

Heterodorus magnificus Altherr, 1952 and *H. arcuatus* (Thorne, 1939) (Nematoda: Dorylaimida) from Arctic Polar Deserts: New Geographic Records

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Abstract: *Heterodorus magnificus* ALTHERR, 1952 and *H. arcuatus* (THORNE, 1939) ANDRÁSSY, 2009 from High Arctic were described and illustrated. *Heterodorus magnificus*, considered as a junior synonym of *H. arcuatus* by ANDRÁSSY (2009), is re-validated and an amended diagnosis is proposed; the species is recorded for the first time from a nival desert of Taymyr Peninsula. *H. arcuatus* represents a new geographic record for polar deserts of Bol'shevik and Ellef Ringnes Islands.

Key words: Cold desert, distribution, morphology, taxonomy

Introduction

The genus *Heterodorus* (family Nordiidae) was erected by ALTHERR (1952) to accommodate one enchodelid species showing a peculiar uterine structure: distal part of uterus represents a cone-like chamber formed by large hyaline cells surrounding the lumen, the latter full of numerous small refractive objects. Subsequently, the author synonymised it with *Enchodelus* THORNE, 1939 (ALTHERR, 1963). SIDDIQI (1969) studied Altherr's specimens, and regarded *Heterodorus* as a distinct genus closely related to *Enchodelus*. In further studies *Heterodorus* was considered as a junior synonym of *Enchodelus* (LOOF, 1971; ZULLINI, 1973; VINCIGUERRA, 1976; AHMAD and JAIRAJPURI, 1980; JAIRAJPURI and AHMAD, 1992). Recently, ANDRÁSSY (2009) re-established *Heterodorus* as a valid genus harbouring all enchodelid species with a conical tail and few ventromedial supplements lying in series at a distance from the adanal pair. He transferred 24 species from *Enchodelus* to *Heterodorus* and synonymised four of them. Lately, molecular data supported the opinion of Andrassy that the species with rounded and conical

tail form two different groups (clades) (PEDRAM et al. 2009, 2011a). Recently, PEDRAM et al. (2011b) published the results of the first molecular study of another member of the family Nordiidae, the genus *Rhysocolpus* ANDRÁSSY, 1971, based on 18S rDNA sequences and observed a close relationship between *Rhysocolpus* and *Heterodorus*, and a more distant relationship with *Enchodelus*.

Heterodorus is similar to *Enchodelus* but clearly distinguishable from its "sister" genus based on several significant differences (ANDRÁSSY, 2011, see Table 1). Currently, genus *Heterodorus* contains 25 species listed by ANDRÁSSY (2011): it is spread mostly in the Northern Hemisphere; so far only three species have been described from the Southern Hemisphere, one from Peru and two species from Papua New Guinea. Species belonging to *Heterodorus* are associated mainly with natural vegetation (mosses, grasses and tree plants). Similarly to the representatives of *Enchodelus*, heterodorids occur at the altitude ranging from 50 to 900 m a.s.l. at high latitudes and up to 5250 m a.s.l. at lower latitudes.

Materials and Methods

Soil samples were collected by Dr Olga Makarova (Institute for Problems of Ecology and Evolution, Russia) from Bol'shevik Island (Severnaya Zemlya Archipelago) and Ellef Ringnes Island (Canadian Arctic Archipelago) representing a zonal type of landscape (polygonal polar deserts) and the highlands of Putorana Plateau, southern Taymyr, representing an altitudinal analogue of the zonal polar deserts, known as nival deserts. Details on the localities, vegetation type and samples are presented in Table 2. Nematodes were extracted from 1-3 g of soil by using the Baerman funnel method for 48 hours exposition, killed by gentle heat, and fixed in 4% formalin. The extracted specimens were processed in anhydrous glycerine by the Seinhorst method (1959) and mounted on permanent slides. Drawings and photographs were taken using an Olympus BX51 compound microscope equipped with a drawing tube, digital camera (ColorView IIIu) and specialised software (Cell^P, Olympus Soft Imaging Solutions GmbH). Measurements were made using an Olympus BX 41 light microscope with a drawing tube and digitizing tablet (CalComp Drawing Board III, GTCO CalCom Peripherals, Scottsdale, AZ, USA) and Digitrak 1.0f computer program (Philip Smith, John Hutton Institute Dundee, UK).

