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Enchytraeidae (Annelida: Oligochaeta) from the North-Western Caucasus, Russia, with the Description of *Fridericia gongalskyi* sp. nov.

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Abstract: The first list of terrestrial enchytraeids of the north-western Caucasus includes 24 species belonging to seven genera. A new enchytraeid species of the genus *Fridericia*, *Fridericia gongalskyi* sp. nov., is described. It clearly differs from other species of the genus by the presence of only three pairs of preclitellar nephridia, the postclitellar position of the chylus cells and two elongated spermathecal diverticula. The phylogenetic relations of the new species within the genus are discussed.

Keywords: soil fauna; potworms; taxonomy; soil biodiversity; soil mesofauna; North Caucasus; new species

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1. Introduction

With more than 120 accepted species [1–4], *Fridericia* Michaelsen, 1889, is currently the largest genus of the Enchytraeidae family. Most species have been described from Western and Central Europe [5,6] and Eastern Asia (e.g., [3]). Little is known about the enchytraeid fauna in the Caucasus, but one new species, *F. samurai* Degtyarev, 2022, was recently described from Eastern Dagestan [7]; therefore, there is a significant opportunity to find new *Fridericia* species in this region.

In this paper, the north-western Caucasus is equated with the mountainous regions of Krasnodar Krai and the Republic of Adygea. These territories are located on the western-most tip of the Greater Caucasus Mountain Ridge. Before this study, nothing was known of the enchytraeid fauna in this area.

In April 2021, we collected soil samples from different localities of the north-western Caucasus, aiming to investigate the local enchytraeid fauna. As a result, a total of 24 species belonging to seven genera were distinguished. Among them, one species belonging to the *Fridericia* genus was detected as being new to science. The morphological studies of the newly described species were supplemented with DNA analyses of the cytochrome c oxidase subunit I (COI).

2. Materials and Methods

Concerning the study localities, the sampling was carried out on 21 April 2021 across five different localities in the north-western Caucasus (Table 1). The studies were conducted in the forest belt at altitudes ranging from 261 to 1473 m above sea level.

Regarding sampling and extraction, within each locality, we obtained a single bulk soil sample (approximately 20 × 20 × 10 cm) with a shovel. The samples were collected by D.I. Korobushkin. The samples were transported to the Laboratory of Soil Ecological Functions at the A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences in Moscow, and stored for about two months at 4–10 °C until the extraction. The enchytraeids were extracted from the soil according to Graefe [8], which is a modified version of O'Connor's [9] extraction technique.

Table 1. Geographical and habitat data of the study localities in north-western Caucasus, Russia.

№	Location	Vegetation	Latitude, °N	Longitude, °E	Altitude, m a.s.l.
1	Nagiezh-Uashkh crest, city of Maikop, Republic of Adygea	Oak forest	44.58434°	40.09813°	261
2	Seryebryany Klyuch, Apsheronsky District, Krasnodar Krai	Beech forest	44.19536°	40.07729°	1179
3	1 km north of Lago-Naki, Apsheronsky District, Krasnodar Krai	Beech–fir forest	44.10902°	40.01897°	1473
4	Dakhovskaya, Maykopsky District, Republic of Adygea	Floodplain linden-alder forest	44.23041°	40.19270°	442
5	2 km south-west of Burny, Mostovsky District, Krasnodar Krai	Beech forest	44.00342°	40.71196°	780

For the morphological study, the extracted enchytraeids were examined, measured, and photographed in vivo under an Olympus BX43F microscope with a Zeiss AxioCam ERc 5s digital camera. We applied the taxonomic system and terminology of taxonomic structures used by Schmelz & Collado [1,2]. The investigated specimens were preserved in 96% ethanol for possible molecular analysis. The materials were deposited in the collection of the Zoological Museum of Moscow University, Russia (ZMMU). The remaining paratypes were retained in the private collection of the first author (stored in the Laboratory of Soil Ecological Functions at the A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow).

For the molecular analysis, the total DNA was extracted from two individuals using an "ExtractDNA Blood" kit (Evrogen, Russia). The entire enchytraeid body was used. Cytochrome c oxidase subunit I (COI) was selected as a genetic marker for amplification. The primers for PCR were synthesized by Evrogen (Russia). The PCR mixture contained 1–3 ng of the DNA, 0.1 μM of each primer, and the precast PCR mixture from DIALAT Ltd (Moscow, Russia). The COI region was amplified using LCO1490 (5′-GGTCAACAAATCATAAAGATATTGG-3′) [10] as a forward primer and COI-E (5′-TATACTTCTGGGTGTCCGAAGAATCA-3′) [11] as a reverse primer. The amplification programs for both loci were set up as described in [12]. The DNA sequencing was performed using an Applied Biosystems 3500 genetic analyzer.

