by Baha (1997) were: "*Nicodrilus caliginosus*" (sic = *Aporrectodea caliginosa* spp-complex including *A. borellii*), *Allolobophora chlorotica, A. rosea* (= *Aporrectodea rosea*), *A. minuscula* (sic = *Murchieona minuscula*), *A. molleri* (= *Eophila molleri*), "*Helodrilus antipai* (Michaelsen, 1891)" (sic = *Proctodrilus antipae*), *Octodrilus complanatus*, *Eiseniella tetraedra* and *Microscolex phosphoreus* plus an *Amynthas* sp." (this oriental genus was mistakenly classed as a "cosmopolitan taxon, native of India"!). All these common exotic species (Blakemore 2010) give more weight to *Cadanera doumandjii* similarly being a non-endemic introduction rather than an endemic worm as thought by Omodeo *et al.* (2003: 463).

Melody & Schmidt (2012) discovered "*Prosellodrilus amplisetosus*" (here as *Ke. armadas* sp. nov.) with its range extension inferred as due to 'global warming'. However, recent and historical trade are likely routes of introduction to Ireland and, moreover, soil temperature is more equable at depth, it being a subsoil species. Aside from legendary "Míl Espáine" or archaeological evidence of tribal "Brigantes" and Roman occupancy (*e.g.* at Drumanagh near Dublin), Aquitaine was historically linked with Anglo-Norman dominion until the end of the Hundred Years' War in 1453 and much Bordeaux wine at least was imported. Transportation of species to Algeria (from Spain and/or Sardinia?) was possibly with citrus trees/ root stocks, as is suggested for *Ca. doumandjii*.

Kenleenus armadas appears particularly similar to what Souto *et al.* (1991) had reported as "*P. amplisetosus*" in Spain that they noted differed somewhat from the original description, as well as with that presented in Qiu & Bouché (1998c) (see Tab. 2), based on material which became types of what Qiu & Bouché (1998c: 45, fig. 8, tab. 4) redescribed (quite differently!) as *Prosellodrilus occidentalis*, here provisionally placed in genus *Cadanera* as *Ca. occidentalis* due to its calciferous diverticula in segment 10. Considerable discrepancies between these two sets of authors'

descriptions of what are supposed to be the same specimens (with regards to Souto *et al.* 1991 *vs.* Qiu & Bouché 1998c, respectively) include:

1/. Prostomium (epilobous *vs.* prolobous); 2/. Dorsal pores (5/6/7 vs. 4/5); 3/. Female pore location (lateral of *b vs.* anterior of *b*); 4/. Spermathecal pore location (in *d vs.* in *c*); 5/. Clitellum (19–28,29 *vs*. 19–½29); 6/. TP (½19–22 *vs.* just 20–21 as figured); 7/. Genital tumescences (13 & 14, 21, 22 *vs.* "13, 22: 23"? or figured in just 13 and 22); 8/. Nephridial form (J-shaped *vs*. U-shaped); 9/. Calciferous glands (11–13 dilated in 11 *vs.* ½10–14 with diverticula in 10! and dilated in 13); 10/. Spermathecae (variation and duplication *vs.* simple paired).

Original authors are invited to reconfirm their respective descriptions.

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APPENDIX 1

Species Checklist
(alphabetical and annotated)

Although there seems no rational system in the order of taxa in Qiu & Bouché (1998c), their Tables 2–4 have what I take to be the type-species of subgenera as first entries; but since explicit designations are not found in this paper, they may have been fixed earlier (see Blakemore 2004: 111 or 2008a: 60.) and are as given herein. In their Prosellodrilini tribe, Qiu & Bouché (1998d: 184) include *Italobalkaniona* Mrsic & Sapkarev, 1988 (type-species: *Eophila pyrenaicoides* Sapkarev, 1977) that is comparable to both *Eophila* and *Karpatodinariona* (see Blakemore 2008a).

Cadanera Blakemore, 2012 nom. nov. pro *Maghrebiella* Baha & Berra, 2001 (preocc.). (Type-species *Prosellodrilus doumandjii* Baha & Berra, 2001, new designation; *cf. A. festae* Rosa, 1892).

Ca. doumandjii (Baha & Berra, 2001: 88). Comb. nov.; *species inquirendum*. [Possibly it belongs in *Eumenescolex, Prosellodrilus* or *Pyrenodrilus* depending on its nephridia].

?*Ca. occidentalis* (Qiu & Bouché, 1998c: 45) (non *occidentalis* Michaelsen, 1922, nec Graff, 1957). Comb. nov.; *species inquirendum*. [Probably to be returned to *Kenleenus*].

Eumenescolex Qiu & Bouché, 1998b: 4 [sometimes mispelt "Emumenescolex"]. (Type-species *Eumenescolex heideti*, by original designnation Qiu & Bouché, 1998b: 4).

Eu. emiliae Qiu & Bouché, 1998b: 5.

Eu. gabriellae gabriellae (Omodeo, 1984: 118) [formerly *Eiseniona gabriellae*].

Eu. gabriellae gallurae (Omodeo, 1984: 120). [Qiu & Bouché (1998b, d) overlook this subspecies].

Eu. heideti Qiu & Bouché, 1998b: 4.

Eu. pereli (Bouché, 1972: 458) [origionally *Allolobophora pereli* and as in Qiu & Bouché (1998b) and by Omodeo & Rota (2008: 71), yet quoted as "*Allolobophora* (sensu lato) *perelae* (correction pro *pereli*) Bouché 1972" by Baha & Berra (2001: 90) (non *perelae*

Kvavadze, 1973). The change to "perelae" is most likely invalid albeit Dr Tamara Perel is female and the previous genus was feminine; *cf. antipae* and *festae* herein and in Blakemore (2008a, 2010)].

Eu. proclitellatus Perez-Onteniente & Rodriguez-Babio, 2004: 59 [from Valencia, Spain and not included in Blakemore (2004), for obvious reasons].

Eu. simplex (Zicsi, 1981: 177) (from Italy; originally as *Allolobophora* (s. lat.) *corsicana simplex*, later transferred as a subspecies of the *Scherotheca corsicana* (Pop, 1947) species-complex that has many invalid names; Omodeo & Rota (2008) say it "fits only partially the diagnosis of the genus [*Eumenescolex*]").

Kenleenus Qiu & Bouché, 1998a: 188, 1998c: 60 [misspelt "Kenlnus" by Qiu & Bouché, 1998a: 187 and variously as "Keeleenus" or "Kelleenus" in Qiu & Bouché 1998: 269]. (Type-species *Prosellodrilus amplisetosus amplisetosus* Bouché, 1972).

Ke. amplisetosus amplisetosus Bouché, 1972: 244.

Ke. amplisetosus hexathecosus Bouché, 1972: 246 (validated by Qiu & Bouché, 1998c: 40).

Ke. armadas Blakemore, 2012 sp. nov.

Ke. ticalus Qiu & Bouché, 1998c: 44.

Prosellodrilus Bouché, 1972: 231. (Type-species: *Prosellodrilus idealis* Bouché, 1972).

Pr. albus Zicsi & Csuzdi, 1999: 1000 [from France; Haute Garonne, Audressein; non *Cataladrilus (Cataladrilus) albus* Qiu & Bouché, 1998: 78].

Pr. biserialis Bouché, 1972: 88 [mispelt "bisearilis" in Qiu & Bouché (1998c: 61), formerly *Pr. fragilis biserialis*; non Černosvitov, 1937].

Pr. calcicolus Qiu & Bouché, 1998c: 54 [emend. Blakemore (2008) of original "*calcicola*" (sic)].

Pr. dactylothecus Qiu & Bouché, 1998c: 58.

Pr. dipterus Qiu & Bouché, 1998c: 55.

Pr. elusatus Bouché, 1972: 88 (sometimes misspelt "elisatus"; formerly *Pr. fragilis elusatus*).

Pr. idealis Bouché, 1972: 232.

Pr. ombrophilus Qiu & Bouché, 1998c: 46.

Pr. praticolus Bouché, 1972: 234 (emend. from original "praticola").

Pr. proporus Qiu & Bouché, 1998c: 42.

Pr. psammophilus Qiu & Bouché, 1998c: 47 [syns. *Pr. psammophilus magnus* Qiu & Bouché, 1998c: 48; *Pr. jamiesoni* Qiu & Bouché, 1998c: 49; *Pr. arenicolus* Qiu & Bouché, 1998c: 56 [emend. Blakemore (2008) of original "*arenicola*" (sic), mispelt "arericola" by Qiu & Bouché (1998c: 62, 184) with clitellum miscounted compared to Qiu & Bouché (1998c: fig. 18)]; synonyms of *psammophilus* as per Csuzdi (2012)].

Pyrenodrilus Qiu & Bouché, 1998a: 187; 1998c: 60. (Type-species *Prosellodrilus fragilis fragilis* Bouché, 1972).

Py. alatus Bouché, 1972: 242.

Py. biauriculatus Bouché, 1972: 241.

Py. bidasoanus Qiu & Bouché, 1998c: 53 (emend., named *bidasoana* after River Bidasoa thus latinized participle changes to agree in gender).

Py. fragilis Bouché, 1972: 238 [misspelt "fragilus" in Qiu & Bouché (1998c: 37)]. [Note: Csuzdi (2012) has *Pr. biserialis* and *Pr. Elusatus* in synonymy of *Py. fragilis*, this not fully accepted here based on their present generic reassignments].

Py. hyperopterus Qiu & Bouché, 1998c: 52.

Py. matoi Qiu & Bouché, 1998c: 57. [As "*P. milo*" lapsus Blakemore & Grygier (2011: 269)].

Py. polythecosus Bouché, 1972: 88 (originally as subspecies of *fragilis*; sometimes misspelt "polytheca").

Py. pyrenaicus abduli Qiu & Bouché, 1998c: 37 [misspelt "abdulridai" in Qiu & Bouché (1998c: 63)].

Py. pyrenaicus aragonicus (Álvarez, 1971: 43, 69) (originally *Eophila pyrenaica aragonica*).

Py. pyrenaicus haasi (Michaelsen, 1925: 186).

Py. pyrenaicus postandrus Qiu & Bouché, 1998c: 43.

Py. pyrenaicus pyrenaicus (Cognetti, 1904: 7) (sometimes mispelt "pirenaicus", *e.g.* in plosone.org/article/info:doi/10.1371). [Note: Csuzdi (2012) has *Eophila haasi*, *Prosellodrilus p. abduli* and *P. p. postandrus* in synonymy of nominal subspecies].

Py. trigoi Qiu & Bouché, 1998c: 50.

Species incertae sedis [= "*of uncertain taxonomic position*" – ICZN (1999: Glossary)]

Allolobophora festae Rosa, 1892: 1 (non *Aptodrilus festae* Cognetti, 1904); originally "*Festae*" named after "Dott. Enrico Festa" and maintained as "*Helodrilus* (*Allolobophora*) *festae*" by Michaelsen (1900: 486) sometimes noun (invalidly?) amended to "festai". Inclusion in *Maghrebiella* (now = *Cadanera*) as Baha & Berra (2001) suggested is dubious and suspect, pending morphological determination of their genus' type-species.

Taxonomic Note. ICZN (1999: Art. 31.1.1) says: "*A species-group name, if a* ***noun*** *in the genitive case formed from a personal name that is Latin, or from a modern personal name that is or has been latinized, is to be formed in accordance with the rules of Latin grammar.*

Examples. Margaret, if latinized to Margarita or Margaretha, gives the genitives margaritae *or* margarethae*; similarly Nicolaus Poda, even though the name of a man, if accepted as a Latin name, gives* podae*;...*". Also, ICZN (1999: Art: 32.5.2.4.2): "*Example.* R.P.Podae*, a specific name dedicated to the Reverendissimus Pater (Most Reverend Father) Poda, becomes* podae."

Thus the latinized genetive of a man's name as a noun may end in feminine "*e*"; and a specific name changes to agree with genus gender only "*if it is or ends in a Latin or latinized* ***adjective*** *or* ***participle*** *in the nominative singular*" (Art. 31.2). Moreover, ICZN (1999: Art. 33.5) states: "*In any case of doubt whether a different subsequent spelling is an emendation or an incorrect subsequent spelling, it is to be treated as an incorrect subsequent spelling (and therefore unavailable), and not as an emendation*", just as *festae* is held herein.

APPENDIX 2

mtDNA Barcode

Kenleenus armadas sp. nov. *H* mtDNA COI gene barcode (courtesy of Dr Hong-Yul Seo of NIBR).

GGTCAACAAATCATAAAGATATTGGAACCCTATACTTTATTCTTGGAGTGTGAGCCGGAATAGTAGGAGCCGGAA
TAAGACTCCTTATCCGTGTTGAACTAAGACAACCCGGAGCATTTCTAGGCAGAGACCAACTATACAACACAATTGT
CACAGCTCACGCATTCGTAATAATCTTCTTTTTAGTTATACCTGTCTTTATTGGAGGATTTGGAAATTGACTTCTAC
CTTTAATATTAGGAGCCCCAGACATAGCATTTCCCCGGCTAAATAATATAAGATTCTGACTACTTCCACCATCATTA
ATTCTACTTGTATCTTCTGCAGCAGTAGAGAAGGGGGCAGGTACAGGCTGAACAGTATACCCGCCTCTAGCTAGAA
ATCTAGCACACGCTGGTCCATCAGTAGACCTAGCTATTTTCTCCCTCCATTTAGCAGGGGCCTCGTCTATTCTAGGG
GCCATCAACTTTATTACCACGGTAATTAATATACGGTGAAGTGGCCTACGCTTAGAGCGCATCCCCCTATTTGTAT
GAGCTGTGGTTATTACAGTCGTTCTTCTTCTCCTATCCCTACCAGTATTAGCGGGAGCCATTACAATACTCCTAACT
GATCGAAACCTAAACACCTCTTTCTTCGATCCAGCCGGAGGCGGGGATCCAATTTTATATCAACATCTATTTTGATT
TTTTGGTCACCCTGAAGTTTA

BLAST (http://blast.ncbi.nlm.nih.gov) max. alignment =<83% for GU013841 an "unclassified Lumbricidae" from Romania or for several *Hormogaster* spp. from Spain; *i.e.*, no similar data presently provided on GenBank (http://www.ncbi.nlm.nih.gov/genbank/).

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Millipedes (Diplopoda) from the Zemplén Mountains, Northeast Hungary, with two julid species new to the Hungarian fauna

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Abstract. New data of millipedes from 92 sites in Northeastern Hungary are presented, based on the examination of more than 1300 individuals. The studied regions were the Zemplén Mountains and its surrounding plains, the Hernád valley and the Bodrogköz area. Altogether 25 millipede species were found, two Carpathian species are new to the fauna of Hungary: *Leptoiulus liptauensis* (Verhoeff, 1899) and *Cylindroiulus burzenlandicus* (Verhoeff, 1907). Remarkable and rare species for the Hungarian fauna are *Trachysphaera costata* (Waga, 1858) and *Brachydesmus dadayi* Verhoeff, 1895.

Keywords. Diplopoda, fauna, Transdanubian Mountains, Hernád Valley, Bodrogköz.

INTRODUCTION

Faunistic knowledge of the Hungarian millipedes (Diplopoda) is still incomplete and novelties can turn up, despite the surveys in the past decades (see e.g. Korsós 2005). Exact distributional records of millipedes are only known from 21.2% of the country area (based on the UTM mapping system of Hungary (Korsós 2005)). Especially the eastern and northeastern parts of the country are represented by only a few data (e.g. Korsós 1994, 1998). This study presents new faunistic records from the almost entirely unknown region of Northeast Hungary: the Zemplén Mountains, ("Zempléni-hegység") and its surrounding plains, the Hernád valley ("Hernád-völgy") and the Bodrogköz area (Fig. 1).

The Zemplén Mountains are volcanic parts of the Hungarian Northern Middle Range. The highest peak of the mountains is the Nagy-Milic (895 m a.s.l.). Dominant base rock types are andesite, rhyolite and tuff, and the soil is mainly acidic (Kiss 2007). Vegetation of the Zemplén Mountains is usually considered intermediate between the plant associations of the Hungarian Middle Ranges and that of the Carpathians, with presence both Pannonian and Carpathian floral elements. The lower parts of the Zemplén Mountains (up to 600 m a.s.l.) are dominated by forest-steppes (such as *Aceri tatarici–Quercetum roboris*) and various oak (*Quercetum*) forests, whereas the native forests in the higher parts (600–840 m a.s.l.) are oak-hornbeam (*Querco–Carpinetum*) and beech (*Fagetum*) forests (Simon 2006). Since 1984 a 26,500 ha area of the Zemplén Mountains has been designated for protection (as a landscape protection area, called "Zempléni Tájvédelmi Körzet"). The Zemplén Mountains are surrounded by lower sandy floodplains of the rivers Hernád and Bodrog. These are covered mainly by floodplain (*Populetum*, *Salicetum*, *Alnetum*) and oak forests (*Convallario–Quercetum roboris*) together with marshes, grasslands and agricultural fields (Tuba & Szirmai 2008).

Our goal was to survey the poorly known diplopod fauna of the area, and to improve our knowledge of the Hungarian millipedes.

MATERIALS AND METHODS

Millipedes were collected by the fourth author (GH) with pitfall trapping (with ethylene-glycol as preservative), singling and litter sifting, altogether in 91 sampling localities. Collecting period was between May 1999 and July 2006. An additional singling (Hejce, Sólyomkő) was made in July 2008 by the first author (DB), so the total number of sampling localities is 92. All materials collected were preserved in 70% ethanol and

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deposited in the Myriapoda Collection of the Hungarian Natural History Museum, Budapest. For identification we used a Nikon SM-800 and a Motic SMZ-168 stereo microscope, and the works by Bielak-Oleksy & Stojałowska (1968), Blower (1985), Schubart (1934) and Verhoeff (1895, 1899). Line drawings were made with Leica M125 stereo microscope and Leica DM-1000 light microscope.

Valid nomenclature was applied according to Fauna Europaea (Enghoff & Kime 2009, 2011). At each species we give a general synonymy list, with the important Hungarian citations of the species; the list of localities (settlement names separated by comma and followed by the local geographical names, all in Hungarian to facilitate localization on a regional map) and additional biogeographical or ecological remarks.

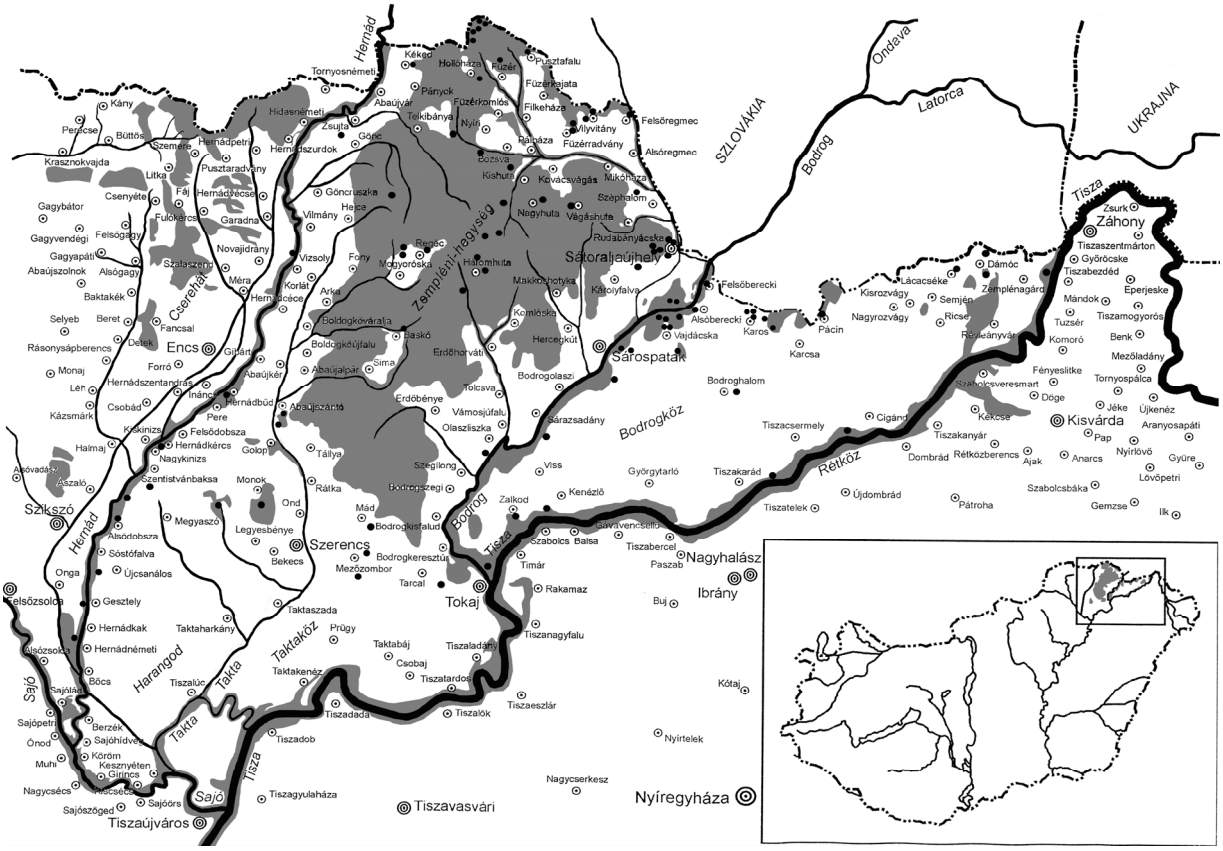


Figure 1. Map of the studied region: Zemplén Mountains, Hernád valley and Bodrogköz area. Black dots: collecting sites; white circles with small black dots: settlements in the area; dark grey area: forested area; light grey area: natural habitats except forests (grasslands, meadows, scrubland...etc.); white area: agricultural and urbanised areas.

RESULTS

POLYXENIDA

Polyxenidae

Polyxenus lagurus (Linnaeus, 1758)

Scolopendra lagura Linnaeus, 1758: 637.
Pollyxenus lagurus: Latreille 1802–1804: 45.
Polyxenus lagurus: Latzel 1884: 70, Loksa 1953: 178.

Localities. Háromhuta, Flórika-forrás; Háromhuta, Huta-völgyi kút; Pácin, Mágócsi-kastély.

Remarks. The species was found only in three, mostly native forest localities with nine specimens altogether. It is a holarctic species though easily overlooked (Enghoff & Kime 2011), relatively common also in Hungary (Korsós 1994). The scarce presence in the samples may be due to the collecting method by pitfall traps.

GLOMERIDA

Glomeridae

Glomeris hexasticha Brandt, 1833

Glomeris hexasticha Brandt, 1833: 197.
Glomeris hexasticha: Jermy 1942: 21–24, Loksa 1968a: 266–272.

Localities. Felsőregmec, Mátyásháza; Fony, Fekete-patak; Fony, Tekenős; Füzér, Drahos; Füzér, Halyagos-rét; Füzér, Kerékgyártó-bükk; Füzér, Torok; Füzér, Vár-forrás; Füzérradvány, Arborétum; Háromhuta, Flórika-forrás; Hejce, Sólyomkő; Hernádbűd, Gaz; Pusztafalu, Kertek alja; Regéc, Ördög-völgy; Regéc, Bálint-hegy; Sátoraljaújhely, Boda-dűlő; Sátoraljaújhely, Gejzír-domb, Sátoraljaújhely, Gyalmos; Sátoraljaújhely, Kecske-hát; Sátoraljaújhely, Májuskút, szőlő; Telkibánya, Kecske-hát; Vilyvitány, Magócsa-patak; Vilyvitány, Vilyi-legelő.

Remarks. An abundant species in the studied regions. It occurred together with *Glomeris tetrasticha* in 6 localities. The species is one of the most abundant species in Hungary and in Central and Southeast Europe as well, widespread mostly in natural woodlands (Korsós 1994, Enghoff & Kime 2011, Voigtländer 2011).

Glomeris tetrasticha Brandt, 1833

Glomeris tetrasticha Brandt, 1833
Glomeris connexa C. L. Koch, 1847: 97.
Glomeris connexa: Schubart 1934: 41–43, Jermy 1942: 37–42, Loksa 1953: 178.
Glomeris tetrasticha: Hoess 2000: 13, Hoess & Scholl 2001: 18, Lazányi & Korsós 2009: 36–37.

Localities. Baskó, Tekeres-patak; Bózsva, Farkas-völgy; Dámóc, Őrhegy; Füzér, Bodó-rét; Füzér, Halyagos-rét; Füzér, Kerékgyártó-bükk; Füzér, Oláh-rét; Füzér, Vár-forrás; Pusztafalu, Kertek alja; Sátoraljaújhely, Gyalmos; Sátoraljaújhely, Kacsa-tó; Sátoraljaújhely, Long-erdő (Háromhonvéd-fa); Telkibánya, Kecske-hát.

Remarks. The species occurred altogether in 13 localities, mainly in the forests of the mountainous Zemplén, but in some cases in the lower floodplains, too. It is a principally montane species, widespread in Eastern Europe (Korsós 1994, Enghoff & Kime 2011, Wytwer *et al.* 2009).

Dideriidae

Trachysphaera costata (Waga, 1857)

Gervasia costata Waga, 1858: 829.
Gervaisia costata: Jermy 1942: 54–59.
Trachysphaera schmidtii Heller, 1858: 317.
Trachysphaera hyrtlii Wankel, 1861: 253–254.
Trachysphaera costata: Strasser 1966: 334, Korsós 1994: 33.

Localities. Füzér, Vár-forrás.

Remarks. Three specimens (2 males, 1 female) were found in August 2005 near the castle ruins of Füzér (Northeast Zemplén) next to a spring located in a closed hornbeam forest (at about 480m a.s.l.). Previously the species was only reported from Budapest (Jermy 1942, Loksa 1959) and Szentdomonkos (Upponyi Hills, Northeast Hungary) (Korsós 1994).

POLYZONIIDA

Polyzoniidae

Polyzonium germanicum Brandt, 1837

Polyzonium germanicum Brandt, 1837: 179.
Polyzonium germanicum: Loksa 1968a: 266.

Localities. Dámóc, Őrhegy; Füzér, Torok; Karcsa, Becskedi-erdő; Pusztafalu, Kertek alja; Sátoraljaújhely, Gyalmos; Sátoraljaújhely, Long-erdő (Háromhonvéd-fa); Sátoraljaújhely, Mocsolya; Telkibánya, Kecske-hát.

Remarks. Thirty-eight specimens were found in 8 localities, almost all in oak-hornbeam forests of the Zemplén Mountains. The species was previously recorded from several other Hungarian localities, especially from old, undisturbed forests (Korsós 1994, Lazányi & Korsós 2009).

CHORDEUMATIDA

Mastigophorophyllidae

Mastigona bosniensis (Verhoeff, 1897)

Heteroporatia bosniense Verhoeff, 1897a: 193–195, Loksa 1968a: 272–276.
Mastigona bosniensis: Jeekel 1971: 67, Loksa 1988: 164.
Heteroporatia bosniense hungaricum Loksa, 1953: 179.

Localities. Abaújszántó, Kassi-szőlő; Kovácsvágás-Somoska; Pácin, Mágocsi-kastély; Sárospatak, Keleti-Bodrog-holtág; Sátoraljaújhely, Boda-dűlő; Sátoraljaújhely, Gyalmos; Sátoraljaújhely, Kecske-hát; Sátoraljaújhely, Long-erdő (Háromhonvéd-fa); Telkibánya, Kecske-hát.

Remarks. The species occurred in 9 localities in all of the three regions, but only with 22 specimens. These sites represent forests under different disturbance levels: oak-hornbeam forests, floodplain forests and in forest edges of former vineyards. The widespread species occurs in various habitats of Eastern Europe (e.g. Jędryczkowski 1992, Korsós 1994, Wytwer *et al.* 2009).

JULIDA

Nemasomatidae

Nemasoma varicorne C. L. Koch, 1847

Nemasoma varicorne C. L. Koch, 1847: 116.
Isobates varicornis: Latzel 1884: 240–243, Loksa 1957: 194.
Nemasoma varicorne: Enghoff 1985: 41.

Localities. Megyaszó, Hernád-part (Tátorjános TVT); Regéc, Rostalló.

Remarks. The species had only two occurrences with 6 specimens, probably due to the use of pitfall traps. It was found in softwood inundation forests (*Salicetum* and *Alnetum*). *N. varicorne* is a bark-dwelling species (Blower 1985), in Hungary moderately common (Korsós 1994).

Blaniulidae

Proteroiulus fuscus (Am Stein, 1857)

Blaniulus fuscus Am Stein, 1857: 139.
Blaniulus pulchellus Porat, 1889: 82.
Amsteinia fuscum: Verhoeff 1911: 539–540.
Proteroiulus fuscus: Korsós 1994: 37.

Localities. Sátoraljaújhely, Ungvári pincék.

Remarks. We found two specimens (one female and one juvenile) in a cellar in Sátoraljaújhely. The species often occurs around human settlements in Hungary (Korsós 1992, 1994), and favors synanthropic localities elsewhere, too (e.g. Riedel *et al.* 2009). However, it can be widespread in natural and seminatural forests in Europe (Schubart 1934, Blower 1985, Kime 1990, 2004). Some authors (e.g. Voigtländer 2011) classify the species as eurytopic, woodland species without obvious preferences.

Julidae

Brachyiulus bagnalli (Brolemann, 1924)

Iulus pusillus Leach, 1815: 379 *sensu* Latzel 1884: 281–283.
Brachyiulus (Microbrachyiulus) pusillus: Verhoeff 1898: 152–153.
Microbrachyiulus bagnalli: Brolemann, 1924: 108.
Brachyiulus bagnalli: Dziadosz 1964: 207–209, Korsós 1994: 37–38, Bogyó & Korsós 2009: 414, 416.
Brachyiulus pusillus kaszabi Loksa, 1956: 389.

Localities. Bodroghalom, Medvetanya; Mezőzombor, Szarkatanya; Szentistvánbaksa, Baksahalom; Tarcal, Ördög-bánya, Vizsoly, Hernád-holtág; Zalkod, Palocsa.

Remarks. The species was found in a few localities at low altitudes in the regions of Bodrogköz and the Hernád valley. The localities are mostly on the floodplains of the rivers Hernád, Tisza and Bodrog with more or less open vegetation (floodplain forests, grasslands, vineyards). *Brachyiulus bagnalli* was characterized by Dziadosz (1964) as a Southeast European steppe species. The species was previously recorded from Hungary (Loksa 1956, Korsós 1994, Korsós *et al.* 2002, Bogyó & Korsós 2009). It seems that *B. bagnalli* has a wide habitat preference, occurring in xerothermic grasslands, floodplain forests, and anthropogenic habitats like city parks as well.

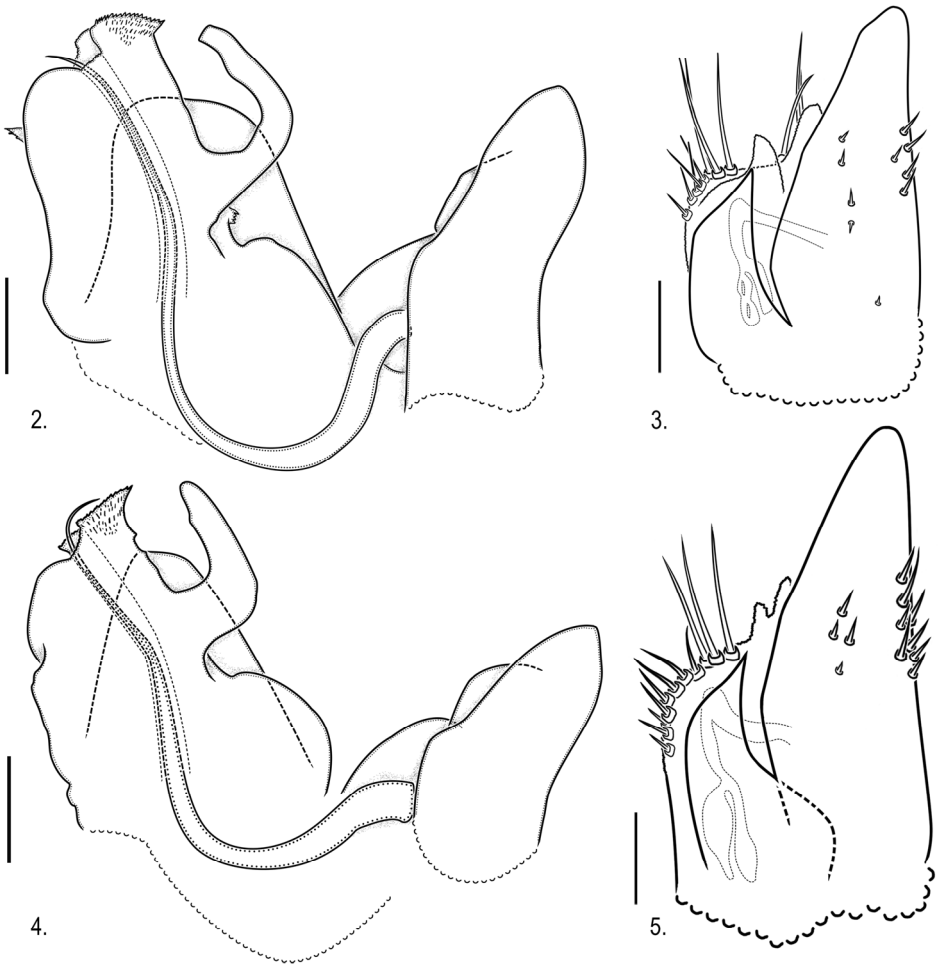
Cylindroiulus burzenlandicus Verhoeff, 1907

(Figures 2–5)

Cylindroiulus burzenlandicus Verhoeff, 1907: 310–311.
Cylindroiulus luridus burzenlandicus: Ložek & Gulička 1962: 63–66, 68, 78.
Cylindroiulus burzenladicus: Schubart 1934: 214, Bielak-Oleksy & Stojałowska 1968: 20–21.

Localities. Bózsva, Szuha-völgy, Füzér, Bodó-rét; Füzér, Halyagos-rét; Füzér, Oláh-rét; Hejce, Sólyom-kő, Nagyhuta, Káváskúti-völgy.