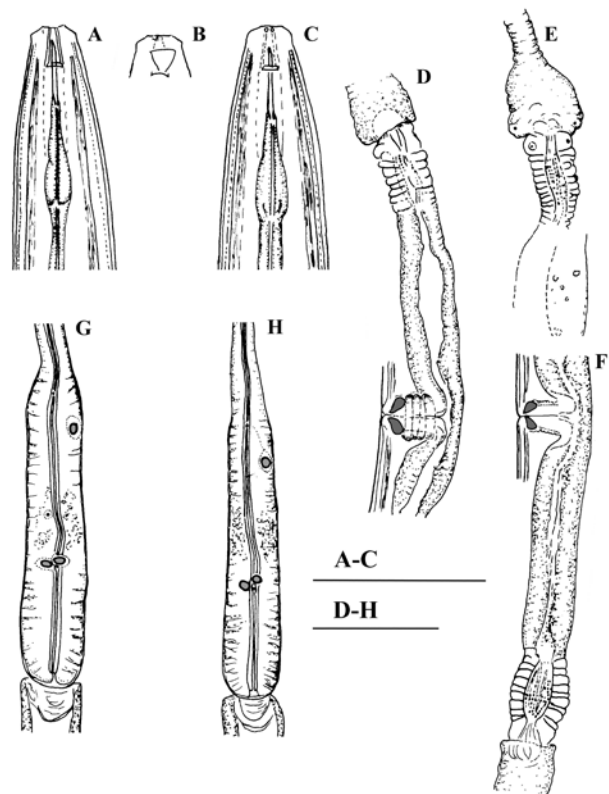


Fig. 1. *Heterodorus magnificentus* Female: A, C – Anterior region; B – Amphidial fovea; D – Anterior uterus and vulval region; E – Distal part of uterus forming peculiar cone-like structure; F- Posterior uterus and vulval region; G, H – Pharyngeal expansion, dorsal and ventrosublateral glands. Scale bars: A-C 50 µm, D-H 25 µm

Results

Heterodorus magnificentus ALTHERR, 1952

(Figs. 1-5)

Measurements

See Table 3.

Description

Females. Moderately slender nematodes of medium size, C-shaped after fixation. Cuticle 2-3 µm thick at post-labial region; 2-5 µm at mid body and 2.5-5.5 µm at post-anal region. Subcuticle with very fine transverse striations. Lateral chord 8-15 µm wide. Lateral pores obscure. Lip region angular, set off by a shallow depression, 3-4 times as broad as high. Labial papillae slightly protruding, clearly perceptible. Cheilostom a truncate cone. Amphid fovea cup-shaped, opening at level of cephalic depression. Odontostyle slender, 1.4-1.6 times as long as diameter of lip region. Odontophore lacking any specialisation, 1.2-1.7 times the odontostyle length. Guiding ring at 0.8-1.0 times diam. of lip region from anterior

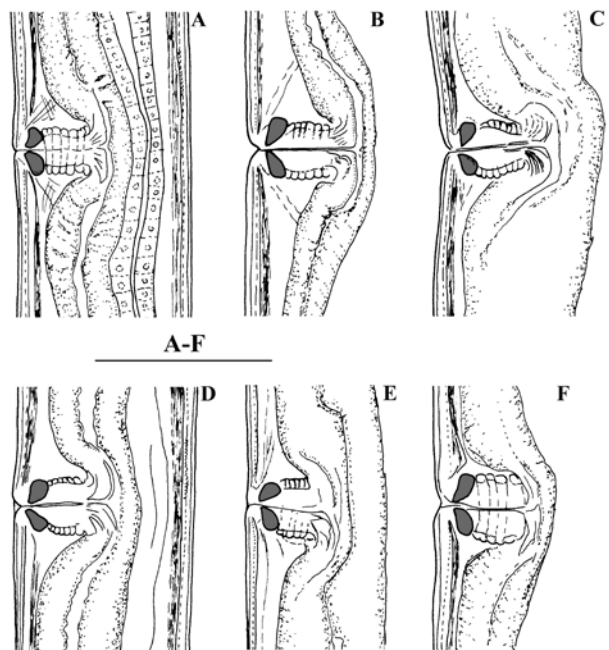


Fig. 2. *Heterodorus magnificentus* Female: A-F – Variability of vulval region. Scale bars: A-F 50 µm