The preprocessing and alignment of the obtained sequences were carried out using SeqMan Pro v. 7.1.0 and BioEdit v. 5.0.9. The phylogenetic analysis of the new species of *Fridericia* was carried out on the basis of the COI sequences obtained by us and deposited in the GenBank NCBI database, a representative of the closely related genus *Buchholzia appendiculata* and the distant genus *Propappus volki* were selected as an outgroup (Table 2).

Table 2. Measures of genetic diversity: SN, COI sequences GenBank NCBI database numbers; n, number of sequences; NS, total number of sites (excluding sites with gaps/missing data); S, number of variable sites; Eta, total number of mutations; h, number of haplotypes; Hd, haplotype (gene) diversity; d, variance of haplotype diversity; Pi, nucleotide diversity; G + C, guanine–cytosine content.

№№	Species	SN	n	NS	S	Eta	h	Hd	d	Pi	G + C
1	*F. gongalskyi* sp. nov.	OQ001427–428	2	522	58	58	2	1.00	0.074	0.0741	0.34
2	*F. bisetosa*	KU586588–589	2	522	4	4	2	1.00	0.250	0.0077	0.37
3	*F. christeri*	GU902060, MG711472	2	522	77	77	2	1.00	0.250	0.1475	0.40
4	*F. connata*	KU586595, KU586594	2	522	0	0	1	0.00	0.000	0.0000	0.39
5	*F. connatiformis*	KU586590–591	2	472	5	5	2	1.00	0.250	0.0106	0.39
6	*F. eiseni*	MG422199, MG422946, MG421415	3	522	23	23	2	0.67	0.099	0.0294	0.36
7	*F. galba*	MF547668, MF547667, GU902063, OK181906, KX618733, GU453371	6	426	78	87	5	0.93	0.015	0.0953	0.38
8	*F. granulocyta*	MH124595–596, KR872343–345	5	522	7	7	2	0.60	0.031	0.0081	0.39
9	*F. isseli*	GU902065	1	522	-	-	1	0.00	0.000	0.0000	0.37
10	*F. longiducta*	KU586593, KU586585–586	3	522	0	0	1	0.00	0.000	0.0000	0.38
11	*F. magna*	GU902066, MT609954–946, MT580288–0340	61	518	67	75	11	0.82	0.001	0.0488	0.40
12	*F. nemoralis*	GU902067	1	522	-	-	1	0.00	0.000	0.0000	0.37
13	*F. paroniana*	MG421432, MG421308, MG421242, MG422308, MG421981	5	522	6	6	2	0.60	0.031	0.0069	0.41
14	*F. peregrinabunda*	KR872337–338	2	522	0	0	1	0.00	0.000	0.0000	0.41
15	*F. phaeostriata*	KU586592, KU586582–584	4	521	16	16	4	1.00	0.031	0.0154	0.36
16	*F. ratzeli*	MF544531, MF544512, MF544261, MF544143, KM612016, HQ920539, MW703529	7	522	20	20	3	0.67	0.026	0.0208	0.34
17	*F. raxiensis*	MF547670, MF547672–674	4	514	59	59	2	0.50	0.070	0.0574	0.40
18	*F. seoraksani*	MZ750800–802, KR872340	4	520	62	62	2	0.67	0.042	0.0795	0.43
19	*F. sohlenii*	MT425081–083, MK580966	4	514	84	88	3	0.83	0.049	0.0863	0.40
20	*F. sphaerica*	KR872333–336	4	522	7	7	2	0.67	0.042	0.0089	0.38
21	*F. tuberosa*	GU902075, AF064047	2	517	11	11	2	1.00	0.250	0.0213	0.41
22	*F. waldenstroemi*	GU902076	1	522	-	-	1	0.00	0.000	0.0000	0.36
23	*Buchholzia appendiculata*	GU902038	1	522	-	-	1	0.00	0.000	0.0000	0.40
24	*Propappus volki*	GU902109, MF458803–804	3	522	58	58	3	1.00	0.074	0.0741	0.34

The genetic distances between the species were calculated using the MEGA X software package (Table A1) [13]. For the reconstruction of the genetic relationships, we used the Maximum Likelihood (ML), Nearest Neighbor (Neighbor-Joining—NJ) [14], and Maximum Parsimony (MP) [15] methods based on the obtained results. The sequences and data from GenBank (NCBI) with the calculation of bootstrap support for the branch nodes (1000 replicas) [16] and the chosen model of molecular evolution General Time Reversible (GTR + G + I; +G, parameter = 0.72 for ML); Tamura-Nei (TN93 + G + I; +G, parameter = 0.83 for NJ) [17]. The phylogenetic tree was built in MEGA X.