Remarks. This species is new to the Hungarian fauna! Altogether 13 specimens were found from 7 localities in the northern Zemplén Mountains. These sites are situated in natural beech forests and in a mountain hay meadow (Füzér, Bodó-rét). *C. burzenlandicus* was described from montane forests around Brașov (formerly Kronstadt), Romania (Verhoeff 1907). It is a Carpathian element, with relatively narrow range: adjoining parts of Poland, Slovakia, Ukraine and Romania (e.g., Jędryczkowski 1992, Mock 2001, Kosyanenko 2003, Kosyanenko & Chumak 2008, Enghoff & Kime 2009). In the neighboring Slovakia and Ukraine the species is typical for old montane beech forests, with a maximum abundance at about 600m a.s.l. in the Ukrainian Carpathians (Kosyanenko & Chumak 2008, Mock 2011 pers. comm.). Reexamination of specimens formerly identified as *C. luridus* from the Zemplén Mountains (2♂, 3♀ Rostalló, 1986. July 23., sifting; 3♂, 2♀, 2 juv., Rostalló, 1986. July 21–25., soil trap; 2♂ Komlóska valley, 1986. July 22., all leg. and det. by Z. Korsós, see Korsós (1994) proved that they are in fact *C. burzenlandicus*. Here we present new illustration of the male gonopods (Fig. 2), illustration for the first time of the female vulvae (Fig. 3), to compare it to the very similar *C. luridus* (Figs. 4–5, gonopods and vulvae, respectively.)



Figures 2–3. *Cylindroiulus burzenlandicus* Verhoeff, 1907 from Nagyhuta, Kávás-völgyi kút (Hungary). 2 = male right gonopods, mesal view. 3 = female right vulva, anterior view.

Figures 4–5. *Cylindroiulus luridus* (C. L. Koch, 1847) from Tardosbánya, Bánya-hegy (Hungary). 4 = male right gonopods, mesal view. 5 = female right vulva, anterior view (scale bars: 0.2 mm).

Enantiulus nanus (Latzel, 1884)

Julus nanus Latzel, 1884: 264–267.
Leptophyllum nanum: Verhoeff 1910: 56, Loksa 1968b: 266–288, 1979: 88, 91.
Enantiulus nanus: Hoffman 1980: 110, Korsós 1994: 43.

Localities. Háromhuta, Flórika-forrás; Pusztafalu, Kertek alja.

Remarks. In spite of the species' relatively high abundance in other northeastern Hungarian mountainous regions (Loksa 1968a, Lazányi & Korsós 2009) we have found only three specimens in the northern part of the Zemplén Mountains, in hornbeam forests. Since it is a small soil- and rock-dwelling species, this can be the result of the pitfall collecting method.

Julus terrestris Linnaeus, 1758

Julus terrestris Linnaeus, 1758: 639.
Julus terrestris Loksa 1973: 81, 1988: 170.
Iulus (L.) terrestris: Szabó 1931: 15, 18, 25–26, 28.

Localities. Alsóberecki, Berecki híd; Bodroghalom, Medvetanya; Felsőberecki, Bodrog-ártér; Fony, Tekenős; Hernádkércs, Hernád (füzes); Hernádnémeti, Török-jussa; Karcsa, Tekerületi-dűlők; Karos, Móka-domb; Karos, Szőlő-máj homok; Kenézlő, Görbe-ér; Kovácsvágás, Somoska; Megyaszó, Hernád-part (Tátorjános TVT); Mezőzombor, Kamara-rét; Olaszliszka, Fenyér; Regéc, Rostalló; Regéc, Bálint-hegy; Sárazsadány, Törökér; Sárospatak, Déli-Bodrog-holtág; Sárospatak, Kapronca; Sátoraljaújhely, Mocsolya; Sátoraljaújhely, Long-erdő (Háromhonvéd-fa); Telkibánya, Kecske-hát; Vajdácska, Diófás-dűlő; Zalkod, Palocsa; Zemplénagárd, Vér-tó.

Remarks. This is an abundant species in localities with open vegetation at low altitudes. It was found mainly on the floodplains and agricultural fields of Bodrogköz and the Hernád valley, sometimes in mass occurrence. In the Zemplén Mountains only a few records were found. *J. terrestris* is a typical millipede species of the Great Hungarian Plain (Korsós 1994) and other Eastern European open lowland areas (e.g. Jedryczkowsky 1992).

Kryphioiulus occultus (C. L. Koch, 1847)

Allajulus occultus C. L. Koch, 1847: 117–118.
Cylindroiulus occultus: Verhoeff 1907: 284, Loksa 1953: 179.
Kryphioiulus occultus: Read 1990: 107, Korsós 1994: 41.

Localities. Dámóc, Darvasi-legelő; Karos, Séta-homoki dűlő; Lácacséke, Ereszvény-dűlő.

Remarks. This generally xerothermic and somewhat synanthropic species (Schubart 1934, Korsós 1992, Bogyó & Korsós 2009, Riedel *et al.* 2009, Voigtländer 2011) was found at three sampling sites with only a few specimens. The localities belong to the low altitude landscape type of the Bodrogköz on sandy soil.

Leptoiulus cibdellus (Chamberlain, 1921)

Julus minutus Porat, 1889: 130–132.
Julus (Leptoiulus) minutus: Verhoeff 1898: 136.
Leptoiulus minutus: Vehoeff 1908: 436.
Iulus cibdellus Chamberlin, 1921: 83.
Leptoiulus cibdellus: Enghoff 1974: 31, Korsós 1994: 40.

Localities. Cigánd, Póherei-dűlő; Olaszliszka, Fenyér; Sátoraljaújhely, Gyalmos; Sátoraljaújhely, Long-erdő (Háromhonvéd-fa); Sátoraljaújhely, Mocsolya; Telkibánya, Kecske-hát; Vajdácska, Diófás-dűlő; Vajdácska, Holt-Bodrog; Zalkod, Palocsa.

Remarks. We have found the species in 9 localities with 15 specimens. The localities are mostly in diverse wetland habitats of the Bodrogköz. The species occurred in the Zemplén Mountains in several places, too. Our findings correspond to the results of previous works which stated that the species occurs mostly in wet woodlands across Central and North Europe, and has the ability to survive submersion during flood (Zulka 1991, Jędryczkowski 1992, Sallai 1993, Enghoff & Kime 2009).

Leptoiulus liptauensis (Verhoeff, 1899)

(Figure 6)

Julus (Leptoiulus) ciliatus liptauensis Verhoeff, 1899: 201.
Leptoiulus liptauensis: Verhoeff 1908: 440, Bielak-Oleksy & Stojałowska 1968: 21–23, Tajovský 1997: 229, Mock 2001: 31.

Localities. Bózsva, Farkas-völgy; Füzér, Vár-

forrás; Háromhuta, Flórika-forrás; Pusztafalu, Kertek alja; Sátoraljaújhely, Kecske-hát.

Remarks. This species is new to the Hungarian fauna! Altogether 13 specimens were found in five localities. All the sites are situated in closed deciduous woodlands in the Zemplén Mountains, between 320 and 480m a.s.l. *L. liptauensis* was described from alpine ranges (1350–2000m a.s.l.) of the Nizke Tatry, Vysoke Tatry and Zapadne Tatry Mountains, Slovakia (Verhoeff 1899). Later Gulička (1975) found the species in a collapsed cave (Duča) in the Slovak Paradise (about 950m a.s.l.) in Slovakia. It was mentioned from Poland as well; Krkonoše/Karkonosze Mts, Western Sudets (e.g. Stojałowska & Staręga 1974). *L. liptauensis* was formerly described as a western Carpathian species, occurring exclusively in alpine and subalpine ecosystems, typical mainly to alpine coniferous woodlands and dwarf shrub heaths (Jawlowsky 1938, Gulička 1956, Tajovský 1997). In spite of these statements Mock (1999) recorded its occurrence in eastern Slovakia from lower altitudes (440–500m a.s.l.) and from deciduous forests (Slanské vrchy Mountains: localities Zámutovská jelšina and Dolina obrov). Zemplén Mts may represent the southernmost occurrence of this Carpathian endemism. In agreement with Mock (1999) we found that the species usually occurs together with *Cylindroiulus burzenlandicus*, *Megaphyllum projectum*, *Unciger foetidus*, *Strongylosoma stigmatosum* and *Polydesmus complanatus* at this altitude and vegetation type. However, in the Zemplén Mountains it was found in four sampling sites together with *Leptoiulus proximus* as well. The ecological background of these co-occurrences has not yet been clarified.

Here we present a new gonopod figure of the species (Fig. 6). Unfortunately those samples which contained females were from regions where other *Leptoiulus* species occurred too, thus we are not able to give the details of female vulvae. The outer morphology of female vulva was already described by Bielak-Oleksy & Stojałowska (1968).

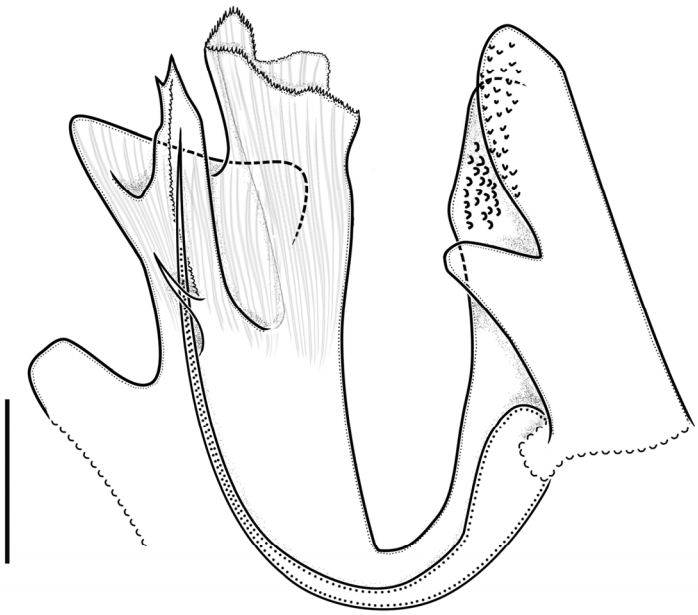


Figure 6. *Leptoiulus liptauensis* (Verhoeff, 1899) from Háromhuta, Flórika-forrás (Hungary). Male right gonopod, mesal view (scale bar: 0.2 mm).

Leptoiulus proximus (Nemec, 1896)

Julus (Leptoiulus) proximus Nemec, 1896: 3–4.
Julus (Leptoiulus) ciliatus buekkensis: Verhoeff 1899: 201.
Leptoiulus trilobatus buekkensis: Verhoeff 1908: 441.
Leptoiulus proximus: Attems 1927: 137, Loksa 1979: 88, 91.

Localities. Alsóregmec, Debrai-forrás; Fony, Fekete-patak; Fony, Tekenős; Füzér, Drahos; Füzér, Kerékgyártó bükk; Füzér, Torok; Füzér, Vár-forrás; Háromhuta, Flórika-forrás; Hejce, Sólyom-kő; Pusztafalu, Kertek alja; Sárospatak, Veresharaszt; Sátoraljaújhely, Gyalmos; Sátoraljaújhely, Kecske-hát; Sátoraljaújhely, Long-erdő; Sátoraljaújhely, Lőtéri-forrás; Telkibánya, Kecske-hát; Zsujta, Haraszka.

Remarks. L. proximus was found in 17 localities of the Zemplén Mountains, with 58 specimens. It was found in different types of undisturbed forests (mainly alderwood, beech, oak-hornbeam) and mountain meadows, in some sites together with *L. cibdellus*, *L. liptauensis* and *L. trilobatus*. *L. proximus* is a widespread forest species in Hungary (Korsós 1994) and in Central and East Europe as well (Enghoff & Kime 2009). It prefers different forest types, mainly with multi-level tree and/or shrub layers (e.g. Schubart 1934, Jedryczkowsky 1992, Wytwer *et al*. 2009, Voigtländer 2011).

Leptoiulus trilobatus (Verhoeff, 1894)

Julus trilobatus Verhoeff, 1894a: 12.
Julus (Leptoiulus) ciliatus Verhoeff, 1897b: 115–116.
Leptoiulus trilobatus: Verhoeff 1908: 440, Korsós 1994: 40.

Localities. Füzér, Halyagos-rét; Hejce, Sólyom-kő; Sátoraljaújhely, Gyalmos.

Remarks. L. trilobatus was found in three localities of the Zemplén Mountains, with 37 specimens. In the 110 years old alderwood grove (*Alnetum*) of Gyalmos (Sátoraljaújhely) it occurred together with *L. cibdellus* and *L. proximus*. *L. trilobatus* has a Central European distribution (Enghoff & Kime 2009). In Hungary it prefers mostly the closed, undisturbed forests (Lazányi & Korsós 2009). However, other studies described it as an „adaptable" species (Tuf & Tufová 2008).

Megaphyllum projectum projectum Verhoeff, 1894

Megaphyllum projectum Verhoeff, 1894b: 323–324.
Brachyiulus projectus: Verhoeff 1897b: 111–112.
Chromatoiulus projectus: Schubart 1934: 278-280, Loksa 1979: 88.
Brachyiulus projectus dioritanus Verhoeff, 1907: 303, 305, Figs 5–8.
Chromatoiulus projectus dioritanus: Loksa 1968a: 268.
Megaphyllum projectum dioritanum: Loksa 1988: 164, 1991: 131–132.
Megaphyllum projectum: Hoffman 1980: 104.
Megaphyllum projectum projectum: Lazányi & Korsós 2011: 45–49, 51–53.

Localities. Dámóc, Őrhegy; Dámóc, Darvasi-legelő; Füzér, Drahos; Füzér, Vár-forrás; Füzér, Torok; Füzér, Kerékgyártó-bükk; Füzérradvány, Arborétum; Háromhuta, Flórika-forrás; Monok, Csörgő-domb; Pusztafalu, Kertek alja; Regéc, Rostalló; Sátoraljaújhely, Kecske-hát; Sátoraljaújhely, Májuskút, szőlő; Sátoraljaújhely, Boda-dűlő; Telkibánya, Kecske-hát; Vilyvitány, Magócsa-patak.

Remarks. This is an abundant julid species in the research area. It lives in the deciduous forests of the Zemplén Mountains, and it was also found in an oak woodland of the Hernád valley (Monok). It is widespread in Hungary as well as in Central and Eastern Europe (Korsós 1994, Enghoff & Kime 2009). In the Eastern European Plain the species is closely associated to the oak woodlands (Wytwer *et al.* 2009), but seems to be more eurytopic in Western Europe (Voigtländer 2011).

Megaphyllum unilineatum (C. L. Koch, 1838)

Iulus unilineatus C. L. Koch, 1838: 22.
Brachyiulus (Chromatoiulus) unilineatus: Verhoeff 1897b: 114–115.
Brachyiulus unilineatus: Szabó 1931: 15, 18, 22–24, 26–28, 30.
Chromatoiulus unilineatus: Attems 1927: 220.
Chromatoiulus unilineatus: Loksa 1953: 179; 1983: 68.
Megaphyllum unilineatum: Hoffman 1980: 104, 113, Loksa 1988: 162–164, 170.

Localities. Abaújszántó, Sátor-hegy; Abaújszántó, Kassi-szőlő; Baskó, Tekeres-patak; Bodroghalom, Medvetanya; Dámóc, Darvasi-legelő; Füzér, Drahos; Gesztely, Ürmös-hát; Hernád-

németi, Török-jussa; Karos, Móka-domb; Mád, Becsek; Mezőzombor, Szarkatanya; Pusztafalu, Kertek alja; Tarcal, Ördög-bánya; Újcsanálos, Ócsanálosi part; Vilmány, Középső-mező; Vizsoly, Hernád-holtág.

Remarks. The species was relatively abundant in the lower altitude habitats of the study area. *M. unilineatum* occurred mainly in the Hernád valley, but it could be found in the Zemplén Mountains and in Bodrogköz, too. It was also abundant in disturbed, anthropogenic habitats. In Europe and in Hungary it is a generally widespread, xerothermic open land species (e. g. Korsós 1994, Tuf & Tufová 2008, Enghoff & Kime 2009, Voigtländer 2011).

Ommatoiulus sabulosus (Linnaeus, 1758)

Iulus sabulosus Linnaeus, 1758: 640.
Julus (Ommatoiulus) sabulosus: Haase 1887: 27–29.
Schizophyllum sabulosum: Verhoeff 1900: 466–473.
Archiulus sabulosus: Attems 1927: 240, 279–282.
Ommatoiulus sabulosus: Jeekel 1968, Korsós 1994: 43.

Localities. Bózsva, Farkas-völgy; Füzér, Drahos; Háromhuta, Márika-forrás; Pusztafalu, Kertek alja.

Remarks. The species had four occurrences with 28 specimens altogether. All localities were in natural forest habitats of the northeastern part of the Zemplén Mountains. It occurs in a wide range of habitats (from open grasslands to different forest types) across Europe (e.g. Blower 1985, Jędryczkowski 1992, Kime 1992, 1996, Wytwer *et al.* 2009, Voigtländer 2011). In Eastern Hungary it is less abundant. Nevertheless, former studies (Korsós 1994, Mock 1999) showed that it was already found close to our present localities.

Unciger foetidus (C. L. Koch, 1838)

Iulus foetidus C. L. Koch, 1838: 22.
Oncoiulus foetidus: Verhoeff 1899: 190–191.
Unciger foetidus: Lohmander 1925: 60–61, Loksa 1953: 179.

Localities. Füzér, Bodó-rét; Füzér, Drahos; Füzér, Halyagos; Füzér, Kerékgyártó-bükk; Füzér, Vár-forrás; Háromhuta, Flórika-forrás; Hejce, Sólyom-kő, Nagyhuta, Káváskúti-völgy.

Remarks. This species was recorded from 8 localities in the central part of the Zemplén Mountains in undisturbed natural forest habitats. In northwestern areas of Europe it tends to be eurytopic (Voigtländer 2011) and sometimes synanthropic (Lindner *et al.* 2010), but in Hungary it is more confined to natural forests (e.g. Korsós 1994, Lazányi & Korsós 2009).

POLYDESMIDA

Paradoxosomatidae

Strongylosoma stigmatosum (Eichwald, 1830)

Julus stigmatosus Eichwald, 1830: 124.
Strongylosoma pallipes (Olivier, 1792): Latzel 1884: 168–170, Loksa 1953: 179.
Strongylosoma stigmatosum: Jeekel 1967: 166, Szlávecz & Loksa 1991: 804.

Localities. Füzér, Vár-forrás; Füzér, Oláh-rét; Füzér, Halyagos-rét; Füzérradvány, Arborétum; Háromhuta, Huta-völgyi-kút; Hejce, Sólyom-kő.

Remarks. The species was found in six localities which represent undisturbed woodland habitats in the Zemplén Mountains. This species is widespread in hilly and montane forests in Hungary and in East Central and East Europe as well (e.g. Jędryczkowski 1992, Korsós 1994, Enghoff & Kime 2011, Lazányi & Korsós 2009).

Polydesmidae

Brachydesmus dadayi Verhoeff, 1895

Brachydesmus dadayi Verhoeff, 1895: 287–288.
Brachydesmus dadayi: Korsós, 1994: 44.

Localities. Tarcal, Ördög-bánya.

Remarks. A single male specimen was found in the mixture of a former vineyard and natural grassland area near an abandoned quarry. The species was described by Verhoeff (1895) from Slovakia (Zlaté Moravce). It is endemic to the Carpathian Basin (Korsós 1998) with relatively few occurrences, but was also found in synanthropic habitats (Korsós 1992).

Polydesmus complanatus (Linnaeus, 1761)

Julus complanatus Linnaeus, 1761: 502.
Polydesmus illyricus Verhoeff, 1893: 273–275.
Polydesmus complanatus: Porat 1870: 820, Lohmander 1925: 16–17, Szabó 1931: 15, 17–18, 21–22, 25–29, Loksa 1954: 217–218.

Localities. Abaújszántó, Kassi-szőlő; Abaújszántó, Sátor-hegy; Alsóberecki, Berecki híd; Alsóregmec, Köblös és Szompoly; Cigánd, Póhereidűlő; Felsőberecki, Bodrog-ártér; Füzér, Drahos; Füzér, Halyagos-rét; Füzér, Vár-forrás; Füzérradvány, Arborétum; Füzérradvány, Fülemülevölgy; Háromhuta, Flórika-forrás; Hernádkércs, Hernád (füzes); Kéked, Kékedfürdő; Mád, Becsek; Megyaszó, Hernád-part (Tátorjános TVT); Monok, Csörgő-domb; Pácin, Mágócsikastély; Pusztafalu, Kertek alja; Regéc, Rostalló; Sárazsadány, Törökér; Sárospatak, Keleti-Bodrogholtág, Sárospatak, Veresharaszt; Sátoraljaújhely, Boda-dűlő; Sátoraljaújhely, Gyalmos; Sátoraljaújhely, Kacsa-tó; Sátoraljaújhely, Kecske-hát; Sátoraljaújhely, Long-erdő (Háromhonvéd-fa); Sátoraljaújhely, Májuskút, szőlő; Sátoraljaújhely, Mocsolya; Sátoraljaújhely, Ungvári pincék; Tarcal, Ördög-bánya; Telkibánya, Kecske-hát; Tiszakarád, Szárnya-szög; Tokaj, Rákóczi-vár; Vágáshuta, Nagypart; Vajdácska, Kopaszló-sarok; Vilyvitány, Magócsa-patak; Vilyvitány, Vilyilegelő; Vizsoly, Hernád-holtág; Zalkod, Palocsa; Zemplénagárd, Vér-tó; Zsujta, Haraszka.

Remarks. Common and widespread millipede species in the region, found altogether in 42 localities. It occurs in almost every kind of habitats, and is common in Central–Eastern Europe and in Hungary, too (Tadler & Thaler 1993, Korsós 1994, 1998, Tuf & Tufová 2008, Enghoff & Kime 2011).

Polydesmus denticulatus C. L. Koch, 1847

Polydesmus denticulatus C. L. Koch, 1847: 135.
Polydesmus denticulatus: Szabó 1931: 15, 17–18, 26–27, 30, Loksa 1954: 217, 220.

Localities. Alsódobsza, Erős-domb; Bodroghalom, Medvetanya; Dámóc, Darvasi-legelő; Fony, Fekete-patak; Füzér, Drahos; Gesztely, Ürmöshát; Hernádbűd, Gaz; Hernádnémeti, Török-jussa; Mád, Becsek; Mezőzombor, Szarkatanya; Monok, Ingvár; Monok, Csörgő-domb; Olaszliszka, Fenyér; Sárazsadány, Törökér; Sárospatak, Füzes-ér; Sátoraljaújhely, Mocsolya; Sátoraljaújhely, Kacsa-tó; Szentistvánbaksa, Baksa-halom; Telkibánya, Kecske-hát; Tiszakarád, Szárnya-szög; Vágáshuta, Nagypart; Vajdácska, Kopaszló-sarok; Vizsoly, Hernád-holtág; Zalkod, Palocsa.

Remarks. This is the most abundant millipede species in the research area, found in 22 localities. In many cases the species was found at low altitudes under human disturbance. In 12 localities it was found together with *P. complanatus*. *P. denticulatus* is an eurytopic species, widespread in Hungary and in Europe, sometimes in synanthropic habitats, too (Tadler & Thaler 1993, Korsós 1994, Enghoff & Kime 2011).

DISCUSSION

The present study lists 25 species with 1370 individuals from the Zemplén Mountains and its surroundings, i.e. 24,3% of the Hungarian millipede fauna (Korsós 2005). The regular use of pitfall trapping may explain this relatively low number of species. Although we worked with 92 sampling sites, some interesting localities were particularly missing from the research area, like the central and southwestern parts of the Zemplén Mountains, and the southeastern, more or less isolated point of the mountains (the Tokaj Hill). All these are protected under the Hungarian nature conservation law.

With the two new species, recorded for the first time, the actual number of Hungarian millipede species increases to 103 (Korsós 2005, Korsós unpublished).

Most of the recorded species (64%) can be characterized as (undisturbed) forest species. The number of eurytopic species (found sometimes also in synanthropic habitats) like *Proteroiulus fuscus* and *Polydesmus denticulatus* was low (8 %), *P. denticulatus* was, however, one of the most abundant species in disturbed lowland areas. The (xerothermic) open land species, like *Brachyiulus*

bagnalli, *Julus terrestris*, *Kryphyioiulus occultus* and *Megaphyllum unilineatum* occurred mainly on the plains around the Zemplén Mountains. The most abundant five species were as it follows: *Polydesmus denticulatus*, *Polydesmus complanatus*, *Glomeris hexasticha*, *Julus terrestris*, *Megaphyllum projectum*.

In biogeographic relations, most of the recorded species (80%) are widespread; e.g. in Central and/or Eastern Europe. Three Carpathian species were found, two of them were new to the Hungarian fanua: *Cylindroiulus burzenlandicus* and *Leptoiulus liptauensis*; the third was *Brachydesmus daday*, endemic to the Carpathian Basin. *Glomeris tetrasticha* was the fourth montane species in our list.

In agreement with faunistical information based on other invertebrate taxa here we present new evidence that the forested habitats of the Zemplén Mountains are suitable for Carpathian faunal elements in Hungary. The forests of the Zemplén Mountains do have a biogeographic connection both with the Slovakian and Ukrainian part of the Carpathians as it was proven by other invertebrate taxa as well (e. g. Nagy *et al.* 1998, Dányi & Korsós 2002, Kontschán *et al.* 2006, Jordán *et al*. 2007, Sólymos 2008). As discussed by Mock (1999) and Lazányi & Korsós (2009) there is still a chance to find new species to the Hungarian millipede fauna in this region. Species occurring in the broader region of Eastern Slovakia, like the Carpathian *Trachysphaera acutula* (Latzel, 1884) and *Xestoiulus carpathicus* (Verhoeff, 1907) can also be expected in the territory of Hungary.

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Checklist of oribatid mites from "Cape Martyan" Nature Reserve (Ukraine), with redescription of *Paralopheremaeus hispanicus* (Ruiz, Kahwash and Subías, 1990) and description of *Ctenobelba martyanensis* sp. nov. (Acari: Oribatida)

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Abstract. An annotated checklist of oribatid mite taxa (85 species, 72 genera, 41 families) in "Cape Martyan" Nature Reserve (Ukraine) is provided. *Paralopheremaeus hispanicus* (Ruiz, Kahwash & Subías, 1990) is redescribed in details. *Ctenobelba martyanensis* sp. nov. is described and illustrated. The new species can be distinguished from all representatives of the genus by having very widely dilated notogastral setae.

Keywords. Fauna, checklist, redescription, new species, Cape Martyan Nature Reserve, Ukraine.

INTRODUCTION

The oribatid mite fauna (Acari: Oribatida) of "Cape Martyan" Nature Reserve (Ukraine, Crimea) is poorly known. Only one brief research of oribatids was published: Yaroshenko & Kuzmina (1983) registered 14 species, 13 genera and 12 families.

The present study is based on oribatid mite material collected from "Cape Martyan" Nature Reserve in 2010. The primary goal of this paper is to present an annotated checklist of the taxa identified.

In the course of taxonomic identification, we have found a species of the genus *Paralopheremaeus* Paschoal, 1987 (Plateremaeidae), namely *Paralopheremaeus hispanicus* (Ruiz, Kahwash & Subías, 1990) which was previously known only from southern Europe (Subías 2004, online version 2012). This species was described by Ruiz, Kahwash & Subías (1990), and later redescribed by Pérez-Íñigo (1997) from Spain. However, the original description and redescription are incomplete and brief (lacking information about the leg setation and solenidia, measures of morphological structures and morphology of gnathosoma). A secondary goal of our paper is to present herewith a detailed redescription of *Paralopheremaeus hispanicus*.

We have also found a new species belonging to the genus *Ctenobelba* Balogh, 1943 (Ctenobelbidae). A tertiary goal of our paper is to describe this species under the name *Ctenobelba martyanensis* sp. nov. At present, the genus *Ctenobelba* comprises 24 species, which are distributed in the Palearctic and Oriental regions (Subías 2004, online version 2012). The main generic characters of *Ctenobelba* have yet been summarized (see for example: Mahunka 1964, 1977, Woas 1986, Miko 1990, Balogh & Balogh 1992, Pérez-Íñigo 1997) and identification keys to some species have also been presented (see Mahunka 1964, 1977, Choi 2005) therefore, these are not dealt with here.

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MATERIAL AND METHODS

The studies were performed in "Cape Martyan" Nature Reserve located at Southern shore of Crimea (Ukraine) to the east from Yalta. Terrestrial part of Nature Reserve covers of some 120 hectares. The "Cape Martyan" Nature Reserve is bounded by the coordinates 44º30' to 44º31' N and 34º14' to 34º15' E. Elevations range up to 245 m a.s.l. This is the smallest Nature Reserve of Ukraine.

The dominating trees of the reserve are oaks (*Quercus pubescens* Willd.), junipers (*Juniperus excelsa* M. Bieb), strawberry trees (*Arbutus andrachne* L.), hornbeams (*Carpinus orientalis* Mill.) and pines (*Pinus pallasiana* D. Don.).

The oribatid mites (more than 2500 specimens) have been collected by A. A. Khaustov from soil and mosses between January–June 2010. The specimens of *Paralopheremaeus hispanicus* were obtained: 1) in soil and mosses, 24 April 2010 (one specimen); 2) in soil, 14 May 2010 (two specimens). The specimens of *Ctenobelba martyanensis* sp. nov. were collected: in soil, 24 March, 2010 (two paratypes); and 14 May, 2010 (holotype and paratype).

All specimens were studied in lactic acid, mounted on temporary cavity slides for the duration of the study then stored in vials in 70% alcohol. All body measurements are presented in micrometers (µm). Body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate to avoid discrepancies caused by different degrees of notogastral distension. Notogastral width refers to the maximum width in dorsal aspect. Formulae for leg setation are given in parentheses according to the sequence trochanter–femur–genu–tibia–tarsus (famulus included). Formulae for leg solenidia are given in square brackets according to the sequence genu–tibia–tarsus. General terminology used in this paper follows that of Norton & Behan-Pelletier (2009).

RESULTS

In the course of studies of oribatid mite fauna of "Cape Martyan" Nature Reserve we have registered 77 species (including one new species), 66 genera and 38 families. Taking into account the previous records of Yaroshenko & Kuzmina (1983) the present oribatid mite fauna of "Cape Martyan" Nature Reserve comprises 85 species, 72 genera and 41 families.

An annotated checklist of recorded oribatids is presented below. Oribatid taxa found in this Reserve for the first time are not marked; one asterisk (*) marks the taxa for which we provide the second record after Yaroshenko & Kuzmina (1983); the taxa which have been recorded before but did not occur in our collection are marked by two asterisks (**).

Checklist of oribatid mites of "Cape Martyan" Nature Reserve

BRACHYCHTHONIIDAE Thor, 1934

Eobrachychthonius oudemansi Hammen, 1952
Poecilochthonius italicus (Berlese, 1910)

SPHAEROCHTHONIIDAE Grandjean, 1957*

Sphaerochthonius splendidus (Berlese, 1910)*

EPILOHMANNIIDAE Oudemans, 1923

Epilohmannia cylindrica (Berlese, 1904)

LOHMANNIIDAE Berlese, 1916

Papillacarus aciculatus (Berlese, 1905)

EUPHTHIRACARIDAE Jacot, 1930*

Acrotritia ardua (Koch, 1841)
Acrotritia curticephala (Jacot, 1938)
Acrotritia duplicata (Grandjean, 1953)**
Euphthiracarus monodactylus (Willmann, 1919)
Mesotritia nuda (Berlese, 1887)

PHTHIRACARIDAE Perty, 1841

Atropacarus inconditus Mahunka, 1991

Atropacarus platakisi (Mahunka, 1979)
Hoplochthonius illinoisensis (Ewing, 1909)
Phthiracarus bryobius Jacot, 1930
Phthiracarus opacus Niedbała, 1986
Phthiracarus subdolus Niedbała, 1983
Steganacarus carinatus (Koch, 1941)

TRHYPOCHTHONIIDAE Willmann, 1931

Trhypochthonius tectorum (Berlese, 1896)

NOTHRIDAE Berlese, 1896

Nothrus anauniensis Canestrini and Fanzago, 1876

CAMISIIDAE Oudemans, 1900

Camisia biurus (Koch, 1839)

HERMANNIELLIDAE Grandjean, 1934

Hermanniella dolosa Granjean, 1931
Hermanniella picea (Koch, 1839)

NEOLIODIDAE Sellnick, 1928

Neoliodes ionicus Sellnick, 1931

PLATEREMAEIDAE Trägårdh, 1926

Paralopheremaeus hispanicus (Ruiz, Kahwash and Subías, 1990)

GYMNODAMAEIDAE Grandjean 1954*

Arthrodamaeus hispanicus (Grandjean, 1928)*
Arthrodamaeus cf. *starki* (Bulanova-Zachvatkina, 1967)*
Gymnodamaeus bicostatus (Koch, 1835)*

ALEURODAMAEIDAE Paschoal & Johnston, 1985

Aleurodamaeus setosus (Berlese, 1883)

DAMAEIDAE Berlese, 1896

Belba dubinini Bulanova-Zachvatkina, 1962
Damaeus gracilipes (Kulczynski, 1902)
Spatiodamaeus fageti (Bulanova-Zachvatkina, 1957)
Metabelbella tichonravovi Bulanova-Zachvatkina, 1967

PELOPPIIDAE Balogh, 1943

Ceratoppia quadridentata (Haller, 1882)
Pyroppia lanceolata Hammer, 1955

GUSTAVIIDAE Oudemans, 1900

Gustavia microcephala (Nicolet, 1855)

LIACARIDAE Sellnick, 1928

Dorycranosus punctulatus (Michelčič, 1956)
Liacarus brevilamellatus Michelčič, 1955
Xenillus tegeocranus (Hermann, 1804)

CTENOBELBIDAE Grandjean, 1965

Ctenobelba martyanensis sp. nov.