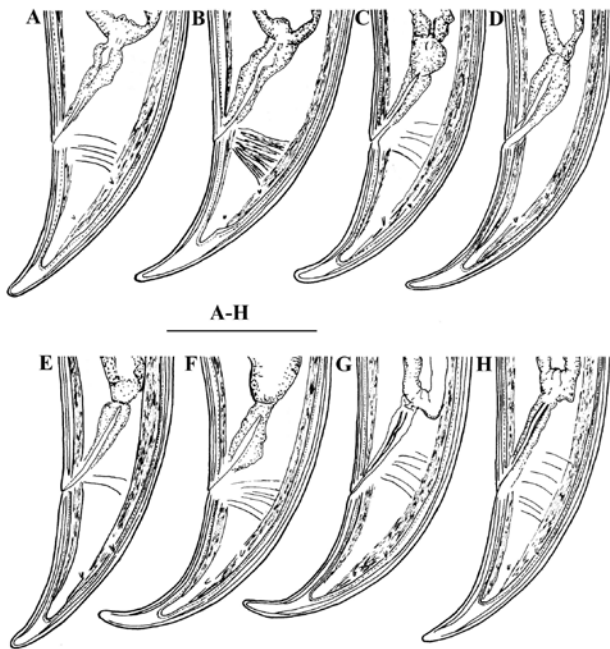


Fig. 3. *Heterodorus magnificus* Female: A-H -Variability of tail end. Scale bars: A-H 50 μ m

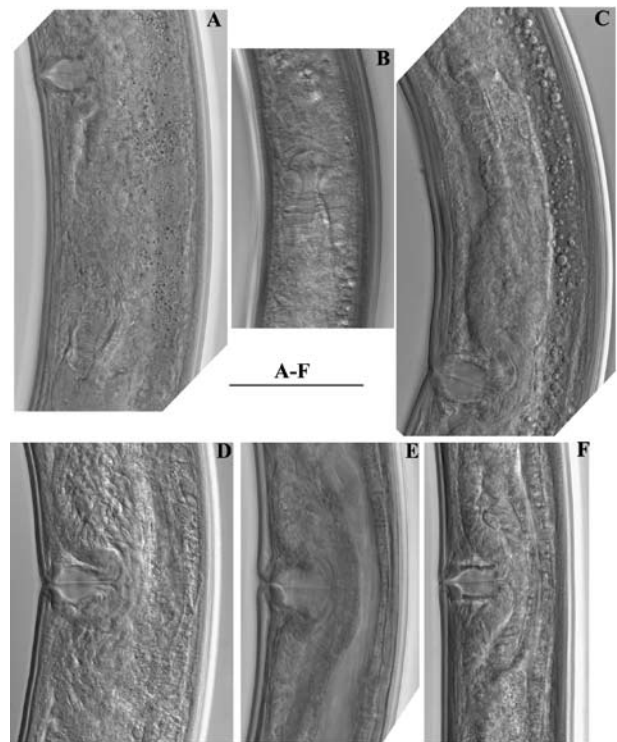


Fig. 5. *Heterodorus magnificus* Female: A – Posterior uterus and vulval region; B – Distal part of uterus forming peculiar cone-like structure; C – Anterior uterus and vulval region; D-F – Vulval region. Scale bars: A-F 50 μ m

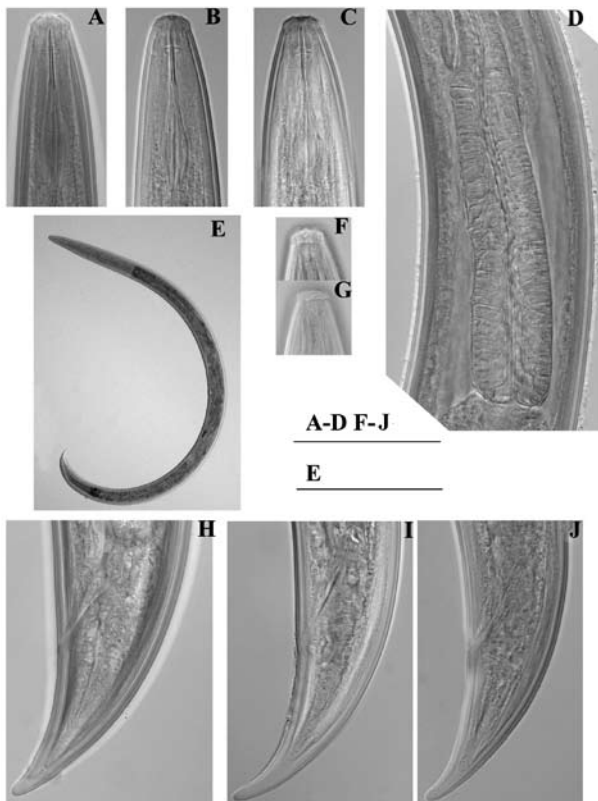


Fig. 4. *Heterodorus magnificus* Female: A-C – Anterior region; D – Pharyngeal expansion; F, G – Amphidial fovea; E – Entire body; H-J – Variability of tail end. Scale bars: A-D, F-J 50 μ m, E 500 μ m

end, apparently double, but rather thin. Pharyngeal expansion 102-137 μ m long, occupying 34-42% of total neck length, and one-third to one-half of cor-