3. Results

In total, 322 specimens were examined. Overall, 24 enchytraeid species belonging to seven genera were found in the samples (Table 3). The enchytraeid fauna consists mostly of species from the genus Fridericia (15 species). There were two species in each of the genera: Achaeta Vejdovský, 1878; Buchholzia Michaelsen, 1886; and Enchytraeus Henle, 1837, and one species each of Henlea Michaelsen, 1889; Mesenchytraeus Eisen, 1878; and Stercutus Michaelsen, 1888. One species, *Fridericia gongalskyi* sp. nov., is new to science.

Table 3. Species of Enchytraeidae found at different sites in north-western Caucasus, Russia. The new species described in the present paper is highlighted in bold. Location numbers correspond to those in Table 1.

№№		Location Number				
		1	**2**	**3**	**4**	**5**
1	*Achaeta affinis* Nielsen & Christensen, 1959			x		
2	*Achaeta eiseni* Vejdovský, 1878		x			
3	*Buchholzia appendiculata* (Buchholz, 1863)	x	x		x	
4	*Buchholzia simplex* Nielsen & Christensen, 1963			x		
5	*Enchytraeus buchholzi* Vejdovský, 1878	x	x	x	x	x
6	*Enchytraeus norvegicus* Abrahamsen, 1969				x	
7	*Fridericia bisetosa* (Levinsen, 1884)			x		
8	*Fridericia bulboides* Nielsen & Christensen, 1959			x		
9	*Fridericia* cf. *christeri* Rota & Healy, 1999	x	x			
10	*Fridericia galba* (Hoffmeister, 1843)			x	x	x
11	*Fridericia gongalskyi* sp. nov.		x		x	
12	*Fridericia* cf. *ilvana* Issel, 1905	x				
13	*Fridericia isseli* Rota, 1994	x	x		x	
14	*Fridericia maculata* Issel, 1905			x	x	x
15	*Fridericia* cf. *miraflores* Sesma & Dózsa-Farkas, 1993		x	x		
16	*Fridericia parathalassia* Schmelz, 2003			x		
17	*Fridericia paroniana* Issel, 1904	x	x	x		
18	*Fridericia perrieri* (Vejdovský, 1878)	x	x	x		
19	*Fridericia ratzeli* s.l. (Eisen, 1872)		x			
20	*Fridericia samurai* Degtyarev, 2022	x				
21	*Fridericia* cf. *ulrikae* Rota & Healy, 1999			x	x	
22	*Henlea perpusilla* Friend, 1911	x				
23	*Mesenchytraeus armatus* (Levinsen, 1884)			x		
24	*Stercutus niveus* Michaelsen, 1888	x				

3.1. Description of the New Species

Class Clitellata Michaelsen, 1919
Order Enchytraeida Kasprzak, 1984
Family Enchytraeidae d'Udekem, 1855
Genus *Fridericia* Michaelsen, 1889
Fridericia gongalskyi Degtyarev, sp. nov. (Figures 1 and 2)
Holotype: ZMMU 1263, adult specimen, fixed in pure alcohol.
Type locality:

A floodplain forest (44.2304° N, 40.1927° E; 442 m a.s.l.), Maykopsky District, Republic of Adygea, Russia. 21 April 2021, D.I. Korobushkin leg.

Paratypes: Two specimens (ZMMU 1264, 1265) from a beech forest (44.19536° N, 40.07729° E; 1179 m a.s.l.), Apsheronsky District, Krasnodar Krai, Russia, same date, and collector. Two specimens (private collection of M. Degtyarev) from type locality, same date, and collector.

Diagnosis: The new species can be recognized by the following combination of characters: (1) less than 40 segments; (2) a maximum of four chaetae per bundle; (3) girdle-shaped clitellum; (4) a-type coelomo-mucocytes; (5) three pairs of preclitellar nephridia; (6) long

oesophageal appendages; (7) postclitellar chylus cells; (8) and spermathecae with two elongated diverticula, and an ectal duct with one ectal gland.