AMEROBELBIDAE Grandjean, 1961

Amerobelba decedens Berlese, 1908

DAMAEOLIDAE Grandjean, 1965

Damaeolus asperatus (Berlese, 1904)
Fosseremus laciniatus (Berlese, 1905)

TECTOCEPHEIDAE Grandjean, 1954

Tectocepheus velatus (Michael, 1880)

OPPIIDAE Grandjean, 1951

Hypogeoppia exempta (Mihelčič, 1958)
Microppia minus (Paoli, 1908)
Moritzoppia unicarinata (Paoli, 1908)
Oppiella nova (Oudemans, 1902)
Ramusella clavipectinata (Michael, 1885)
Rhinoppia obsoleta (Paoli, 1908)

QUADROPPIIDAE Balogh, 1983

Quadroppia quadricarinata (Michael, 1885)

SUCTOBELBIDAE Jacot, 1938

Suctobelbella forsslundi (Strenzke, 1950)
Suctobelbella latirostris (Strenzke, 1950)

MICREREMIDAE Grandjean, 1954**

Micreremus brevipes (Michael, 1888)**

LICNEREMAEIDAE Grandjean, 1931

Licneremaeus licnophorus (Michael, 1882)

SCUTOVERTICIDAE Grandjean, 1954

Lamellovertex caelatus (Berlese, 1895)
Scutovertex sculptus Michael, 1879

PHENOPELOPIDAE Petrunkevitch 1955

Eupelops torulosus (Koch, 1839)
Peloptulus phaeonotus (Koch, 1844)

ACHIPTERIIDAE Thor 1929*

Achipteria acuta Berlese, 1908
Parachipteria punctata (Nicolet, 1855)**

TEGORIBATIDAE Grandjean, 1954**

Lepidozetes singularis Berlese, 1910**

ORIBATELLIDAE Jacot, 1925*

Oribatella hungarica Balogh, 1943
Oribatella quadricornuta (Michael, 1880)
Oribatella superbula (Berlese, 1904)**

CERATOZETIDAE Jacot, 1925*

Ceratozetes mediocris Berlese, 1908
Ceratozetoides cisalpinus (Berlese, 1908)
Latilamellobates naltschicki Shaldybina, 1971
Trichoribates trimaculatus (Koch, 1835)**

ZETOMIMIDAE Shaldybina, 1966**

Zetomimus furcatus (Pearce & Warburton)**

CHAMOBATIDAE Grandjean 1954

Chamobates dentotutorii Shaldybina, 1969

MYCOBATIDAE Grandjean 1954

Punctoribates mundus Shaldybina, 1973
Minunthozetes pseudofusiger (Schweizer, 1922)
Minunthozetes semirufus (Koch, 1841)
Mycobates bicornis (Strenzke, 1954)

ORIBATULIDAE Thor, 1929*

Lucoppia burrowsi (Michael, 1890)
Oribatula tibialis (Nicolet, 1855)
Zygoribatula exarata Berlese, 1916
Zygoribatula frisiae (Oudemans, 1900)*

PSEUDOPPIIDAE Mahunka, 1975

Pseudoppia mediocris (Mihelčič, 1957)

SCHELORIBATIDAE Grandjean, 1933*

Scheloribates fimbriatus Thor, 1930
Scheloribates laevigatus (Koch, 1835)*

HAPLOZETIDAE Grandjean 1936

Peloribates europaeus Willmann, 1935

GALUMNIDAE Jacot 1925*

Galumna dorsalis (Koch, 1835)**
Pergalumna myrmophila (Berlese, 1914)
Pilogalumna crassiclava (Berlese, 1914)

TAXONOMY

Paralopheremaeus hispanicus (Ruiz, Kahwash & Subías, 1990)

(Figures 1–19)

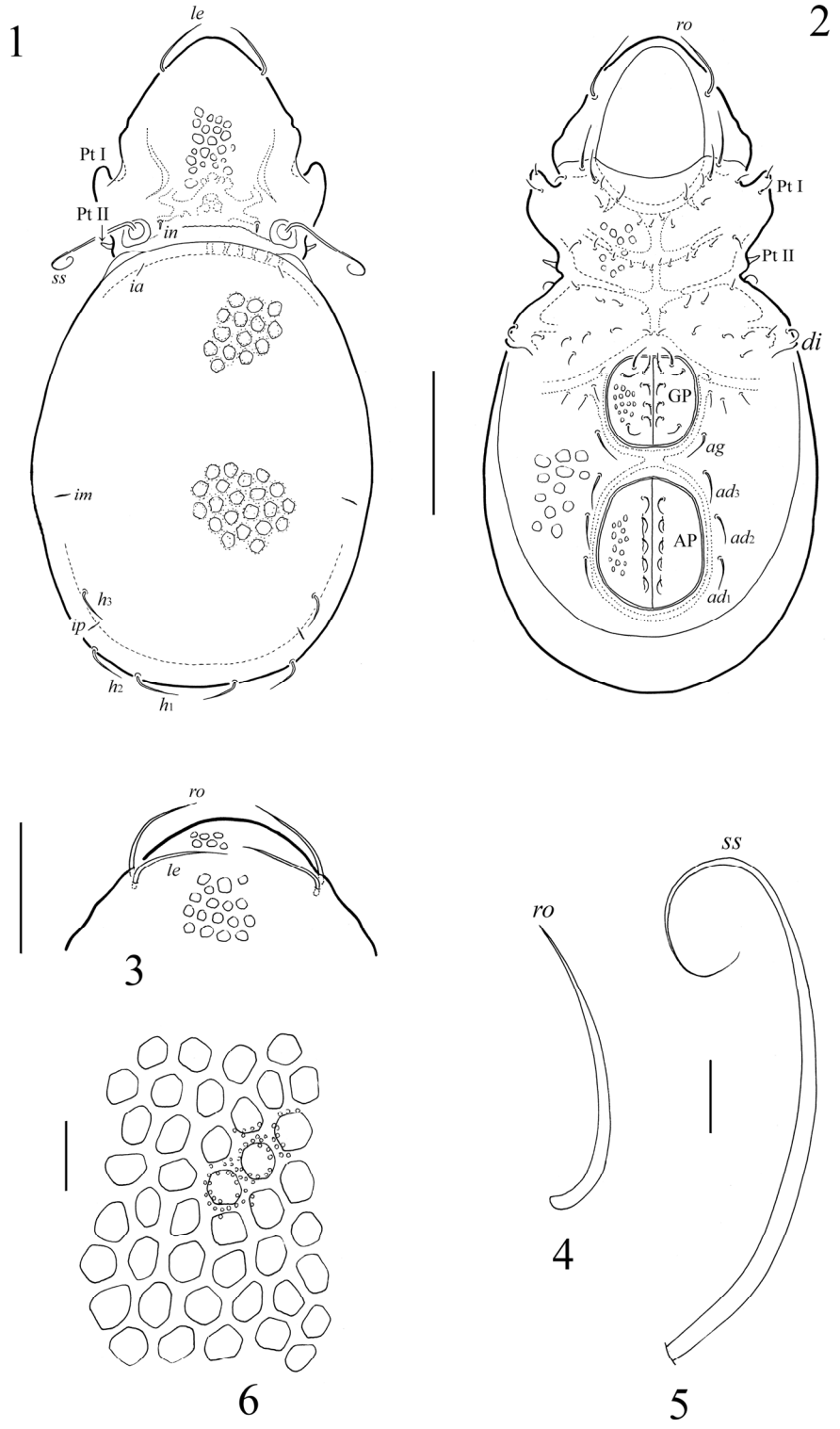
Diagnosis. Body length 415–448 × 215–232 (three specimens); body surface foveolate; rostral and lamellar setae similar in length, setiform, smooth; rostral setae inserted ventrally, sensilli setiform, smooth, weakly spiral-form distally; notogaster with six pairs of setae; pedotecta II developed, thorn-like; epimeral setal formula 10–6–5–11; anal plates with six or seven pairs of setae.

Measurements. Three specimens (male and two females): body length 415–448 (mean 437); body width 215–232 (mean 226).

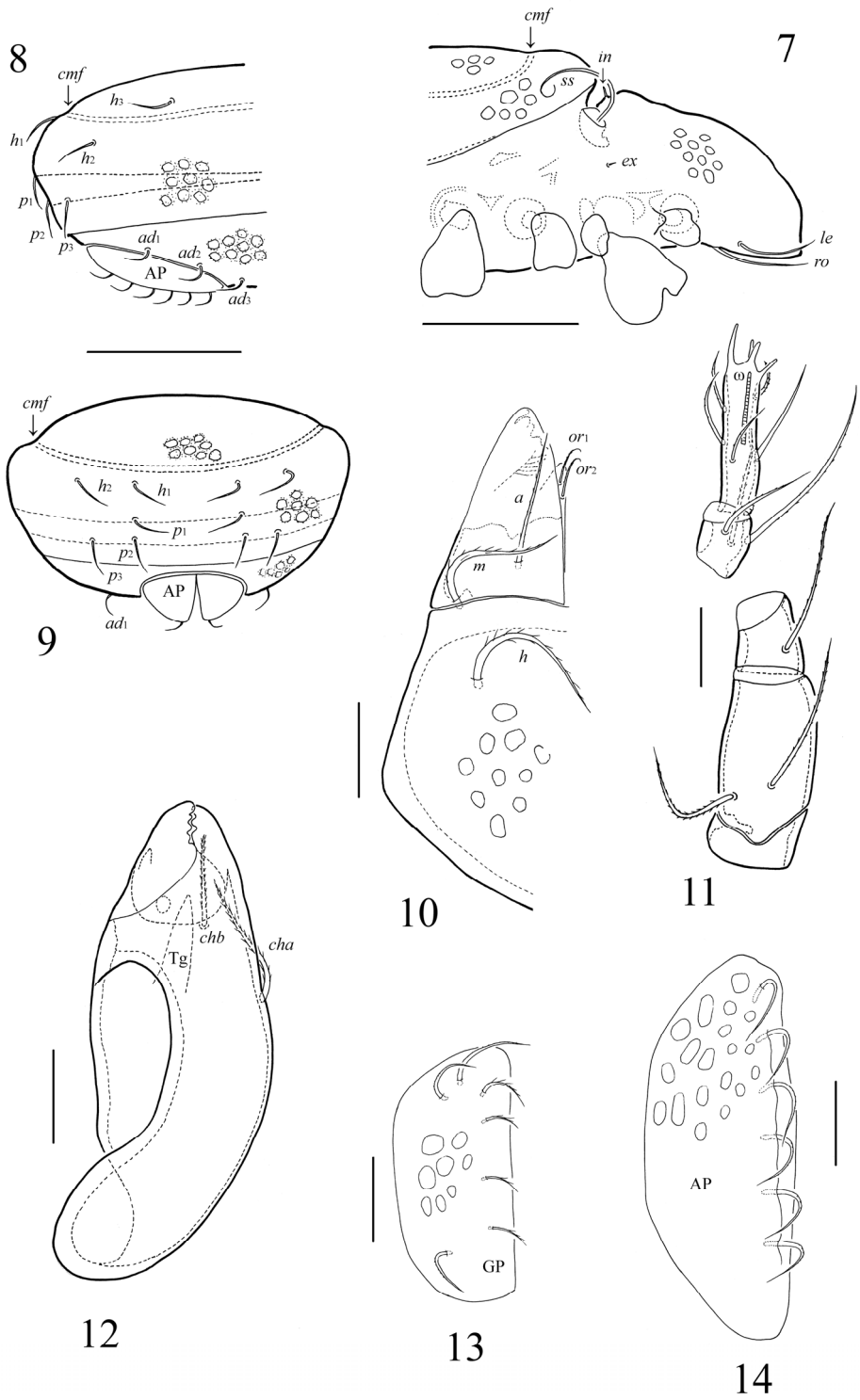
Integument (Figs. 1, 3, 6, 7–9, 10, 13, 14). Color: yellow-brownish. Dorsal and ventral surfaces with foveolae forming reticulate ornamenttation (diameters up to 8 on prodorsum and epimeral region, 16 on notogaster and 12 on anogenital region). Body and legs covered with round or conical cerotegumental granules (diameter or length up to 1). Setae with or without cerotegument.

Prodorsum (Figs. 1, 3–5, 7). Rostrum rounded. Lateral parts with weakly visible lines in dorsal view. Medio-basal part with unclear lineate ornamentation (foveolae absent). Rostral (*ro*) and lamellar (*le*) setae similar in length (41–49) and shape, setiform, smooth. Interlamellar setae (*in*, 6) thorn-like. Sensilli (*ss*, 86–90) setiform, smooth, weakly spiral-form distally.

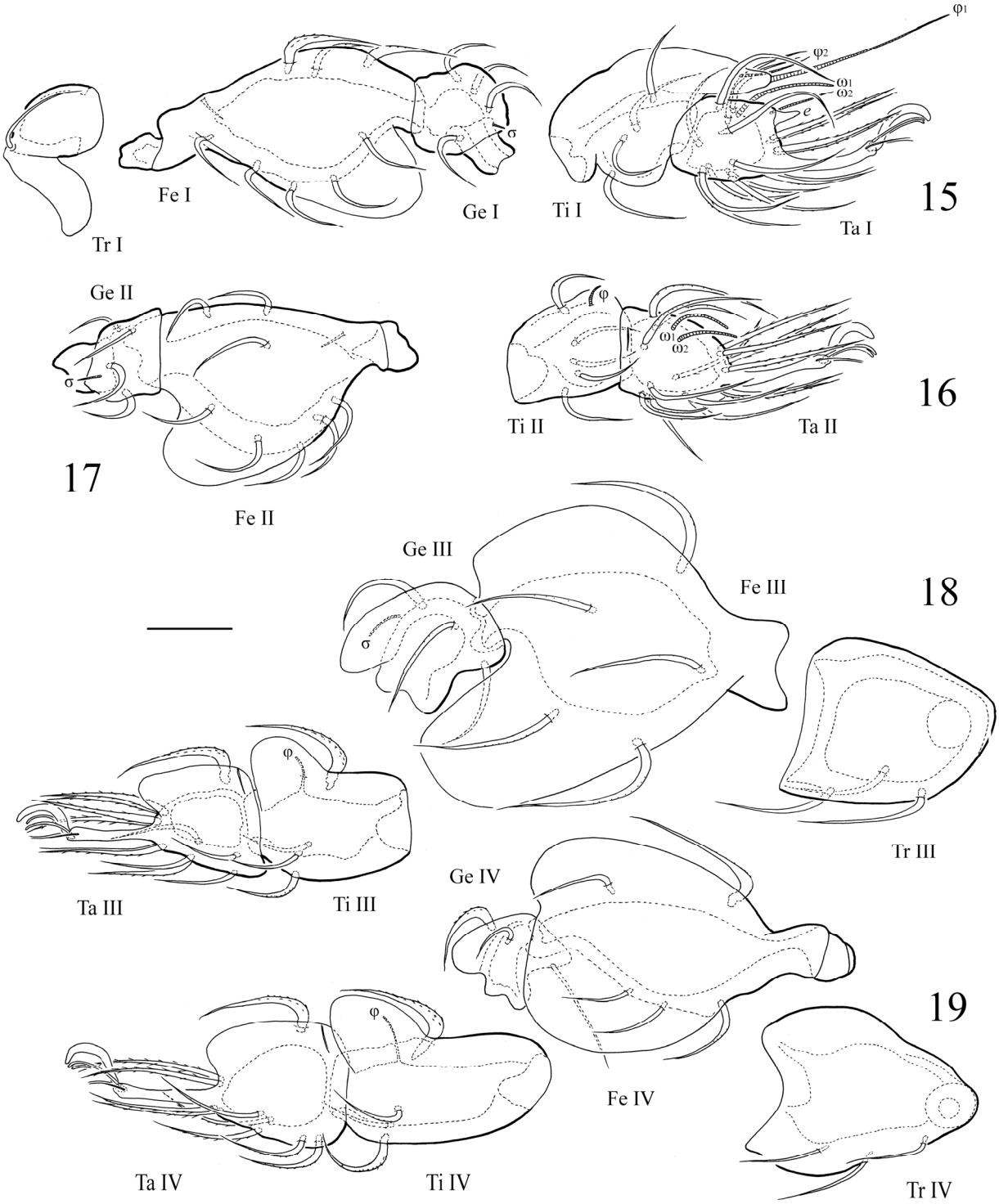
Notogaster (Figs. 1, 7–9). Oval in dorsal view and weakly flattened in lateral view. Anterior part of notogaster weakly extending over basal part of prodorsum. Posterior margin rounded. Circummarginal furrow (*cmf*) poorly developed, visible in dorso-lateral, lateral and dorso-posterior views. Six pairs of setiform, smooth notogastral setae present. Setae h_1–h_3, p_1 (28–32) visible in dorsal or lateral views. Setae p_2–p_3 (24–28) visible in lateral or posterior views. Lyrifissures *ia*, *im* and *ip* thin. Opisthonotal gland openings not evident.



Figures 1–6. *Paralopheremaeus hispanicus* (Ruiz, Kahwash & Subías, 1990). 1 = Dorsal view of body, 2 = ventral view of body, gnathosoma and legs not shown, 3 = rostrum, dorso-anterior view, 4 = rostral seta, 5 = sensillus, 6 = foveolae in central part of notogaster. Scale bars (1, 2) 100 µm, (3) 50 µm, (4, 5) 10 µm, (6) 20 µm.



Figures 7–14. *Paralopheremaeus hispanicus* (Ruiz, Kahwash & Subías, 1990). 7 = Prodorsum and anterior part of notogaster, lateral view, epimeral setae, gnathosoma and legs (except basal parts) not shown, 8 = posterior part notogaster, lateral view, 9 = notogaster, posterior view, 10 = subcapitulum, ventral view of right half, 11 = palp, 12 = chelicera, 13 = genital plate, right, 14 = anal plate, right. Scale bars (7–9) 100 µm, (10, 12–14) 20 µm, (11) 10 µm.



Figures 15–19. *Paralopheremaeus hispanicus* (Ruiz, Kahwash & Subías, 1990). 15 = Leg I, right, antiaxial view, 16 = tarsus and tibia of leg II, left, paraxial view, 17 = genu and femur of leg II, left, antiaxial view, 18 = leg III, right, antiaxial view, 19 = Leg IV, right, antiaxial view. Scale bar 20 µm.

Lateral part of body (Figs. 1, 2, 7, 8). Exobothridial setae (*ex*, 4) setiform, smooth. Pedotecta I (Pt I) normally developed, convex. Pedotecta II (Pt II) thorn-like. Discidia (*di*) triangular, blunt. Lyrifissures *ih* and *ips* not evident.

Gnathosoma (Figs. 10–12). Subcapitulum longer than wide (98 × 69). Subcapitular setae setiform, barbed; *h* and *m* longer (both 32–36) and thicker than *a* (28–32). Adoral setae (or_1, or_2 10–12) setiform, barbed, hook-like distally. Palps (61) with setation 0–2–1–3–9(+1ω). Solenidion (ω) long, thickened, not fused with *acm*, pressed to surface of palptarsus. Chelicerae (106) with two long, setiform, barbed setae; *cha* (32) longer than *chb* (20). Trägårdh's organ (Tg) well visible.

Epimeral region (Fig. 2). Epimeral setal formula 10–6–5–11 in all specimens. Setae setiform, smooth or with indistinct barbs. One pair of setae on epimeres I (anterior in ventral view) longest (32), other shorter (10–20).

Anogenital region (Figs. 2, 8, 9, 13, 14). Genital plates (GP) with seven pairs of genital setae. Four pairs of genital setae inserted in medial longitudinal row, short (12–16), setiform, with long cilia; other longer (16–20), setiform, slightly barbed. One pair of aggenital (*ag*, 24) and three pairs of adanal (ad_1–ad_3, 24) setae setiform, smooth or with indistinct barbs. Adanal setae ad_1 and ad_2 in paraanal position, ad_3 in preanal position. Anal plates (AP) with six or seven pairs of setiform, smooth anal setae (20). Lyrifissures *iad* not evident.

Legs (Figs. 15–19). Tridactylous; median claw thicker than lateral claws. Articulations with sockets. Tarsi, tibiae and genua III, IV with wide dorsal ridge. Femora I, II with wide ventral ridge. Femora III, IV with wide dorsal and ventral ridges. Formulae of leg setation and solenidia: I (1–8–4–4–20) [1–2–2], II (1–8–4–5–18) [1–1–2], III (3–5–3–4–14) [1–1–0], IV (3–5–3–4–12) [0–1–0]; homology of setae and solenidia indicated in Table 1. Many setae setiform, smooth or slightly barbed. Setae *it*, *tc*, *u* setiform, thickened, ciliate. Famulus (*e*) very thick. Tibiae I with dorso-distal projection, having a long, setiform solenidion φ_1. Other solenidia considerable shorter (very short on genua I–III and tibiae II– IV), rod-like, blunt

Table 1. Leg setation and solenidia of *Paralopheremaeus hispanicus* (Ruiz, Kahwash & Subías, 1990)

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	*v′*	*d*, *(l₁)*, *(l₂)*, *bv″*, *v″₁*, *v″₂*	*d*, *(l)*, *v′*, σ	*(l)*, *(v)*, φ_1, φ_2	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, *(v)*, *(pl)*, *e*, ω_1, ω_2
II	*v′*	*d*, *(l₁)*, *(l₂)*, *bv″*, *v″₁*, *v″₂*	*d*, *(l)*, *v′*, σ	*d*, *(l)*, *(v)*, φ	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, *(v)*, *l″*, ω_1, ω_2
III	*l′₁*, *l′₂*, *v′*	*d*, *(l₁)*, *l′₂*, *ev′*	*d*, *l′*, *v′*, σ	*d*, *l′*, *(v)*, φ	*ft″*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*
IV	*l′₁*, *l′₂*, *v′*	*d*, *(l₁)*, *l′₂*, *ev′*	*d*, *l′*, *v′*	*d*, *l′*, *(v)*, φ	*ft″*, *(tc)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*

Roman letters refer to normal setae (*e* – famulus), Greek letters refer to solenidia. One apostrophe (') marks setae on anterior and double apostrophe ("') setae on posterior side of the given leg segment. Parentheses refer to a pair of setae.

Remarks. The present Ukrainian specimens of *Paralopheremaeus hispanicus* are morphologically and in general appearance similar to the Spanish specimens (see the original description of Ruiz, Kahwash & Subías 1990 and later redescription by Pérez-Íñigo 1997), but there are slight differences as well; i.e. body size (415–448 × 215–232 in the Ukrainian specimens versus 562 × 275 in the Spanish specimens), epimeral formula (10 (I epemeres)–6 (II)–15 (III and IV) in the Ukrainian specimens versus 8 (I)–7 (II)–14 (III and IV) in the Spanish specimens). We believe

that these differences represent intraspecific (perhaps geographical) variability. Furthermore, the Ukrainian specimens possess six pairs of notogastral setae and thorn-like pedotecta II. Ruiz, Kahwash & Subías (1990) and Pérez-Íñigo (1997) specifies only four pairs of notogastral setae and absence of pedotecta II. We had no possibility to study the type material of *Paralopheremaeus hispanicus*, but assume that the Spanish specimens also have setae p_2, p_3 and thorn-like pedotecta II as in the Ukrainian specimens.

***Ctenobelba martyanensis* sp. nov.**

(Figures 20–39)

Diagnosis. Body length 498–564 × 282–315 (four specimens); rostrum truncate, with two lateral tubercles; prodorsal setae setiform, barbed, similar in length; sensilli with four or five long branches; notogastral setae medium sized, widely dilated; three pairs of slightly phylliform, smooth aggenital setae present.

Measurements. Holotype (male): body length 514; body width 290. Paratypes (male and two females): body length 498–564 (mean 536); body width 282–315 (mean 298).

Integument (Figs. 20, 21). Color: brownish-grey to brown. Dorsal and ventral surfaces covered with round (in dorsal view; diameter up to 8) or conical (in lateral view; length up to 12) cerotegumental granules. Setae with or without cerotegument.

Prodorsum (Figs. 20, 22–26). Rostrum truncate, with two lateral tubercles. Costulae long, distinct, almost straight. Transcostular line absent. All prodorsal setae (rostral, lamellar, interlamellar) setiform, barbed, inserted on small tubercles, similar in length (41–49) but rostral setae thinner and with smaller barbs. Sensilli (86–90) with five (four in one specimen) long branches, which are inserted unilaterally.

Notogaster (Figs. 20, 27, 28). Anterior border straight, with triangular, blunt-ended medial (one pair) and humeral (one pair) condyles. One pair of humeral crista present. Ten pairs of notogastral setae medium sized, similar in length (24–32), widely dilated distally or in medio-distal part, smooth or with indistinct internal longitudinal lines. Opisthonotal gland openings and lyrifissures *ia*, *im*, *ip* developed, but poorly visible under the cerotegumental layer.

Lateral part of body (Figs. 20, 26). Exobothridial setae (16) setiform, slightly barbed. Pedotecta I and II well developed. Discidia triangular, rounded distally. One triangular, blunt tubercle *Sl* present on each side of the body. Lyrifissures *ih* and *ips* developed, but poorly visible under the cerotegumental layer.

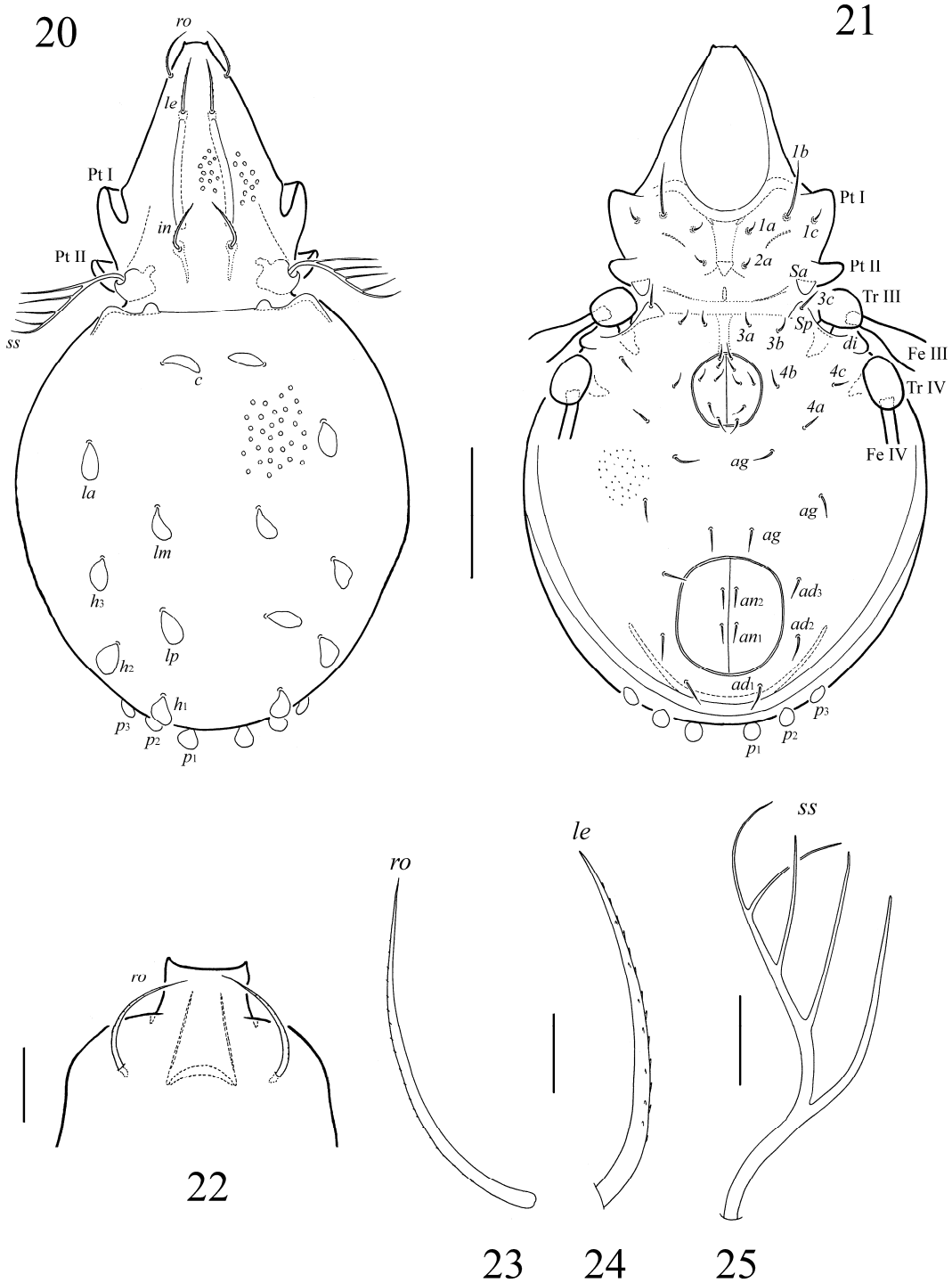
Gnathosoma (Figs. 29–31). Subcapitulum longer than wide (114 × 73–77). Subcapitular setae setiform, barbed; *h* (28) and *a* (24–28) shorter than *m* (32–36). Adoral setae (8) setiform, slightly barbed, hook-like distally. Palps (69) with setation 0–2–1–3–8(+1ω). Solenidion long, thickened, not fused with *acm*, pressed to surface of palptarsus. Chelicerae (114) with two long, setiform, barbed setae; *cha* (28) longer, than *chb* (20). Trägårdh's organ well visible.

Epimeral region (Fig. 21). Epimeral setal formula 3–1–3–3. Setae *1b* longest (45), setiform, smooth; all the others short (16–20), slightly widened, smooth. Two pairs of strongly developed, triangular, blunt-ended tubercles *Sa* and *Sp* present on epimeral region. Setae *3c* inserted on tubercles *Sp*.

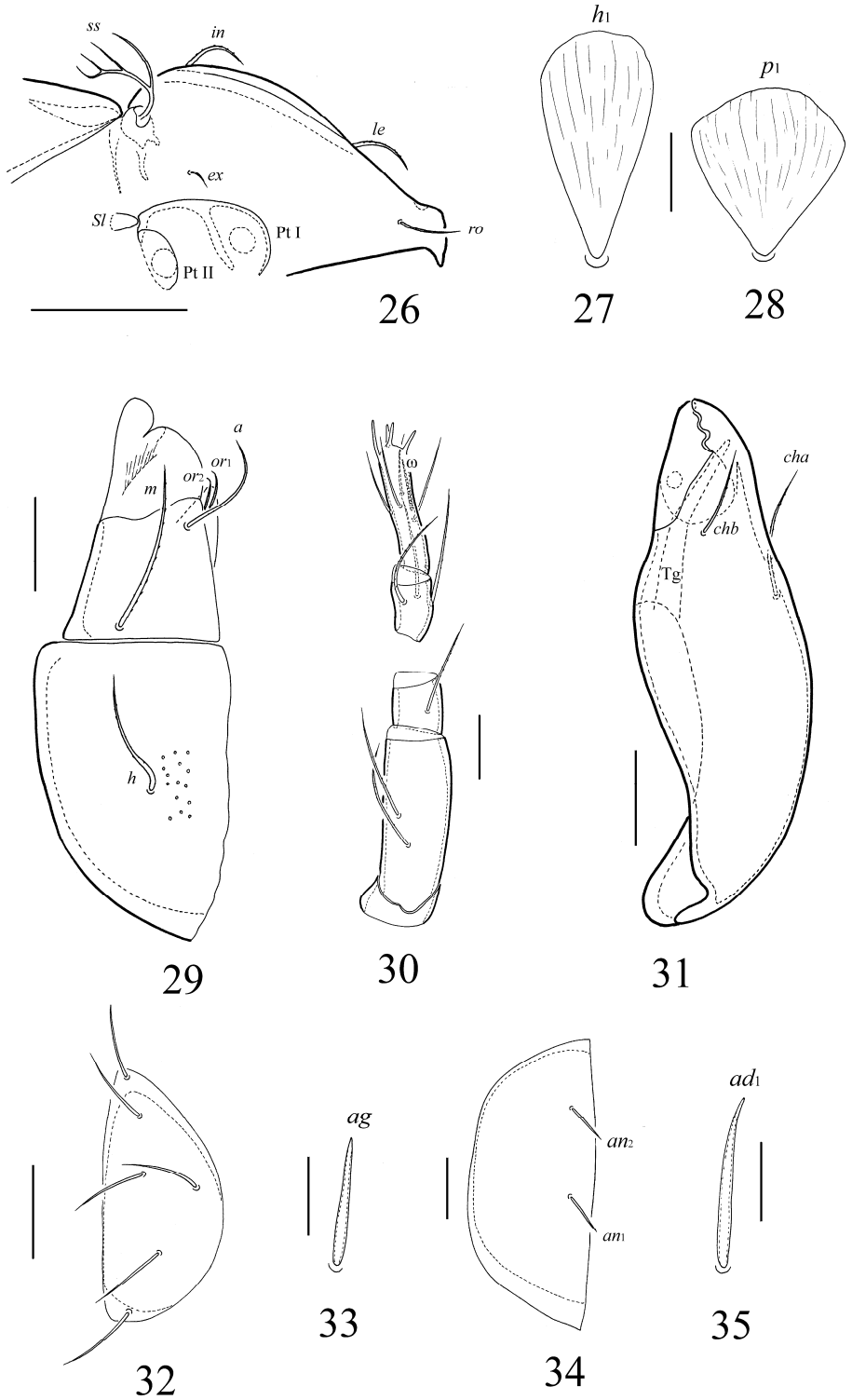
Anogenital region (Figs. 21, 32–35). Six pairs of genital setae (14–18) setiform, smooth. Three pairs of aggenital (16–20), three pairs of adanal (18–20) and two pairs of anal (16) setae slightly phylliform, smooth. Lyrifissures *iad* not evident.

Legs (Figs. 36–39). Monodactylous, claws smooth. Formulae of leg setation and solenidia: I (1–5–3–4–19) [1–2–2], II (1–5–3–4–16) [1–1–2], III (2–3–1–2–15) [1–1–0], IV (1–2–2–3–12) [0–1–0]; homology of setae and solenidia indicated in Table 2. Many setae setiform, slightly barbed, rarely smooth. Setae *p* on tarsi II–IV spiniform. Famulus setiform. All solenidia rod-like, blunt.

