

# On the enchytraeid fauna of Kőszeg Mountains with description of a new *Fridericia* species (Clitellata, Enchytraeidae).

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**Abstract.** The enchytraeid fauna of Kőszeg Mountains (Western Hungary and Eastern Austria), hitherto unknown, was investigated in this study. Fifteen enchytraeid genera including 59 species and two other annelid worms (*Hrabeiella periglandulata* Pižl & Chalupský, 1984 and *Parergodrilus heideri* Reisinger, 1925) were identified. The latter is a new record for Hungary. One enchytraeid species, proved to be new to science, is described in this paper as *Fridericia szoevenyii* sp. nov. The new species is distinguished from similar species on the basis of both morphological characters and molecular data (mitochondrial cytochrome c oxidase subunit I and nuclear histone 3 gene sequences). Based on the presence of subalpine-alpine species, the enchytraeid fauna of Kőszeg Mountains is similar to that of Rax Mountains (Northern Alps, Austria). The two most species-rich sites were the alder carr at a creekside near Paprét (33 species) and a mesophile montane hay meadow at Steirer Houses (27 species). Interestingly, a mixed forest with dense underwood of *Vaccinium myrtillus* harbored only a single species.

**Key words.** new *Fridericia* species, enchytraeid fauna, Kőszeg Mts., CO1 gene

## INTRODUCTION

The enchytraeid fauna of western Hungary (Kőszeg Mountains and Órség National Park) was studied between 2014–2016. The composition of enchytraeid fauna in Órség National Park has already been published (Dózsa-Farkas & Felföldi 2016). Two other works (Dózsa-Farkas *et al.* 2017 and Dózsa-Farkas & Felföldi 2017a) dealt with the comparative morphological and molecular taxonomic analysis of *Cernosvitoviella* and *Achaeta* species of this area including the description of a new *Cernosvitoviella* and a new *Achaeta* species (*C. farkasi* and *A. tothi*, respectively). Here, we present the faunistic results from Kőszeg Mountains with the description of a new *Fridericia* species, *Fridericia szoevenyii* sp. nov. The morphological studies was supplemented with molecular taxonomic analysis targeting the mitochondrial cytochrome c oxidase subunit I (CO1) and nuclear histone 3 (H3) genes.

## MATERIAL AND METHODS

*Study area.* Kőszeg Mountains is the easternmost unit of the Alps, and has an area of ca. 60 km<sup>2</sup>. The territory of the mountain range is shared between Austria and Hungary. The highest point of Kőszeg Mts. is Írott-kő with a height of 883 m, but the majority of this area is hilly with an average altitude of 300–700 m. The main mass of the mountains is built of crystalline rocks (schist). The mean annual temperature of this region is 9.2°C, at the Steirer Houses site is 8.5–9.0°C. The mean temperature in January is -2 – -3°C, the mean temperature in July is 19°C. The winter is mild and due to the low temperature fluctuation, submediterranean vegetation could also be found, but the cool summer favors dealpine elements in the flora. Annual sunshine hours has the lowest value in this region within Hungary (< 1800 h). The average precipitation in the last 50 years was 779 mm in Kőszeg town (285 m a.s.l.) and 912

mm at Steirer Houses (551 m a.s.l.) with a maximum in July. Majority of this area belongs to the mountain beech forest zone. The characteristic soil types are non-podzolic brown forest soils, which are extremely acidic, while in the deeper valleys pseudogley brown forest soils are more common (Markovics 1994).

*Collection sites.* In total, 20 macro- and microhabitats were sampled at 16 localities (Appendix 1).

*Morphological methods.* Animals were extracted from the soil by the wet funnel method (O'Connor 1962). Worms were first studied and measured alive, and subsequently preserved in 70% ethanol. Later, a part of the adult specimens was stained with borax-carmin then passed through an ethanol (70% to absolute) dehydration series, mounted temporarily in clove oil, and later mounted in Euparal on a slide between two coverslips. The important morphological structures were recorded *in vivo*, drawn, and photographed using an Axio Imager.A2 microscope with DIC (differential interference contrast) illumination and an AxioCam MRc 5 (Zeiss) digital camera with Axiovision software. The whole-mounted specimens were reinvestigated and also photographed. Holotype and paratypes of the new species are deposited in the collection of the Department of Systematic Zoology and Ecology, Eötvös Loránd University (Budapest, Hungary).

*Methods of molecular analysis.* Genomic DNA was extracted from the specimens with the DNeasy Blood & Tissue Kit (Qiagen) following the instructions given by the manufacturer. The mitochondrial cytochrome c oxidase subunit I (CO1) and the nuclear histone 3 (H3) genes were amplified using the primers HCO2198 (5'-TAA ACT TCA GGG TGA CCA AAA AAT CA-3') and LCO1490 (5'-GGT CAA CAA ATC ATA AAG ATA TTG G-3') (Folmer *et al.* 1994), and H3a-F (5'-ATG GCT CGT ACC AAG CAG ACV GC-3') and H3a-R (5'-ATA TCC TTR GGC ATR ATR GTG AC-3') (Colgan *et al.* 1998) [if amplification failed, with primers designed by

AllGenetics, A Coruña (and used here with permission of ECT Oekotoxikologie GmbH, Flörsheim), H3Frid-M13F (5'-GTA AAA CGA CGG CCA GTT ACC AAG CAG ACG GCH CGY-3') with H3Frid-M13tR (5'-GCG GAT AAC AAT TTC ACA CAG GGG CGT GAA TBG CRC ACA GGT-3')], respectively. PCRs were performed applying the parameters given by Dózsa-Farkas & Felföldi (2015). Purification and sequencing of PCR products were carried out by LGC Genomics GmbH (Berlin, Germany). Removal of primer sequences and manual correction of automatic base calling on chromatograms were performed using the Chromas software v. 1.45 (Technelysium). Phylogenetic analysis (which included the search for the best-fit model) was conducted with the MEGA 7.0 software (Kumar *et al.* 2013). Sequences determined in this study were deposited in GenBank under the following accession numbers: MF142359-MF142361 (CO1) and MF361128-MF361130 (H3).