Description: A small-sized *Fridericia* species with a body length of 6–7 mm and a width of 190–220 μm at VIII and 220–245 μm at the clitellum. The segment number (33)–(35)–(38). Chaetal formula 3,4–4,3,2 : (3),4–4,3,2. The chaetae within almost all of the bundles are arranged in pairs: larger outer chaetae (length is c. 30 μm and diameter 2–3 μm) and smaller inner chaetae (length is c. 25 μm and diameter is c. 1.5 μm). In a few caudal segments, there are only two chaetae per bundle, and the ventral caudal chaetae are slightly enlarged (c. 40 μm). A head pore at 0/1. Dorsal pores from VII. The epidermal gland cells are pale and arranged in one row per segment; each epidermal gland cell c. 10 μm wide and 20–35 μm long. Subneural glands are absent.

Body wall c. 15 μm thick, cuticle thick, 6–7 μm in thickness. The brain is posteriorly truncated and is 120–130 μm long and 90–100 μm wide. The oesophageal appendages are long but not coiled, prolonged to V–VI or even VII (Figure 1A). The pharyngeal glands appear in IV–VI, and the first and second pairs have broad dorsal connections; in all pairs, both the dorsal and ventral lobes are present. Secondary glands are absent. The chylus cells appear in XIII–XIV, occupying two segments. The chloragocytes from V are brownish in transparent light. Midgut pars tumida not seen. Three pairs of nephridia in the preclitellar segments from 7/8 to 9/10 (Figure 2), the length ratio anteseptale:postseptale 1:1.5–2 (Figure 1B). Dorsal blood vessel rising in XVII (sometimes in XVIII?). The blood is colorless. Two types of coelomocytes: coelomo-mucocytes ellipsoid, hyaline, without refractile vesicles, "type a" [18], 20–30 μm long and 15–20 μm wide; coelomo-lenticytes large, 6–12 μm long and 3–4 μm wide. Coelomo-lenticytes are very abundant and visually dominating.

The clitellum in XII–1/3XIII are girdle-shaped; the cells appear in 19–20 regular rows and are elevated (Figure 3). The testes and sperm funnels appear in XI. Mature spermatozoa are about 100 μm long and aligned on top of the sperm funnel. The heads of the spermatozoa are not distinguished. The sperm funnels are barrel-shaped, yielding, and are 85–110 μm long and 40–60 μm wide; the collar is narrower than the funnel body, which is 20–25 μm wide (Figure 1C). The vasa deferentia is confined to XII in a dense coil and is c. 6 μm wide. The seminal vesicle in XI occupies one segment. The male copulatory organs are 50–55 μm long and are c. 40 μm wide. The bursal slit is mostly longitudinal and 20 μm long, with small protrusions at the tips. The spermathecal ectal gland is as wide as the ectal duct and sessile. The spermathecal ectal ducts are 170–180 μm long and 10 μm wide; the ectal duct proximally projects into the ampulla, and the canal is 2.5–3.5 μm wide. The ampulla is thin and almost not visible because of diverticulae. The spermathecae each have two diverticula (oriented ectad) (Figure 1D). The lumen of the diverticula and the distal part of the ampulla form a common U-shaped sperm-containing chamber. The length of the diverticula is c. 30 μm and the width is c. 10 μm. The ampullae open separately into the oesophagus in V. There are one to three mature eggs at a time.