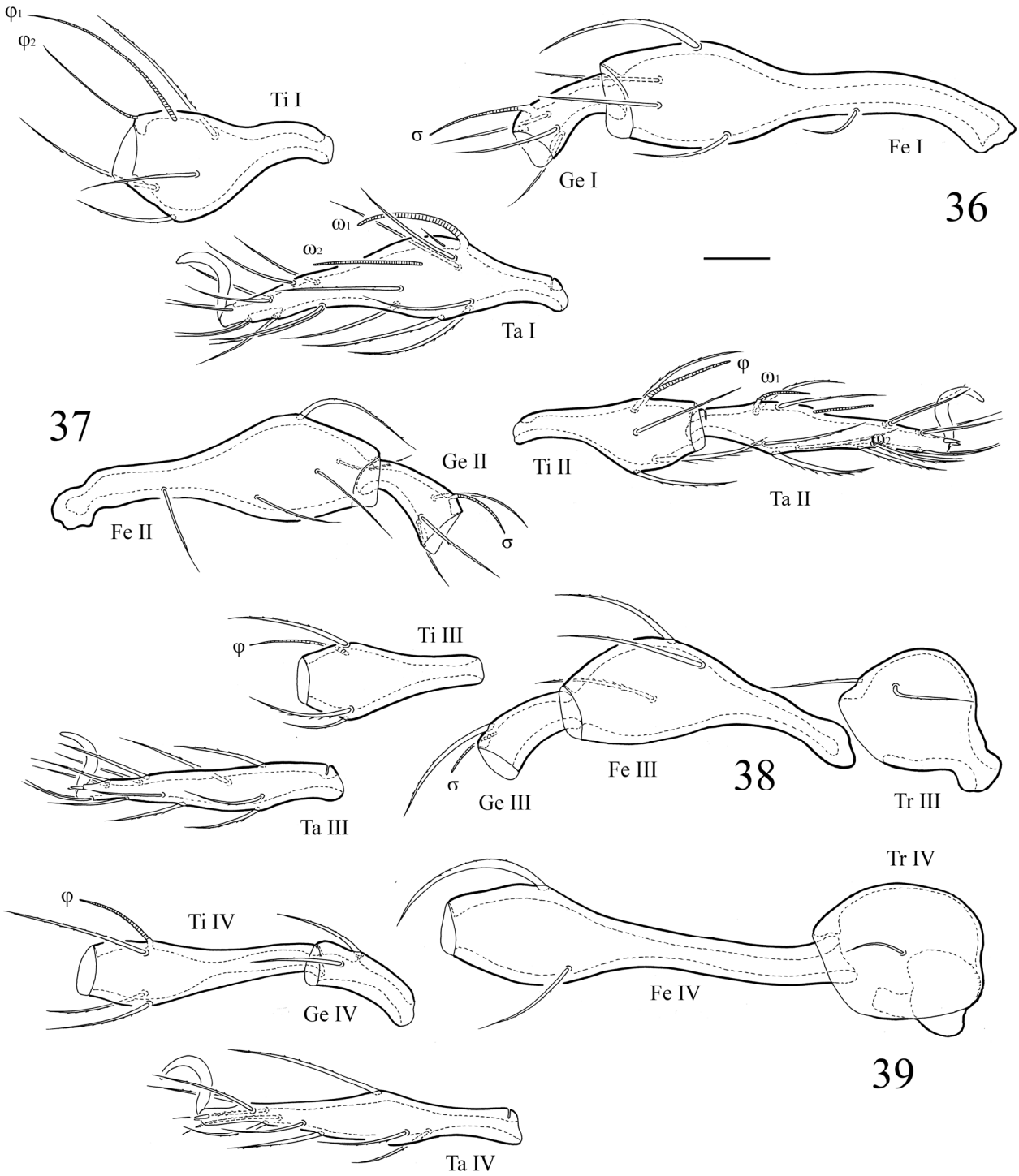
Remarks. *Ctenobelba martyanensis* sp. nov. is very similar to *Ctenobelba serrata* Mahunka, 1964 (see Mahunka 1964, 1977) from southern Europe in having sensilli with four to five long branches and dilated notogastral setae. However,



Figures 20–25. *Ctenobelba martyanensis* sp. nov. 20 = Dorsal view of body, 21 = ventral view of body, gnathosoma and legs (except basal parts of legs III, IV) not shown, 22 = rostrum, dorso-anterior view, 23 = rostral seta, 24 = lamellar seta, 25 = sensillus. Scale bars (20, 21) 100 µm, (22, 25) 20 µm, (23, 24) 10 µm.



Figures 26–35. *Ctenobelba martyanensis* sp. nov. 26 = Prodorsum, lateral view, epimeral region, gnathosoma and legs not shown, 27 = notogastral seta h_1, 28 = notogastral seta p_1, 29 = subcapitulum, ventral view of right half, 30 = palp, 31 = chelicera, 32 = genital plate, left, 33 = aggenital seta, 34 = anal plate, right, 35 = adanal seta ad_1. Scale bars (26) 100 µm, (27, 28, 30, 33, 35) 10 µm, (29, 31, 32, 34) 20 µm.



Figures 36–39. *Ctenobelba martyanensis* sp. nov. 36 = Leg I, without trochanter, left, antiaxial view, 37 = leg II, without trochanter, right, antiaxial view, 38 = Leg III, right, antiaxial view, 39 = leg IV, right, antiaxial view. Scale bar 20 μm.

it can be clearly distinguished from the latter by the larger body size (498–564 × 282–315 in *C. martyanensis* sp. nov. versus 416–431 × 240–250 in *C. serrata*), morphology of rostrum (truncate, with two lateral tubercles in *C. martyanensis* sp. nov. versus rounded in *C. serrata*), similar setiform structure of all lamellar and interlamellar setae (versus interlamellar setae narrowly dilated, lamellar setae setiform in *C. serrata*) and widely dilated notogastral setae (versus narrowly dilated in *C. serrata*).

Ctenobelba martyanensis sp. nov. is also similar to *Ctenobelba heterosetosa* Murvanidze and Weigmann, 2007 described from the Caucasus region in having widely dilated notogastral setae and morphology of rostrum. However, it can clearly be distinguished from the latter by the larger body size (498–564 × 282–315 in *C. martyanensis* sp. nov. versus 375–410 × 200–205 in *C. heterosetosa*), the notogastral setae all dilated (versus some notogastral setae setiform in *C. heterosetosa*) and sensilli with four to five long branches (versus sensilli with nine to 11 short cilia in *C. heterosetosa*).

Type deposition. The holotype is deposited in the collection of the Zoological Institute of the Russian Academy of Sciences, St. Petersburg, Russia; one paratype is in the collection of Siberian Zoological Museum, Novosibirsk, Russia; two paratypes are in the collection of the first author.

Etymology. The new species is named after the "Cape Martyan" Nature Reserve (Ukraine).

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Table 2. Leg setation and solenidia of *Ctenobelba martyanensis* sp. nov.

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	*v′*	*d*, *(l)*, *bv″*, *v″*	*(l)*, *v′*, σ	*(l)*, *(v)*, φ_1, φ_2	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, *(v)*, *pl″*, *e*, ω_1, ω_2
II	*v′*	*d*, *(l)*, *bv″*, *v″*	*(l)*, *v′*, σ	*(l)*, *(v)*, φ	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*, *l″*, ω_1, ω_2
III	*l′*, *v′*	*d*, *l′*, *ev′*	*l′*, σ	*l′*, *(v)*, φ	*(ft)*, *(tc)*, *(it)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*
IV	*v′*	*d*, *ev′*	*d*, *l′*	*l′*, *(v)*, φ	*ft″*, *(tc)*, *(p)*, *(u)*, *(a)*, *s*, *(pv)*

See Table 1 for explanations.

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Two new oribatid mite species with auriculate pteromorphs from Southern Vietnam (Acari: Oribatida: Parakalummidae, Galumnidae)

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Abstract. Two new oribatid mite species, *Neoribates spindleformis* sp. nov. and *Globogalumna biporosa* sp. nov. are described from soil and litter of pine and acacias artificial plantations of Dong Nai Culture and Nature Reserve (Southern Vietnam). First new species is differs from all other species of *Neoribates* by combination of the following characters; morphology of sensilli, number of leg claws and genital setae. Second new species differs from type-species of *Globogalumna* by the body surface and number of notogastral porose areas. The genus *Globogalumna* is recorded for the first time from the Oriental region.

Keywords. Oribatid mites, new species, *Neoribates*, *Globogalumna*, Vietnam.

INTRODUCTION

This work is a part of our continuing study of Vietnamese oribatid mite fauna (*e.g.* Ermilov & Anichkin 2010, 2011a, 2012). The present study is based on material collected during Russian–Vietnamese expedition in June–August 2012. In the course of taxonomic identification of oribatids from Dong Nai Culture and Nature Reserve (Dong Nai Province, Southern Vietnam), we found two new species having auriculate pteromorphs; one belonging to the genus *Neoribates* Berlese, 1914 (Parakalummidae) and the other to *Globogalumna* Balogh & Balogh, 1990 (Galumnidae).

Neoribates was proposed by Berlese (1914) with *Oribata roubali* Berlese, 1910 as the type species. Currently, this genus comprises 42 species and one subspecies and has a cosmopolitan distribution (Subías 2004, online version 2012). Earlier, two species of this genus were recorded from Vietnam (Krivolutsky *et al.* 1997): *N. aurantiacus* (Oudemans, 1914) and *N. jacoti* (Balogh & Mahunka, 1967).

Globogalumna was proposed by Balogh & Balogh (1990) with *Allogalumna globulifera* (Balogh & Mahunka, 1978) as the type species. Currently, this genus comprises only the type species, which is distributed in Brazil (Subías 2004, online version 2012). Hence, the new species is the first member of *Globogalumna* recorded for the Oriental region.

MATERIAL AND METHODS

The collection locality and habitat of the new species are given in the "*Material examined*" sections. Specimens were studied in lactic acid, mounted on temporary cavity slides for the duration of the study, then stored in vials in 70% alcohol. All body measurements are presented in micrometers (μm). Body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the ventral plate to avoid discrepancies caused by different degrees of notogastral distension. Notogastral width refers to the maximum width in dorsal aspect. General terminology used in this paper follows that of Norton & Behan-Pelletier (2009). Formulae for leg setation

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are given in parentheses according to the sequence trochanter–femur–genu–tibia–tarsus (famulus included). Formulae for leg solenidia are given in square brackets according to the sequence genu–tibia–tarsus.

TAXONOMY

Neoribates spindleformis sp. nov.

(Figures 1–9)

Diagnosis. Body size 481–498 × 332–348. Body surface smooth. Rostral, lamellar and interlamellar setae long. Sensilli spindle-form. Four pairs of genital setae. Leg tarsi I with one claw, leg tarsi II–IV with two claws.

Material examined. The holotype (male) and three paratypes (males) have the following collection data: Southern Vietnam, Dong Nai Province, Dong Nai Culture and Nature Reserve, 11°16', E 107°4', pine needles, branches and cones processed with sifter from pine artificial plantation (*Pinus kesiya* Royle ex Gordon), July 2012, collected by A.E. Anichkin and S.G. Ermilov.

Measurements. Body length: 498 (holotype), 481 (two paratypes), 498 (one paratype). Body width: 348 (holotype), 332 (one paratype), 348 (two paratypes).

Integument (Fig. 1). Body color brown. Body surface smooth. Anterolateral parts of notogaster with radiate impressions. Pteromorphs with thin wrinkles.

Prodorsum (Figs. 1, 2, 4). Rostrum protruding, rounded in dorsal view. Rostral (*ro*, 69–77), lamellar (*le*, 110–114), interlamellar (*in*, 135–143) and exobothridial (*ex*, 8–12) setae setiform, slightly or indistinctly barbed. Sensilli (*ss*, 131–151) spindle-form, smooth or indistinctly barbed, with well developed stalk (69–82), oblong head (20–28) and thin apex (28–41). Porose areas *Ad* absent. Lamellae (*Lam*) thin.

Notogaster (Figs. 1, 4, 5). Anterior notogastral margin present, convex. Notogastral setae represented by 10 pairs of alveoli. Four pairs of sacculi (*Sa*, *S1–S3*) and all lyrifissures located typical for genus. Median pore absent.

Gnathosoma. Morphology typical for *Neoribates* (*e.g.* Travé 1972, Grishina & Vladimirova 2009, Nakamura, 2009).

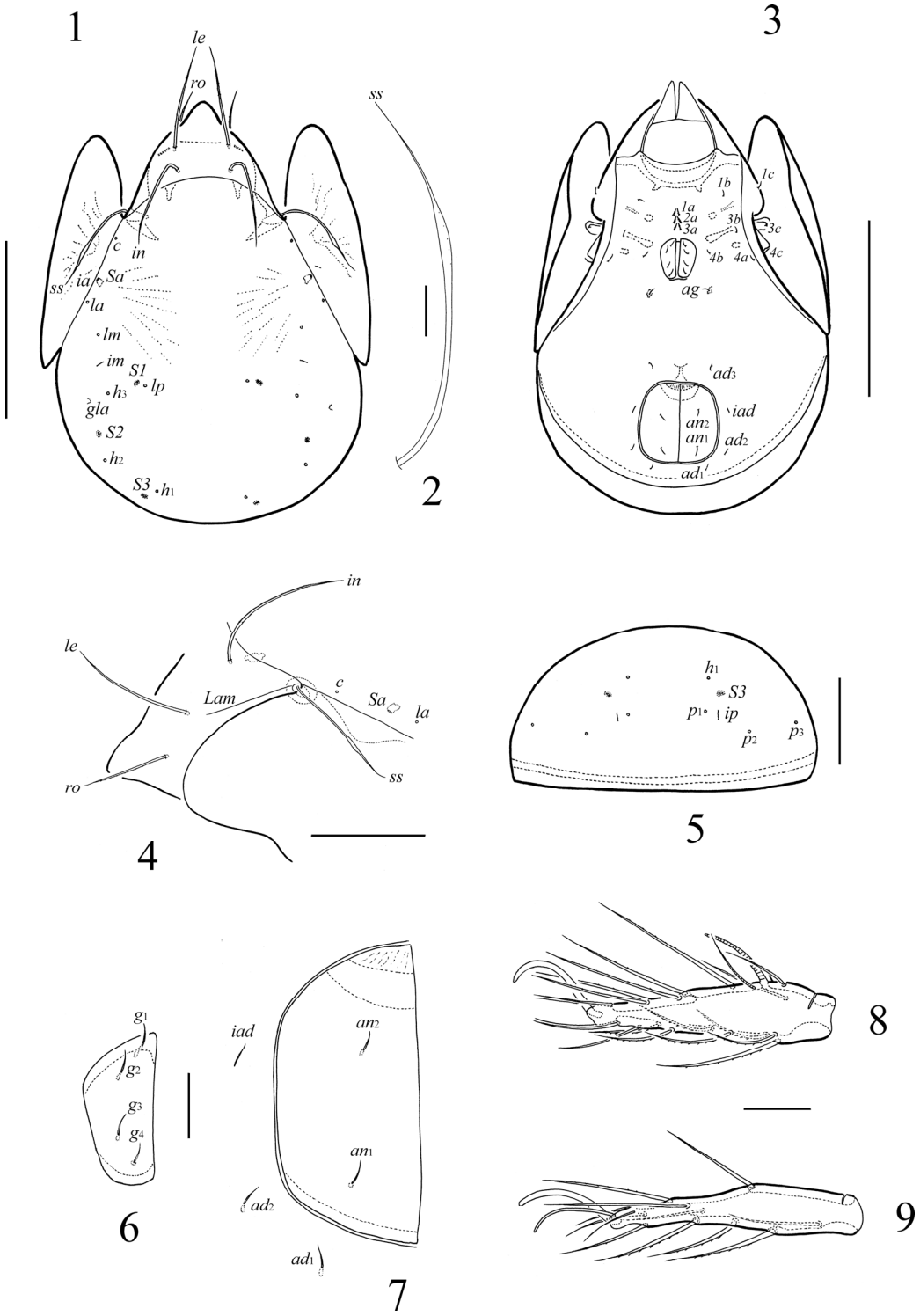
Epimeral region (Fig. 3). Apodemes 1, 2, sejugal and 3 well visible. Epimeral setal formula: 3–1–3–3. All setae setiform. Centroepimeral setae *1a*, *2a*, *3a* (12–20) straight, thicker and more strongly barbed than others. Setae *3c* inserted on pedotectae II, longest (24), slightly barbed. Setae *1b*, *1c*, *3b*, *4a*, *4b*, *4c* short (4–8), thin.

Anogenital region (Figs. 3, 6, 7). Four pairs of genital (g_1–g_4, 8–10), one pair of aggenital (*ag*, 8–10), three pairs of adanal (ad_1–ad_3, 10–12) and two pairs of anal (an_1, an_2, 8) setae thin and smooth. Aggenital setae inserted on rhombus-like cuticular structures. Lyrifissures *iad* located in inverse apoanal position. Adanal setae ad_3 inserted preanally. Postanal porose area absent.

Legs (Figs. 8, 9). Morphology of leg segments, setae and solenidia typical for *Neoribates* (*e.g.* Travé 1972, Grishina & Vladimirova 2009, Nakamura 2009). Leg tarsi I with one claw, leg tarsi II–IV with two claws (one thicker than the other). Formulae of leg setation and solenidia: I (1–5–3–4–20) [1–2–2], II (1–5–3–4–15) [1–1–2], III (2–3–1–3–15) [1–1–0], IV (1–2–2–4–12) [0–0–0]; homology of setae and solenidia indicated in Table 1.

Comparative analysis. In general morphology (medium body size; spindle-form sensilli; long rostral, lamellar and interlamellar setae; short openings of notogastral sacculi) *Neoribates spindleformis* sp. nov. is most similar to *Neoribates gracilis* Travé, 1972 from Southern Europe, but it clearly differs from the latter by the following characters: sensilli with longer apex (versus shorter in *N. gracilis*); leg tarsi I with one claw, leg tarsi II–IV with two claws (versus all leg tarsi with three claws in *N. gracilis*); genital plates with four pairs of genital setae (versus five pairs in *N. gracilis*).

Type deposition. The holotype is deposited in the collection of the Zoological Institute of the Russian Academy of Sciences, St. Petersburg,



Figures 1–9. *Neoribates spindleformis* sp. nov. 1 = dorsal view of body, 2 = sensillus, 3 = ventral view of body, legs, palps and subcapitular setae not shown, 4 = lateral view of prodorsum, exobothridial seta not shown, 5 = posterior view of notogaster, 6 = right genital plate, 7 = right anal plate with adanal setae ad_1, ad_2 and lyrifissure *iad*, 8 = left leg tarsus I, antiaxial view, 9 = right leg tarsus IV, antiaxial view. Scale bars (1, 3) 200 µm, (2, 6–9) 20 µm, (4, 5) 100 µm.

Russia; two paratypes are deposited in the collection of Siberian Zoological Museum Novosibirsk, Russia; one paratype is in the collection of the first author.

Etymology. The specific name "*spindleformis*" refers to the morphology of sensilli (spindleform).

***Globogalumna biporosa* sp. nov.**

(Figures 10–18)

Diagnosis. Body size 250 × 159–164. Body surface with granular cerotegument. Notogaster characteristically ornamentation by a thickened longitudinal line with thin lateral branches. Rostral and lamellar setae short. Interlamellar setae represented by alveoli. Sensilli clavate, with spines bilaterally. Two pairs of porose areas (*Aa*, *A1*) developed. Median pore and postanal porose area present.

Material examined. Holotype (female) and paratype (female) have the following collection data: Southern Vietnam, Dong Nai Province, Dong Nai Culture-Nature Reserve, 11°18', E 107° 3', soil from acacias artificial plantation (*Acacia auriculiformis* A.Cunn. ex Benth), July 2012, collected by A.E. Anichkin and S.G. Ermilov.

Measurements. Body length: 250 (holotype and paratype). Body width: 164 (holotype), 159 (paratype).

Integument (Figs. 10, 12–14). Body color brown. Body surface covered by granular cerotegument; granules very small (up to 1). Centro-anterior part of notogaster with specific ornamentation: thickened longitudinal line with thin lateral branches.

Prodorsum (Figs. 10, 11, 13, 15). Rostrum rounded in dorsal view. Rostral and lamellar setae similar in length (6–8), setiform, thin and smooth. Interlamellar setae absent, represented only by alveoli. Sensilli (36–40) with well developed stalk (16) and head (20–24). Sensillar head is oblong disk-like, with strong spines bilaterally. Porose areas *Ad* not evident. Sublamellar line (*S*) poorly visible.

Notogaster (Figs. 10, 14, 16). Anterior notogastral margin present, straight. Notogastral setae represented by 10 pairs of alveoli. Only two pairs of porose areas visible: *Aa* (6–8) and *A1* (3–4). All lyrifissures located as typical for majority of Galumnidae. Median pore (*mp*) large, inserted little below of level the localization of porose areas *A1*.

Gnathosoma. Morphology typical for Galumnidae (*e.g.* Engelbrecht 1972, Ermilov & Anichkin 2010, 2011b).

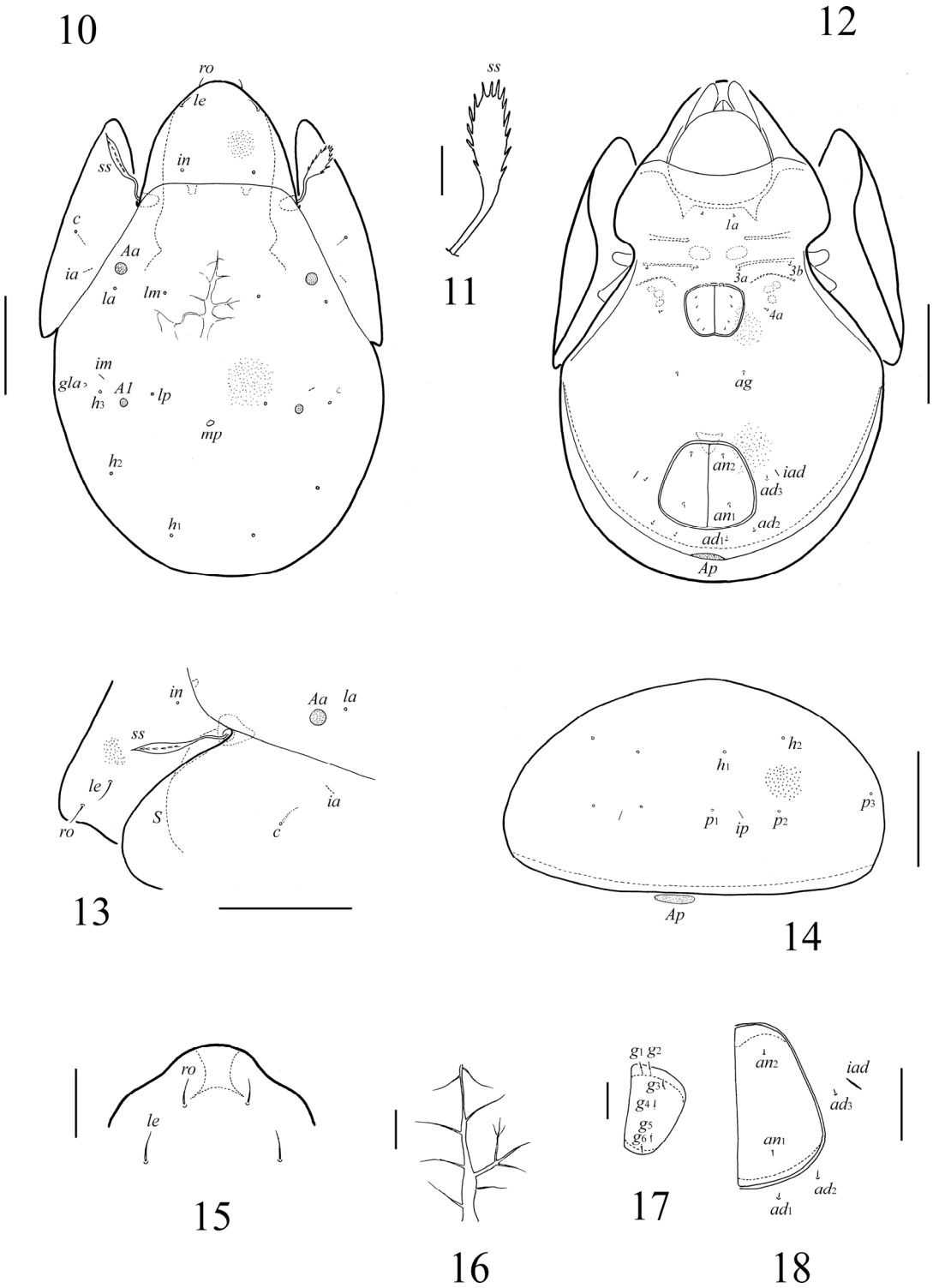
Epimeral region (Fig. 12). Apodemes 1, 2, sejugal and 3 well visible. Epimeral setal formula: 1–0–2–1. All setae minute (1–2), thin.

Anogenital region (Figs. 12, 17, 18). Six pairs of genital, one pair of aggenital, three pairs of adanal and two pairs of anal setae similar, minute (1–2), thin. Postanal porose area oval (12 × 4).

Legs. Morphology of leg segments, setae and solenidia typical for Galumnidae (*e.g.* Engelbrecht 1972, Ermilov & Anichkin 2010, 2011b). Leg heterotridactylous. Formulae of leg setation and solenidia: I (1–4–3–4–20) [1–2–2], II (1–4–3–4–15) [1–1–2], III (1–2–1–3–15) [1–1–0], IV (1–2–2–3–12) [0–1–0]; homology of setae and solenidia indicated in Table 2.

Comparative analysis. *Globogalumna biporosa* sp. nov. is clearly differs from the type-species, *G. globulifera* by the presence of specific ornamentation on notogaster (absent in *G. globulifera*), presence only of two pairs of notogastral porose areas (four pairs in *G. globulifera*), absence transverse line anteriorly to interlamellar setae (present in *G. globulifera*).

Also, in having the combination of specific notogastral ornament and clavate sensilli, *Globo galumna biporosa* sp. nov. is similar to *Allogalumna congoensis* (Starý, 2005) from the Ethiopian region, *Allogalumna exigua* Popp, 1960 from Egypt, *Allogalumna gedaii* Mahunka, 1995 from Thailand and *Allogalumna pellucida* (Wallwork, 1965) also from the Ethiopian region, but it differs from these listed species by the localization of lyrifissures *iad* (far from anal plates in *G biporosa* sp. nov. versus close to anal plates in the other species), presence of two pairs of notogastral porose areas (versus three to four in the other species) and sensillar head with strong spines (versus with cilia or barbs in the other species).



Figures 10–18. *Globogalumna biporosa* sp. nov. 10 = dorsal view of body, 11 = sensillus, 12 = ventral view of body, legs, palps and subcapitular setae not shown, 13 = lateral view of prodorsum, 14 = posterior view of notogaster, 15 = dorso-anterior view of rostrum, 16 = notogastral ornament, 17 = left genital plate, 18 = left anal plate with adanal setae and lyrifissure *iad*. Scale bars (10, 12–14) 50 µm, (11, 16, 17) 10 µm, (15, 18) 20 µm.

Table 1. Leg setation and solenidia of *Neoribates spindleformis* sp. nov.

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	*v′*	*d, (l), bv″, v″*	*(l), v′*, σ	*(l), (v)*, φ_1, φ_2	*(ft), (tc), (it), (p), (u), (a), s, (pv), v′, (pl), l″, e*, ω_1, ω_2
II	*v′*	*d, (l), bv″, v″*	*(l), v′*, σ	*(l), (v)*, φ	*(ft), (tc), (it), (p), (u), (a), s, (pv)*, ω_1, ω_2
III	*l′, v′*	*d, l′, ev′*	*l′*, σ	*l′, (v)*, φ	*(ft), (tc), (it), (p), (u), (a), s, (pv)*
IV	*v′*	*d, ev′*	*d, l′*	*d, l′, (v)*	*ft″, (tc), (p), (u), (a), s, (pv)*

Roman letters refer to normal setae (*e* – famulus), Greek letters refer to solenidia. One apostrophe (') marks setae on anterior and double apostrophe ("') setae on posterior side of the given leg segment. Parentheses refer to a pair of setae.

Table 2. Leg setation and solenidia of *Globogalumna biporosa* sp. nov.

Leg	Trochanter	Femur	Genu	Tibia	Tarsus
I	*v′*	*d, (l), bv″*	*(l), v′*, σ	*(l), (v)*, φ_1, φ_2	*(ft), (tc), (it), (p), (u), (a), s, (pv), v′, (pl), l″, e*, ω_1, ω_2
II	*v′*	*d, (l), bv″*	*(l), v′*, σ	*(l), (v)*, φ	*(ft), (tc), (it), (p), (u), (a), s, (pv)*, ω_1, ω_2
III	*v′*	*d, ev′*	*l′*, σ	*l′, (v)*, φ	*(ft), (tc), (it), (p), (u), (a), s, (pv)*
IV	*v′*	*d, ev′*	*d, l′*	*l′, (v)*, φ	*ft″, (tc), (p), (u), (a), s, (pv)*

See Table 1 for explanations.

Type deposition. The holotype is deposited in the collection of the Zoological Institute of the Russian Academy of Sciences St. Petersburg, Russia; one paratype (dissected) is in the collection of the first author.

Etymology. The specific name "*biporosa*" refers to the presence of only two pairs of notogastral porose areas.

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New Uropodina records and species from the Korean Peninsula (Acari: Mesostigmata)*

J. KONTSCHÁN[1], S. J. PARK[2], T. J. YOON[3] & W. Y. CHOI[2]

Abstract. Thirteen Mesostigmata species are recorded from the Korean Peninsula. Two of them *Nenteria koreana* and *Leonardiella koreana* spp. nov. are new to science, and further eleven species are recorded for the first time from the Korean Peninsula.

Keywords. Acari, Uropodina, new species, new records, Korean Peninsula.

INTRODUCTION

Uropodina is a widely distributed soil inhabiting group of the order Mesostigmata which are very diverse in the tropical areas, especially in the tropical rain forests (Lindquist *et al.* 2009). However, the Uropodina fauna of the European countries of Northern temperate zone are extensively studied; more than 100 species are listed from several countries (Poland, Slovakia, Romania, Hungary, Germany (Wiśniewski 1993, Mašán 2001, Kontschán 2008)). In contrary, the temperate region of Asia is scarcely investigated. Only the fauna of Japan, with more than 100 known species, is well known in this region (Wiśniewski 1993). Less than 25 species are listed from the Asian part of Russia, and only 5 species are recorded from China (Chen *et al.* 2008, Ma 2001, Wiśniewski 1993).

Recently two countries (Democratic People's Republic of Korea and Republic of Korea) are found on the Korean Peninsula, which is one of the hardly studied regions of temperate Asia. Wiśniewski (1993) listed only three species (*Discourella koreae* Hirschmann, 1981; *Nenteria koreae* Hirschmann, 1981 and *Trichouropoda rafalskii* Wiśniewski & Hirschmann, 1984) from the Korean Peninsula without providing exact locality data.

Our present paper contains new occurrences of eleven already known species and description of two new species from the Korean Peninsula.

MATERIAL AND METHODS

The specimens elaborated here were found in the Collection of the Soil Zoology of Hungarian Natural History Museum (Budapest, Hungary) (HNHM) and in the National Institute of Biological Resources, Incheon, Republic of Korea (NIBR). The specimens were cleared in lactic acid and observed in deep and half covered slides, with a scientific microscope. Illustrations were made with the aid of a drawing tube. Measurements are given in micrometers (µm), width of idiosoma was taken at the level of coxae IV.

The specimens examined are deposited in the mentioned collections.

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*Zoological Collectings by the Hungarian Natural History Museum in Korea No. 203

TAXONOMY

Trachytidae Trägårdh, 1938

Polyaspinus schweitzeri (Huțu, 1976)

Material examined. One female. As960: Republic of Korea, Jeollanam-do, Gurye-gun, Jirisan, (Mt.). Nogodan, beneath Nogodan shelter, rocky stream in deciduous forest, 1280m, N35° 17.738' E127°31.430', moss from streamside rocks, 15.IX.2010., leg. Hye Woo Byeon, Tae Woo Kim and Murányi, D (NIBR).

Distribution. Romania, Slovakia, Poland, Ukraine, Hungary and Korean Peninsula.

Dinychidae Berlese, 1916

Dinychus kurosai Hiramatsu, 1978

Material examined. One female. As659: Republic of Korea, Jeju-do, Hallasan National Park, same site, moss and soil samples (four different items) were taken from mosses, detritus, litter and upper layers of soil, 30.X.1993., leg. Peregovits, L. and Ronkay, L (NIBR).

Distribution. Japan and South Korea

Trematuridae Berlese, 1917

Trichouropoda ovalis (C. L. Koch, 1839)

Material examined. One male. As571: Democratic People's Republic of Korea, Yanggang-do, NW of Samjiyon, 31 km on Baekdusan (Mt.) road, *Larix vologensis*-forest (not mixed with *Betula pendula*) with rather poor underwood, not far from the tree borderline, sifting decayed trunks, 28.VI.1988., leg. Merkl, O. and Szél, Gy (NIBR).

Distribution. Europe and Korean Peninsula.

Trichouropoda shakaii Hiramatsu, 1979

Material examined. One female, two males, and two deutonymphs. As663: Republic of Korea, Jeju-do, Hallasan National Park, tree bark, 30.X.1993., leg. Peregovits, L. and Ronkay, L (NIBR).

Distribution. Japan and Korean Peninsula.

Nenteriidae Hirschmann, 1979

Nenteria japonensis Hiramatsu, 1979

Material examined. One female, two males. As461: Democratic People's Republic of Korea: Pyeonganbuk-do., Myohyangsan (Mt.), soil sample from mixed forest under Hwajangam, to be extracted in Berlese-funnel, 19.VII.1982., leg. Forró, L. and Ronkay, L (NIBR).

Distribution. Japan and Korean Peninsula.

Nenteria koreana sp. nov.

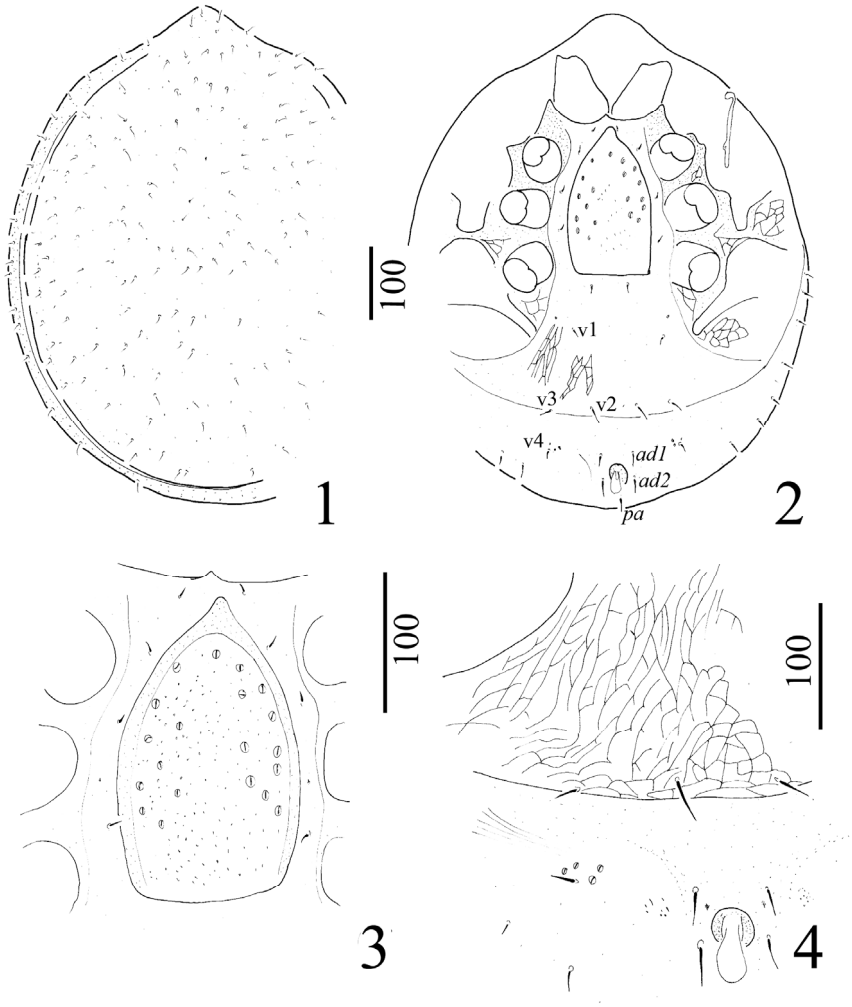
(Figures 1–11)

Diagnosis. All dorsal setae short and needle-like, surface of dorsal idiosoma smooth. Four sternal setae present, sternal shield without ornamentation. Ventral shield with reticulate sculptural pattern, ventral setae smooth and needle-like. Genital shield of female scutiform, covered by oval pits. Peritremes hook-shaped.