## RESULTS

### Results of morphological analysis

In total, 59 species were recorded which belonged to 15 enchytraeid genera, moreover two terrestrial polychaete species, *Hrabeiella periglandulata* Pižl & Chalupský, 1984 and *Parergodrilus heideri* Reisinger, 1925 were also detected in the samples (Appendix 1). *Parergodrilus heideri* is a new record for the fauna of Hungary, while all enchytraeid species represent new records for the Kőszeg mountain range. One species (described here as *F. szoevenyii* sp. nov.) is new to science and the status of *Fridericia* sp. and *Enchytraeus* sp. has not been ascertained yet. Probably, they also represent new species for science, but further investigations are needed to clarify their taxonomic status. A list of species recorded in individual samples, which represented microhabitats at the studied sites, is given in Appendix 1.

It should be mentioned that the presence of the terrestrial polychaete *Parergodrilus heideri*, was

recorded not during this sampling campaign, but was found earlier and but has not been published yet.

These samples were collected at a site near Velem village, in a mixed deciduous forest (horn-beam-oak-beech-pine), 47°35.194 N, 16°48.583 E, 430 m a.s.l., 07.09.2008, leg. B. Németh. About the anatomy of this very small polychaeta (0.8–1 mm long, Fig. 4A–B) detailed description can be found in Reisinger (1925, 1960), Karling (1958), Rota (1998), and ultrastructure analysis in Purschke (1987, 1988, 2002). Here, only some micrographs on the Hungarian female specimens are given (only female specimens were found): forepart (Fig. 4C–D) and body-end (Fig. 4E–F), the nephridia in II–III segments (Fig. 4G) and the chaetae at the body-end (Fig. 4H).

## DESCRIPTION OF THE NEW SPECIES

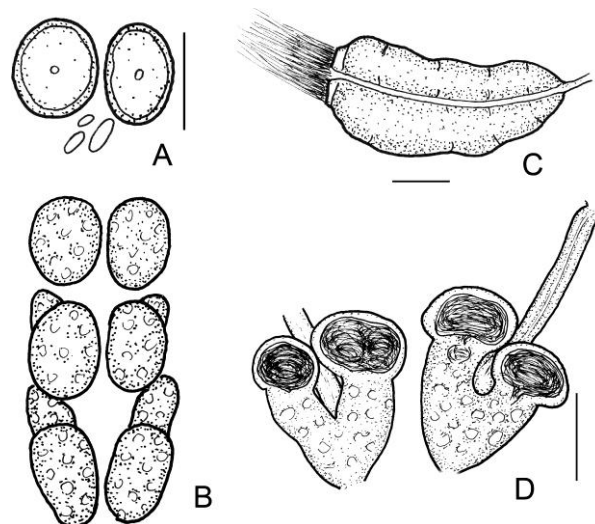
### *Fridericia szoevenyii* sp. nov.

(Figures 1–3)

*Type material.* *Holotype.* F. 28. slide No. 2138, DNS 939, Velem, in Irottkő landscape protection area, Hungary, streamside area of willow (site 16.a), 47°20.271 N, 16°30.047 E, 325 m a.s.l., 27.03.2016. Leg. G. Szövényi. *Paratypes.* In total 6 specimens. P.111.1–111.6 slide No. 2139, 2142–2143, 2145–2147, at the type locality, 27.03.2016.

*Etymology.* Named in the honor of our colleague, Dr. Gergely Szövényi, who collected samples with this species.

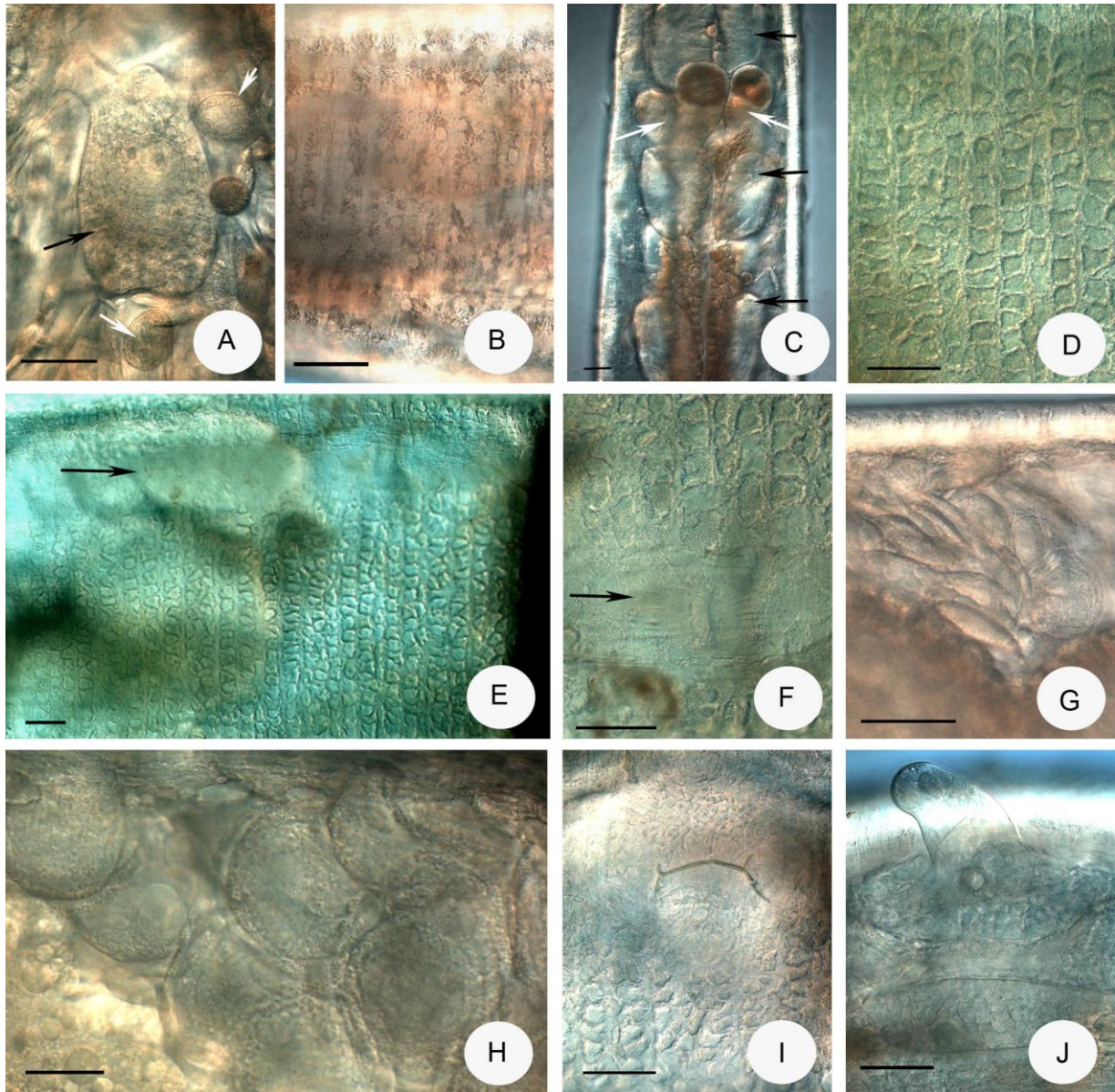
*Diagnosis.* The new species can be recognized by the following combination of characters: (1) large size (body length 13–19 mm *in vivo*), segments 44–56; (2) maximum 4 chaetae per bundle; (3) clitellum weakly and only laterally developed, interrupted ventrally and dorsally, hyalocytes and granulocytes arranged in transverse rows; (4) five preclitellar pairs of nephridia;