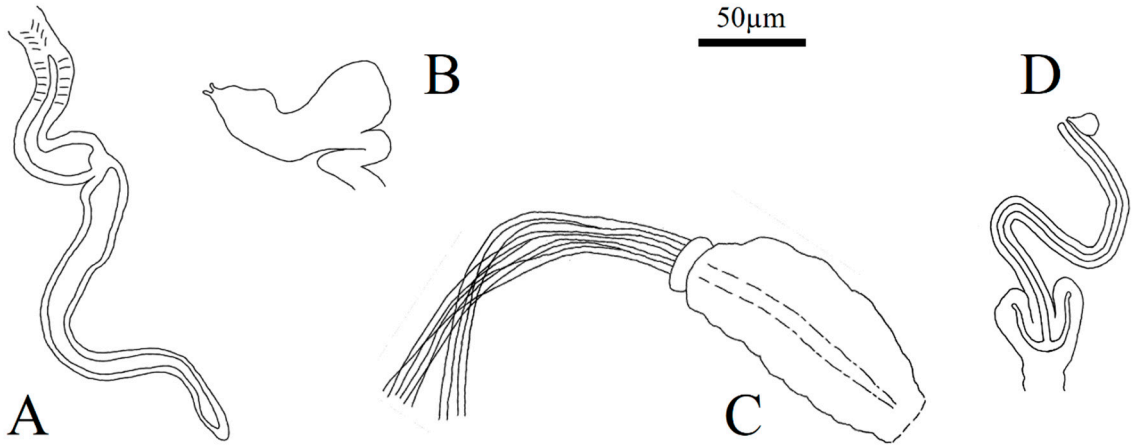

Figure 1. Several features of the holotype *Fridericia gongalskyi* sp. nov. (**A**) Oesophageal appendage. (**B**) Preclitellar nephridium. (**C**) Sperm funnel with brush of spermatozoa. (**D**) Spermatheca.

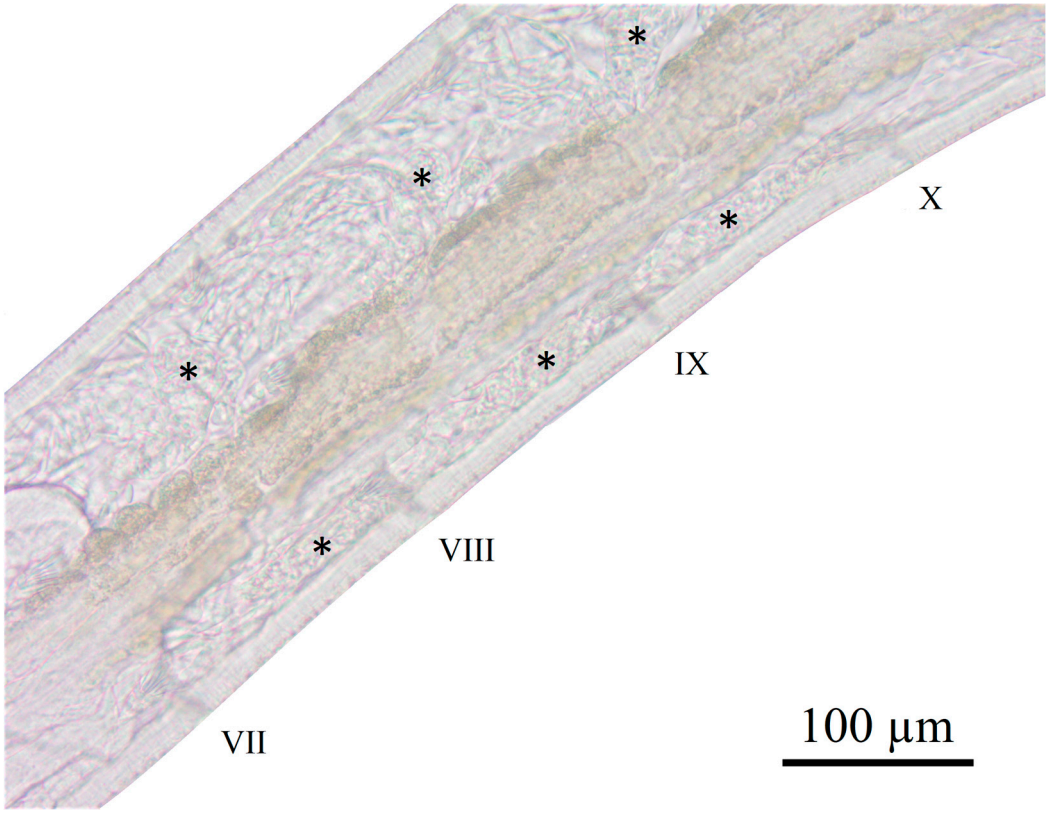

Figure 2. *Fridericia gongalskyi* sp. nov., subadult specimen, segments VII–X. All six preclitellar nephridia are marked with asterisks (*).