responding body diameter. Location of pharyngeal gland nuclei is presented in Table 4. Nuclei of dorsal glands 3-4 μ m diam. and second pair ventrosublateral 2-3 μ m, first pair observed in two specimens, their nuclei ca 1 μ m. Cardia rounded conoid, measuring 12-18 x 9-13 μ m. Genital system amphidelphic, both branches almost equally developed, anterior 185-280 μ m, posterior 191-300 μ m. Ovaries relatively large, 111-121 μ m long (n=4). Anterior and posterior oviduct 88-127 μ m (n=8) and 98-127 μ m (n=7) long or 1.9-2.0 and 1.4-2.0 times corresponding body diam. respectively, consisting of a slender part and moderately developed *pars dilatata oviductus*. Sphincter well-developed, 8-10 μ m long. Anterior 105-139 μ m (n=13) and posterior 92-141 μ m (n=10) uterus long, bipartite, consisting of a tubular proximal portion with distinct lumen and a distal part representing structure 17-31 μ m long (Figs. 1D-F, 5A-C) with shape varying from oval to cone-like. This structure consists of hyaline cells surrounding distal part of uterus, small refractive granules located just behind sphincter arranged in longitudinal and transverse rows. Vagina extending inwards 44-61% of body diam., *pars proximalis vaginae* 13-19 x 20-25 μ m,

Table 1. Differences between the genera *Heterodorus* and *Enchodelus* based on literature (Andrássy, 2011) and present observations

<i>Heterodorus</i> ALTHERR, 1952	<i>Enchodelus</i> THORNE 1939
Odontophore rod like, lacking basal flanges or very poorly developed	Odontophore flanged
Posterior ventrosublateral pair of pharyngeal nucleoli lying far anterior to the end of cylindrus, close to the middle of glandularium	Posterior ventrosublateral pair of pharyngeal nucleoli lying close to the end of cylindrus
Pharynx gradually expanding into basal expansion	Pharynx abruptly expanding into basal expansion
Uterus bipartite	Uterus tripartite (except for <i>E. distinctus</i> and <i>E. ponorensis</i>)
Tail conoid and ventrally arcuate	Tail rounded (hemispherical)
Saccate bodies always absent	Saccate bodies may present in some species.
Ventromedial supplements 1–10 in number	Ventromedial supplements 7–16 in number (2-4 in <i>E. signyensis</i> , lacking in <i>E. arcticus</i>)
The posterior supplement is located at a considerable distance from the adcloacal pair, and always outside of the spicule range (except for <i>H. brevidentatus</i>)	The posterior one or two ventromedial supplements rather close to the adcloacal pair and inside the spicule range (except <i>E. signyensis</i>)

Table 2. Distribution of the examined materials of *Heterodorus magnificus* and *H. arcuatus*

Locality and samples	Type of landscape and vegetation	Abbreviation	Nematode species/ numbers
Putorana Plateau, Vicinity of Lake Sobach'e (Yt-Kuel) Taymyr Peninsula 69°09'N; 91°52'E	Polygonal nival desert		<i>Heterodorus magnificus</i>
Site 1 750 m a.s.l Collected on 3.08.1996			
Sample №10	Large green <i>Deschampsia borealis</i> (Trautv.) Roshev. tuft	DB1	2♀
Samples №5 and 6	<i>Tortula ruralis</i> (Hedw.) Gaertn.	TR	7♀
Samples №7 and 8	Old <i>D. borealis</i> tuft with <i>Gymnomitrium corralioides</i> Nees. and <i>Cladonia sp.</i>	DB, GC, C	5♀
Site 2 900 m a.s.l Collected on 31.7.1996			
Sample №4	Small tuft of <i>D. borealis</i> among bare soil	DB2	2♀
Ellef Ringnes Island Canadian Arctic Archipelago 78°47' N; 103°33' W Collected on 23-30 July, 2005	Typical zonal polar desert with polygonal structure		<i>Heterodorus arcuatus</i>
Sample №15	<i>Aulacomnium turgidum</i> (Wahlenb.) Schwögr.	AT	1♀
Sample №41	<i>Potentilla hyparctica</i> Malte	PH	1♀
Bol'shevik Island, Solnechnaya bay Severnaya Zemlya Archipelago 78°12'N; 103°17'E Collected on 21.08.2000	Polygonal polar desert		<i>Heterodorus arcuatus</i>
Sample №23	<i>Dicranoweisia crispula</i> (Hedw.) Milde	DC	1♀

with almost straight walls and well developed circular musculature; *pars refringens vaginae* with two arcuate drop-like sclerotised pieces (in lateral view), which have a combined width of 11-17 μm ; *pars distalis vaginae* 4-7 μm long. Vulva a transverse slit. One egg located in anterior *pars dilatata oviductus*, measuring 37 x 86 μm . Only one female observed to contain sperm cells in uterus (Fig. 5D). Prerectum 2.6-3.8 and rectum 0.7-1.2 times the anal body diam. Tail conical, curved ventrad, with narrowly rounded tip; hyaline part of cuticle 11-25 μm thick or 16-40% of total tail length. Two pairs of subterminal caudal pores located at different levels.