**Figure 1.** *Fridericia szoevenyii* sp. nov. A = coelomocytes, B = pharyngeal glands in dorsal view, C = sperm funnel, D = spermathecae; schematic, scale bars = 100 µm (except in A 50 µm).

(5) coelomo-mucocytes b-type with a thickened cell border, lenticytes large 10–23 µm; (6) chylus cells in IX–X; (7) bursal slit H-shaped; (8) seminal vesicle in XI; (9) subneural glands absent; (10) sperm funnel cylindrical, approximately as long as body diameter or slightly shorter, collar narrower as funnel body, sperm 120–170 µm long, sperm heads 50–80 µm long (*in vivo*); (11) spermathecae separate entally, with two large stalked, spherical diverticula, ectal glands absent.

*Description.* Large, milk-white (caused by the large chloragocytes filled with very strong refractile vesicles), strong and slow-moving worms. *Holotype* 15.3 mm long, 380 µm wide at VIII and 490 µm at the clitellum (*in vivo*). The fixed worms 9.3 mm long 480 µm wide at VIII and 500 µm at the clitellum, 44 segments (from the last 8 segments, a 2.15 mm-long region was removed for molecular analysis). Body length of the *paratypes* 13–17.5 mm, width 350–450 µm at VIII and 400–540 µm at the clitellum (*in vivo*). Length of fixed specimens 8.3–11 mm, width 400–480 µm at VIII and 420–450 µm at the clitellum.



**Figure 2.** Micrograph of *Fridericia szoevenyii* sp. nov. A = brain (coelomo-mucocytes marked with arrows), B = epidermal glands, C = pharyngeal glands (marked with black arrows, spermathecae marked with white arrows), D = clitellar glands in lateral view, E = clitellar glands in dorso-lateral view (dorsal gap marked with arrow), F = dorsal gap of clitellar glands (marked with arrow), G–H = coelomocytes, I = bursal slit, J = everted bursa; all *in vivo*; scale bars = 50 µm (except in H = 20 µm).

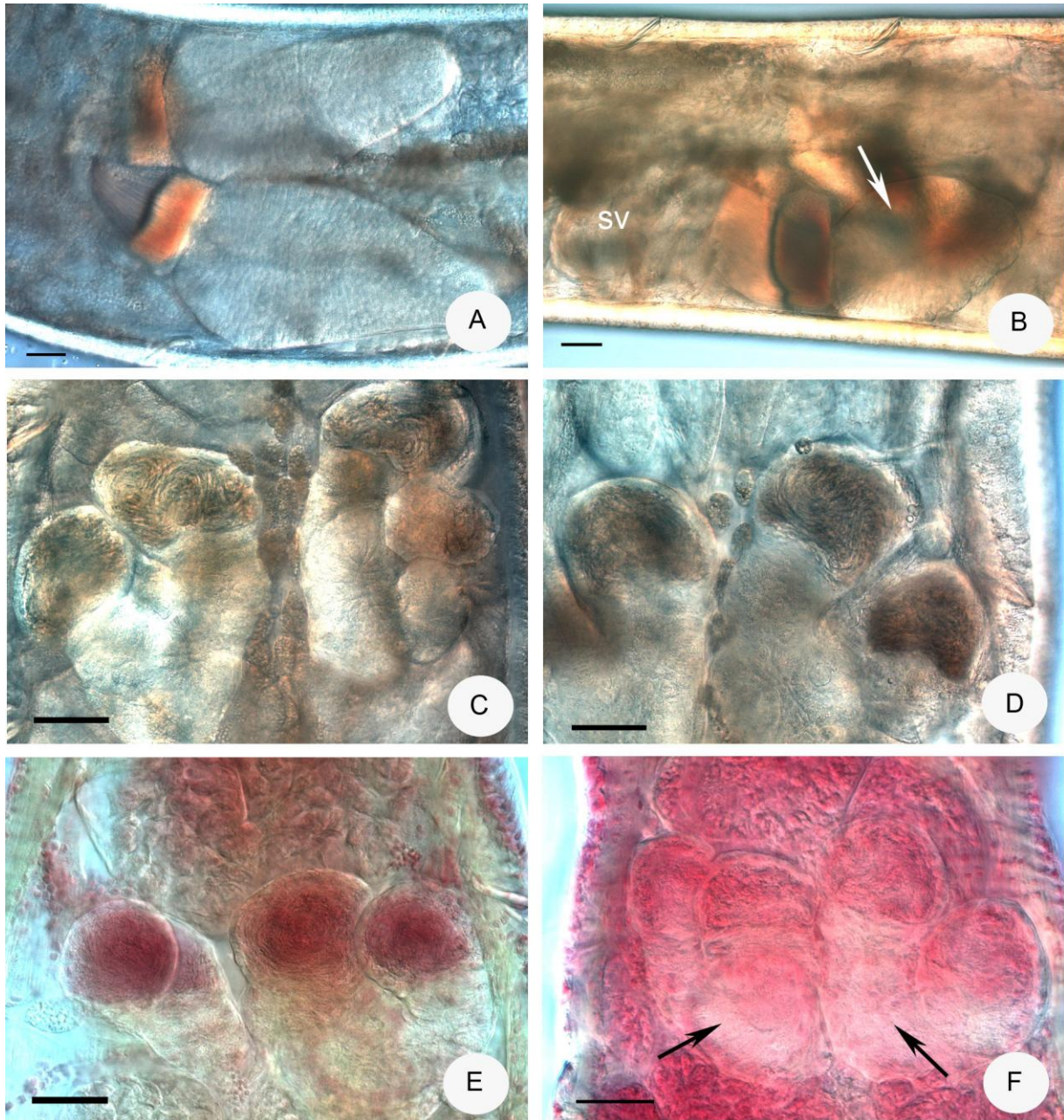
Segments 44–56. Chaetal formula: 2,3,4,5 – 4,3,2 : (2),3,4 – 4,3,(0),2. In segment XII two chaetae present laterally. As in other *Fridericia* species, chaetae in bundles arranged in pairs with the outer pairs being longer and thicker than the inner pairs: 70–73 x 4–5 µm against 41–48 x 3.5–