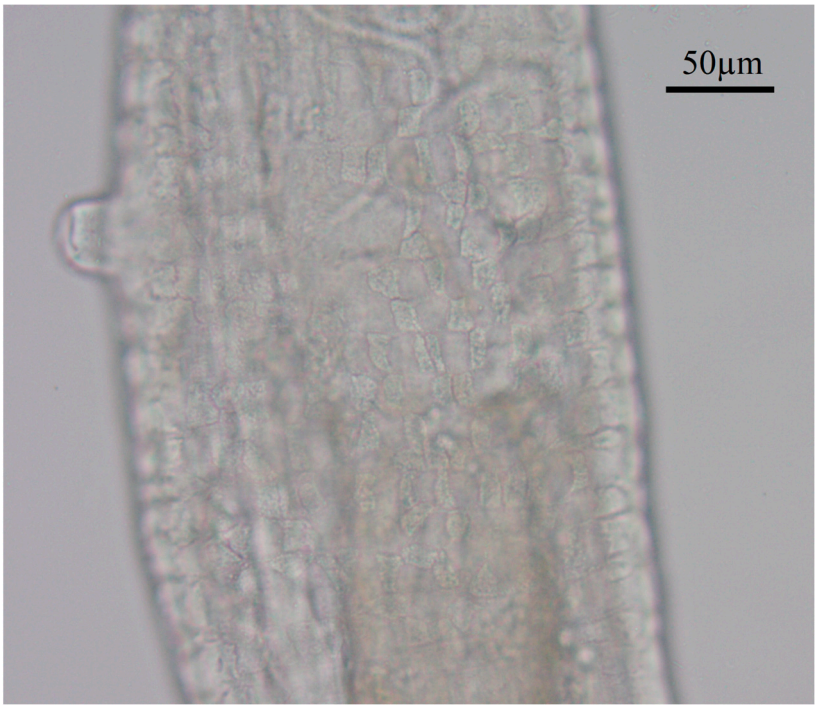

Figure 3. Clitellum of the holotype *Fridericia gongalskyi* sp. nov., lateral view.

Etymology: The species name *gongalskyi* is dedicated to Prof. Dr. K.B. Gongalsky (Moscow, Russia), a prominent soil zoologist who has organized studies of enchytraeid fauna in Russia.

Molecular data: the sequences were deposited in GenBank: OQ001427, OQ001428.

Remarks: Among *Fridericia*, the only yet described species with fewer than four pairs of preclitellar nephridia are *F. lacii* Dózsa-Farkas, 2009; *F. profundicola* Dózsa-Farkas, 1991; (See [19]) and *F. parasitica* Černosvitov, 1928. *F. gongalskyi* differs from *F. lacii* due to its longer oesophageal appendages, the postclitellar position of the chylus cells, and the elongated spermathecal diverticulae. Unlike *F. profundicola*, *F. gongalskyi* has simple (not coiled) oesophageal appendages and spermathecal diverticulae bent ectad [19]. Ecto-commensalic *F. parasitica* has only two pairs of preclitellar nephridia, four spermathecal diverticulae, up to 16 chaetae per bundle, and other peculiar characteristics, probably related to its lifestyle.

The oesophageal appendages of *F. gongalskyi* have an unusual feature that we did not mention in the description section. They can be divided into proximal and distal parts. The proximal part is characterized by a thicker and more robust wall. The wall of the longer distal part is thinner. Two parts are clearly visible, and each one has its own lumen (See Figure 1A). We did not find any mention of a similar structure of oesophageal appendages in the literature for any other species. Something similar can be seen in some *Fridericia* species whose appendages have many branches: each branch has thinner walls than the proximal duct leading into the oesophagus (e.g., in Figures 1 and 3 in [20]). The characteristic structure of the oesophageal appendages of *F. gongalskyi* can serve as a good diagnostic feature but require further investigation.

3.2. Results of Molecular Analysis

Phylogenetic analysis of COI supports the diagnosis that *F. gongalskyi* sp. nov. can be considered a separate species. It is to be noted that the bootstrap support values of the tree are mostly lower than 50; therefore, the reliability of the branching of that analysis is low (Figure 4). The results of the molecular analyses confirmed that the new species are genetically separate from other *Fridericia* species, and their sequences form distinct lineages on the phylogenetic trees. This was also supported by interspecific genetic distances since, in the case of the new species, these values were similar to the interspecific sequence

distances of other species (See Table A1) and were significantly greater than the nucleotide diversity of most other *Fridericia* species (See Table 2).