Material examined. Holotype. Female. As571: Democratic People's Republic of Korea, Yanggang-do, NW of Samjiyon, 31 km on Backdusan (Mt.) road, *Larix volgensis*-forest (not mixed with *Betula pendula*) with rather poor underwood, not far from the tree borderline, sifting decayed trunks of *Larix volgensis*, 28.VI.1988., leg. Merkl, O. and Szél, Gy. *Paratypes*. One female and two deutonymphs; with same data as for holotype. Holotype with a deutonymph paratype deposited in HNHM, female and one deutonymph paratype in NIBR.

Description. *Female:* length of idiosoma 670–680 µm, width 530–540 µm (n=2). Shape oval, posterior margin rounded.

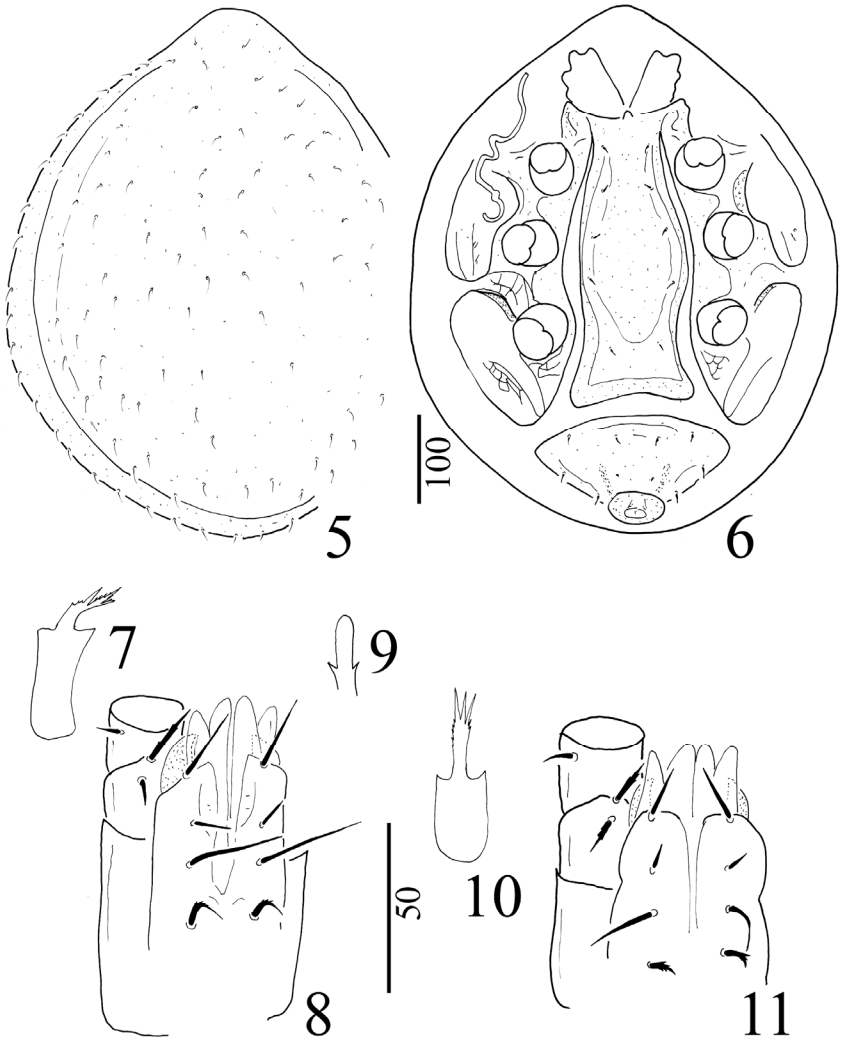
Dorsal aspect of idiosoma (Fig. 1). Dorsal and marginal shields fused anteriorly, all dorsal setae



Figures 1–4. *Nenteria koreana* sp. nov., female. 1 = dorsal view, 2 = ventral view, 3 = genital shield, 4 = ventrianal region.

short (*ca.* 15–17 µm), smooth and need-like. Marginal setae similar in shape and length to dorsal setae. Dorsal and marginal shields without sculptural pattern.

Ventral aspect of idiosoma (Fig. 2). Surface of sternal shield smooth. Four pairs of smooth sternal setae present (ca. 8–10 µm), St1 placed near to anterior margin of sternal shield, St2 at level of anterior margin of coxae II, St3 at level of anterior margin of coxae III, St4 at level of posterior margin of coxae III, St5 situated near the basal line of genital shield. Ventral setae smooth and needle-like, v1 placed at level of pedofossae IV (*ca.* 8–10 µm), v2 (*ca.* 15–16 µm) and v3 (*ca.* 30–32 µm) situated near the metapodal line, v4 (*ca.* 8–10 µm) associated with oval pits and situated at level of *ad1*. Adanal (ad1 *ca.* 20–22 µm; ad2 *ca.* 28–30 µm) and postanal (pa *ca.* 20 µm) setae smooth and needle-like, situated near the anal opening. Ventral shield covered by reticulate sculptural pattern between basis of genital shield and metapodal line, surface of ventral shield smooth (or nymphal skin can be seen) posteriorly to metapodal line (Fig. 4). Genital shield scutiform acuminously pulled out on the anterior edge, its surface ornamented by several oval pits (Fig. 3). Stigmata situated between coxae II and III, peri



Figures 5–11. *Nenteria koreana* sp. nov., deutonymph. 5 = dorsal view, 6 = ventral view, 7 = tritosternum of female, 8 = ventral view of gnathosoma of female, 9 = apical part of epistome of female, 10 = tritosternum of deutonymph, 11 = ventral view of gnathosoma of deutonymph.

tremes hook-shaped. Tritosternum with narrow basis, laciniae marginally serrate, apically divided into three branches (Fig. 7).

Gnathosoma (Fig. 8). Hypostomal setae h1, h2 and h3 smooth and needle-like, h4 marginally serrate. Setae h2 short, h1 and h4 two times longer than h2, h3 2.5 times longer than h2. Palp trochanter with one long, serrate and one short, smooth seta. Corniculi short and horn-like, internal malae smooth, and longer than corniculi, paralaciniae present. Epistome marginally serrate, apical part smooth and rounded (Fig. 9).

Deutonymph. Length of idiosoma 540–610 µm, width 470–500 µm (n=2). *Dorsal idiosoma* (Fig. 4). Dorsal shield without sculptural pattern. Dorsal setae smooth and needle-like (*ca.* 10–12 µm).

Ventral idiosoma (Fig. 5). Sternal setae short (*ca.* 8–9 µm), smooth, and needle-like. St1 placed

on level of anterior margin of coxae II, St2 at level of posterior margin of coxae II, St3 at level of central area of coxae III, St4 at level of posterior margin of coxae III, St5 at level of posterior margin of coxae IV. Sternal shield without sculptural pattern, reticulate ornamentation can be found around coxae IV on endopodal shield. Surface of ventrianal shield smooth. Ventral setae smooth, needle-like (*ca.* 8–9 µm), their position illustrated on Fig. 5. Anal opening large, oval, its surroundings without adanal setae. Peritremes long, with several bends. Tritosternum with narrow basis, laciniae marginally serrate and apically divided into three branches (Fig. 10).

Gnathosoma (Fig. 11). Corniculi horn-like, with one apical tooth, internal malae smooth and longer than corniculi, paralaciniae present. Hypostomal setae h1 and h3 smooth, h2 and h4 marginally serrate. Epistome marginally serrate. Palp trochanter bearing one long and one short, marginally serrate seta.

Larva, protonymph and male unknown.

Etymology. The name of the new species refers to the country where it was collected.

Remarks. The reticulate sculptural pattern, which is present in the new species, is a rarely observed character in the genus *Nenteria*. The most of *Nenteria* species have smooth surface or oval pits on ventral shield. Reticulate sculptural pattern can be found in the species *N. chihuahuaensis* Hirschmann, 1978, *N. eutamiasae* Hirschmann, 1978 and *N. microti* Hirschmann, 1978, but the peritremes of these species are S-shaped, in contrary the new species, which has hook-shaped peritremes.

Urodinychidae Berlese, 1917

***Uroobovella varians* Hirschmann & Zirngiebl-Nicol, 1962**

Material examined. One female and one male. As466: Democratic People's Republic of Korea, Gangwon-do., Geumgangsan (Mt.), sifted material from strongly decayed, moist litter, extracted in Moczarsky-Winkler apparatus, 23.VII.1982., leg. Forró, L. and Ronkay, L (NIBR).

Distribution. Central-Europe and Korean Peninsula.

Uropodidae Kramer, 1881

***Uropoda spiculata* Hirschmann, 1972**

Material examined. Two females. As664: Republic of Korea, Jeju-do Hallasan National Park, leaf litter and soil, 30.X.1993., leg. Peregovits, L. and Ronkay, L (NIBR).

Distribution. Japan, Vietnam, and South Korea (Fig. 29).

***Uropoda setata* Kontschán & Starý, 2011**

Material examined. One female. As664: Republic of Korea, Jeju-do Hallasan National Park, leaf litter and soil, 30.X.1993., leg. Peregovits, L. and Ronkay, L (NIBR).

Distribution. Vietnam and South-Korea.

Oplitidae Johnston, 1968

***Oplitis conspicua* (Berlese, 1903)**

Material examined. One female. As573: Democratic People's Republic of Korea, Gangwon-do, Geumgangsan (Mt.), Onjong-ri, sifting forest litter and rotten trunks of *Pinus densiflora,* 19.VI.1988., leg. Merkl, O. and Szél, Gy (NIBR).

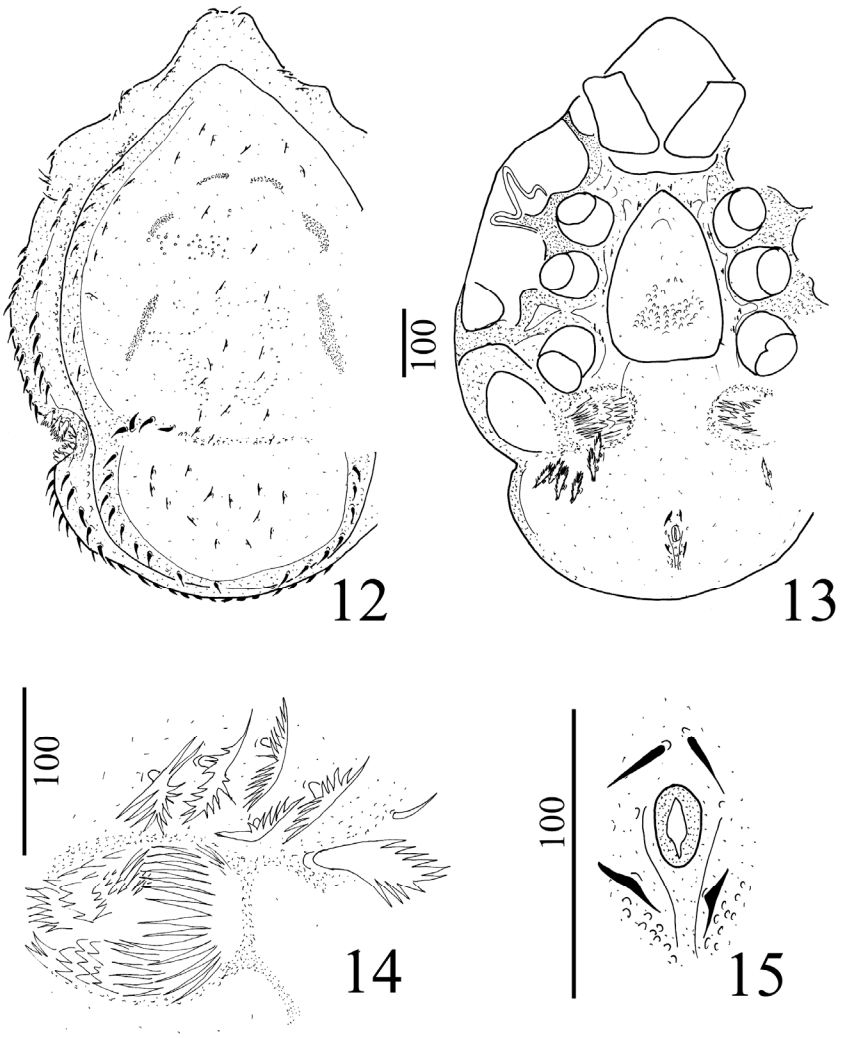
Distribution. Europe and Korean Peninsula.

Trachyuropodidae Berlese, 1917

***Leonardiella koreana* sp. nov.**

(Figures 12–18)

Diagnosis. Dorsal and marginal shields hypertrichous bearing robust and spine-like on marginal shield and on lateral area of dorsal shield, T-



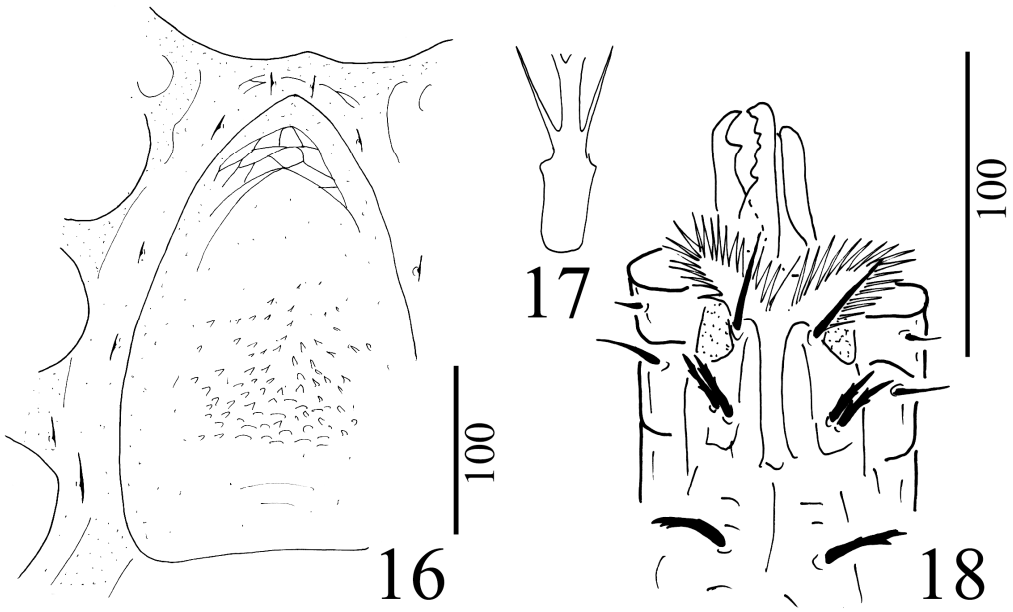
Figures 12–15. *Leonardiella koreana* n. sp., female. 12 = Dorsal view, 13 = ventral view, 14 = setae near transversal furrow, 15 = anal region.

shaped setae on central area of dorsal shield and marginally pilose setae near the dorsal incisions. Dorsal idiosoma covered by small, oval pits. Transversal furrows present and bearing wide, apically serrate setae near posterior margin of coxae IV, around these furrows several pilose and smooth setae situated. Surface of ventral shield smooth. Genital shield of females with reticulate sculptural pattern on anterior area and with small spines on central area. Peritremes M-shaped.

Material examined. Holotype. Female. As461: Democratic People's Republic of Korea, Pyeong-anbuk-do, Myohyangsan (Mt.), soil sample from mixed forest under Hwajangam, extracted in Berlese-funnel, 19.VII.1982., leg. Forró, L. and Ronkay, L. *Paratypes*. One female with same data as for holotype. Holotype deposited in HNHM, paratype in NIBR.

Description. Female. Length of idiosoma 870–880 µm, width 600–610 µm (n=2). Shape oval, anterior margin with two pairs of rounded horns, and one pair of incisions below level of coxae IV, posterior margin rounded.

Dorsal aspect of idiosoma (Fig. 12). Marginal and dorsal shields completely separated. Dorsal



Figures 16–18. *Leonardiella koreana* n. sp., female. 16 = genital shield, 17 = basal part of tritosternum, 18 = ventral view of gnathosoma.

and marginal shields hypertrichous, setae on marginal shield and on lateral area of dorsal shield robust and spine-like, other setae on central area of dorsal shield T-shaped. Three pairs of strongly sclerotized lines present on dorsal shield. Marginal shield wide, its anterior margin with two pairs of rounded horns and one pair of incisions below level of coxae IV, here situated several marginally pilose setae. Dorsal and marginal shields covered by small, oval pits.

Ventral aspect of idiosoma (Fig. 13). Sternal shield without sculptural pattern, only its anterior edge covered by reticulate sculptures (Fig. 16). All sternal setae T-shaped, their position illustrated on Fig. 16. Ventral setae T-shaped, setae ad1 smooth, ad2 T-shaped and placed around the anal opening, postanal seta absent (Fig. 15). Transversal furrows bearing wide, apically serrate setae near posterior margin of coxae IV, around these furrows several pilose and smooth setae can be observed (Fig. 14). Ventral shield without ornamentation. Stigmata situated between coxae II and III. Peritremes M-shaped. Genital shield scutiform, without anterior process (Fig. 16). Its surface ornamented by reticulate sculptural pattern near anterior margin and several small, spines on central area. Base of tritosternum narrow, tritosternal laciniae divided into four branches, two central branches maybe apically pilose (not clearly visible), two lateral branches smooth (Fig. 17).

Gnathosoma (Fig. 18). Corniculi horn-like, internal malae subdivided into several smooth branches. Hypostomal setae as follows: h1 smooth and placed near the anterior margin of gnathosoma, h2, h3 and h4 marginally serrate. Epistome pilose, movable digit of chelicerae shorter than fixed digit, movable digit with one tooth, fixed digit with four teeth, internal sclerotized node present.

Male, nymphs and larvae unknown.

Etymology. The new species is named after the peninsula where it was collected.

Remarks. The marginally pilose setae around the transversal furrows and the ornamentation of genital shield of female is an unique character combination in the genus *Leonardiella*.

Discourellidae Baker & Wharton, 1952

***Discourella modesta* (Leonardi, 1899)**

Material examined. Three female. As973: Republic of Korea, Gyeonggi-do, Gapyeong-gun, Hwaaksan (Mt.), Hwaak pass, at the Hwaak tunnel, forest stream, deciduous forest and open grassland, 875m, N37°59.829' E127°31.558', moss from streamside rocks and bank, deciduous forest litter, 11.IX.2010, leg. Forró, L., Makranczy, Gy., Murányi, D., Sun Jae Park and Jung Do Yoon (HNHM).

Distribution. Europe and Korean Peninsula.

***Discourella koreae* Hirschmann, 1971**

Material examined. One female. As973: Republic of Korea, Gyeonggi-do, Gapyeong-gun, Hwaaksan (Mt.)., Hwaak pass, at the Hwaak tunnel, forest stream, deciduous forest and open grassland, 875m, N37°59.829' E127°31.558', moss from streamside rocks and bank, deciduous forest litter, 11.IX.2010., leg. Forró, L., Makranczy, Gy., Murányi, D., Sun Jae Park, Jung Do Yoon (HNHM). Four females, As561, Democratic People's Republic of Korea, Gangwon-do, Geumgangsan (Mt.), pathway Kuryong sifted litter material, extracted by Moczarsky-Winkler-funnel, 21.X.1987., leg. Korsós, Z. and Ronkay, L (NIBR). One female, As557, Democratic People's Republic of Korea, Pyeonganbuk-do, Myohyangsan (Mt.), material extracted from the litter of a mixed forest on the bank of the stream Hyangsam by Moczarsky-Winkler-funnel, 08.X. 1987., leg. Korsós, Z. and Ronkay, L (NIBR).

Distribution. Korean Peninsula.

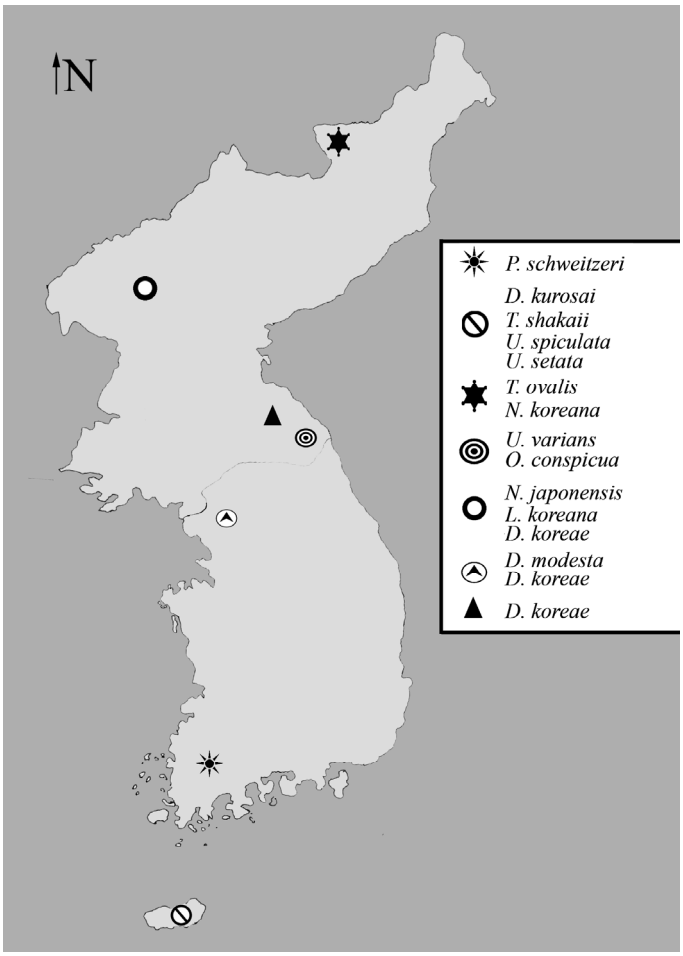


Figure 19. Occurrences of the Uropodina species found on the Korean Peninsula

ZOOGEOGRAPHICAL NOTES

Previously, the Uropodina fauna of the Korean Peninsula belonged to the most scarcely known ones of the world. Three of the presented thirteen species (*Nenteria koreana, Leonardiella koreana* and *D. koreae*) seem to be endemic in the Korean Peninsula, five species (*P. schweitzeri, T. ovalis, U. varians, O. conspicua* and *D. modesta*) have Palearctic distribution, they can be found in Europe and in the Korean Peninsula as well. These species have not yet been recorded from other parts of Asia, but this can be explained by the poor investigation of this group in Asia. Three species (*D. kurosai, T. shakaii* and *U. spiculata*) are shared elements with the Japanese fauna, however *U. spiculata* is known from South-East Asia (Vietnam) as well. Maybe this species is a typical subtropical element of the fauna, similarly to *U. setata* which was described from North-Vietnam.

Regarding the fauna of the two countries of the peninsula (Democratic People's Republic of Korea and Republic of Korea), six species were collected in Republic of Korea (*P. schweitzeri, D. kurosai, T.shakaii, U. spiculata, U. setata* and *D. modesta*) and six species in Democratic People's Republic of Korea (*T. ovalis, N. japonica, N. koreana, U. varians, O. conspicua* and *L. koreana*), only one species was recorded from both countries, this was the endemic species, *D. koreae* (Fig 19.).

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Opusc. Zool. Budapest, 2012, 43(2): 179–186

Some spiders (Araneae) new to the Hungarian fauna, including three genera and one family

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Abstract. We report the occurrence of new species of spiders to Hungary: *Acantholycosa lignaria* (Clerck, 1758), *Episinus maculipes* Cavanna, 1876, *Oecobius maculatus* Simon, 1870 and *Pandava laminata* (Thorell, 1878). We also report *Clubiona neglecta* O. P.-Cambridge, 1862 (previously only mentioned in a table in a Hungarian-language dissertation). The genus *Acantholycosa* (Dahl, 1908) was hitherto unknown in Hungary, yet expected to occur. The family Oecobiidae Blackwall, 1862 is new to the Hungarian fauna. The Southeast-Asian neozoon *Pandava laminata* is also recorded as new to Hungary. All further species found to be new to the Hungarian fauna or described in Hungary after the most recent publication of a Hungarian spider checklist are briefly mentioned.

Keywords. Araneae, faunistics, neozoon, rare species.

INTRODUCTION

Hungarian spider faunistics dates back to the 1860s, when Ottó Herman first published on the spider fauna of the Hungarian Kingdom. Later Chyzer & Kulczynski (1891, 1894, 1897) enumerated the spiders of the Hungarian Kingdom at the end of the 1800s. In the middle of the 20th century, Loksa published two volumes in the series Fauna Hungariae on Hungarian spiders; however the third and final volume was never published. Loksa also included information about spiders not yet found but expected to occur in Hungary, among others, about *Acantholycosa lignaria*, which he classified as a possible glacial relict (Loksa, 1969, 1972). (For a complete list of pre-1990s Hungarian arachnid literature, see Szinetár & Samu, 1995.)

The most recent checklist of the Hungarian spider fauna was published in 1999 (Samu & Szinetár) and includes some 725 species and also mentioned probable occurences of further species from some difficult species groups (that have been partially confirmed since). In 2003, a checklist of the salticid spiders of Hungary was published, which included 4 species new to the fauna (Szűts *et al.* 2003). Since then, the checklist has not been updated, although several new species have since been described from Hungary and new additions to the fauna have been reported. The new species that were described are *Parasyrisca arrabonica* Szinetár & Eichardt, 2009, *Pelecopsis loksai* Szinetár & Samu, 2003, and *Trebacosa europaea* Szinetár & Kancsal, 2007. Species reported as new to Hungary since publication of the 1999 checklist include *Alopecosa psammophila* Buchar, 2001 (Szinetár *et al.* 2005); *Araeoncus crassiceps* (Westring, 1861) in Dudás & Varga 2002; *Bathyphantes parvulus* (Westring, 1851) in Samu 2007; *Chrysso nordica* (Chamberlin & Ivie, 1947) in Szinetár *et al.* 2004; *Clubiona neglecta* O. P.-Cambridge, 1862 (Samu 2007); *Cnephalocotes obscurus* (Blackwall, 1834) in Szita *et al.* 2002; *Entelecara omissa* O. P.-Cambridge, 1902 (Kancsal *et al.* 2010); *Gongylidiellum latebricola* (O.P. - Cambridge, 1871) in Kovács & Szinetár 2004; *Gongylidiellum vivum* (O. P.-Cambridge, 1875) in Szita *et al.* 2002; *Holocnemus pluchei* (Scopoli, 1763) in Kovács *et al.* 2006; *Larinia bonneti* Spassky, 1939 and *Larinia jeskovi* Marusik, 1986 (Szinetár & Eichardt 2004); *Megalepthyphantes pseudocollinus* Saaristo, 1997 (Saaristo 1997); *Micrargus subaequalis* (Westring, 1851) in Kancsal *et al.* 2010; *Palliduphantes allutacius* (Simon 1884) and *Panamomops affinis* (Miller & Kratochvíl, 1939) in Kovács & Szinetár 2004; *Pardosa maisa* Hippa & Mannila, 1982 (Szinetár

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& Guitprecht, 2001); *Pardosa vittata* (Keyserling, 1863) in Kancsal *et al.* 2007; *Sintula corniger* (Blackwall, 1856) in Kovács *et al.* 2009; *Segestria florentina* (Rossi, 1790) in Kovács & Szinetár, 2005; *Spermophora senoculata* (Dugès, 1836) in Szinetár *et al.* 1999; *Syanageles subcingulatus* (Simon, 1878) in Szita *et al.* 2002; *Zora armillata* Simon, 1878 in Szita *et al.* 2002 and *Zora parallela* Simon, 1878 (Kovács *et al.* 2009). The presence of *Bathyphantes parvulus* and *Clubiona neglecta* in Hungary, although previously included in table in a Hungarian-language dissertation (Samu 2007), has not been noted in any checklist or other publication.

Here we present further four species new to the Hungarian fauna, and for the record, we also report on *Clubiona neglecta*.

MATERIALS AND METHODS

During several field trips conducted by the authors in Hungary in 2009 and thereafter spider specimens were collected by hand and sweep net photographed, then stored in 75% ethanol for further studies. Identification was made under binocular stereo microscopes (BTC STM-3C). Genitalia were dissected from the specimens and studied either under a binocular stereo microscope or under an optical biological microscope (Coic XSZ-G).

Some epigynes were cleared with lactic acid. Specimens are maintained in the collections of the authors and partly in the collection of the Department of Evolutionary Zoology and Human Biology, University of Debrecen. Drawings of genitalia were made after actual specimens. Name combinations reflect current nomenclature and synonymies in accordance with Platnick (2012).

LIST OF SPECIES RECORDED

Lycosidae

Acantholycosa lignaria (Clerck, 1758)

(Figures 1 a–b, 2 a–d)

Material. Bükk Mts., Kis-mező, elev. approx. 750 m, (48°4'51"N, 20°30'36"E), dry meadow by forest, leg. W. P. Pfliegler & G. Somlai, 9. May 2009, 1 female. Bükk Mts., Jávorkút, elev. approx. 660 m, (48° 5' 51"N, 20° 32' 1"E), beech forest, around lumber, leg. A. Grabolle & W. P. Pfliegler, 16. May 2009, 2 males.

Description. Prosoma black, with bright greyish median stripes, legs are dark brown with grey spots and stripes. Opisthosoma almost black (somewhat darker in females), with yellowish-grey hairs. Tibia I with a row of 4 spines laterally. The specimens dark brown in alcohol.

Measurements. Body length of female 9.1 mm, prosoma 4.1 mm; male (n=2) body length 6.8–6.9 mm, prosoma 3.3–3.4 mm.

Remarks. Easily recognisable species that often inhabits lumber piles in mountain forests. Several specimens sighted at both collection sites. Loksa (1972) mentioned this species as one which may occur in Hungary. The body length of male is given as 6.5 mm and that of female is 8 mm in Nentwig *et al.* (2011).

Clubionidae

Clubiona neglecta O. P.-Cambridge, 1862

(Figures 2 e–f)

Material. Bükk Mountains, Bükkszentkereszt, elev. approx. 570 m, (48°04'16"N 20°37'40"E), meadow near forest, coll. A. Grabolle, 16 May 2009 - 1 male.

Description. Prosoma reddish yellow, the chelicerae darker and about half the length of the prosoma. Opisthosoma reddish grey, with white hairs. Embolus of the pedipalp possesses long, conspicuously curving tip. The tegulum, embolus and chelicerae clearly match the drawings by Merrett (2001).

Measurements. Body length of male: 4.2 mm, prosoma: 2.1 mm.

Remarks. This species is widely distributed in Europe and was thought to occur in Hungary as well. Following the recent description of its sister species, *Clubiona pseudoneglecta* Wunderlich,

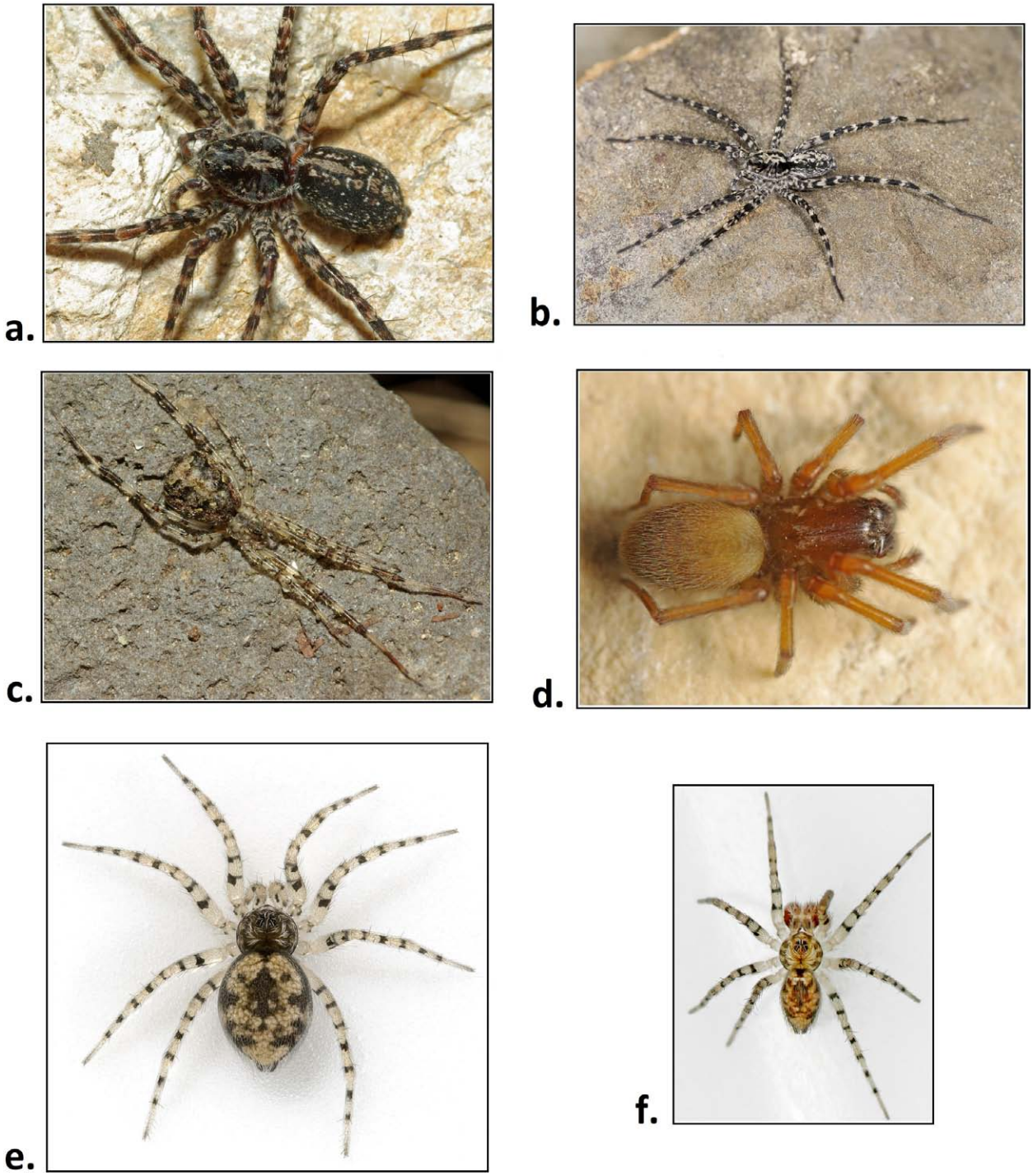


Figure 1. Photos of the species. a = *Acantholycosa lignaria* female, b = male. c = *Episinus maculipes* female. d = *Pandava laminata* female. e = *Oecobius maculatus* female, f = male

1994, Samu & Szinetár (1999) removed *C. neglecta* from their checklist, stating that all previous records of *C. neglecta* in Hungary proved to be *C. pseudoneglecta* (as described in detail by Mikhailov & Szinetár, 1997). Since then, no other faunistical data has been published on *C. neglecta*, however Samu (2007) mentioned the catch of 10 specimens in a table in his appendix but without providing any site collection data. The characteristic differences between *C. neglecta* and *C. pseudoneglecta* were reviewed in Merrett (2001), whose drawings are also available in Nentwig *et al*. (2011).