4 µm (preclitellar bundles), after the clitellum about in 10–15 segments slightly shorter. At the body-end only 2 chaetae per bundle, size about 60–80 x 5 µm. Head pore at 0/I. Dorsal pores from VII. Epidermal gland cells mostly weakly developed sometimes 5–6 brownish glands (in

transmittent light) in transverse rows (Fig. 2B). Clitellum in XII–1/2XIII, only laterally, hyalocytes and granulocytes arranged in transverse rows, about the same size (14–19  $\mu\text{m}$ , *in vivo*) (Fig. 2D), dorsally and ventrally absent,

but in some specimens weakly developed glands also observable (dorsally the gap 60–70  $\mu\text{m}$  wide) (Fig. 2E–F). Body wall about 27–35  $\mu\text{m}$ , cuticle about 1–1.5  $\mu\text{m}$ , fixed.

Brain egg-shaped, about 150  $\mu\text{m}$  long, 1.5 times



**Figure 3.** Micrograph of *Fridericia szoevenyii* sp. nov. A–B = sperm funnels (in B marked with arrow, sv = seminal vesicle) C–F = spermathecae (in F marked with arrows); A–D *in vivo*, E–F fixed, stained; scale bars = 50  $\mu\text{m}$ .

longer than wide *in vivo* (Fig. 2A), and 120 µm in the fixed specimens. Oesophageal appendages a-type, short, with wide lumen, without branches. All pharyngeal glands free dorsally, with ventral lobes in V and VI, all primary lobes ca. the same in size (Fig. 1B, 2C). Chloragocytes from V, 28–33 µm long and dark-brown in transmittent light *in vivo*, therefore the worms have milk-white color under top light. Dorsal vessel from XV–XVI, blood colourless. Midgut pars tumida not observable. Five pairs of preclitellar nephridia from 6/7 to 10/11, length ratio anteseptale : postseptale about 1:1 or preseptale slightly shorter than postseptale, midventral origin of efferent duct. Coelomo-mucocytes with refractile vesicles mainly peripherally with a thickened cell border (length 36–50 µm *in vivo*, (22–23 µm fixed), lentocytes large and wide 11–20 by 6–7 µm *in vivo* (Fig. 1A, 2G–H), fixed 8–10 µm. Chylus cells between IX–X, occupying 2 segments, difficult to observe. Seminal vesicle in XI not brown (Fig. 3B). Sperm funnel (Figs. 1C, 3A–B) cylindrical, approximately as long as body diameter or slightly shorter, about 300–500 µm long *in vivo* and 150–200 µm, fixed, 1.5–2 times as long as wide, collar narrower as funnel body, spermatozoa about 120–170 µm long, sperm heads 50–80 µm long *in vivo*, while in fixed specimens 85–100 µm and 30–35 µm, respectively. Diameter of sperm ducts 9 µm (*in vivo*). Male copulatory organs 180–200 µm long, 100–130 µm wide and 70–80 µm high (*in vivo*) (170–185, 90–100 and 40–60 µm in fixed specimens, respectively) with large eversible bursa (Fig. 2J). Bursal slits longitudinal with additional transverse extension or H-shaped (Fig. 2I). Subneural glands absent. Spermathecae (Figs. 1D, 3C–F): no ectal gland, ectal ducts about 200–270 µm long and 25–27 µm wide, canal 5 µm *in vivo* (180–230 µm long, 21–26 µm wide, fixed). Duct projecting into ampulla without ental bulb. Ampullae longer than wide, about 100–125 µm wide (fixed), thick-walled, tapering proximad, no separation into distal and proximal part. Separate communication of ampullae with oesophagus. Two very large spherical diverticula with unequally long, thick-walled

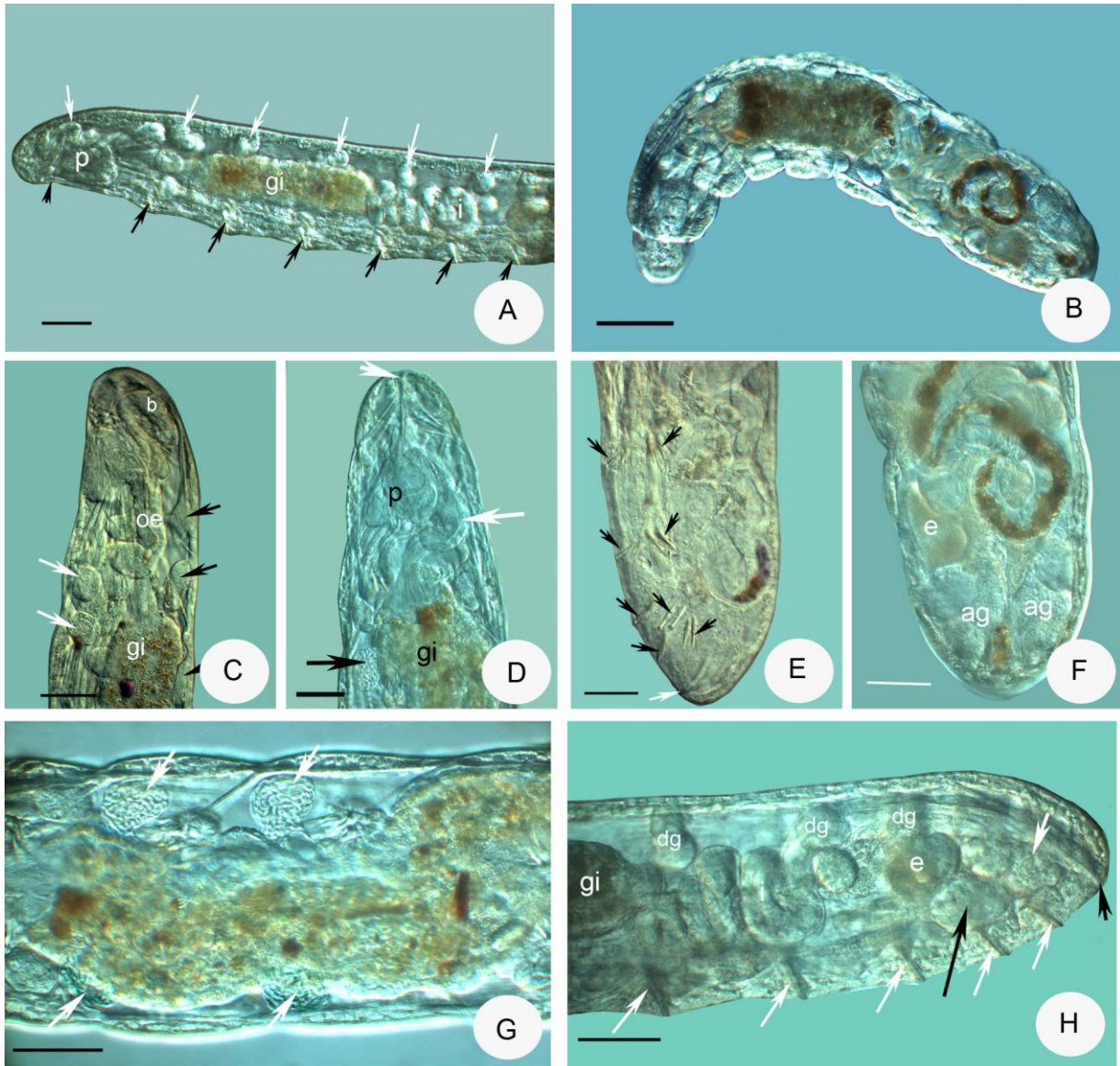
stalks (length of stalks 50–65 µm *in vivo*, 35–55 µm fixed). The diverticula thin-walled, diameter 75–100 µm *in vivo* and fixed alike, mostly filled with brown sperm (in transmitted light), sperm not rotating. One, rarely two mature eggs at a time.