Male

Unknown

Locality and habitat

Putorana Plateau, Taymyr Peninsula, Russian Arctic, polygonal nival desert, different types of plant associations (Table 2).

Remarks

ANDRÁSSY (2011) synonymised *Heterodorus magnificus* ALTHERR, 1952 with *H. arcuatus* THORNE, 1939 on the basis of their almost identical morphometrics. Despite the similarity in main morphometric characters, there are some morphological differences between them such as the features of reproductive system: in *H. magnificus* the distal part of the uterus represents an oval to cone-like structure while in type specimens of *H. arcuatus* the distal part is a long tube distinctly narrower than the proximal part (see Figs. 2F and 3C in GUERRERO and PEÑA-SANTIAGO (2007). They observed hyaline cells surrounding sphincter and distal part of uterus and small refractive granules in uterus lumen, close to the sphincter. *Heterodorus magnificus* differs from *H. arcuatus* also by prerectum 4-5 times anal body diam. vs 2.1-2.9; lip region apparently almost continuous (following fig. 12 of ALTHERR, 1952, and fig. 4 of ALTHERR, 1963) vs offset by shallow constriction. Our specimens are very close to *H. magnificus* in every respect although the absence of data on some important morphological characters in the original description (neck length, length of basal expansion of pharynx, location of oesophageal gland nuclei and description of vagina structure) complicate the comparison. Furthermore, current females of *H. magnificus* differ from *H. arcuatus* in the shape of sclerotised pieces of *pars refringens vaginae* (drop shaped vs well developed trapezoid); also from *H. thornei* (BAQRI & JAIRAJPURI, 1974) ANDRÁSSY, 2009, which is

regarded as a synonym of *H. arcuatus* by ANDRÁSSY, (2011). *Heterodorus magnificus* can be distinguished from *H. thornei* by its wider lip region (12.5-14 vs 11-12 μm), longer odontostyle (19.5-22 vs 17-18 μm), different structure of odontophore (without any specialisation vs with flanges), oesophago-intestinal disc absent vs present, cone like structure at distal part of uterus present vs not present.

Diagnosis emended. *Heterodorus magnificus* is distinguished by its body 1.39-1.92 mm long, lip region 12-14 μm diam., odontostyle 18-22 μm long or 1.4-1.6 times the lip region diam., odontophore rod-like, 1.2-1.7 times the odontostyle length, neck length of 284-329 μm , pharyngeal expansion 102-137 μm or 34-42% of total neck length; female genital system amphidelphic, uterus bipartite, *pars refringens vaginae* with two arcuate drop-like sclerotised pieces, vulva a transverse slit, equatorial to slightly post-equatorial (V = 50-56%); tail conical, curved ventrad (56-80 μm , c = 21.6-38, c' = 1.5-2.5), males not found.

Heterodorus magnificus was originally described from moss at high elevation in Swiss National Park, and subsequently from subalpine vegetation in Dischma Valley at 2000 m a.s.l., Switzerland (ALTHERR, 1952, 1963), on the Sphagnaceae in the Tatra Mountains in Poland (Brzeski, 1963), and from high mountain vegetation in Austria (Gerber, 1991). This represents a new geographic record for Taymyr Peninsula.

Heterodorus arcuatus (THORNE, 1939) ANDRÁSSY, 2009

(Figs 6-8)

Measurements

See Table 3.

Description

Females. Moderately slender nematodes of medium size, C- shaped after fixation. Cuticle 3 μm thick at anterior region; 4-5 μm at mid body and 4-5.5 μm at tail, with fine transverse striations. Lateral chord 14-16 μm wide. Lateral pores obscure. Lip region rounded, offset by a slight constriction, 3-4 times as broad as high. Labial papillae slightly protruding. Cheilostom a truncate cone. Amphid fovea cup-shaped, opening at a level a cephalic constriction and occupying ca two-thirds of lip region diam. Odontostyle slender, 1.5 times the lip region diam. Odontophore rod like, 1.3-1.5 times the odontostyle length long. Guiding ring double, thin, 0.8-0.9 times the lip region diam. from anterior end. Pharynx con-

Table 3. Morphometrics of *Heterodoros magnificus* and *H. arcuatus*. All measurements, unless indicated otherwise, are in μm and in the form: mean \pm SD (range)