Theridiidae

Episinus maculipes Cavanna, 1876

(Figures 1 c, 2 g–h)

Material. Badacsony Mt., near Badacsonytomaj, Klastrom-kút, elev. approx. 280 m, (46°48' 22.3"N, 17°29'59.9"E), deciduous forest, under stone, leg. W. P. Pfliegler, 7. July 2009, 1 female.

Description: Prosoma yellowish-white, almost circular in shape, with distinct brownish median stripes reaching chelicerae. The region around the eyes is distinctly protruding and also brown. Sternum is blackish, with bright median stripe. The legs are yellowish-white, annulated with brown. Specimen displays a rather dark abdomen with yellowish median markings. Opisthosoma is greyish in alcohol.

Measurements. Body length of female: 5 mm, prosoma: 2 mm.

Remarks. *E. maculipens* is said to be a rather southern species, this spider has been reported from Austria, Slovenia, Croatia and Ukraine. According to Nentwig *et al*. (2011) the opisthosoma is usually whitish with a dark brown pattern, most distinct posteriorly. Ventrally dark pattern can only be found in the range of spinneret glands and epigaster. Body length of male is given as 3.9–4.3 mm, body length of female 4.3–5.6 mm.

Oecobiidae

Oecobius maculatus Simon, 1870

(Figures 1 e–f, 2 j–k.)

Material. Budapest, Várhegy (Castle hill), elev. approx. 200 m, (47°30'11"N, 19°1'59"E), 28. May 2009, on parapet wall, leg. K. Pfeiffer & A. Grabolle, 1 male, 3 females.

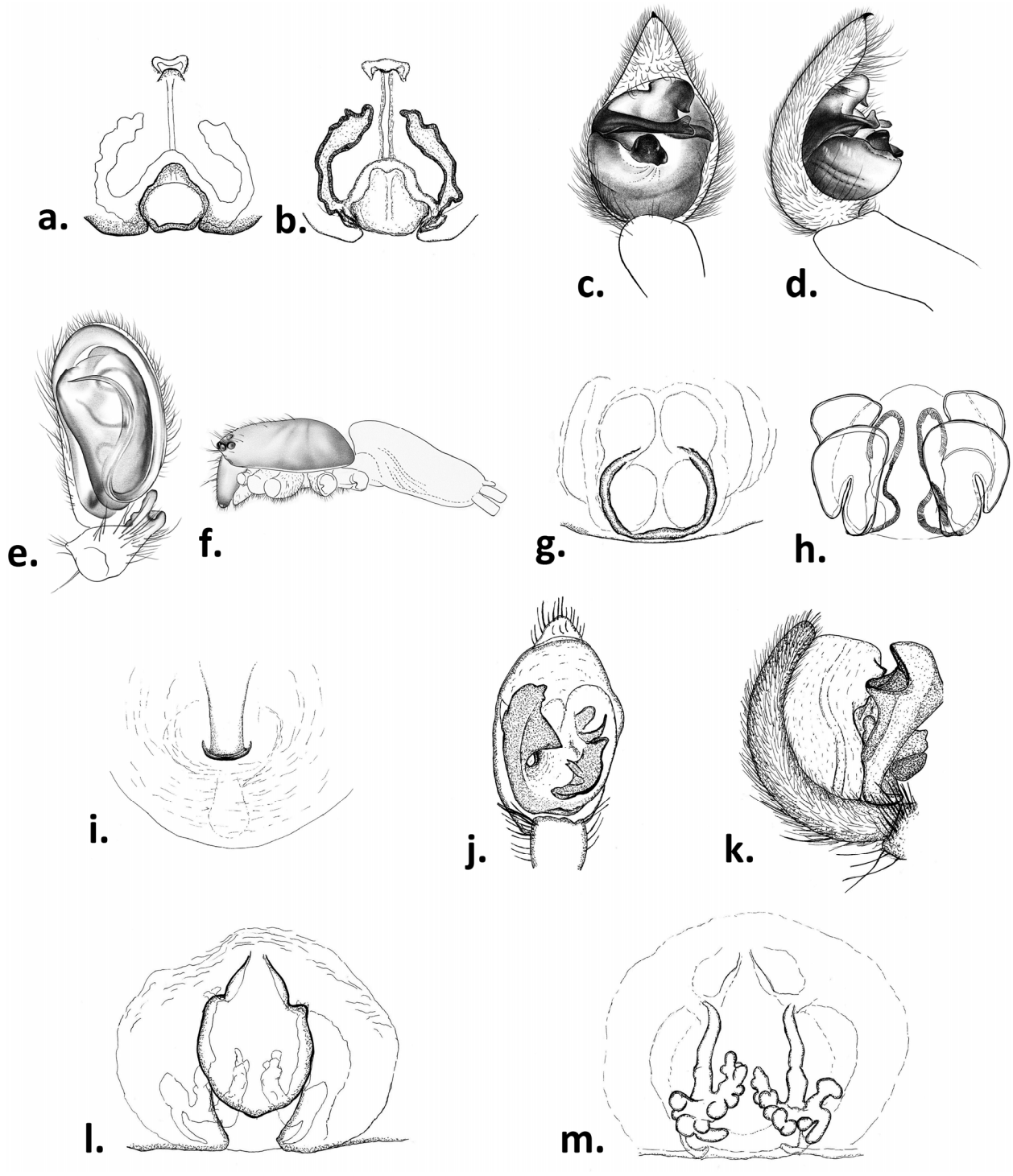
Description. *Male*. Visible region of carapace subcircular, clypeus gently protruding, orange-brown with dusky regions, three paired submarginal darker maculations overlaid with clusters of pale plumose setae; dark marginal line likewise overlaid with plumose setae. Eye region dark, with single prominent medial dorsal spine. Sternum bluntly pointed behind, pale milky-yellow, glabrous, margin darker with several small spines peripherally. Legs pale yellow (almost colourless alive) dark brown maculations pairwise laterally. Opisthosoma elongate oval, tapering to rear, dusky yellow with white flecks except in cardiac region, irregular paired brown maculations clothed in long setae.

Female. Similar to male. Epigyne very lightly sclerotised.

Measurements. Male. Prosoma 0.7 mm long body length 1.6 mm. *Female* (n=2). Prosoma 0.7–0.8 mm long body length 2.0–2.3 mm.

Remarks. A southern European oecobiid species found throughout the Mediterranean region, as well as in Switzerland and Austria (Nentwig *et al*., 2011; Thaler & Noflatscher, 1990). Several specimens, including juveniles, were sighted at the collection site beneath the stone coping of the parapet wall, suggesting an established population. However this has to be confirmed by further collection data.

It can be an introduced species in Budapest. Its presence on the fortification wall of Castle Hill, a well-visited tourist destination also suggests a synanthropic aspect. According to Wunderlich (1994), the epigyne has a short, indistinct scapus, the male pedipalp is distinguished by a substantial



Figures 2. Drawings of genital organs of the species. a = *Acantholycosa lignaria* epigyne, b = vulva, c = left pedipalp ventrally, d = left pedipalp prolaterally. e = *Clubiona neglecta* left pedipalp ventrally, f = body laterally. g =*Episinus maculipes* epigyne, h = vulva. i =*Oecobius maculatus* epigyne, j = left pedipalp ventrally, k = left pedipalp prolaterally. l =*Pandava laminata* epigyne, m = vulva

radix apophysis with a large notch distally. We observed that the genital structures of the specimens collected in Hungary closely resemble the drawings presented by Wunderlich (1994). The drawings of Baum (1974) show an epigyne quite different from those of our specimens and also the drawings of Wunderlich.

There is a very rarely used vernacular Hungarian name for the family Oecobiidae: *lemezeshálós pókok*.

Titanoecidae

Pandava laminata (Thorell, 1878)

(Figures 2 l–m)

Material. Debrecen, elev. approx. 120 m, (47°32'26"N 021°37'09"E), 28. May 2009, in house, in pot of a commercially obtained *Phalaenopsis* orchid, leg. W. P. Pfliegler & T. Torda, 1 female.

Description. Prosoma and chelicerae dark brown, opisthosoma dorsally creamy yellowish brown, ventrally somewhat darker. Prosoma bears a median row of thick erect hairs. Opisthosoma without any spots or markings. Legs and pedipalp yellowish brown, sternum and coxae darker. A black ring around spinnerets and cribellum present.

Measurements. Body length of female 5.3 mm, prosoma 2.6 mm.

Remarks. This spider species is easily distinguished from the other titanoecid spiders in Europe by the lack of any spots on the opisthosoma and a visible ring around the spinnerets. A detailed diagnosis and description of the species is given by Jäger (2008) who documented the occurrence of the species in Europe for the first time from the Cologne Zoo in Germany. He noted that the occurrence of the species in civilian buildings is unlikely because of the low humidity in homes. However, the specimen reported here was found in a pot of a common ornamental orchid (*Phalaenopsis* sp.) obtained from a shop in the city of Debrecen. It remained alive for about 3 months in this location, producing webs that were regularly removed until the spider itself was noted and then collected. Pots of these orchids contain humidity holes big enough for these spiders and seem suitable for surviving a species not adapted to low humidity. The trade of such plants may help these animals in dispersal thus *Pandava laminata* probably occurs in other greenhouses and nurseries as well.

DISCUSSION

Four species are reported for the first time and *Clubiona neglecta* is reported officially for the first time as present in the Hungarian fauna. Of these species, one represents a new family for Hungary (Oecobiidae) and is probably an introduced species (additional Budapest records of the species from areas not frequented by tourists might help to clarify this observation). The lycosid species *Acantholycosa lignaria* was only found at two locations by the authors, and thus may be rather scarce, even within the Bükk region. Further excursions into its habitat in Jávorkút by the first author in 2010 and in 2011 yielded no other specimens. We recommend that this species receive further attention with respect to its presence in Hungary, it may be even plausible to include it in the Hungarian list of protected species. A vernacular Hungarian name is proposed for this spider: *sávos hegyifarkaspók* (striped mountain wolf spider). The Southeast Asian species *Pandava laminata* is a neozoon. As it was found in a home, in the pot of a commercially obtainable plant, it is speculated that this species may have a wider occurrence in Europe than is presently known.

Colour photographs (of live specimens and genitalia) of all collected species are available on the website 'Wiki des Spinnen-Forums' (http://wiki.spinnen-forum.de/index.php?title=Hauptseite) or directly from the authors.

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Diversity of zooplankton in a tropical floodplain lake of the Brahmaputra river basin, Assam (Northeast India)

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Abstract. The zooplankton diversity of a floodplain lake of the Brahmaputra river basin of lower Assam is analyzed on the bases of net plankton samples collected from the littoral (station 1) and semi-limnetic (station 2) regions during January–December 2010. The species-rich zooplankton (143 species) hypothesized environmental heterogeneity of this wetland. They showed high monthly richness (81 ± 11 and 72 ± 11 species) and recorded 44.7–79.3% and 46.7–89.7% community similarities at two sampling stations, respectively. Zooplankton formed 55.5 ± 10.9 % and 63.9 ± 9.6 % of net plankton abundance. Rotifera > Cladocera mainly influenced their richness and density variations. Copepoda is a sub-dominant quantitative group while *Mesocyclops* spp., *Asplanchna priodonta, Chydorus sphaericus, Bosmina longirostris* and *Sinantherina socialis* are relatively important taxa. High species diversity and low densities of majority of species are hypothesized to fine niche portioning amongst different species in combination with high micro- and macro-scale habitat heterogeneity. The zooplankton is characterized by high equitability and low dominance. Individual abiotic factors recorded limited influence on richness and abundance. Canonical correspondence analysis with ten abiotic factors explained 56.0 % and 55.8 % cumulative variance of zooplankton assemblages along axis 1 and 2. The CCA affirmed micro-environmental differences between the sampling stations.

Keywords. Abundance, diversity, species richness, tropical wetland, zooplankton.

INTRODUCTION

The floodplain lakes, an important component of inland aquatic resources of India, are hypothesized to be rich habitats for zooplankton diversity (Sharma & Sharma 2008). Ironically, several routine limnological reports from the floodplains of this country invariably provide poor data on diversity of these important fish-food organisms because of incomplete species inventories or unidentified species. This generalization also holds true to the floodplain lakes (commonly called '*beels*' or '*pats*') of northeast India. The detailed studies on zooplankton from this region are restricted to selected *beels* of Assam (Sharma 2011a, Sharma & Sharma 2008), and *pats* of Manipur (Sharma 2011b, Sharma & Sharma 2011). The works of Sharma (2009, 2010) and Sharma & Sharma (2012) are, however, limited to the rotifer diversity.

This study deals with zooplankton communities of Ghorajan Beel, a floodplain lake of the Brahmaputra river basin of lower Assam, with special reference to monthly variations in their richness and abundance, community similarities, species diversity, dominance and evenness. In addition, the influence of abiotic parameters on qualitative and quantitative variations of zooplankton is analyzed. The results assume biodiversity and limnological value in view of the paucity of works from India in general and fewer works from its northeast region in particular.

MATERIALS AND METHODS

The observations were undertaken during January–December, 2010 in Ghorajan Beel (Long. 91^0 41' 25'' E; Lat. 26^0 09'26'' N; area: 117 ha) located in the Kamrup district of lower Assam (Northeast India). Various aquatic macrophytes of this wetland included *Azolla pinnata, Eichhornia crassipes, Hydrilla verticillata, Ipomea fistulosa, Lemna* sp., *Najas indica, Vallisneria spiralis* and *Utricularia flexuosa.*

Water samples, collected monthly from the littoral (station 1) and station 2 (semi-limnetic (station 2) regions of Ghorajan Beel, were analyzed for nineteen abiotic factors. Water temperature, specific conductivity and pH were recorded by field probes, transparency was noted with Secchi

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disc, dissolved oxygen was estimated by Winkler's method and other parameters were analyzed following APHA (1992). The qualitative (by towing) and quantitative (by filtering 25 l water each) net plankton samples were collected monthly, from both sampling stations, by nylobolt plankton net (No. 25) and were preserved in 5% formalin. The zooplankton was identified following the works of Koste (1978), Michael & Sharma (1988), Sharma (1998) and Sharma & Sharma (1999a, 1999b, 2000, 2008). Quantitative enumeration of zooplankton (ind. L^{-1}) was done with a Sedgewick-Rafter counting cell. The community similarities (Sørensen's index), species diversity (Shannon's index), dominance (Berger–Parker's index) and evenness (Pileou's index) were calculated following Ludwig & Reynolds (1988) and Magurran (1988). Hierarchical cluster analysis, based on Sørensen's similarities, was done using SPSS (version 11.0). The significance of variations of richness and abundance of zooplankton between sampling stations and months was ascertained by ANOVA (two-way). The linear relationships between abiotic parameters and zooplankton were examined by correlation coefficients (r_1 and r_2 respectively) for each sampling station; their P values were calculated and significance was ascertained after use of Bonferroni corrections. Canonical correspondence analysis (ECOM II: version 2.1.3.137, PISCES Conservation Ltd. 2007) was used to elucidate the relationships between zooplankton assemblages and ten abiotic parameters namely water temperature, rainfall, transparency, pH, specific conductivity, dissolved oxygen, free carbon dioxide, alkalinity, hardness and phosphate.

Table 1. Temporal variations (range, average ± SD) of zooplankton

Parameters↓ Stations→	**Station 1**		**Station 2**	
RICHNESS				
Zooplankton	138 species 57 – 97 81 ± 11		143 species 48 – 89 72 ± 11	
Rotifera	35 –55	46 ± 6	24 – 52	36 ± 5
Cladocera	14 – 31	25 ± 4	19 – 27	23 ± 2
Rotifera (84 species) > Cladocera (42 species) > Rhizopoda (12 species)				
QUANTITATIVE				
Net Plankton ind. L^{-1}	432 – 727	631 ± 112	324 – 671	528 ± 123
Zooplankton ind. L^{-1}	188 – 496	354 ± 103	154 – 456	342 ± 111
% composition	33.0 – 69.0	55.5 ± 10.9	44.8 – 76.5	63.3 ± 9.6
Species Diversity	3.799 – 4.223	4.009 ± 0.129	3.905 – 4.213	3.981 ± 0.138
Dominance	0.040 – 0.120	0.079 ± 0.025	0.048 – 0.137	0.091 ± 0.030
Evenness	0.885 – 0.964	0.915 ± 0.026	0.865 – 0.994	0.932 ± 0.042
Different Groups Rotifera > Cladocera > Copepoda > Rhizopoda				
Rotifera ind. L^{-1}	111 – 242	185 ± 45	92 – 245	188 ± 58
% composition	42.8 – 62.2	53.3 ± 5.1	49.2 – 60.5	55.6 ± 3.6
Cladocera ind. L^{-1}	50 – 156	106 ± 36	45 – 120	85 ± 23
% composition	21.3 – 36.1	29.7 ± 4.1	19.9 – 32.1	25.7 ± 4.0
Copepoda ind. L^{-1}	9 - 81	40 ± 24	9 – 93	45 ± 27
% composition	4.8 – 17.7	10.6 ± 4.3	5.8 – 20.5	12.0 ± 4.6
Rhizopoda ind. L^{-1}	5 – 23	12 ± 5	6 – 35	17 ± 11
Ostracoda ind. L^{-1}	0 – 20	9 ± 5	1 – 8	5 ± 2
Conchostraca ind. L^{-1}	0 – 6	2 ± 2	0 – 4	2 ± 1
Important species (ind. L^{-1})				
Mesocyclops spp.	7 – 59	37 ± 15	8 – 59	39 ± 17
Asplnanchna priodonta	0 – 32	22 ± 6	0 – 32	16 ± 10
Chydorus sphaericus	3 – 32	16 ± 8	3 –20	10 ± 4
Bosmina longirostris	0 – 24	11 ± 9	4 –20	11 ± 7
Sinantherina. socialis	0 – 20	11 ± 7	0 – 20	10 ± 9

RESULTS

The temporal variations in abiotic parameters of the littoral (station 1) and semi-limnetic (station 2) regions of Ghorajan Beel are indicated in Appendix I. The details of occurrence and abundance of zooplankton are included in Appendices II and III and their variations (annual ranges and average ± SD) are summarized in Table 1. A total of 143 species of zooplankton are recorded in this study; of these 138 species are observed in our collections from the littoral region (station 1) while all of them occurred at station 2 (semi-limnetic region). Their monthly richness ranged between 57–97 and 48–89 species, community similarities (Sørensen's index) varied between 46.6–80.4% and 37.0–95.9% (Tables 2–3) while annual variations in the hierarchical cluster analysis, based on Sørensen's community similarity values at station 1 and station 2, are indicated in Figs. 1–2, respectively. ANOVA indicated significant richness variations between months ($F_{11, 23}$ = 2.536, P = 0.023) and between the sampling stations ($F_{1, 23}$ = 7.122, P = 0.022).

The monthly variations in abundance of zooplankton and their constituent groups are shown in Figs. 3–4. The zooplankton (354 ± 103 ind. L^{-1}, 342 ± 111 ind. L^{-1}) comprised 55.5 ± 10.9 % and 63.3 ± 9.6 % of net plankton abundance in littoral (station 1) and semi-limnetic (station 2) regions, respectively (Table 2). Their abundance varied significantly between months ($F_{11, 23}$ = 141.659, P = 3.3E-10). Rotifera (185 ± 45 ind. L^{-1}, 188 ± 58 ind. L^{-1}) > Cladocera (106 ± 36 ind. L^{-1}, 85 ± 23 ind. L^{-1}), main quantitative groups are followed by Copepoda (40 ± 24 ind. L^{-1}, 45 ± 27 ind. L^{-1}); Rhizopoda (12 ± 5 ind. L^{-1}, 17 ± 11 ind. L^{-1}) abundance is low while Ostracoda (9 ± 5 ind. L^{-1}, 5 ± 111 ind. L^{-1}) and Conchostraca (2 ± 2 ind. L^{-1}, 2 ± 1 ind. L^{-1}) showed poor abundance. Rotifera abundance showed insignificant temporal variations between stations while it varied significantly between months ($F_{11, 23}$ = 24.927, P < 0.001). Cladocera abundance varied significantly between months ($F_{11, 23}$ = 8.619, P = 0.0006) and sampling stations ($F_{1, 23}$ = 13.224, P = 0.004). Copepoda abundance varied significantly between months ($F_{11, 23.}$ = 8.302, P = 0.0007).

Table 2. Percentage similarities of Zooplankton (Station 1)

Months	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Jan.	-	64.5	61.7	51.8	62.0	70.1	73.1	68.3	62.0	67.5	69.1	69.1
Feb.		-	60.8	61.1	59.4	60.0	71.0	66.2	67.5	71.6	60.9	73.3
March			-	50.6	59.6	66.7	68.6	63.3	67.4	68.1	68.5	67.4
April				-	61.1	44.7	63.7	52.9	62.3	56.5	61.1	65.3
May					-	62.7	70.4	63.9	54.8	68.4	59.6	72.8
June						-	67.0	63.9	60.3	69.0	70.5	69.4
July							-	71.2	63.1	69.9	64.2	79.3
Aug.								-	55.7	70.2	62.3	71.8
Sept.									-	58.6	66.7	68.9
Oct.										-	59.4	70.9
Nov.											-	65.5

Table 3. Percentage similarities of Zooplankton (Station 2)

Months	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Jan.	-	55.3	89.9	60.2	58.6	73.0	61.0	79.7	74.5	72.7	86.9	68.9
Feb.		-	74.8	67.9	52.6	61.5	72.1	80.9	72.6	72.2	68.7	72.5
March			-	67.7	58.1	77.2	74.1	84.9	79.5	78.4	81.1	78.4
April				-	62.3	46.7	64.2	66.1	69.1	65.0	72.9	67.2
May					-	55.8	51.1	55.4	51.5	53.3	52.4	60.6
June						-	56.4	70.3	68.7	81.7	74.6	68.4
July							-	69.1	65.5	76.6	64.1	71.0
Aug.								-	64.6	74.3	75.5	77.1
Sept.									-	65.8	72.1	77.4
Oct.										-	64.8	78.7
Nov.											-	66.7

The zooplankton species diversity (Table 1) ranged between 4.009 ± 0.129 and 3.981 ± 0.138 and its monthly variations are shown in Fig. 5; their dominance varied between dominance 0.079 ± 0.025 and 0.091 ± 0.030 while evenness ranged between 0.915 ± 0.026 and 0.932 ± 0.042 at two sampling stations, respectively (Table 1). Our results showed no significant linear relationship of abiotic factors on zooplankton richness while their abundance is positively correlated with sulphate (r_1=0.859, P=0.001, r_2=0.844, P = 0.002). The results of canonical correspondence analysis (CCA) with ten abiotic parameters on cumulative variance of zooplankton assemblages at stations 1 and 2 are presented in Figs.6–7, respectively; their important features are summarized in Appendix IV.

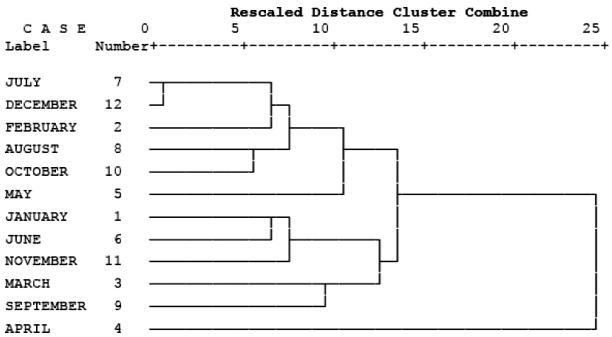

Figure 1. Hierarchical cluster analysis for zooplankton (Station 1).

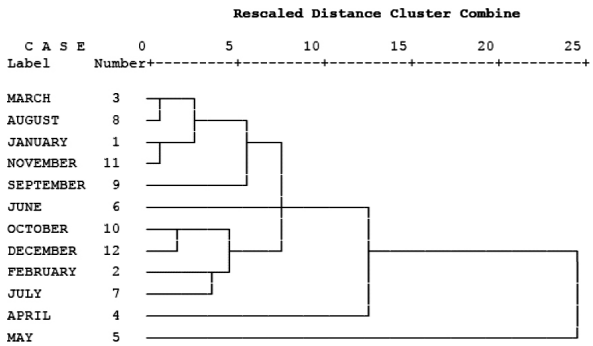

Figure 2. Hierarchical cluster analysis for zooplankton (Station 2).

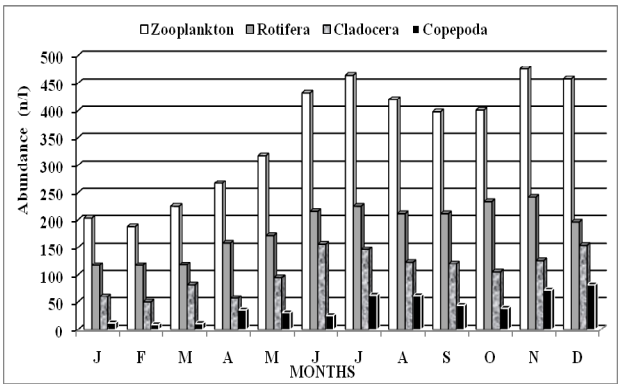

Figure 3. Monthly variations in Abundance (n/l) of zooplankton and important groups (Station 1).

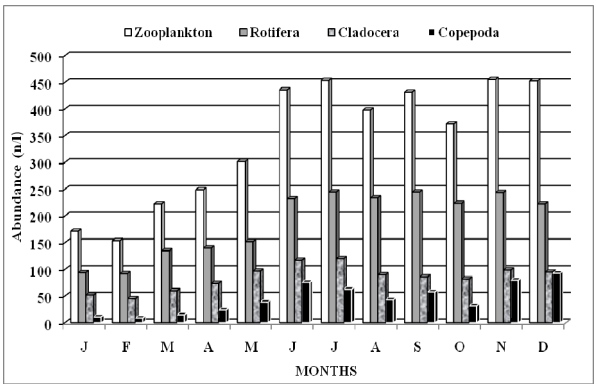

Figure 4. Monthly variations in Abundance (n/l) of zooplankton and important groups (Station 2).

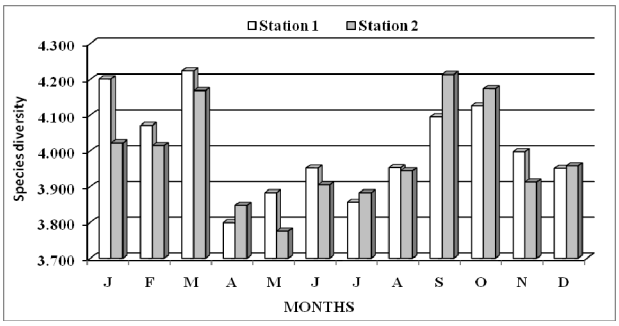

Figure 5. Monthly variations in Species diversity of zooplankton.

DISCUSSION

Abiotic parameters

The circum-neutral and marginally hard waters of sub-tropical Ghorajan Beel recorded low ionic concentrations, moderate dissolved oxygen, low free CO_2, low chloride content and low concentrations of nutrients and other parameters. Annual ranges of abiotic factors differed marginally between the sampling stations (Sharma & Sharma 2012).

Richness and community similarities

The species-rich (143 species) and diverse (six groups) character of zooplankton hypothesized general environmental heterogeneity and habitat diversity of Ghorajan Beel. This wetland is qualitatively more diverse than the 102–118 species reported various *beels* of Assam (Sharma & Sharma 2008) as well as 110 and 103 species observed two '*pats*' of Manipur (Sharma 2011b). Further, Ghorajan zooplankton is distinctly diverse than the reports from other Indian floodplain lakes i.e., 51 species (Khan 1987) and 26 species (Yousuf *et al.* 1986) from Kashmir; 19 species (Baruah *et al.* 1993) and 31 species (Sanjer & Sharma 1995) from Bihar, and 71 species (Khan 2003) from West Bengal. The stated comparisons affirm our remarks on environmental heterogeneity of Ghorajan vis-à-vis other floodplain lakes of this country. The richness is, however, relatively lower than the reports of 189 species from Deepor *beel* (Sharma 2011a) and 171 species from Loktak Lake (Sharma & Sharma 2011) - two biodiversity 'hot-spots (Ramsar sites) and important floodplain lakes of northeast India.

The occurrence of all the species at station 2 and 138 species at station 1 showed homogeneity in zooplankton composition between the sampling stations. They mainly contributed to richness of net plankton (194 species) of Ghorajan. The zooplankton biocoenosis exhibited 'tropical character' with distinct richness of cosmopolitan species and occurrence of various cosmotropical, circumtropical and pantropical species. This generalizetion affirmed earlier remarks of Sharma & Sharma (2008).

The occurrence of > 70 species at station 1, except during April and May, and > 60 species at station 2, except during February and April affirmed zooplankton speciose composition and hence affirmed environmental heterogeneity of this *beel* practically throughout the study period. They showed high monthly richness at both sampling stations and followed oscillating patterns concurrent with the reports of Sharma & Sharma (2010) and Sharma (2011a, 2011b). Their composition is mainly influenced by the species-rich Rotifera > Cladocera. The diverse nature of the rotifer communities concurred with the reports from the floodplain lakes of Argentina (Jose De Paggi 1993, 2001), Africa (Segers *et al.* 1993), Brazil (Bonecker *et al.* 1998), Thailand (Sanoamuang 1998) and Australia (Shiel et al. 1998).

The community similarities (*vide* Sørensen's index) reflected notable monthly variations in zooplankton species composition in general and in the limnetic region (station 2) in particular. The matrices indicated similarity between > 60–70 percent in maximum instances at station 1 while it ranged between > 60–80 percent in maximum instances at station 2. These features are attributed to common occurrence of cosmopolitan, tropicopolitan and pantropical species. At both stations, highest similarities are recorded between July–December and January–March respectively. The cluster analysis indicated more heterogeneity of the monthly groupings in the littoral region (station 1) in general than at station 2 (limnetic region); this generalization affirmed the authors earlier remarks based on Rotifera (Sharma & Sharma 2012) - the most speciose group. Our results at station 1 showed high affinity between July–December while the April, September and May communities differed distinctly from the rest of the months and April collections exhibited maximum divergence. On the other hand, high affinities at station 2 are noticed between March–August and again between January–November samples while May and April communities exhibited distinct divergence in their composition.

Abundance

The zooplankton formed an important component of net plankton abundance with relatively high percentage composition at station 2. Their quantitative significance concurred with the reports from certain flood-plain lakes of northeast India (Sharma & Hussain 2001, Sharma 2011a, 2011b, Sharma & Sharma 2011). This feature differed from higher phytoplankton abundance reported from the floodplain lakes and wetlands of Kashmir (Kaul & Pandit 1982), Bihar (Baruah *et al.*

1993, Sanjer & Sharma 1995), Assam (Yadava et al. 1987) and West Bengal (Sugunan 1989). The zooplankton abundance in Ghorajan *beel* is, however, higher than the reports of Yadava et al. (1987), Baruah et al. (1993) and Sharma & Sharma (2011) while it is lower than that of Sharma (2011) as well as the results of Khan (1987), Vaas (1989), Sanjer & Sharma (1995), Khan (2002) and Sharma (2011b). This study indicated marginal differences of zooplankton abundance between two sampling stations, respectively. It followed nearly concurrent oscillating quantitative monthly variations with relatively high densities (> 350 ind. L^{-1}) from June through December and lowest abundance during February at both stations but showed maxima during July and November at stations 1 and 2 respectively. This is in contrast to winter maxima observed by Sharma (2011a, 2011b) and Sharma & Sharma (2011) as well as bimodal patterns noted by Yadava *et al.* (1987) and Sanjer and Sharma (1995).

Rotifera, main quantitative component of zooplankton, followed broadly concurrent quantitative annual variations at both sampling stations with higher abundance (> 200 ind. L^{-1}) from June through November. Brachionidae > Lecanidae influenced the rotifer abundance while *Asplanchna priodonta* > *Sinantherina socialis* are important species. A detailed account of the rotifer diversity of this wetland is dealt with separately (Sharma & Sharma 2012). Cladocera, second quantitative group, followed oscillating annual patterns with high densities from May through December and peaks during June and July respectively while their lowest densities are noticed during February at both the stations. The quantitative importance of the Chydoridae concurred with the results of Sharma (2011a, 2011b) and Sharma & Sharma (2011) but differed from lack of any such trend as reported by Khan (1987), Sanjer & Sharma (1995), Sharma & Hussain (2001) and Khan (2003). *Chydorus sphaericus* and *Bosmina longirostris* are notable cladoceran species in our study.

Copepoda quantitative sub-dominance in Ghorajan *beel* is in contrast to their dominant role reported by Yadava *et al.* (1987), Baruah *et al.* (1993), Sharma & Hussain (2001) and Khan (2003). The copepods exhibited broadly bimodal patterns with maxima during June and December (peaks) and minima during February in both stations. The cyclopoids (*Mesocyclops* spp.) mainly influenced abundance of this group and concurred with the reports of Khan (1987), Sanjer & Sharma (1995), Sharma & Hussain (2001), Sharma (2011a, 2011b) and Sharma & Sharma (2011). The occurrence of nauplii throughout the study period showed an active continuous reproductive phase of the cyclopoids concurrent with the reports of Sharma (2011a, 2011b) and Sharma & Sharma (2011). Amongst other groups of zooplankton, Rhizopoda recorded low abundance while Ostracoda and Conchostraca showed very poor densities.

Diversity indices

Our results are characterized by high zooplankton species diversity at two stations, respecttively with relatively high values (> 4.000) during January–March and again during September–October at both the sites. In fact, the mean diversity at Station 1 is the second highest known till date from any freshwater ecosystem of India and followed that of Loktak Lake (Sharma & Sharma 2010). This interesting feature re-affirmed general environmental heterogeneity of Ghorajan *beel*. The salient features of high species diversity with relatively lower densities of majority of species of our study may be ascribed to fine niche portioning amongst zooplankton species in combination with high micro- and macro-scale habitat heterogeneity as hypothesized by Segers (2008) and affirmed by Sharma (2011a, 2011b) and Sharma & Sharma (2011, 2012). The diversity followed oscillating but different annual patterns at both sampling stations with low values during summer. High evenness of zooplankton observed in our results affirmed equitable abundance of various species and it is endorsed by lower dominance. In general, high evenness and low dominance concurred with the results from floodplain lakes of northeast India (Sharma 2011a, 2011b; Sharma & Sharma 2008, 2011).