*Distribution and habitat.* Known only from the type locality: Velem, in Irottkő landscape protection area in the western geographic region of Hungary, creekside area of willow, 47°20.271 N 16°30.047 E, 325 m. a.s.l.

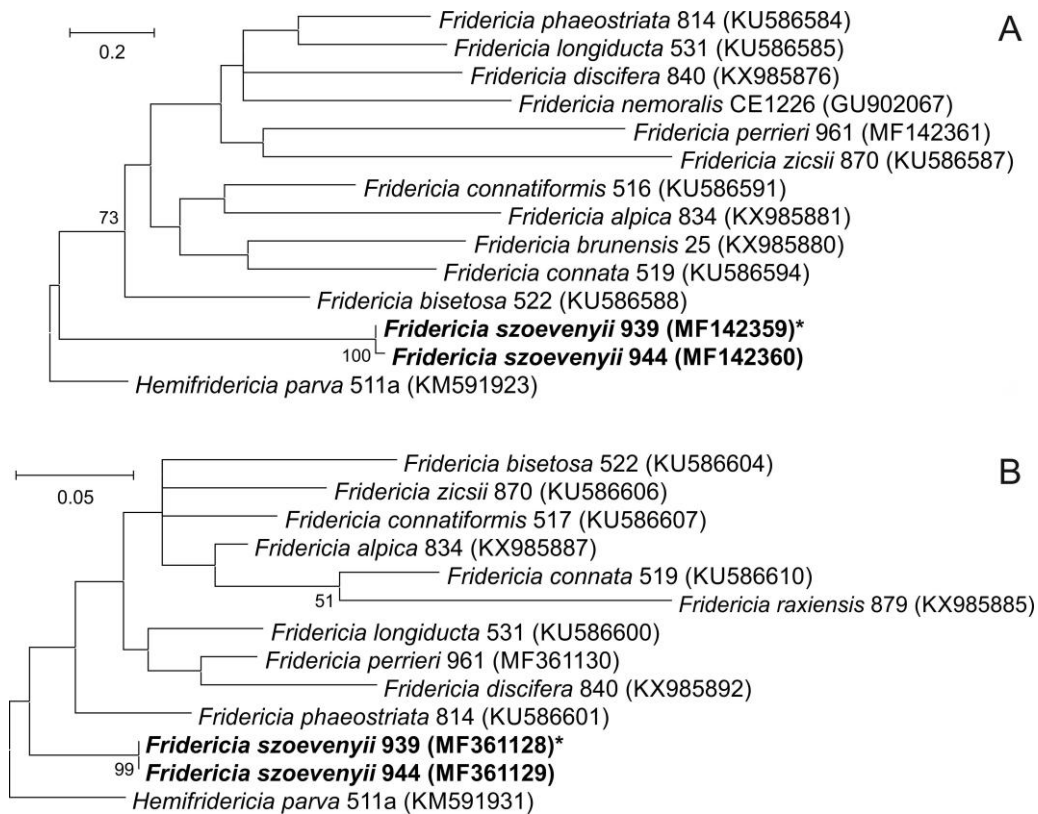
*Remarks.* The new species can easily be distinguished from all *Fridericia* species that also possess two globular spermathecal diverticula with well-developed stalks, and entally separate ampullae: *F. rendsinata* Dózsa-Farkas, 1972, *F. perrieri* (Vejdovksý, 1878), *F. healyae* Schmelz, 2003, *F. dozsae* Schmelz, 2003, *F. omeri* Stephenson, 1932 and *F. galba* (here the form with 2 spermathecal diverticula, see Dózsa-Farkas 2009, Table 5), moreover from *F. connatiformis* Dózsa-Farkas, 2015. The new species differs from all these species leaving other characters out of consideration, by the very large spermathecal diverticula without ciliated subchambers, so that sperm is not rotating, by the origin of dorsal vessel in XV–XVI (in the other species more backwards) and by the preclitellar position of the chylus cells. Additionally, *F. perrieri*, *F. healyae*, *F. dozsae*, *F. omeri* and *F. galba* have more than 4 chaetae in a bundle, and *F. connatiformis* has only 2 chaetae in a bundle and larger extra sexual glands.

### Results of molecular analysis

Two specimens (including the holotype) of *Fridericia szoevenyii* sp. nov. were subjected to molecular taxonomic analysis. Based on the mitochondrial CO1 and nuclear H3 genes, sequences of the new species formed highly supported (100% and 99% bootstrap value respectively) and well separated clades on the phylogenetic trees (Fig. 5) which confirms that *F. szoevenyii* sp. nov. is a distinct species.