Character	<i>Heterodoros magnificus</i>				<i>Heterodoros arcuatus</i>		
	Russian Arctic				Russian Arctic	Canadian Arctic	
	Putorana Plateau				Bol'shevik Island	Ellef Ringnes Island	
	TR (n=7)	DB, GC, C (n=5)	DB ₁ (n=2)	DB ₂ (n=2)	DC (n=1)	AT (n=1)	PH (n=1)
L (mm)	1.52 \pm 0.1 (1.45-1.67)	1.47 \pm 0.1 (1.39-1.54)	1.50, 1.63	1.59, 1.58	1.86	1.79	1.51
a	29.9 \pm 4.8 (21.3-34)	29.2 \pm 3.8 (23.7-34)	23.8, 29.8	29, 28.4	30.3	30.7	28.5
b	4.8 \pm 0.1 (4.7-5.1)	4.8 \pm 0.3 (4.3-5.2)	4.8, 5.0	5.0, 4.9	5.0	4.9	4.4
c	24.3 \pm 2.2 (21.6-27.9)	24.2 \pm 1.0 (23-25)	24.3, 27.9	25.6, 22.3	23.6	24.6	19.7
c'	1.8 \pm 0.3 (1.5-2.3)	1.9 \pm 0.2 (1.5-2.1)	2.1, 1.9	1.9, 2.0	2.0	1.8	2.1
V %	52.9 \pm 1.9 (50.5-56)	53.2 \pm 2.2 (50-56)	52, 51	54.5, 54	55	53	58
Lip region width	13.3 \pm 0.6 (12.5-14)	13.4 \pm 0.6 (12.5-14)	14, 13	14, 14	14	14	14
Odontostyle	20.6-0.7 (20-22)	20.4 \pm 0.8 (19.5-22)	21, 21	22, 22	22	21	21
Odontophore	32.3 \pm 2.8 (29-35)	29.3 \pm 2.0 (26-32)	35, 31	34, 31	30	30	33
Spear	53.0 \pm 3.3 (47-57)	49.8 \pm 1.5 (48-52)	55.5, 52	56, 54	51	50.5	53.5
Anterior end guiding ring	11.9 \pm 0.5 (11-13)	12, 12	13, 12	13, 13	11	12	13
Neck length	313.5 \pm 13.4 (297-329)	307.5 \pm 13.4 (284-320)	311, 328	319, 324	370	360	338
Width at pharynx base	45.7 \pm 8.1 (40-60)	45.7 \pm 3.7 (42-51)	59, 48	48, 49	55	52	47
Width at mid body	52.0 \pm 9.2 (44-69)	51 \pm 5.0 (45-59)	63, 55	55, 56	62	59	53
Prerectum length	107.8 \pm 22.6 (92-124)	93 \pm 4.5 (88-100)	96	112, 115	96	78	62
Rectum length	30.6 \pm 5.5 (26-40)	33.8 \pm 7.2 (27-44)	36	35, 33	33	35	31
Tail	62.7 \pm 3.6 (56-66)	61.1 \pm 4.4 (57-66)	62, 59	62, 71	79	73	77

sisting of a slender, well muscled portion expanding gradually into basal expansion, occupying 126-144 μm or 37-39% of total neck length. Location of pharyngeal gland nuclei presented in Table 4. Cardiacoid rounded, measuring 12x11 μm . Genital system amphidelphic, both branches almost equally developed (anterior 290-331 μm and posterior 269-334 μm long). Ovaries relatively large, 165 μm long (n=1); oviduct 134-154 μm (n=3) or 2.3-2.5 times

body diam. Sphincter between uterus and *pars dilatata oviductus* distinct, 9-11 μm long. Uterus bipartite, consisting of a wider proximal portion with distinct lumen, and a narrower distal part with narrow lumen; length of uterus relatively long 122-180 (n=4) μm long; distal part of uterus surrounded by hyaline cells at a long distance, small refractive granules located just behind sphincter. Vagina extending inwards 47-56% of body diam., *pars proxi-*