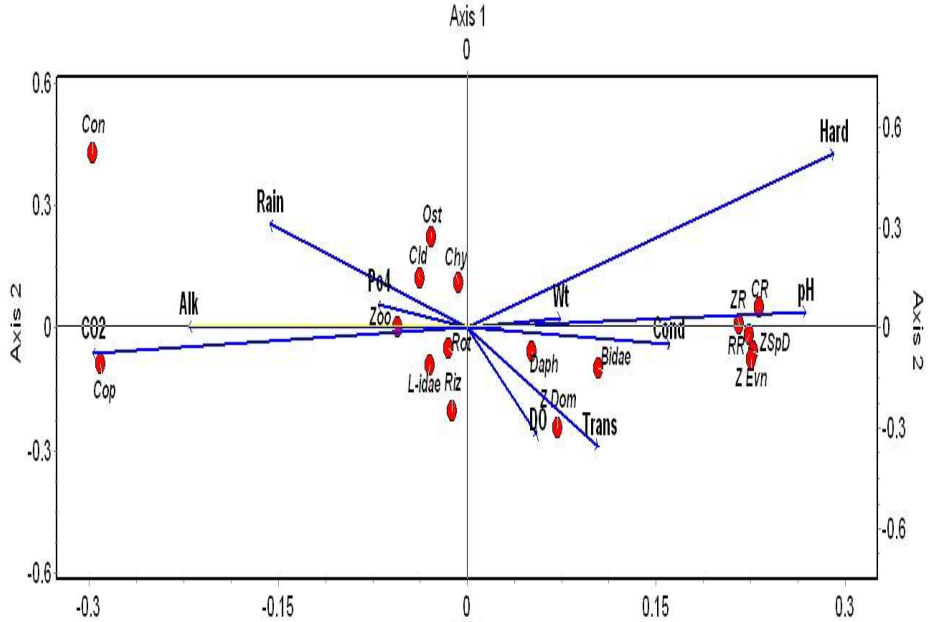

Figure 6. CCA ordination biplot of zooplankton assemblages and environmental variables (Station 1).

Abbreviations. *Biotic***.** Bidae (Brachionidae), CR (Cladocera richness), Cld (Cladocera), Chy (Chydoridae), Con (Conchostraca), Cop (Copepoda), Dap (Daphniidae), L-idae (Lecanidae), Ost (Ostracoda), Riz (Rhizopoda), RR (rotifer richness), Rot (Rotifera), Zoo (zooplankton), Z SpD (zooplankton species diversity), Z Dom (zooplankton dominance), Z Evn (zooplankton evenness); *Abiotic*. Alk (alkalinity), CO_2 (free carbon dioxide), Cond (conductivity), DO (dissolved oxygen), Hard (hardness), pH (hydrogen-ion concentration), Po4 (phosphate), Rain (rainfall), Trans (transparency), Wt (water temperature)

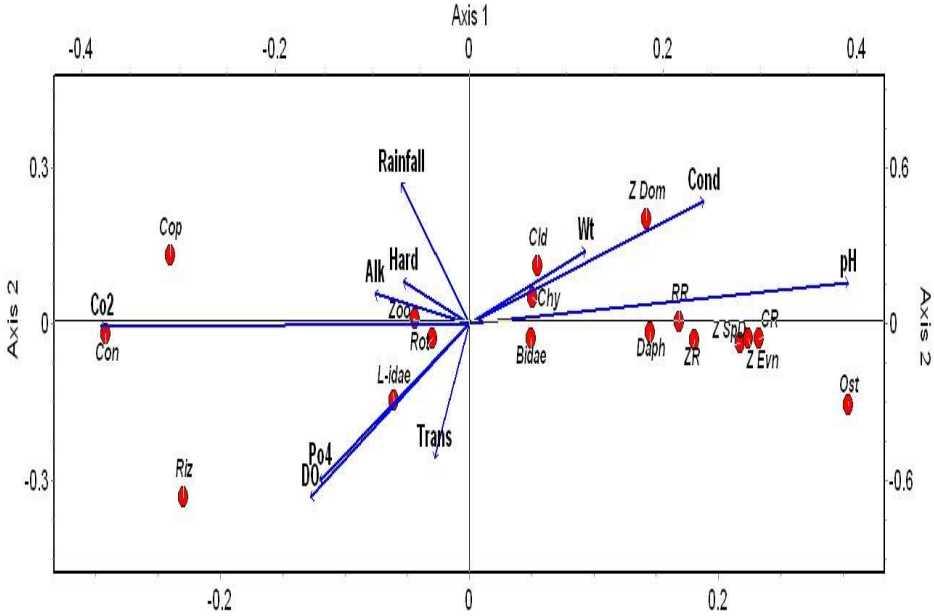

Figure 7. CCA ordination biplot of zooplankton assemblages and environmental variables (Station 2)

Abbreviations. *Biotic.* Bidae (Brachionidae), CR (Cladocera richness), Cld (Cladocera), Chy (Chydoridae), Con (Conchostraca), Cop (Copepoda), Dap (Daphniidae), L-idae (Lecanidae), Ost (Ostracoda), Riz (Rhizopoda), RR (rotifer richness), Rot (Rotifera), Zoo (zooplankton), Z SpD (zooplankton species diversity), Z Dom (zooplankton dominance), Z Evn (zooplankton evenness); *Abiotic.* Alk (alkalinity), CO_2 (free carbon dioxide), Cond (conductivity), DO (dissolved oxygen), Hard (hardness), pH (hydrogen-ion concentration), Po4 (phosphate), Rain (rainfall), Trans (transparency), Wt (water temperature)

Ecological relationships

Interestingly this study showed lack of influence individual abiotic factors on zooplankton richness and also much limited influence on their abundance. The canonical correspondence analysis (CCA) with ten abiotic parameters, however, explained nearly equal cumulative variance (56.0 % and 55.8 %) of zooplankton assemblages along axis 1 and 2 with importance of free carbon dioxide, hardness and pH, and free carbon dioxide, pH, dissolved oxygen and conductivity at stations 1 and 2, respectively. At station 1, richness of zooplankton, Rotifera and Cladocera; Brachionidae and Daphniidae abundance, species diversity and evenness are influenced by pH; zooplankton, Rotifera, Rhizopoda and Lecanidae abundance are influenced by high values of free carbon dioxide. Low free carbon dioxide influenced Copepoda abundance. Cladocera, Chydoridae and Ostracoda densities are influenced by high rainfall and zooplankton dominance is influenced by low transparency and dissolved oxygen. On the other hand, Rotifera richness, Cladocera richness, zooplankton richness, Brachionidae, Daphniidae, species diversity and evenness are influenced by pH; zooplankton, Rotifera and Lecanidae abundance is influenced by dissolved oxygen and phosphate; Cladocera, Chydoridae and Ostracoda densities are influenced by high conductivity and zooplankton dominance is influenced by low conductivity. Consequently, the littoral and semi-limnetic stations are characterized by micro-environmental differences.

CONCLUSION

The zooplankton mainly contributed to richness and abundance net plankton, showed species-rich and diverse character with rich diversity and quantitative importance of Rotifera > Cladocera. This study exhibited no definite monthly pattern of richness variations while abundance is relatively high from July through December. Our results showed high species diversity, high evenness, low dominance, and low densities of majority of zooplankton. The results indicated no significant relationship of individual abiotic factors on richness and also showed much limited influence on abundance. CCA with ten abiotic parameters explained 56.0 % and 55.8 % cumulative variance of zooplankton assemblages along axis 1 and 2 at stations 1 and 2, respectively. The importance of different abiotic factors in CCA analysis consequently reflected micro-environmental differences between the sampling stations.

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Supporting online material: Appendix I–IV. (http://opuscula.elte.hu/PDF/Tomus43_2/Sharma_Appendix.pdf)

Appendix I. Temporal variations (range, average ± SD) of abiotic parameters
(after Sharma & Sharma 2012)

		Station 1		Station 2	
FACTORS		Range	Average ± SD	Range	Average ± SD
Water temperature	^{0}C	19.7 – 33.2	27.8 ± 4.0	20.2 – 32.7	27.9 ± 3.7
Rainfall	mm	4.8 – 365.0	150.4. ± 145.7	4.8 – 365.0	150.4 ± 145.7
Transparency	cm	16.0 – 76.0	52.7 ± 20.5	17.0 – 79.0	55.4 ± 21.2
pH		6.72 – 7.16	6.95 ± 0.12	6.75 – 7.12	6.94 ± 0.11
Specific conductivity	μS cm^{-1}	99.0 – 193.0	137.8 ± 30.0	108.0 – 190.0	136.9 ± 27.8
Dissolved oxygen	mg L^{-1}	4.0 – 8.0	6.5 ± 1.2	4.0 – 8.2	6.1 ± 1.4
Free carbon dioxide	mg L^{-1}	4.0 – 30.0	11.3 ± 7.0	2.0 – 28.9	10.9 ± 6.8
Alkalinity	mg L^{-1}	50.0 – 84.0	64.8 ±10.0	52.0 – 81.0	66.3 ± 9.4
Hardness	mg L^{-1}	48.0 – 68.0	56.8 ± 75.1	46.0 – 70.0	57.3 ± 7.8
Calcium	mg L^{-1}	24.1 – 42.4	35.1 ± 5.9	25.7 – 47.3	34.5 ± 5.8
Magnesium	mg L^{-1}	0.9 – 7.5	4.9 ± 2.2	0.8 – 7.5	5.3 ± 2.1
Chloride	mg L^{-1}	18.9 – 42.9	28.5 ± 6.4	16.9 – 43.9	27.5 ± 6.8
Dissolved organic matter	mg L^{-1}	0.9 – 3.8	2.66 ± 0.87	0.8 – 3.8	2.38 ± 0.80
Total dissolved solids	mg L^{-1}	1.1 – 2.9	1.97 ± 0.52	1.1 – 2.9	2.01 ± 0.50
Phosphate	mg L^{-1}	0.095 – 0.351	0.171 ± 0.083	0.099 – 0.341	0.170 ± 0.077
Sulphate	mg L^{-1}	6.3 – 30.3	15.52 ± 7.41	6.8 – 26.3	14.43 ± 6.23
Nitrate	mg L^{-1}	0.272 – 1.548	1.011 ± 0.375	0.268 – 1.521	1.016 ± 0.373
Silicate	mg L^{-1}	0.599 – 2.657	1.687 ± 0.692	0.543 –2.704	1.710 ± 0.700
B.O.D$_5$	mg L^{-1}	1.6 – 4.4	2.72 ± 0.70	1.4 – 4.8	2.63 ± 0.86

Appendix II: Monthly zooplankton abundance (ind. L^{-1}) at station 1

Species ↓ Months→	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Rotifera												
Family : Brachionidae												
Anuraeopsis coelata De Beauchamp	0	0	1	0	0	0	0	0	0	0	2	0
A. fissa Gosse	0	1	0	0	3	2	0	3	0	0	0	2
Brachionus angularis Gosse	1	0	3	2	0	0	3	3	0	0	5	2
B. bidentatus Anderson	0	2	1	0	0	4	0	0	3	6	0	4
B. calyciflorus (Pallas)	1	1	3	0	0	0	2	3	6	2	4	0
B. caudatus (Barrois & Daday)	3	5	2	3	0	3`	2	0	3	0	8	4
B. diversicornis (Daday)	1	1	3	0	0	0	0	2	0	4	3	0
B. falcatus Zacharias	5	13	7	17	21	25	19	10	7	15	9	6
B. forficula Wierzejski	2	3	3	0	1	0	2	2	2	0	0	2
B. mirabilis (Daday)	0	0	0	2	1	2	0	0	0	2	0	1
B. quadridentatus (Hermann)	2	1	2	0	4	0	0	4	2	2	0	3
B. rubens Ehrenberg	0	0	0	2	2	0	0	0	2	0	0	1
Plationus patulus (Muller)	7	7	8	8	7	5	6	9	10	10	7	7
Platyias quadricornis (Ehrenberg)	3	1	2	6	8	7	2	1	3	2	6	5
Keratella cochlearis Gosse	12	10	4	9	9	5	3	4	9	14	12	9
K. lenzi Hauer	2	1	0	2	0	0	0	0	2	1	0	2
K. procurva (Thorpe)	0	0	0	2	3	2	0	0	1	0	2	0
K. quadrata (Muller)	0	1	1	0	0	3	4	0	0	4	2	0
K. tropica (Apstein)	3	2	1	0	4	4	2	1	3	8	10	5
Family : Euchlanidae												
Dipleuchlanis propatula (Gosse)	0	0	0	0	2	0	0	0	0	0	0	3
Euchlanis dilatata Ehrenberg	4	6	8	6	9	3	6	7	4	6	5	7
E. triquetra Ehrenberg	1	0	0	0	0	0	2	0	0	0	0	0
Family : Mytilinidae												
Mytilina bisulcata (Lucks)	0	0	2	2	0	0	0	0	2	0	1	2
M. ventralis (Ehrenberg)	3	2	0	3	2	0	0	2	0	2	3	4
Family : Trichotriidae												
Macrochaetus sericus (Thorpe)	2	1	0	1	1	0	1	0	2	2	3	2
Trichotria tetractis (Ehrenberg)	1	2	0	2	2	2	3	2	3	0	0	2
Family : Lepadellidae												
Colurella obtusa(Gosse)	1	0	2	0	2	1	0	0	2	0	0	2
C. uncinata (Muller)	2	0	0	3	0	0	2	2	3	0	1	1
Lepadella apsicora (Myers)	0	0	0	0	0	0	0	0	0	0	2	0
L. ehrenbergi (Perty)	1	0	1	0	2	3	0	1	0	2	0	2
L. heterostyla (Murray)	0	1	0	2	0	2	2	0	1	2	1	3
L. ovalis (Muller)	1	1	1	0	3	0	0	4	0	3	4	2
L. patella (Muller)	2	1	0	0	0	1	1	0	2	0	3	1
L. rhomboides (Gosse)	1	0	1	4	2	0	2	0	2	1	0	0
Family : Lecanidae												
Lecane aculeata (Jakubski)	0	0	2	3	3	0	0	0	1	2	0	0
L. bulla (Gosse)	6	1	1	4	4	5	6	10	8	16	23	12
L. closterocerca (Schmarda)	1	1	1	3	2	0	2	2	3	3	0	2
L. crepida (Harring)	0	0	0	0	1	0	2	0	0	2	0	0
L. curvicornis (Murray)	5	6	9	5	5	3	3	2	6	9	7	5
L. furcata (Murray)	0	3	0	0	2	0	0	2	0	3	0	1
L. hamata (Stokes)	1	2	1	0	0	0	0	0	2	0	0	0
L. hornemanni (Ehrenberg)	3	0	0	0	0	0	0	0	4	0	0	0
L. inermis (Bryce)	0	0	0	0	0	2	0	0	0	0	0	0

Appendix II: Monthly zooplankton abundance (ind. L^{-1}) at station 1 (continued)

Species ↓ Months→	J	F	M	A	M	J	J	A	S	O	N	D
Rotifera (continued)												
Family : Lecanidae												
Lecane inopinata (Harring &Myers)	0	0	0	2	0	2	0	0	2	0	1	0
L. lateralis Sharma	0	0	1	0	0	0	0	0	0	0	2	0
L. leontina (Turner)	2	2	3	4	0	5	8	12	7	4	6	5
L. luna (Muller)	1	0	0	0	0	4	3	2	0	1	3	0
L. lunaris (Ehrenberg)	1	1	0	0	0	3	0	2	0	3	2	0
Lecane nana (Murray)	0	0	0	1	0	4	0	0	0	2	0	0
L. ohioensis (Herrick)	0	0	0	3	0	0	0	0	0	2	4	6
L. papuana (Murray)	0	0	1	0	0	3	0	0	2	0	2	0
L. pertica (Harring & Myers)	0	2	0	0	2	0	0	0	0	2	0	0
L. ploenensis (Voigt)	0	4	1	0	0	0	0	0	2	3	0	1
L. pyriformis (Daday)	0	1	0	2	0	0	0	0	1	2	0	1
L. quadridentata (Ehrenberg)	2	0	1	0	0	3	0	6	4	0	3	5
L. thienemanni (Hauer)	0	2	0	3	0	4	2	2	0	0	1	0
L .unguitata (Fadeev)	2	1	2	4	2	3	4	3	2	3	6	2
L. ungulata (Gosse)	1	2	1	0	0	6	4	0	6	4	0	5
Family : Notommatidae												
Cephalodella forficula (Ehrb.)	0	2	0	0	2	0	3	2	0	2	0	1
Monommata longiseta (Muller)	0	1	2	4	2	0	2	4	0	2	2	0
Family : Scaridiidae												
Scaridium longicaudum (Muller)	1	0	2	0	6	5	0	2	0	1	4	2
Family : Trichocercidae												
Trichocerca capucina (Wierzejski & Zacharias)	0	1	0	3	2	3	2	0	2	2	0	0
T. cylindrica (Imhof)	0	2	1	3	0	0	2	2	6	5	0	2
T. elongata(Gosse)	0	0	4	2	0	0	0	2	0	0	2	0
T. longiseta (Schrank)	1	0	1	0	0	3	0	3	2	4	2	6
T. porcellus (Gosse)	0	1	1	0	4	2	3	3	0	2	0	1
T. similis (Wierzejski)	1	3	1	0	0	2	0	0	4	3	1	0
Family : Asplanchnidae												
Asplanchna priodonta Gosse	0	1	7	8	14	23	28	32	24	18	26	13
Family : Synchaetidae												
Polyarthra vulgaris Carlin	6	2	3	11	4	3	14	4	14	6	16	9
Family : Floscularíidae												
Sinantherina socialis Bory de St. Vincent	17	0	9	0	14	18	12	20	0	14	0	10
S. spinosa (Thorpe)	0	0	0	7	6	12	30	0	12	6	12	0
Family : Conochilidae												
Conochilus unicornis Rousselet	0	5	0	0	0	8	12	14	10	16	0	8
Family : Hexarthridae												
Hexarthra mira (Hudson)	0	1	0	0	0	0	0	0	1	0	2	0
Family : Trochosphaeridae												
Filinia camascela Myers	0	4	0	0	0	8	0	0	0	0	8	6
F. longiseta (Ehrenberg)	1	0	1	0	0	0	0	0	4	0	3	0
F. pejleri (Hutchinson)	0	1	1	0	0	4	2	2	0	3	0	0
F. opoliensis (Zacharias)	0	1	0	2	0	0	3	3	0	0	0	2
Trochosphaera aequatorialis Semper	0	0	0	0	4	6	0	10	0	0	0	0
Family : Testudinellidae												
Testudinella emarginula (Stenroos)	0	1	0	2	0	0	2	0	2	0	0	2
T. greeni Koste	0	0	0	0	0	0	0	0	0	0	3	0
T. patina (Hermann)	3	0	4	3	3	6	14	4	6	0	8	5
T. tridentata Smirnov	0	0	0	3	0	0	0	2	0	0	0	0
Family : Philodinidae												
Rotaria rotatoria (Pallas)	1	0	1	0	0	0	0	0	0	0	0	0
R. neptunia (Ehrenberg)	1	0	0	0	1	0	0	0	1	0	0	0

Appendix II. Monthly zooplankton abundance (ind. L^{-1}) at station 1 (continued)

Species ↓ Months→	J	F	M	A	M	J	J	A	S	O	N	D
Cladocera												
Family: Sididae												
Diaphanosoma excisum Sars	1	1	1	4	3	2	4	8	4	6	3	3
D. senegal Gauthier	1	3	2	3	3	2	3	4	2	3	2	2
Pseudosida bidentata Herrick	0	0	1	0	0	4	0	0	2	3	0	0
Sida crystallina (O.F.Muller)	0	1	0	0	3	4	0	6	0	0	4	0
Family: Daphnidae												
Ceriodaphnia cornuta Sars	0	2	2	0	0	4	4	6	3	2	3	0
C. quadrangula (O.F.Muller)	0	0	1	0	0	0	3	0	2	0	1	0
Scapholeberis kingi Sars	3	1	6	4	2	3	7	4	3	3	5	4
Simocephalus vetulus (O.F.Muller)	1	2	2	3	4	4	5	2	-	4	4	2
S. serrulatus (Koch)	1	2	1	2	2	3	3	2	2	0	3	2
Family : Moinidae												
Moina micrura Kurz	0	3	3	0	0	8	7	8	0	0	6	8
Moinodaphnia macleayi (King)	0	0	0	0	0	0	2	2	0	2	0	0
Family : Bosminidae												
Bosmina longirostris (O.F.Muller)	4	0	8	0	14	19	24	0	0	0	14	17
Bosminopsis deitersi Richard	3	0	0	2	12	16	19	0	0	4	10	12
Family : Macrothricidae												
Macrothrix triserialis (Brady)	1	1	3	4	0	0	3	2	3	2	1	2
M. laticornis (Jurine)	3	3	1	0	0	4	0	3	2	2	4	3
Grimaldina brazzai Richard	0	0	0	0	2	3	0	0	4	0	0	2
Family: Ilyocryptidae												
Ilyocryptus spinifer Herrick	0	1	3	0	0	8	4	0	3	2	2	0
Family: Chydoridae												
Acroperus harpae (Baird)	2	0	1	0	3	8	3	0	4	0	2	2
Alona affinis (Leydig)	3	0	4	0	0	2	0	0	4	0	2	0
A. cheni Sinev	0	4	2	3	2	0	3	0	3	2	0	4
A. guttata Sars	0	0	0	0	0	0	0	0	0	4	5	0
A. intermedia Sars	3	0	3	4	3	0	2	4	3	0	2	4
A. quadrangularis (O.F.Muller)	0	3	3	0	3	3	2	4	0	3	2	3
Alonella excisa (Fischer)	3	0	7	0	0	3	4	0	5	8	0	6
Camptocercus uncinatus Smirnov	1	0	3	0	0	3	2	2	1	2	0	0
C. faviformis Birge	0	0	3	0	0	4	0	0	0	3	0	0
C .ovalis Kurz	1	2	2	0	4	0	0	0	2	0	2	0
C. reticulatus Daday	0	0	2	0	0	0	0	0	4	2	0	0
C. sphaericus (O.F.Muller)	8	3	4	9	7	18	10	8	16	22	12	32
Coronatella rectangula (Sars)	0	1	0	0	0	2	0	2	0	0	0	1
Dadaya macrops (Daday)	0	0	0	0	0	0	0	8	6	0	0	0
Dunhevedia serrata King	0	0	2	0	3	4	0	0	0	0	2	0
Ephemeroporus barroisi (Richard)	7	2	3	7	12	4	6	8	6	5	12	17
Euryalona orientalis (Daday)	1	2	0	0	0	6	2	0	2	0	0	4
Grimaldina testudinaria (Fischer)	3	0	1	0	2	1	0	2	0	2	0	0
Karualona karua (King)	2	3	2	3	4	4	8	10	7	6	9	12
Kurzia longirostris (Daday)	2	0	1	0	3	2	3	4	0	3	2	1
Leydigia acanthocercoides (Fischer)	1	1	0	0	0	4	0	4	0	3	0	0
Leydigiopsis sp.	4	0	0	0	0	0	0	0	0	0	0	0
Notalona globulosa (Daday)	0	4	3	7	4	0	7	12	14	0	8	7
Oxyurella singalensis (Daday)	1	3	1	2	0	0	3	0	3	0	4	0
Picripleuroxus similis Vavra	0	2	0	0	0	4	3	8	10	7	0	4

Appendix II: Monthly zooplankton abundance (ind. L^{-1}) at station 1 (continued)

Species ↓ Months→	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Copepoda												
Mesocyclops spp.	8	9	7	32	28	16	52	38	27	22	53	59
Diaptomus sp.	3	0	2	0	0	6	7	16	7	5	12	10
Nauplius larvae	1	0	2	4	3	3	4	8	10	12	7	12
Rhizopoda												
Arcella discoides Ehrenberg	1	4	6	0	0	4	3	2	0	3	13	2
A.dentata Ehrenberg	0	0	0	0	0	0	0	0	0	0	0	0
A. megastoma Ehrenberg	0	0	0	0	0	0	0	0	0	0	0	0
A. vulgaris Ehrenberg	0	0	0	0	0	0	0	0	0	0	0	0
Centropyxis aculeata (Ehrenberg)	2	3	0	4	0	0	0	2	1	3	3	1
C. arcelloides Penard	0	0	0	0	0	0	0	0	0	0	0	0
C. hemispherica (Bernard)	1	4	1	0	3	0	4	4	3	2	1	2
Difflugia lebes Penard	1	0	1	0	0	3	0	4	2	2	1	1
D .oblonga Ehrenberg	0	0	0	0	0	0	0	0	0	0	0	0
D. urceolata Carter	1	0	0	0	0	4	7	2	3	3	2	2
Euglypha ciliata Ehrenberg	0	1	1	6	2	0	4	0	2	0	3	2
Ostracoda												
Cypricercus sp.	2	0	2	6	8	16	9	0	0	4	3	3
Oncocypris sp.	6	0	3	0	4	4	0	6	7	5	8	8
Conchostraca	0	0	1	0	3	4	3	3	4	2	2	6
Rotifera ind.L^{-1}	**117**	**117**	**118**	**158**	**171**	**216**	**225**	**212**	**212**	**233**	**242**	**196**
Cladocera ind.L^{-1}	**60**	**50**	**81**	**57**	**95**	**156**	**146**	**123**	**120**	**105**	**126**	**154**
Copepoda ind.L^{-1}	**12**	**9**	**11**	**36**	**31**	**25**	**63**	**62**	**44**	**39**	**72**	**81**
Rhizopoda ind.L^{-1}	**6**	**12**	**9**	**10**	**5**	**11**	**18**	**14**	**11**	**13**	**23**	**10**
Ostracoda ind.L^{-1}	**8**	**0**	**5**	**6**	**12**	**20**	**9**	**6**	**7**	**9**	**11**	**11**
Conchostraca ind.L^{-1}	**0**	**0**	**1**	**0**	**3**	**4**	**3**	**3**	**4**	**2**	**2**	**6**
ZOOPLANKTON ind.L^{-1}	**203**	**188**	**225**	**267**	**317**	**432**	**464**	**420**	**398**	**401**	**476**	**458**

0 refers to below detection limit, Rotifera (after Sharma & Sharma 2012)

Appendix III. Monthly zooplankton abundance (ind. L^{-1}) at station 2

Species ↓ Months→	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Rotifera												
Family : Brachionidae												
Anuraeopsis fissa (Gosse)	2	0	1	0	3	4	0	3	4	0	2	2
Brachionus angularis Gosse	1	0	3	2	0	0	2	3	0	0	6	0
B. bidentatus Anderson	0	2	1	0	0	4	0	0	3	6	0	4
B. calyciflorus (Pallas)	1	1	3	0	0	0	0	6	12	0	4	0
B. caudatus (Barrois & Daday)	2	2	13	3	0	0	4	0	3	0	14	8
B. diversicornis (Daday)	1	1	3	0	0	0	0	2	0	4	3	0
B. falcatus Zacharias	0	5	7	0	17	19	14	0	7	14	0	8
B. forficula Wierzejski	0	1	3	0	0	3	2	2	2	0	3	0
B. mirabilis (Daday)	0	0	0	0	3	2	0	0	0	2	0	1
B. quadridentatus (Hermann)	2	1	2	0	4	0	0	4	2	2	0	3
B. rubens Ehrenberg	0	0	0	2	2	0	0	0	2	0	0	1
Plationus patulus (Muller)	3	4	3	11	9	7	15	3	13	2	11	23
Platyias quadricornis (Ehrenberg)	1	1	2	0	0	3	4	6	4	2	2	4
Keratella cochlearis Gosse	7	2	4	6	4	0	7	8	6	10	7	4
K. lenzi Hauer	1	1	0	4	0	0	0	0	2	3	0	2
K. procurva (Thorpe)	0	0	0	2	3	4	0	0	0	0	2	0
K. quadrata (Muller)	0	1	1	0	0	3	4	0	0	4	2	0
K. tropica (Apstein)	1	0	1	0	0	4	0	2	0	4	3	0
Family : Euchlanidae												
Dipleuchlanis propatula (Gosse)	0	2	1	0	0	4	3	4	2	0	3	2
Euchlanis dilatata Ehrenberg	4	13	9	14	9	7	10	14	8	10	16	22
Family : Mytilinidae												
Mytilina bisulcata (Lucks)	3	0	1	0	0	2	0	0	2	0	3	0
M. ventralis (Ehrenberg)	2	1	4	0	0	3	4	2	4	0	0	6
Family : Trichotriidae												
Macrochaetus sericus (Thorpe)	0	2	1	2	0	0	3	5	4	2	0	3
Trichotria tetractis(Ehrenberg)	1	2	1	0	2	0	3	2	3	0	0	2
Family : Lepadellidae												
Colurella obtusa (Gosse)	1	0	2	0	0	4	0	0	2	3	0	2
C. uncinata (Muller)	2	0	0	3	0	0	2	2	3	0	1	1
Lepadella apsicora (Myers)	0	1	0	0	4	3	1	0	3	0	2	2
L. ehrenbergi (Perty)	1	0	1	0	2	3	0	1	0	2	0	2
L. heterostyla (Murray)	1	0	0	2	0	0	2	0	1	4	0	3
L. ovalis (Muller)	1	1	1	0	3	0	0	4	0	3	4	2
L. patella (Muller)	1	0	2	0	0	3	0	2	2	0	3	0
L. rhomboides (Gosse)	0	0	1	4	3	0	0	0	2	1	0	0
Family : Lecanidae												
Lecane aculeata (Jakubski)	0	0	2	3	3	0	0	0	1	2	0	0
L. bulla (Gosse)	6	1	1	4	4	5	6	10	8	16	23	12
L. crepida (Harring)	0	0	1	0	1	3	2	0	0	2	0	0
L. closterocerca (Schmarda)	1	1	1	3	2	0	2	2	3	3	0	2
L. curvicornis (Murray)	2	0	8	2	4	4	3	2	8	6	4	3
L. hamata (Stokes)	1	2	1	0	0	0	0	0	2	0	0	0
L. hornemanni (Ehrenberg)	3	0	1	0	0	2	0	0	4	3	2	1
L. inopinata (Harring & Myers)	0	0	0	2	0	1	0	0	2	1	1	0
L. leontina (Turner)	2	2	3	4	0	5	8	12	7	4	6	5
L. ludwigii (Eckstein)	0	0	1	3	2	0	2	2	4	3	0	2
L .luna (Muller)	1	0	0	0	0	2	3	2	0	1	3	0

Appendix III. Monthly zooplankton abundance (ind. L^{-1}) at station 2 (continued)

Species ↓ Months→	J	F	M	A	M	J	J	A	S	O	N	D
Rotifera (continued)												
Family : Lecanidae												
L. lunaris (Ehrenberg)	1	1	0	0	0	3	0	2	0	3	2	0
Lecane nana (Murray)	0	3	0	1	2	4	0	2	0	2	0	0
L. ohioensis (Herrick)	0	0	0	3	0	0	0	0	0	2	4	6
L. papuana (Murray)	0	0	1	0	0	3	0	0	2	0	2	0
L. pertica (Harring &Myers)	0	2	0	0	2	0	0	0	0	2	0	0
L. ploenensis (Voigt)	0	4	1	0	0	0	0	0	2	3	0	1
L. pyriformis (Daday)	0	1	0	2	1	0	0	0	1	2	0	1
L. quadridentata (Ehrenberg)	2	0	1	0	0	3	0	6	4	0	3	5
L. thienemanni (Hauer)	0	2	0	3	0	4	2	2	0	0	1	0
L .unguitata (Fadeev)	2	1	2	4	2	3	4	3	2	3	6	2
L. ungulata (Gosse)	1	2	1	0	0	6	4	0	6	4	0	5
Family : Notommatidae												
Cephalodella forficula (Ehrb.)	1	2	1	0	2	0	3	2	2	2	0	1
Monommata longiseta(Muller)	0	1	2	4	2	0	2	4	0	2	2	0
Family : Scaridiidae												
Scaridium longicaudum (Muller)	1	0	2	0	6	5	0	2	0	1	4	2
Family : Trichocercidae												
Trichocerca capucina	0	1	0	3	2	3	2	0	2	2	0	0
T. cylindrica (Imhof)	1	2	1	3	0	0	2	2	6	5	o	2
T. elongata(Gosse)	0	0	4	2	0	0	0	2	0	0	2	0
T. longiseta (Schrank)	1	0	1	0	0	3	0	3	2	4	2	6
T. porcellus (Gosse)	0	1	1	0	4	2	3	3	0	2	0	1
T. similis (Wierzejski)	1	3	1	0	0	2	0	0	4	3	1	0
Family : Asplanchnidae												
Asplanchna priodonta Gosse	0	1	7	8	14	23	28	32	24	18	26	13
Family : Synchaetidae												
Polyarthra vulgaris Carlin	6	2	3	11	4	3	14	4	14	6	16	9
Family : Dicranophoridae												
Dicranophorus forcipatus(Muller)	1	0	1	3	0	0	0	2	2	0	3	2
Family : Flosculariidae												
Sinantherina socialis Bory de St.Vincent	17	0	9	0	14	18	12	20	0	14	0	10
S. spinosa (Thorpe)	0	0	0	7	6	12	30	0	12	6	12	0
Family : Conochilidae												
Conochilus unicornis Rousselet	0	5	0	0	0	8	12	14	10	16	0	8
Family : Hexarthridae												
Hexarthra mira (Hudson)	0	1	0	0	0	0	0	0	1	0	2	0
Family : Trochosphaeridae												
Filinia camascela Myers	0	3	0	0	0	8	0	0	0	0	8	6
F. longiseta (Ehrenberg)	1	0	1	0	0	0	0	0	4	0	3	0
F. pejleri (Hutchinson)	1	1	1	0	0	3	2	2	0	2	0	0
F. opoliensis (Zacharias)	0	2	1	2	0	0	3	3	0	1	0	4
Trochosphaera aequatorialis Semper	0	1	0	2	0	0	2	0	1	0	0	2
Family : Testudinellidae												
Testudinella emarginula (Stenroos)	0	0	0	0	4	6	0	10	0	0	0	0
T. greeni Koste	0	0	0	0	0	0	0	0	0	0	3	0
T. patina (Hermann)	2	0	3	3	3	6	14	4	7	0	8	3
T. tridentata Smirnov	0	0	0	3	0	0	0	2	0	0	0	0
Family : Philodinidae												
Rotaria neptunia (Ehrenberg)	0	0	0	0	0	0	0	3	2	0	4	2

Appendix III. Monthly zooplankton abundance (ind. L^{-1}) at station 2 (continued)