**Figure 4.** Micrograph of *Parergodrilus heideri* Reisinger, 1925. A–B = entire specimens (chaetae marked with black arrows, dorsal glands marked with white arrows, mouth marked with short arrow, p = pharynx, gi = gastrointestinal, I = intestine), C = forepart of body lateral view (dorsal glands marked with black arrows, ventral glands marked with white arrows, b = brain, oe = oesophagus, gi = gastrointestinal), D = forepart of body dorsal view (oesophages marked with white arrow, nephridium marked with black arrow, mouth marked with short white arrow, p = pharynx, gi = gastrointestinal), E = body-end lateral view (chaetae marked with black arrows, anus marked with white arrow), F = body-end dorsal view (ag = anal glands, e = egg), G = nephridia in II–III segments (marked with arrows), H = posterior part of body lateral view (chaetae marked with white arrows, anal gland marked with short white arrow, subneural gland marked with long black arrow, anus marked with short black arrow, gi = gastrointestinal, dg = dorsal glands, e = egg).



**Figure 5.** Maximum likelihood phylogenetic tree of selected *Fridericia* species based on the CO1 (A) and H3 (B) genes (439 and 181 nucleotide positions, TN93+G+I and K2+G substitution models, respectively). Bootstrap values greater than 50 are shown at the nodes. Sequences from the new species described here appear in bold (holotype marked with an asterisk).

## DISCUSSION

The diverse enchytraeid fauna consisting of 59 species distributed in 15 genera (Appendix 2) of Kőszeg Mts. is worth comparing with the fauna of Rax Mts. in Austria (Dózsa-Farkas & Felföldi 2017b); both have subalpine or alpine climate. Comparing these two regions, similarities could be found regarding the enchytraeid fauna, which includes some characteristic species of the Alps. For example, *F. alpica* described from Rax was also found in Kőszeg Mts., moreover, at site 15a (alder carr at creekside) with its very cool and humid subclimate, a habitat is provided for such species as *F. discifera*, *F. raxiensis*, *Euenchytraeus clarae* and *Fridericia* sp. This latter represents a new species within the genus which will be described soon. Additionally, these four species were recorded only from the Kőszeg Mts (in site 15a) and nowhere else within Hungary,

therefore they could be regarded as relict species from the Ice age.

*Euenchytraeus clarae* is possibly identical with *Euenchytraeus bisetosus*, which was described by Bretscher (1906) from Swiss Alps but, based on immature material (Schmelz & Collado 2010, Martinsson *et al.* 2014). For the correct synonymization, it will be necessary to compare individuals from the type locality with those from Kőszeg Mts. It is also worth mentioning that *Oconnorella tubifera*, which is widespread from Sweden to Italy in moist soils (Schmelz & Collado 2010), was found at first time in Hungary in the Kőszeg Mts., only from the sites 15a (alder carr along a creek) and site 10 (spruce forest).

From Kőszeg Mts., three new species, namely *Fridericia szoevenyii* sp. nov. (described here), *Achaeta tothi* Dózsa-Farkas & Felföldi, 2017 and



*Cernosvitoviella farkasi*, Dózsa-Farkas *et al.*, 2017 were also found. Two of them occurred only in one locality: *F. szoevenyii* only at site 16a (Velem, area of willow along a creek) and *C. farkasi* only at site 8b (Ólmod, young Scots pine forest in stagnant mud); while *A. tothi* were recorded from three sites: site 10 (near Hörmann-spring, spruce forest), site 12 (Steirer Houses, mesophile montane hay meadow) and site 11 (between Hörmann-spring and Velem village, mixed forest). It is possible that all are endemic to this region.

In terms of species numbers recorded at the investigated sites, the alder carr at a creekside near Paprét (site 15) showed the highest value with 33 species. The second is in this regard was the mesophile montane hay meadow at Steirer Houses (site 13) with 27 species. Remarkable that in a mixed forest on a hillside (site 12) only a single species (*Marionina clavata*) was found, probably due to the dense underwood of *Vaccinium myrtillus*.

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**Appendix 1. Investigated sites and habitats (with sampling dates) in Kőszeg Mts. with the recorded enchytraeid and the two Polychaeta species (dominant species are underlined).**