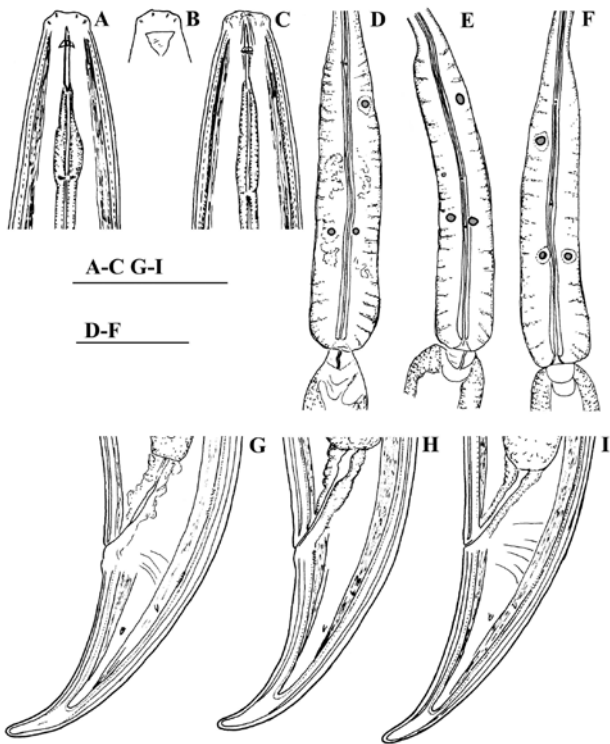


Fig. 6. *Heterodorus arcuatus* Female: A, C – Anterior region (A – specimen from Bol'shevik Island; C – specimen from Ellef Ringnes Island); B – Amphidial fovea (specimen from Bol'shevik Island); D-F – Pharyngeal expansion, dorsal and ventrosublateral glands (D – specimen from Bol'shevik Island; E, F – specimens from Ellef Ringnes Island); G-I – Variability of tail end (G – specimen from Bol'shevik Island; H, I – specimens from Ellef Ringnes Island). Scale bars: A-C, G-I 50 µm D-F 25 µm

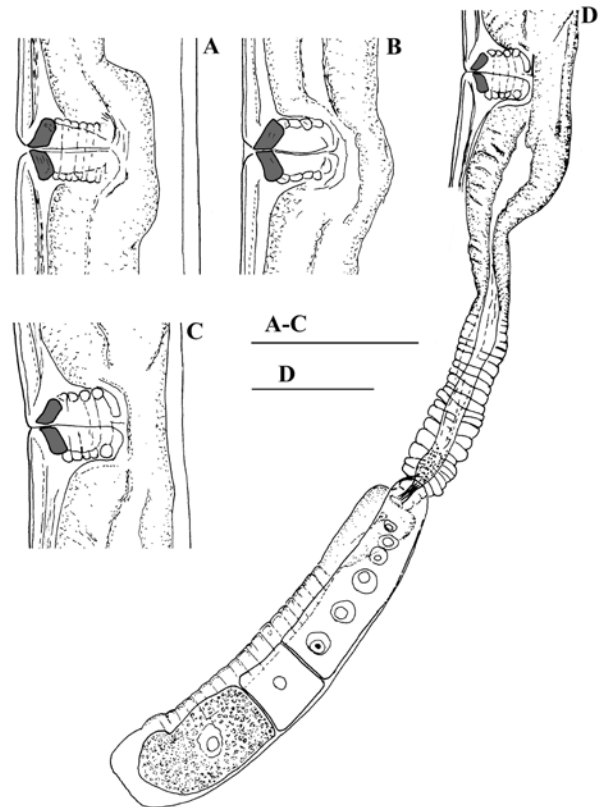


Fig. 7. *Heterodorus arcuatus* Female: A-C – Vulval region (A, B – specimens from Ellef Ringnes Island; C – specimen from Bol'shevik Island); D – Posterior genital branch (specimen from Bol'shevik Island). Scale bars: A-C 50 µm, D 25 µm

malis vaginae 21-24×18-21 µm, with almost straight walls and well developed circular musculature; *pars refringens vaginae* with two well developed arcuate trapezoid sclerotised pieces (in lateral view), with an overall width of 17-18 µm; *pars distalis vaginae* 6-7 µm long. Vulva a transverse slit. Sperm cells not observed in genital tract. Prerectum 1.8-2.5 times and rectum 0.9 times anal body diam. long. Tail conical regularly ventrad curved, with rounded tip; hyaline part of cuticle 19-22 µm thick or 24-30 % of total tail length. Two pairs of subterminal caudal pores located at different levels.

Male. Not found.

Locality and habitat

Polar deserts on Bol'shevik (Severnaya Zemlya Archipelago) and Ellef Ringnes Islands (Canadian Arctic Archipelago) (Table 2).