Species ↓ Months→	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Cladocera	0	0	0	0	0	0	0	0	0	0	0	0
Family: Sididae	0	0	0	0	0	0	0	0	0	0	0	0
Diaphanosoma excisum Sars	2	1	2	4	2	2	4	5	4	6	3	3
D senegal Gauthier	1	3	2	2	0	0	0	2	0	0	0	2
Pseudosida bidentata Herrick	0	0	0	0	0	4	0	0	0	2	0	0
Sida crystallina (O.F.Muller)	0	0	0	0	0	1	0	0	0	0	0	0
Family: Daphnidae												
Ceriodaphnia cornuta Sars	2	3	4	3	4	4	4	8	4	2	4	0
C. quadrangula (O.F.Muller)	0	0	1	0	0	0	0	0	0	0	1	0
Scapholeberis kingi Sars	2	1	4	2	2	3	4	4	3	3	4	4
Simocephalus vetulus (O.F.Muller)	1	2	2	1	4	4	2	2	0	4	4	2
S. serrulatus (Koch)	1	0	1	0	0	0	0	0	2	0	3	0
Family : Moinidae	0	0	0	0	0	0	0	0	0	0	0	0
Moina micrura Kurz	1	3	3	2	2	8	8	10	4	0	6	8
Moinodaphnia macleayi (King)	0	0	0	0	2	1	2	2	2	2	0	2
Family : Bosminidae	0	0	0	0	0	0	0	0	0	0	0	0
Bosmina longirostris (O.F.Muller)	6	8	10	12	20	20	24	8	4	6	10	5
Bosminopsis deitersi Richard	2	1	0	6	8	10	7	2	1	3	7	6
F : Macrothricidae	0	0	0	0	0	0	0	0	0	0	0	0
Macrothrix triserialis (Brady)	1	0	0	0	0	4	1	0	2	2	4	3
M. laticornis (Jurine)	1	1	3	2	0	0	3	2	3	2	1	2
Grimaldina brazzai Richard	0	0	0	0	2	3	0	0	4	0	0	2
Family: Ilyocryptidae												
Ilyocryptus spinifer Herrick	0	1	0	0	0	0	4	0	3	2	2	0
Family: Chydoridae												
Acroperus harpae (Baird)	2	0	1	0	3	0	2	0	4	0	2	2
Alona affinis (Leydig)	2	1	0	0	0	2	0	0	4	0	2	0
A. cheni Sinev	0	4	2	3	3	0	3	1	3	2	0	4
A. guttata Sars	0	0	0	0	0	1	0	0	0	1	1	0
A. intermedia Sars	3	0	1	4	4	0	2	0	3	0	2	0
A. quadrangularis (O.F.Muller)	0	2	0	0	2	1	2	2	0	0	0	0
Alonella excisa (Fischer)	3	0	3	0	0	2	4	1	2	6	0	6
Camptocercus uncinatus Smirnov	1	0	1	0	0	3	2	2	1	2	0	0
Chydorus sphaericus (O.F.Muller)	6	3	4	12	10	20	10	10	6	12	10	12
C. faviformis Birge	0	0	3	0	0	2	0	0	0	3	0	0
C. parvus Daday	0	0	2	0	1	2	1	0	0	0	0	0
C .reticulatus Daday	0	0	0	0	0	0	0	0	2	2	0	0
Coronatella rectangula (Sars)	0	1	0	0	0	0	0	2	0	0	0	1
Dadaya macrops (Daday)	0	0	0	0	0	1	0	4	4	0	0	0
Dunhevedia serrata King	0	0	2	1	2	2	1	0	0	0	3	0
Ephemeroporus barroisi (Richard)	6	2	3	8	12	4	6	4	6	5	10	6
Euryalona orientalis (Daday)	1	2	0	0	0	2	2	0	0	0	0	2
Grimaldina testudinaria (Fischer)	2	0	1	0	2	1	0	0	0	2	0	0
Karualona karua (King)	2	1	2	4	4	4	6	6	4	6	10	12
Kurzia longirostris (Daday)	2	0	1	0	4	4	3	4	0	2	2	1
Leydigia acanthocercoides (Fischer)	0	0	0	0	0	0	1	0	0	1	0	0
Leydigiopsis sp.	1	0	0	0	0	0	0	0	0	0	0	0
Notalona globulosa (Daday)	0	2	2	6	4	0	6	8	6	0	4	6
Oxyurella singalensis (Daday)	1	1	0	2	0	0	3	1	3	0	4	0
Picripleuroxus similis Vavra	0	2	0	0	0	2	3	0	2	4	0	4

Appendix III. Monthly zooplankton abundance (ind. L^{-1}) at station 2 (continued)

Species ↓ Months→	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Copepoda												
Mesocyclops spp.	8	9	10	20	31	60	52	29	39	20	53	61
Diaptomus sp.	2	0	2	0	0	6	7	6	7	4	12	12
Nauplius larvae	1	0	3	4	8	10	4	8	12	8	15	20
Rhizopoda												
Arcella discoides Ehrenberg	3	2	3	0	2	2	4	8	10	6	8	10
B.dentata Ehrenberg	0	0	0	0	0	0	0	0	0	0	0	0
B. megastoma Ehrenberg	0	0	0	0	0	0	0	0	0	0	0	0
A. vulgaris Ehrenberg	0	0	0	0	0	0	2	2	0	0	0	0
Centropyxis aculeata (Ehrenberg)	2	2	0	3	0	0	2	2	4	3	3	4
C. arcelloides Penard	0	0	0	0	0	0	0	0	0	0	0	0
C. hemispherica (Bernard)	1	2	1	0	3	0	2	4	6	3	2	6
Difflugia lebes Penard	1	0	1	0	0	0	0	0	4	3	2	3
D .oblonga Ehrenberg	0	0	0	0	0	0	0	0	0	0	0	0
D. urceolata Carter	1	0	0	0	0	2	0	3	4	3	2	4
Euglypha ciliata Ehrenberg	0	1	1	2	2	0	0	3	3	2	4	4
Actinosphaerium eichhorni Ehrenberg	1	0	2	3	3	2	3	4	5	4	4	4
Ostracoda												
Cypricercus sp.	2	1	4	3	4	3	7	5	6	4	5	2
Cypris sp.	4	0	0	0	0	0	2	2	1	4	2	1
Conchostraca	0	0	1	0	0	3	4	2	3	2	1	4
Rotifera ind.L^{-1}	**94**	**92**	**135**	**140**	**152**	**232**	**245**	**234**	**245**	**224**	**244**	**223**
Cladocera ind.L^{-1}	**52**	**45**	**60**	**74**	**97**	**117**	**120**	**90**	**86**	**82**	**99**	**95**
Copepoda ind.L^{-1}	**11**	**9**	**15**	**24**	**39**	**76**	**63**	**43**	**58**	**32**	**80**	**93**
Rhizopoda ind.L^{-1}	**9**	**7**	**8**	**8**	**10**	**6**	**13**	**26**	**36**	**24**	**25**	**35**
Ostracoda ind.L^{-1}	**6**	**1**	**4**	**3**	**4**	**2**	**9**	**3**	**4**	**8**	**7**	**3**
Conchostraca ind.L^{-1}	**0**	**0**	**1**	**0**	**0**	**3**	**4**	**2**	**3**	**2**	**1**	**4**
ZOOPLANKTON ind.L^{-1}	**172**	**154**	**223**	**249**	**302**	**436**	**454**	**398**	**432**	**372**	**456**	**453**

0 refers to below detection limit, Rotifera (after Sharma & Sharma 2012)

Appendix IV: Variance explained in the Canonical Correspondence Analysis (CCA) by the first two axes

Sampling Stations ↓ Canonical Axis →		**Axis 1**	**Axis 2**
Station 1			
Total variance in species data =	0.032469		
Sum of canonical Eigen values =	0.027169		
Sum of non-canonical Eigen values =	0.0053		
Canonical Eigen value =		0.0128441	0.00534
% variance explained =		39.5582	16.4466
Cumulative % variance =		39.5582	56.0048
Station 2			
Total variance in species data =	0.029389		
Sum of canonical Eigen values =	0.024149		
Sum of non-canonical Eigen values =	0.00524		
Canonical Eigen value =		0.0111394	0.0052678
% variance explained =		37.9039	17.9248
Cumulative % variance =		37.9039	55.8287

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Accidental vaginal parasitism by oligochaete worms (Annelida: Oligochaeta)

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Abstract. Two independent cases of oligochaete worms recovered from Korean women's vaginas are reported. Both specimens were non-parasitic cosmopolitan exotics identified as: microdrile tubificid *Limnodrilus hoffmeisteri* Claparède, 1862 (Tubificidae) and megadrile dichogastrid *Dichogaster bolaui* (Michaelsen, 1891) (Octochaetidae) – a new record for Korea. The tubificid is a freshwater euryhaline species that may reach high numbers in organically rich water e.g. in a paddy field, whereas the earthworm is commonly intercepted by quarantine in plant or vegetable cargos and also appears in bathtubs when it inhabits drainage systems. Thus, bathing/douching, field working or picnicking without a blanket are suggested as possible modes of ingress. Oligochaetes rarely occur in live human bodies but the few previous historical records are reviewed.

Keywords. Vagina, pseudo-parasitism, gynecology, medical, free-living, exotic worms.

INTRODUCTION

Terrestrial oligochaetes (earthworms and others) are diverse (~10,000 named species) and vitally important for primary production as their burrowing and saprophagic habits maintain healthy soil structure and fertility; furthermore, they form the basis of all terrestrial, and aquatic, trophic food-chains. Occasionally such worms are obtained from humans as accidental pseudo-parasites. Aside from helminths and parasitic nematodes, a few reports of incidental infections by non-parasitic worms are provided by Savignac (1910), Friend (1916a), Heymons (1926), Michaelsen (1926), Stiles & Hassall (1926), Müller (1927), Stephenson (1930, 1931), Stolte (1962) and Gates (1972, 1982). Species involved are sometimes relatively ineffectual enchytraeid "pot worms" [Enchytraeidae, e.g. *Enchytraeus sp.* in urine of a soldier, *Lumbricillus lineatus* (Müller, 1774) in a Mainz gentleman's excrement pot, etc.]. Other small, aquatic microdriles (Oligochaeta: Microdrilacea) have no previous data (T. Timm pers. comm.).

Larger, terrestrial earthworms (Oligochaeta: Megadrilacea) are beneficial and free-living, only rarely obtained from live human bodies. Summaries from historical records are:

1. *Eisenia fetida* (Savigny, 1826): as cited by Gates (1972: 103), this lumbricid compost-worm was identified by Dr D. Rosa from Italy as passed in urine of a female patient. An obscure Japanese report is of a male farmer supposedly coughing up a dozen or so *E. fetida* with (bloody?) phlegm over the course of three days and thus interpreted as a likely case of lung parasitism (Ryujin 1952).

2. "*Lumbricus melitensis*" an unknown entozoa, possibly a nematode, from arm of a Russian woman after it entered through her thumb (Duncan and Duncan 1798: 396).

3. *Lumbricus terrestris* Linnaeus, 1758: reports mentioned by Stephenson (1930: 644 ex Stiles and Hassall 1926) from vomitus and an ulcerated ankle are dismissed as almost certainly mistaken identity for this large, deep-burrowing European species with a false epithet of 'the common earthworm' (see Blakemore 1997).

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4. *Octolasion cyaneum* (Savigny, 1826): also cited by Gates (1972: 125) in a medical literature report of a specimen lodging in a woman's vagina for more than a year.

5. *Microscolex phosphoreus* (Dugès, 1837): a cosmopolitan bioluminescent acanthodrilid, reported by Stephenson (1930) as *Microscolex modestus* in a fistula.

6. *Dichogaster bolaui* (Michaelsen, 1891): Stephenson (1931: 38, 64) obtained two specimens of this octochaetid from the Australian Institute of Tropical Medicine from Kavieng, New Ireland (PNG), "*washed out of the vagina of a native woman*" but he found "*no reason to assume a prolonged sojourn of the worms in the vagina*". Gates (1982: 68–69) notes a case from Bulawayo "Southern Rhodesia" (= Zimbabwe) on 1st January, 1962 "*found by Dr. D. A. Parker, as reported by Miss I. M. Bennie, in litt., to R. W. Sims* [British Natural History Museum]*, in relation to the corpus callosum of a five year old African female who had died the previous day. No cysts were seen in the brain section and no other evidence of parasitic infestation was seen*".

MATERIAL AND METHODS

Medical specimens and photos were provided to the senior author for identification. Species were keyed using Blakemore (2000, 2010) and identification of the aquatic species compared to Brinkhust (1971). Small tissue samples were taken for DNA analysis although it was noted that formalin preservation was used for at least one specimen that may preclude results. If successful, data will be provided to GenBank (http://www.ncbi.nlm.nih.gov/genbank/). Specimens deposited in NIBR invertebrate collection have prefix INV. Discussion is confined to Remarks after the species accounts.

TAXONOMIC RESULTS

Annelida Lamarck, 1802
Oligochaeta Grube, 1850
Microdrilacea Benham, 1890
Naididae Ehrenberg, 1828
(alternatively known as Tubificidae Vejdovský, 1876)
Limnodrilus Claparède, 1862.

***Limnodrilus hoffmeisteri* Claparède, 1862**

(Figure 1)

Material examined. NIBR.INV000249940, specimen flattened but complete "*2012 April 18, collected from menstrual blood, live worm was fixed in 100% alcohol*". Provided by Professor J.-S. Ryu. Small tissue samples were taken for mtDNA COI barcoding (codes WO38, W15, W60).

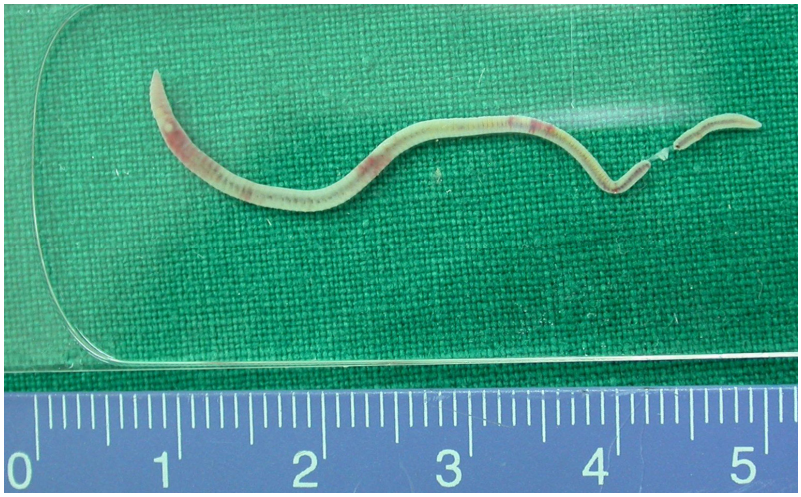

Figure 1. *Limnodrilus hoffmeisteri* photo

Remarks. This specimen was keyed using Brinkhurst (1971) to Tubificidae, an aquatic microdrile worm, with the closest morphological genus *Limnodrilus* and the specimen identified as *Limnodrilus hoffmeisteri* Claparède, 1862. Widespread and abundant, it is often found with ubiquitous *Tubifex tubifex* (Müller, 1774) and both species are already known from Korea (Brinkhurst *et al*. 1994, Timm 1999). Note that these early described species have extensive synonymies, for example, *Limnodrilus socialis* Stephenson, 1912 is a junior synonym of *L. hoffmeisteri*. mtDNA COI gene barcodes, thus far unsuccessful, should help confirm this tentative identification if obtained.

No previous account of such a microdrile obtained from a human could be found.

Megadrilacea Benham, 1890
Octochaetidae Michaelsen, 1900
(sub-family Benhamiinae Michaelsen, 1897 or
Trigastrinae Michaelsen, 1900)
Dichogaster Beddard, 1888.

***Dichogaster bolaui* (Michaelsen, 1891)**

(Figure 2)

Material examined. NIBR.INV000261269, adult worm provided in two halves "*2012.4.13, 91114, 117072 Cho-Rong Hwang, Iwon Medical Foundation*". A small tissue sample was taken for DNA (W58).

Remarks. This specimen was readily identified with *Dichogaster bolaui*. A full synonymy and description of the species is provided by Blakemore (1994, 2010).

D. bolaui is presumed to be a native to eastern Africa (Csuzdi et *al.* 2008) but often transported to the Caribbean, this possibly relating to the 'slave trade' or other commerce. It now has the wide tropical and subtropical distribution of a cosmopolitan species and is frequently found in greenhouses in temperate countries. Its type-locality was a tannery in Hamburg, Germany, by introduction, where it was found in fermenting bark.

Gates (1982) catalogued plant quarantine interceptions to the USA and gave this species' recorded distributions as: "*Australia (1 state), Bolivia, Borneo, Brasil, Burma (25 districts), Cameroons, Ceylon, Colombia, Congo, Dominica, Germany, Guyana, Haiti, India, Jamaica, Java, Madagascar, Malay Peninsula, Mexico, Mozambique, New Caledonia, New Hebrides, Nigeria, Pakistan, Panama, Philippines, South Africa, Sumatra, Trinidad, Uganda, United States (3 states), Cape Verde, Caroline, Christmas, Comoro, Easter, Hawaiian, Loyalty, Marianna, Palau and Solomon Islands.*" He seemingly overlooked his earlier (Gates 1972: 279) records from Bangladesh, Hainan, Krakatau, New Hebrides, Pakistan and Togo.

To this distribution Blakemore (1994, 2010) added reports from Australia e.g. NSW and Qld. including from a beach and "Domus" composting toilet septic tank (pers. obs.), plus further reports from Kenya, Oman, China, Venezuela, Paraguay, Argentina, El Salvador, Honduras, Belize, Costa Rica, Cuba, Dominican Republic, Honduras, Jamaica, Santa Cruz (Galapagos Islands, Ecuador – confirmation of Csuzdi (2000)), Papua New Guinea (PNG as noted above) and Europe. These latter European reports were from sewage systems in several towns of Finland (Terhivuo 1991) and in Stockholm, Sweden (Erséus *et al*. 1994) and from drains of a heated indoor swimming pool in Cork, Ireland (Rota & Schmidt 2006). The latter authors claimed first record of *D. bolaui* from Ireland but were incorrect to say this was the first from the British Isles since Friend (1916b) had already recorded it from Botanic Gardens at Oxford, England.

Reports in baths/toilet bowls and drains in Allahabad, Uttar Pradesh in India (Gates 1972: 280) and more recently in such fixtures in Scandinavia, as well as in bathtubs, showers, and sewer pipes in Hungary and Israel led Csuzdi *et al.* (2008) to suggest it as a first 'domicole' species, i.e., adapted to inhabit houses, and further provides a possible means of entry into the patients, viz. during ablutions. Ingestion is obviously excluded as a mode of access, but at least one of the current patients douched daily which may be a source of such opportunistic infection.

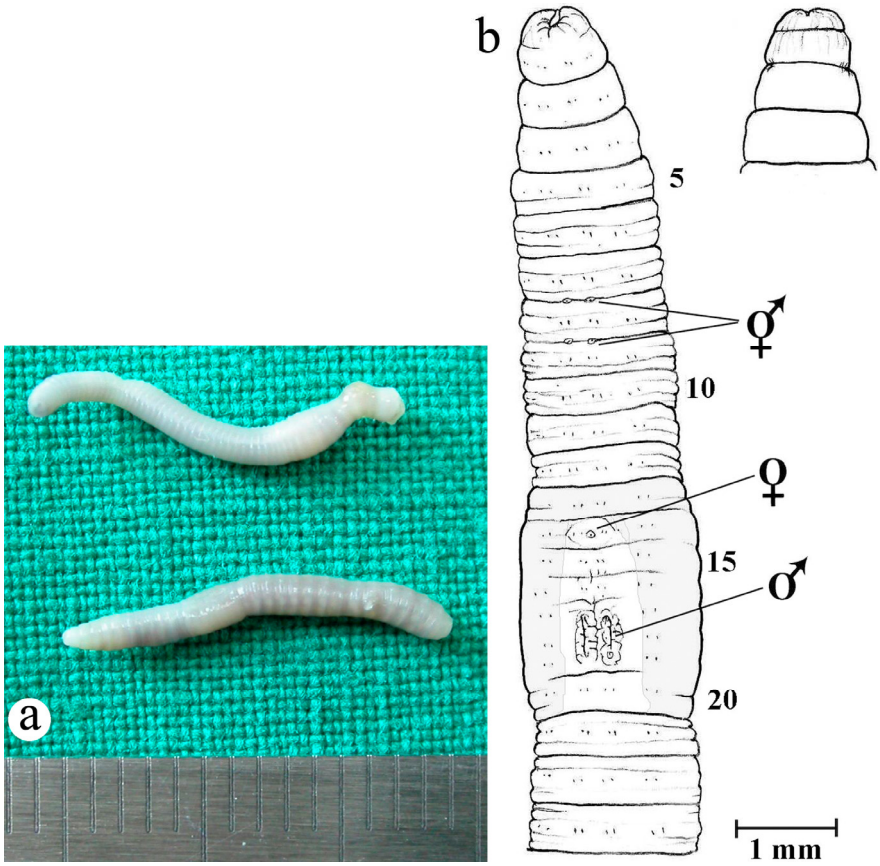

Figure 2. a = *Dichogaster bolaui* photo, b = *camera lucida* sketch of habitus and anterior dorsum (scale 1 mm).

The current paper, whilst providing the first record of *Dichogaster bolaui* for Korea, also confirms earlier reports of it as an adventitious pseudo-parasite of humans. Residence by these worms is presumably benign – apart from anxiety or embarrassment induced in the patient upon initial discovery – albeit earthworms host their own diverse parasitic and symbiotic burdens (Stephenson 1930, Gates 1972, Poinar 1978, Yeates *et al.* 1998).

Such intimate pseudo-parasitic encounters, if more frequent, may resemble behavioural events precursory to the parasitic lifestyle as adopted by the earthworm's cousin, the blood-feeding leech (Hirudinea) and as indicated by Michaelsen (1926).

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Requirements for representative sampling for fluvial fish assemblages – literary review

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Abstract. Fish are good indicators of long-term changes of fluvial ecosystems therefore, assessment of fish assemblages is frequently used in evaluation of the ecological status of surface waters, especially since the implementation of the EU Water Framework Directive. Long-term changes of fish fauna and old-time abundance of fish populations in the Danube can be documented by historical data of fisheries. Direct detection of long-term changes of fish populations in large rivers is a difficult task due to large-scale temporal and spatial variability of fish distribution. The present study provides a review of river fish sampling methods, with special attention to approaches based on electrofishing. Our goal is to develop a standard monitoring method in large rivers to get more reliable and consistent data for description of long-term changes of fish populations.

Keywords. Monitoring, standard sampling, electric fishing, Danube.

INTRODUCTION

Fish are sensitive indicators of the environmental changes of rivers. The continuously changing water regime, as well as hydraulical and hydromorphological characteristics of large rivers have significant impact on composition and spatial distribution of fish assemblages (Amoros *et al.* 1987, Welcomme 1985, Fausch *et al.* 1990, Sheehan & Rasmussen 1999, Guti 2002a, Lapointe *et al.* 2006). Growing needs of human population have had a major impact on river ecosystems, leading to the loss of aquatic habitats and providing several threats to fish populations and biodiversity since the 18th century. The long-term changes of the Danube fish fauna and abundance are detectable in the differences between the historical records of fisheries documented in the Middle Ages (Herman 1887, Khin 1957) and those of present times, as well as in the decreasing trends of annual catch of traditional fishing in the second half of the 20th century (Guti 1993, 2008, Schiemer et al. 2004, Guti & Gaebele 2009).

In the qualification of surface waters the assessment of biological integrity or ecological status has gained more and more emphasis in the latter decades (Angermeier & Karr 1986, Karr *et al.* 1987, Schmutz *et al.* 2007a). Fish-based methods of the assessment of ecological integrity of water bodies began to appear in the 1980s, *eg.* Index of Biotic Integrity (Karr 1981) and European Fish Index (Schmutz *et al.* 2007b). Fish are essential objects in evaluation of ecological status of freshwater ecosystems, as the organisms on the top of the aquatic food web, because they integrate the changes taking place on lower trophic levels. Their habi-tat needs change continuously on the course of their ontogenesis, thus occurrence of self-sustaining populations may indicate the diversity and connectivity of aquatic habitats (Copp 1989, Wel-comme 1995, Jungwirth, Schmutz & Weiss 1998, Schmutz & Jungwirth 1999). In Europe, in relation with the Water Framework Directive (WFD) (EC 2000), the assessment methods elaborated to qualify surface waters place great emphasis on biological examinations, in which fish take an essential role, opposed to traditional physical and chemical monitoring.

Trends of long-term changes of fish populations indicate alteration of the ecological integrity of rivers. One of the essential criteria of detection of long-term changes in fish populations is the establishment of a dataset, based on the consistent and representative surveys of the abundance and composition of fish assemblages (Guti 2002b). One of the crucial design problems of the fish monitoring of large rivers is determination of the appropriate temporal and spatial scale of sampling, which need to fit into extent of expected impacts. In this case variability of sampling results indicates the actual changes of the fish populations.

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The database of annual catches of the commercial fishermen, who fish more than 200 days per year in the Danube, are based on a large scale "observation" in space and time (Jancsó & Tóth 1987, Guti 2008). The robust data of fisheries are indicative to the interannual changes, because less dependent on the local environmental (water level, flow velocity, *etc*.) and biological (diurnal and seasonal movements, *etc*.) factors, which can result sampling distortion in smaller scale long-term studies. If the methods and intensity of fishing is unchanged for many years, data of annual catches can be treated as a consistent dataset in case of some fish species. However, the traditionnal commercial fishing is a disappearing occupation along the Danube in Hungary, so catch statistics of fisheries becoming less and less evaluable for the indirect monitoring of the fluvial fish populations.

In the case of direct monitoring of the long-term changes of fish populations, the consistency of datasets can be secured on the one hand by precise definition of sampling methods (equipment and techniques), on the other hand by elaboration and application of an appropriate sampling strategies (spatial and temporal scale of sampling, timing, *etc*.), which reduce the "disturbing" environmental and biological factors (Peterson & Rabeni 1995, Noble *et al.* 2007).

The applicability and effectiveness of fish sampling methods is influenced by numerous environmental factors, such as water depth, flow velocity, weather conditions, *etc.* Nevertheless, the composition and quantitative metrics of the fish assemblages of large rivers can only be examined to a limited degree on the basis of a single survey, because of several biological factors, as the diurnal and seasonal variation of spatial distribution of fish, which reduce the sampling representtativeness on a given section of the river (Ericksen & Marshall 1997, Specziár 2001). The diurnal movements of fish between the feeding area and shelters usually depends on the ligth conditions (Hayward *et al*. 1989, Gaygusuz *et al.* 2010), while changes of seasonal activity are often related to migratory movements between spawning, feeding and wintering areas (Harden Jones 1968, Anras *et al.* 1999). Differences can be considerable in the lateral extension of floodplain rivers between droughty and flood-rich years, so the reproductive success and the recruitment of the fish populations are quite different in single years (Welcomme 1985, Guti & Gaebele 2009).

In this study the topic of fluvial fish sampling methods is discussed with reviewing of literature data, paying special attention to the factors affecting the application of electrofishing in large rivers.

METHODS

When selecting from the literary articles concerning the various sampling methods of fish surveys and the factors influencing their effectiveness, the more important research results of the past few decades (1979–2012) were taken into consideration.

We studied the number of publications dealing with electrofishing in the database of ScienceDirect, with directed search on several key words. With the evaluation of literary data, the conditions and problems of fluvial electrofishing were characterized, with special regard to the spatial and temporal variability of the fish distribution (diurnally and seasonally), and the environmental factors affecting the efficiency of electrofishing (water depth, flow velocity, turbidity, conductivity, *etc.*).

RESULTS

In the ScienceDirect, 811 publications were found by the „electrofishing" key word. The annual number of articles shows an increasing trend from the middle of the 1970s (Fig. 1). At the same time there are only few literature data about requirement of representative sampling methods with electric and other fishing tools.

In the literarture analyis, 68 publications were examined which deal with the assessment of fish assemblages of rivers, streams, lakes, reservoirs *etc.* and the comparative analysis of the effectiveness and applicability of fishing gears.

According to the studies reviewed, most of the electrofishing surveys were implemented on lakes and reservoirs (43%), as well as small streams (42%), but sampling in large rivers (15%) is less

frequent, presumably due to lower efficiency of electrofishing under fluvial conditions (Casselman *et al.* 1990, Penczak & Jakubowski 1990, Grossman & Ratajczak 1998) (Fig. 2).

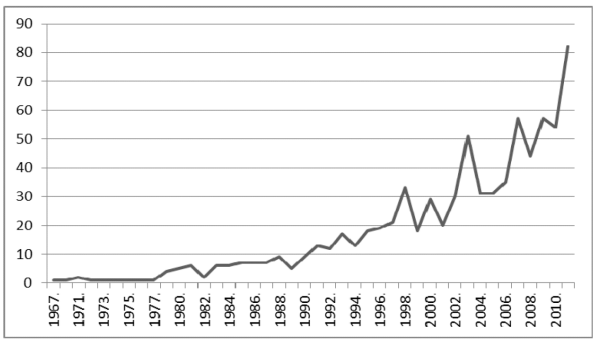

Figure 1. The annual number of publications dealing with electrofishing.

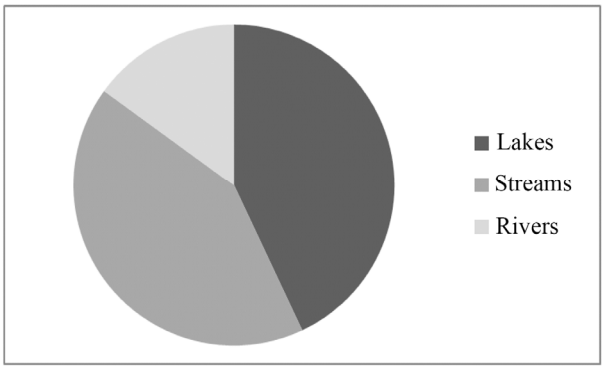

Figure 2. Proportion of main types of surface waters in literature of electrofishing.

Electrofishing is one of the most widely used sampling methods in routine ichtyological surveys of fluvial fish assemblages all over the world (Cowx & Lamarque, 1990, Hendricks *et al.* 1980, Harvey & Cowx 1996, Reynolds, 1996). The advantage of electrofishing in large rivers and streams is its utility for the examination of the spatial distribution of fish. Its usage is not limited by the roughness of the riverbed and trees fallen into the water, and it is simply applicable along the shoreline, where fish are often accumulated in larger numbers (Reynolds 1996). Nevertheless, its application and effectiveness is affected by numerous environmental, biological and technical factors (Bagenal 1979, Bohlin *et al.* 1989, Cowx 1990, Zalewski & Cowx 1990, Rodgers *et al.* 1992, Bayley & Dowling 1993, Reynolds 1993, Lobón-Cerviá *et al.* 1994, Anderson 1995, Peterson *et al.* 2004, Beamount 2011), as shown in Table 1.

Comparisons of the sampling efficiency of different fishing gears (Thurow & Schill 1996, Wildman & Neumann 2003, Goffaux *et al.* 2005, Lapointe *et al.* 2006, Benejama 2012 *etc.*) and the diurnal sampling variability (Sanders 1992, Thurow & Schill 1996, Gaygusuz *et al.* 2010, Vasek *et al.* 2009, Riha *et al.* 2011 *etc.*) are common subjects in the articles, but issue of representative sampling of fluvial fish is a neglected area of research, according to our literature analysis.

For example, in comparison of effectiveness of four different sampling gear (seine net, ring-framed fish trap, Windermere trap and electrofishing), seine net seemed to be the most efficient in abundance and species richness, in an American survey carried out on the Detroit river (Lapointe *et al.* 2006). At the same time, electrofishing is described as the most effective way of assessing fluvial fish assemblages in other publications (Goffaux *et al.* 2005). In a survey of the Belgian section of the river Meuse, electrofishing were compared to gillnetting, and electrofishing proved to be more efficient, althuogh less selective for larger individuals of fish. With regard to the different efficiency of the various fishing gears, the elaboration of combined sampling methods is recommendable (Goffaux *et al.* 2005). For the more complete exploration of the fish assemblages of varied water types combination of different tools was suggested by several studies: combined application of electrofishing with gillnets (Mehner e*t al.* 2005), or combination of electrofishing with trammelnet (Fischer & Eckmann 1997, Paukert 2004).

For sampling of shorline fish assemblages in the Danube Guti (2009) suggested a combinated application of two types of electrofishing units. On the one hand, a conventional design, medium powered (5 kW) electrofishing unit, with hand held anode placed in boat, for the shallow (<1,5 m) stretches along the shoreline of the river. On the other hand, a high powered (13,5 kW) electrofishing boat with fixed anodes is advised getting farther from the shoreline, in deeper (<2,5 m) water.

ENVIRONMENTAL	BIOLOGICAL	TECHNICAL
1. Abiotic Conductivity Water quality Water clarity	**1. Community structure** Species diversity Species composition	**1. Personnel** Size of crew Experience Motivation
2. Habitat Habitat structure Habitat dimensions Substrate Water velocity	**2. Population structure** Density Size distribution Age structure	**2. Equipment** Design Maintenance
3. Seasonality Temperature Weather	**3. Species specific** Behavior Physiology Morphology	**3. Organization** Site selection Standard effort

Table 1. Factors affecting electrofishing (adapted from Zalewski & Cowx 1990).

Night sampling by electrofishing in large rivers is usually more effective than in daytime, because of the diurnal changes of the activity and spatial distribution of the fluvial fish (Witt & Cambell 1959, Paragamian 1989, Sanders 1992, Reynolds 1993). The species richness and abundance of fish in the night samples is usually significantly higher than in the daytime samples, according to surveys carried out on the Ohio and Muskingum rivers, because at night, fish move from the deeper locations of the riverbed to the shallower inshore zone to feed, and all fish seem less apt to avoid capture (Graham 1986, Sanders 1992).

DISCUSSION

For the standardized monitoring of the European fish fauna, the CEN's regulation for electrofishing (CEN 2003) it has to be taken into consideration. The sampling protocol of national ichthyologcal monitoring network in Hungary (NBmR, Natura 2000, *etc.*) was elaborated taking into account the instructions of the international standards. At the same time the problem of taking representative sampling arose increased on larger rivers, especially on the Danube, that is why it is so important the examination of reliability of information got by the recently accepted monitorring methods, with consideration of further developments.

One direction of the relevant research projects is the comparative examination of the efficiency and selectivity of the electrofishing tools applied in standardized surveys. Another important direction in research is the revision of the sampling strategy, with special attention to the issues of spatial and temporal scaling of sampling. Further tasks are among others: study of impact of hydrological changes (raising or dwindling water level, *etc.*) on spatial distribution of fish, evaluation of impacts of hydraulic patterns and geomorphology of river bed, assessment of diurnal and seasonal changes, *etc.*

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