1. **Near Reichnitz, Austria, mixed deciduous forest** with *Fagus sylvatica* and *Quercus petraea*, 47°20.194' N, 16°23.993' E, 671 m a.s.l., 21.05.2014. **8+1 species** (*Chamaedrillus chlorophilus*, *Enchytraeus norvegicus*, *Enchytronia parva*, *Fridericia bisetosa*, *F. alpica*, *F. sohlenii*, *Mesenchytraeus glandulosus*, *Oconnorella cambrensis*, *Hrabeiella periglandulata*). 33.882' E, 345 m a.s.l., 27.03.2016. **5 species** (*Achaeta affinis*, *A. camerani*, *Chamaedrillus chlorophilus*, *Marionina clavata*, *Mesenchytraeus pelicensis*)
2. **Near Reichnitz, Austria, mixed forest** with *Fagus sylvatica*, *Quercus petraea*, *Pinus sylvestris*, *P. nigra* and *Picea abies*, 47°19.749' N, 16°25.666' E, 634 m a.s.l., 21.05.2014. **6 species** (*Achaeta* cf. *danica*, *Bryodrillus ehlersi*, *Buchholzia appendiculata*, *Enchytraeus buchholzi* s.l., *E. norvegicus*, *Marionina clavata*).
3. **Near Reichnitz, Austria, clearing in the woodland**, 47°20.195' N, 16°23.992' E, 624 m a.s.l., 21.05.2014. **8 species** (*Buchholzia appendiculata*, *Enchytraeus buchholzi* s.l., *Enchytronia parva*, *Fridericia benti*, *F. bisetosa*, *F. bulboides*, *F. miraflores*, *Henlea perpusilla*).
4. **Between Reichnitz and Lockenhaus, Austria, spruce (*Picea abies*) forest**, 47°20.195' N, 16°23.992' E, 739 m a.s.l., 21.05. 2014. **3 species** (*Achaeta* cf. *danica*, *Enchytraeus norvegicus*, *Fridericia dura*).
5. **Hammerteich, Austria, hay meadow**, 47°24.630' N, 16°26.680' E, 327 m a.s.l., 21.05.2014. **8 species** (*Enchytraeus bulbosus*, *Enchytronia christensenii*, *En. parva*, *Fridericia bisetosa*, *F. bulboides*, *F. connata*, *F. miraflores*, *F. paroniana*)
6. **Alsóerdő, Hungary, old *Sphagnum* mire**, 47°40.370' N, 16°56.460' E, 350 m a.s.l., 31.10.2014. **4 species** (*Cernosvitoviella atrata*, *C. minor*, *Chamaedrillus chlorophilus*, *Mesenchytraeus pelicensis*).
7. **Alsóerdő, Hungary, mixed forest near an old *Sphagnum* mire**, 47°24.241' N, 16°33.918' E, 319 m a.s.l.
8. **Near Ólmod, Hungary**, 47°24.345' N, 16°33.918' E, 319 m a.s.l.
  - a. ***Sphagnum* mire**, 21.05.2014, 13.10.2014. **4 species** (*Cernosvitoviella minor*, *Chamaedrillus glandulosus* s.l., *Ch. cognettii*, *Globulidrilus riparius*).
  - b. **Young Scots pine forest (*Pinus sylvestris*), on the edge of a *Sphagnum* mire, stagnant mud with *Molinia* stocks**, 47°24.345' N, 16°33.918' E, 319 m a.s.l., 21.05.2014, 13.10.2014 and 24.10.2016. **11 species** (*Achaeta camerani*, *A. cf. danica*, *Cernosvitoviella atrata*, *C. minor*, *C. farkasi*, *Chamaedrillus chlorophilus*, *Fridericia dura*, *F. paroniana*, *Marionina simillima*, *M. vesiculata*, *Mesenchytraeus pelicensis*).
9. **Meadow, Hungary, near a Scots pine forest**, 47°24.116' N, 16°33.600' E, 297 m a.s.l., 13.10.2014. **15 species** (*Achaeta camerani*, *A. unibilba*, *Buchholzia appendiculata*, *Cernosvitoviella minor*, *Enchytraeus buchholzi* s.l., *Fridericia connata*, *F. dura*, *F. galba* with 5–8 diverticula, *F. hegemon*, *F. nemorialis*, *F. ratzeli*, *F. schmelzi*, *F. semisetosa*, *F. sohlenii*, *Marionina argentea*).
10. **Near Hörmann-spring, Hungary, spruce forest**, 47°21.493' N, 16°27.642' E, 757 m a.s.l., 21.05.2014, 13.10.2014, 20.06.2015, 24.10.2016. **12 species** (*Achaeta* cf. *danica*, *A. tothi*, *Bryodrillus ehlersi*, *Chamaedrillus chlorophilus*, *Enchytraeus norvegicus*, *Enchytronia parva*, *En. baloghi*, *Fridericia alpica*, *Marionina simillima*, *Mesenchytraeus pelicensis*, *Oconnorella cambrensis*, *O. tubifera*).
11. **Between Hörmann-spring and Velem village, Hungary, mixed forest** with *Carpinus betulus*, *Quercus petraea* and *Pinus*

- sylvestris*, 47°21.058' N, 16°29.110' E, 467 m a.s.l., 2014.10.13. **7+1 species** (*Achaeta tothi*, *Chamaedrillus chlorophilus*, *Ch. glandulosus* s.l., *Fridericia dura*, *F. sohlenii*, *Marionina simillima*, *Mesenchytraeus pelicensis*, *Hrabeiella periglandulata*).
- 12. Near Hörmann-spring, Hungary, mixed forest** with *Fagus sylvatica*, *Quercus robur*, *Laryx decidua* and *Vaccinium*, 47°22.088' N, 16°28.277' E, 667m a.s.l., 21.05.2014. **1 species** (*Marionina clavata*).
- 13. Steirer Houses, Hungary**, 47°22.201 N 16°28.045 E, 667 m a.s.l.
- a. **Mesophile montane hay meadow**, 21.05.2014, 13.10.2014, 20.06.2015, 24.10.2016. **26+1 species** (*Achaeta affinis*, *A. bohemica* s.s., *A. cf. danica*, *A. tothi*, *Buchholzia appendiculata*, *Cernosvitoviella minor*, *Chamaedrillus chlorophilus*, *Ch. glandulosus* s.l., *Enchytraeus buchholzi* s.l., *E. bulbosus*, *E. sp.*, *Enchytronia christenseni*, *En. parva*, *Fridericia benti*, *F. bisetosa*, *F. connata*, *F. connatiformis*, *F. dura*, *F. maculata*, *F. miraflores*, *F. nemoralis*, *F. paroniana*, *F. perrieri*, *F. schmelzi*, *F. semisetosa*, *F. sohlenii*, *F. sp.* (with only ventral chaeta), *Hrabeiella periglandulata*).
- b. **Near „Ciklamen-spring”, wet soil under old *Picea abies* trees**, 21.05.2014. **4 species** (*Enchytraeus lacteus*, *Fridericia perrieri*, *Henlea perpusilla*, *Marionina argentea*).
- 14. Near Steirer Houses, Hungary, mixed deciduous forest with *Quercus robur* and *Fagus sylvatica***, 47°22.685' N, 16°30.026' E, 521 m a.s.l., 21.05.2014. **9+1 species** (*Buchholzia simplex*, *Enchytraeus norvegicus*, *Enchytronia parva*, *Fridericia bisetosa*, *F. connata*, *F. alpica*, *F. dura*, *F. ratzeli*, *F. sohlenii*, *Hrabeiella periglandulata*).
- 15. Near Paprét, Hungary, alder carr at Creekside**. 47°24.091' N, 16°26.878' E, 478 m a.s.l.
- a. **Soil and leaf-litter**, 21.05.2014, 13.10.2014, 24.10.2016. **31+1 species** (*Achaeta affinis*, *A. camerani*, *A. cf. danica*, *Bryodrillus ehlersi*, *Buchholzia appendiculata*, *B. simplex*, *Cernosvitoviella minor*, *Chamaedrillus cognettii*, *Ch. glandulosus* s.l., *Enchytraeus buchholzi* s.l., *E. norvegicus*, *Enchytronia parva*, *Euenchytraeus clarae*, *Fridericia benti*, *F. discifera*, *F. alpica*, *F. dura*, *F. galba* with 5-8 diverticula, *F. perrieri*, *F. phaeostriata*, *F. raxiensis*, *F. ratzeli*, *F. sohlenii*, *Globulidrilus riparius*, *Henlea perpusilla*, *Marionina argentea*, *Mesenchytraeus armatus*, *M. glandulosus*, *M. pelicensis*, *Oconnorella cambrensis*, *O. tubifera*, *Hrabeiella periglandulata*).
- b. **Decaying bark on tree stumps**, 21.05.2014. **3 species** (*Bryodrillus ehlersi*, *Chamaedrillus chlorophilus*, *Mesenchytraeus pelicensis*).
- 16. Velem, Hungary, creekside area of willow**, 47°20.451' N, 16°30.078' E, 325 m a.s.l., 27.03.2016, 24.10.2016.
- a. **Creekside under *Salix* sp. on the side of the road**. 47°20.451' N, 16°30.078' E **20+1 species** (*Achaeta cf. danica*, *Buchholzia appendiculata*, *Cernosvitoviella aggtelekiensis*, *Chamaedrillus chlorophilus*, *Ch. glandulosus* s.l., *Enchytraeus buchholzi* s.l., *Enchytronia parva*, *Fridericia benti*, *F. connata*, *F. dura*, *F. galba* with 5-8 diverticula, *F. miraflores*, *F. paroniana*, *F. perrieri*, *F. phaeostriata*, *F. sohlenii*, *F. szoevenyii* sp. n., *Henlea perpusilla*, *Mesenchytraeus armatus*, *Oconnorella cambrensis*, *Hrabeiella periglandulata*).
- b. **Creekside under *Salix* sp. on the other side of the road** 47°20.501' N, 16°30.173E. **10 species** (*Buchholzia appendiculata*, *Chamaedrillus glandulosus* s.l., *Enchytraeus buchholzi* s.l., *Fridericia benti*, *F. maculata*, *F. perrieri*, *F. phaeostriata*, *Globulidrilus riparius*, *Henlea perpusilla*, *Marionina argentea*).