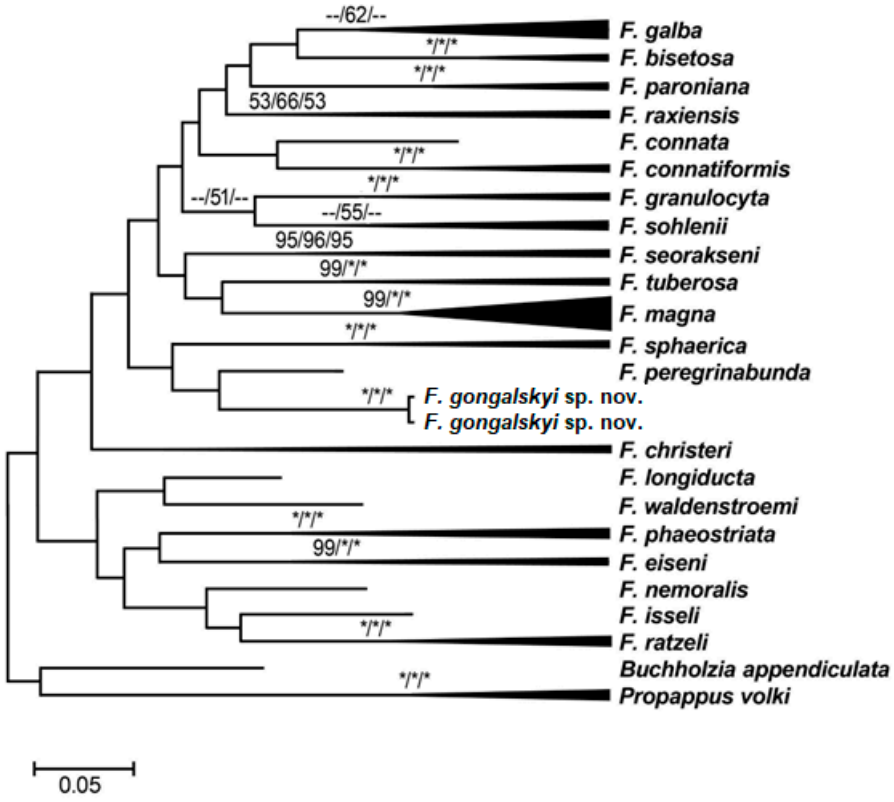

Figure 4. Reconstruction of the phylogenetic relationships of representatives of the genus *Fridericia* based on the variability of the COI fragment (522 bp) carried out by the maximum likelihood method in accordance with the GTR + G + I model of molecular evolution; +G, parameter = 0.72. The length of the branches is proportional to the genetic distances between haplotypes; bootstrap support (Felsenstein, 1985) is indicated next to the branching nodes, calculated on the basis of building trees using ML/NJ/MP methods from 1000 replicas ("*"—bootstrap support equal to 100%, "–" or not specified—bootstrap support less than 50%).

4. Discussion

The fauna of enchytraeids at most of the studied sites is extremely diverse. The relatively poor fauna at site 5 (see Table 3) could be explained by active erosion, which leads to the washing out of the litter and soil matter. The wide distribution of litter-dwelling species over the studied sites appears to be highly interesting. A widespread litter-dweller *Stercutus niveus* Michaelsen, 1888, was only found in the lowest site, 1, while *Buchholzia appendiculata* (Buchholz, 1863), another litter-dwelling enchytraeid with a wide distribution range [6] was found at different elevations up to 1179 m a.s.l. In the most elevated study location (site 3, beech–fir mountainous forest), neither *S. niveus* nor *B. appendiculata* were found. Instead, *B. simplex* Nielsen & Christensen, 1963, was detected there. Little is known about the ecology of the latter species, but it has been established that it prefers mountainous habitats and occurs in the beech, mixed and fir litter (Rota, 1995), which is in perfect agreement with our own observation. There is still too little data for any conclusions about the ecological profile and biogeographic patterns of the enchytraeid communities of the studied region, but the revealed spatial distribution of litter-dwelling enchytraeid species can be tentatively associated with altitude.

Based on our results, the enchytraeid fauna of north-western Caucasus consists mostly of species common in Europe but also includes some unique species. Apart from *F. gongalskyi* sp. nov., some other specimens may belong to species new to science. The morphology

of *F.* cf. *christeri* Rota & Healy, 1999 (Table 3), fits the description of *F. christeri* in [21]. However, all of the observed specimens of *F.* cf. *christeri* were thecate, though normally, *F. christeri* is an athecate species. The spermatheca of our *F.* cf. *christeri* differs from the description of thecate *F. christeri* in [6] due to the absence of the ectal gland. Thus, we leave this species with a .cf status, and do not claim that it is new to science. *F.* cf. *ulrikae* Rota & Healy, 1999, is much smaller in comparison to the original description (5 mm vs. 13–18 mm in total length; 36–37 vs. 50–55 segments) and has five pairs of preclitellar nephridia. *F.* cf. *miraflores* Sesma & Dózsa-Farkas, 1993, is likely to be a new species and its most peculiar difference from the original description is the saddle-shaped clitellum. *F.* cf. *ilvana* Issel, 1905, generally fits the re-description of *F. ilvana* made by Rota [22], except for its blood color. In these specimens, we found that the blood was colorless, although it was described in [22] as "pink-yellow". This may be due to both a regional variation and a difference between different species. In all of the above cases, additional material is required for a taxonomic decision.