Remarks

After the original description, several European populations of *H. arcuatus* were described

(ANDRÁSSY, 1958, 1959; ZULLINI, 1970; VINCIGUERRA and DE FRANCISCI, 1973; VINCIGUERRA and LA FAUCI 1978; CIOBANU *et al.*, 2010; KISS, 2011). According to GUERRERO and PEÑA-SANTIAGO (2007), the material described by VINCIGUERRA and DE FRANCISCI (1973) and VINCIGUERRA and LA FAUCI (1978) are not conspecific with *H. arcuatus*. Specimens reported by KISS (2011) from Hungary are characterised with a shorter body (1.16-1.50 mm), a more posterior position of guiding ring (14.5-16.0 µm) or 1.2-1.3 times lip region, shorter oviduct (76-98 µm), a shorter uterus (61-79 µm), the occurrence of the male frequent (n=8). Considering these differences, Hungarian material also can not be regarded as *H. arcuatus*. Specimens of *H. arcuatus* from polar deserts are within the range of main morphometric characters of type material redescribed by GUERRERO and PEÑA-SANTIAGO (2007) and a subsequent report on the same species from Romania (CIOBANU *et al.* 2010). *Heterodorus thornei* was synonymised with

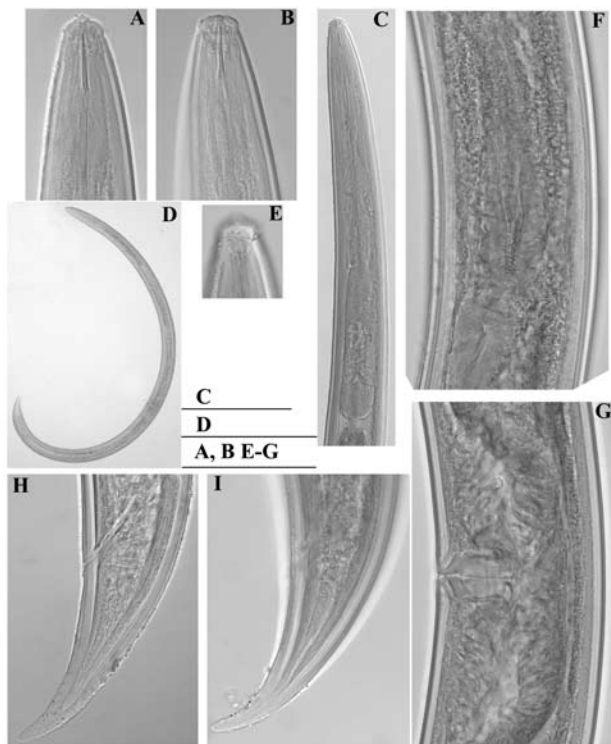


Fig. 8. *Heterodorus arcuatus* Female: A, B – Anterior region (A – specimen from Bol’shevik Island; B – specimen from Ellef Ringnes Island); C – Anterior region with pharyngeal expansion; D – Entire body; E – Amphidial fovea (specimen from Bol’shevik Island); F – Distal part of uterus surrounded by hyaline cells; H, I – Tail ends (H – specimen from Bol’shevik Island; I – specimen from Ellef Ringnes Island); G – Vulval region. Scale bars: A, B, E-G 50 µm, C 100 µm, D 500 µm

H. arcuatus by ANDRÁSSY (2011), however *H. thornei* differs by a different uterus structure (uterus of almost equal width vs uterus with a narrower distal part), the lip region set off from body by a slight depression vs constriction, a shorter odontostyle 17-18 vs 18.5-20 µm or 1.4 vs 1.5-1.6 times lip region diam., and the presence of oesophago-intestinal disc vs absent, flanged odontophore vs not flanged. These differences indicate that considering *H. thornei* as a junior synonym of *H. arcuatus* is not justified. *Heterodorus arcuatus* was originally described from soil around pine woods from Arlington Farm, Kailab Forest, Arizona and sod from Tryal Lake, Uinta Mountains, Utah, USA (THORNE, 1939). Subsequently, this species was reported from various natural habitats in Europe (ANDRÁSSY, 1958, 1959; ZULLINI, 1970; CIOBANU et al., 2010; CIOBANU et al., 2004) and appeared as the most common species of this genus for Holarctic. KUZMIN (1973) reported it from tundra zone in Western Taymyr. This is a first record of this species from polar deserts.

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Table 4. Pharyngeal characters of *H. magnificus* and *H. arcuatus*. For abbreviations see (*) LOOF and COOMANS (1970) and (**) ANDRÁSSY (1998). All *Heterodorus* data are given as percentages

Characters	Putorana Plateau				Bol’shevik Island	Ellef Ringnes Island	
	<i>H. magnificus</i>				<i>H. arcuatus</i>		
	DB ₁	TR	DB, GC, C	DB ₂	DC	AT	PH
n	2	7	4	1	1	1	1
DN=D	69, 67	65-74	63-69	69	70	75	73
S ₁ N ₁ *		76	76				
S ₁ N ₂ *							
S ₂ N ₁ *	85, 85	82-87	81-85	86	86	86	89
S ₂ N ₂ *	84, 81	82-88	82-85	87	85	87	89
AS ₁ **		29	38				
AS ₂ **							
PS ₂ **	51, 55	47-56	48-55	56	53	51	59
PS ₂ **	50, 44	48-54	50-53	57	51	52	59

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