## Appendix 2. List of Enchytraeidae and Hrabeiellidae species recorded in the Kőszeg Mountains.

(the *Cernosvitoviella* and *Achaeta* species of this mountain have already been published by Dózsa-Farkas *et al.* 2017 and Dózsa-Farkas & Felföldi 2017a)

- Achaeta affinis* Nielsen & Christensen, 1959  
*Achaeta bohémica* (Vejdovský, 1879) *sensu stricto*  
*Achaeta camerani* (Cognetti, 1899)  
*Achaeta cf. danica* Nielsen & Christensen, 1959  
*Achaeta tothi* Dózsa-Farkas & Felföldi, 2017  
*Achaeta unibulba* Graefe, Christensen & Dózsa-Farkas, 2005  
*Bryodrilus ehlersi* Ude, 1892  
*Buchholzia appendiculata* (Buchholz, 1862)  
*Buchholzia simplex* Nielsen Christensen, 1963  
*Cernosvitoviella aggtelekiensis* Dózsa-Farkas, 1970  
*Cernosvitoviella atrata* (Bretscher, 1903)  
*Cernosvitoviella farkasi* Dózsa-Farkas, Csitári & Felföldi, 2017  
*Cernosvitoviella minor* Dózsa-Farkas, 1990  
*Chamaedrillus (Cognettia) chlorophilus* Friend, 1913  
*Chamaedrillus (Cognettia) cognettii* (Issel, 1905)  
*Chamaedrillus (Cognettia) glandulosus sensu lato* (Michaelsen, 1888)  
*Enchytraeus buchholzi* Vejdovský, 1879 *sensu lato*  
*Enchytraeus bulbosus* Nielsen & Christensen, 1963  
*Enchytraeus lacteus* Nielsen & Christensen, 1961  
*Enchytraeus norvegicus* Abrahamsen, 1969  
*Enchytraeus* sp.  
*Enchytronia baloghi* Dózsa-Farkas, 1988  
*Enchytronia christenseni* Dózsa-Farkas, 1970  
*Enchytronia parva* Nielsen & Christensen, 1959  
*Euenchytraeus clarae* Bauer, 1993  
*Fridericia alpica* Dózsa-Farkas & Felföldi, 2017 (in press)  
*Fridericia benti* Schmelz, 2003  
*Fridericia bisetosa* (Levinsen, 1884)  
*Fridericia bulboides* Nielsen & Christensen, 1959  
*Fridericia connata* Bretscher, 1902  
*Fridericia discifera* Healy, 1975  
*Fridericia dura* (Eisen, 1879) (= *F. ratzeli* sensu Dózsa-Farkas 2005)  
*Fridericia galba* (Hoffm., 1843) with 5–8 diverticula  
*Fridericia hegemon* (Vejdovský, 1878)  
*Fridericia maculata* Issel, 1905  
*Fridericia miraflores* Sesma & Dózsa-Farkas, 1993  
*Fridericia nemoralis* Nurminen, 1970  
*Fridericia paroniana* Issel, 1904  
*Fridericia perrieri* (Vejdovský, 1878)  
*Fridericia phaeostriata* Dózsa-Farkas, 2015  
*Fridericia ratzeli* (Eisen, 1872) (= *F. eiseni* Dózsa-Farkas, 2005)  
*Fridericia raxiensis* Dózsa-Farkas & Felföldi, 2017  
*Fridericia schmelzi* Cech & Dózsa-Farkas, 2005  
*Fridericia semisetosa* Dózsa-Farkas, 1970  
*Fridericia sohlenii* Rota *et al.*, 1998  
***Fridericia szoevenyii* sp.n.**  
*Fridericia* sp.  
*Globulidrilus riparius* (Bretscher, 1899)  
*Henlea perpusilla* Friend, 1911  
*Marionina argentea* (Michelsen, 1889) *sensu lato*  
*Marionina clavata* Nielsen & Christensen, 1961  
*Marionina simillima* Nielsen & Christensen, 1959  
*Marionina vesiculata* Nielsen & Christensen, 1959  
*Mesenchytraeus armatus* (Levinsen, 1884)

*Mesenchytraeus glandulosus* (Levinsen, 1884)

*Mesenchytraeus pelicensis* Issel, 1905

*Oconorella cambrensis* (O'Connor, 1963)

*Oconorella tubifera* (Nielsen & Christensen,  
1959)

*Stercutus niveus* Michelsen, 1888

*Hrabeiella periglandulata* Pižl & Chalupský,  
1984

*Parergodrilus heideri* Reisinger, 1925