F. parathalassia Schmelz, 2003, is considered to be coastal, living near salty and brackish waters [6,21]. However, we find *F. parathalassia* at site 3 (see Table 3) in a mixed forest of c. 1500 m a.s.l. We preserved some specimens of *F. parathalassia* from site 3 in 96% alcohol for future comparison with specimens from habitats more typical of this species.

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Data Availability Statement: The specimens described in this study are available at the Zoological Museum of Moscow University, Russia. Voucher IDs: *Fridericia gongalskyi* sp. nov.: holotype ZMMU 1263, paratypes ZMMU 1264, 1265.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Interspecies genetic distances p-distance.

№№	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	*F. gongalskyi* sp. nov.																							
2	*F. bisetosa*	0.15																						
3	*F. christeri*	0.08	0.09																					
4	*F. connata*	0.16	0.17	0.09																				
5	*F. connatiformis*	0.15	0.13	0.08	0.14																			
6	*F. eiseni*	0.14	0.13	0.07	0.15	0.14																		
7	*F. galba*	0.12	0.11	0.06	0.13	0.13	0.09																	
8	*F. granulocyta*	0.14	0.16	0.07	0.16	0.14	0.14	0.11																
9	*F. isseli*	0.14	0.14	0.08	0.15	0.13	0.14	0.12	0.16															
10	*F. longiducta*	0.15	0.16	0.09	0.17	0.16	0.11	0.12	0.15	0.16														
11	*F. magna*	0.15	0.15	0.07	0.13	0.13	0.12	0.10	0.13	0.16	0.13													
12	*F. nemoralis*	0.16	0.16	0.08	0.18	0.17	0.13	0.12	0.17	0.12	0.16	0.15												
13	*F. paroniana*	0.15	0.17	0.08	0.17	0.16	0.12	0.10	0.15	0.15	0.15	0.14	0.14											
14	*F. peregrinabunda*	0.13	0.15	0.08	0.16	0.13	0.14	0.11	0.15	0.14	0.16	0.12	0.16	0.15										
15	*F. phaeostriata*	0.15	0.13	0.07	0.18	0.15	0.11	0.12	0.13	0.16	0.13	0.14	0.14	0.14	0.14									
16	*F. ratzeli*	0.15	0.16	0.10	0.18	0.16	0.13	0.11	0.14	0.12	0.16	0.14	0.13	0.16	0.16	0.12								
17	*F. raxiensis*	0.10	0.09	0.02	0.10	0.10	0.07	0.06	0.08	0.12	0.09	0.08	0.11	0.08	0.10	0.10	0.12							
18	*F. seoraksani*	0.10	0.11	0.04	0.12	0.09	0.10	0.08	0.10	0.11	0.11	0.09	0.11	0.10	0.08	0.12	0.12	0.05						
19	*F. sohlenii*	0.11	0.10	0.05	0.14	0.10	0.08	0.08	0.08	0.12	0.12	0.10	0.13	0.11	0.11	0.09	0.10	0.06	0.06					
20	*F. sphaerica*	0.16	0.16	0.09	0.17	0.16	0.14	0.13	0.18	0.15	0.17	0.14	0.16	0.15	0.13	0.14	0.17	0.11	0.13	0.13				
21	*F. tuberosa*	0.14	0.13	0.06	0.15	0.14	0.12	0.09	0.13	0.15	0.14	0.10	0.16	0.14	0.11	0.15	0.14	0.07	0.09	0.09	0.13			
22	*F. waldenstroemi*	0.17	0.16	0.08	0.16	0.18	0.14	0.11	0.17	0.15	0.13	0.13	0.16	0.16	0.16	0.14	0.16	0.12	0.13	0.13	0.16	0.15		
23	*Buchholzia appendiculata*	0.18	0.19	0.12	0.19	0.18	0.14	0.15	0.18	0.21	0.18	0.17	0.18	0.18	0.18	0.16	0.19	0.12	0.13	0.15	0.19	0.17	0.19	
24	*Propappus volki*	0.21	0.21	0.14	0.21	0.20	0.17	0.18	0.21	0.20	0.19	0.20	0.22	0.21	0.22	0.18	0.19	0.15	0.19	0.17	0.20	0.21	0.20	0.21

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