

The genus *Boreolaimus* gen. n. and its six species (Dorylaimida: Qudsianematidae), nematodes from the European Arctic

István ANDRÁSSY

Eötvös Loránd Tudományegyetem, Állattrendszertani és Ökológiai Tanszék, 1088 Budapest, Puskin-u. 3, Hungary.

Accepted for publication 31 March 1998.

Summary – A new genus, *Boreolaimus* gen. n., is proposed for five new and a known species described in this paper. *Boreolaimus* is placed in the family Qudsianematidae; it differs from other genera of the family by the wide buccal lining around spear, presence of four oesophageal nuclei instead of five and "empty" posterior part of tail. The total lack of males and spermatozoa in uterus of mature females seems to be also a characteristic feature for this genus. The genus *Boreolaimus* is also characterized by the occurrence and distribution of its member species: they all inhabit interstitial biotopes and are, as far as known, only found in the northern regions of the Globe. The members of *Boreolaimus* are: one known species, *B. encelli* (Andrássy, 1967) comb. n., and five new species, *B. arcticus*, *B. borealis* (type species), *B. lapponicus*, *B. norvegicus*, and *B. septentrionalis*. Although these species are closely related, they can be differentiated from each other by differences in shape and slenderness of body, shape and length of tail, presence or absence of sclerotization in vulval lips, cuticular structure of tail, and extent of "empty" region in percentage of tail length. © Orstom/Elsevier, Paris

Résumé – Le genre *Boreolaimus* gen. n. et ses six espèces (Qudsianematidae), nématodes provenant d'Europe arctique – Le nouveau genre *Boreolaimus* gen. n. est proposé pour contenir cinq espèces nouvelles et une déjà connue, toutes décrites dans cet article. *Boreolaimus* peut se ranger dans la famille des Qudsianematidae où il diffère des autres genres par la spacieuse paroi buccale entourant le stylet, la présence de quatre, au lieu de cinq, noyaux oesophagiens et une portion postérieure de la queue "vide". L'absence de mâles et celle de spermatozoïdes dans l'utérus des femelles matures paraissent être également une caractéristique du genre. Les membres du genre *Boreolaimus* sont: une espèce déjà connue, *B. encelli* (Andrássy, 1967) n. comb., *B. arcticus*, *B. borealis* (espèce type), *B. lapponicus*, *B. norvegicus* et *B. septentrionalis*. Bien que ces espèces soient proches l'une de l'autre, elles peuvent être séparées par des différences dans la forme et le caractère plus ou moins élancé du corps, la forme et la longueur de la queue, la présence ou l'absence d'une sclérotisation associée aux lèvres vulvaires, la structure de la cuticule caudale et la longueur de la portion "vide" de la queue, calculée en pourcentage de la longueur de celle-ci. La présence et la répartition des espèces sont également typiques pour le genre: toutes proviennent de biotopes interstitiaux et n'ont été rencontrées, à notre connaissance, que dans les régions les plus nordiques de notre globe. © Orstom/Elsevier, Paris

Keywords: Arctic, *Boreolaimus*, interstitial nematodes, morphology, reproduction, Scandinavia, taxonomy.

Dr P.H. Enckell (Zoological Institute of the University, Lund, Sweden) carried out for many years very extensive and systematic collections during the sixties in Scandinavia, with the aim of discovering the interstitial fauna of that part of Europe. He thoroughly covered all four Scandinavian countries – Denmark, Norway, Sweden, Finland – and sampled almost the entire region. A very large number of groundwater samples were collected in areas adjoining river banks and lake shores. Among several other animals, the samples contained nematodes in great number. Dr Enckell was so kind as to offer the latter to the present author for study.

Nematodes were extracted from the original samples in Lund, killed and fixed with 4-5 % formaldehyde solution, then sent to Budapest in small vials. They were transferred to glycerine and mounted in pure glycerine for microscopic examinations.

Although nearly 30 years have passed since, the animals on permanent slides are still well preserved.

I have already published an article (Andrássy, 1967) about the nematodes from Enckell's collection. A report was given on the nematode fauna of the interstitial zones of two lakes (Vätter- and Torneträsk Lake) in Sweden. Also, a new species was described and named in honour of the collector, *Eudorylaimus encelli* Andrássy, 1967. When enumerating the morphological characters of this species, I mentioned an unusual feature by which it differed from every other representative of the genus: the posterior half of the tail was completely "empty", showing no traces of body tissues or filler cuticle.

Going through more nematode material of the Scandinavian collection, I recently found that a number of specimens originating from the northernmost region (Fig. 1) strongly resembled *E. encelli*, yet were at the same time distinctly different from that

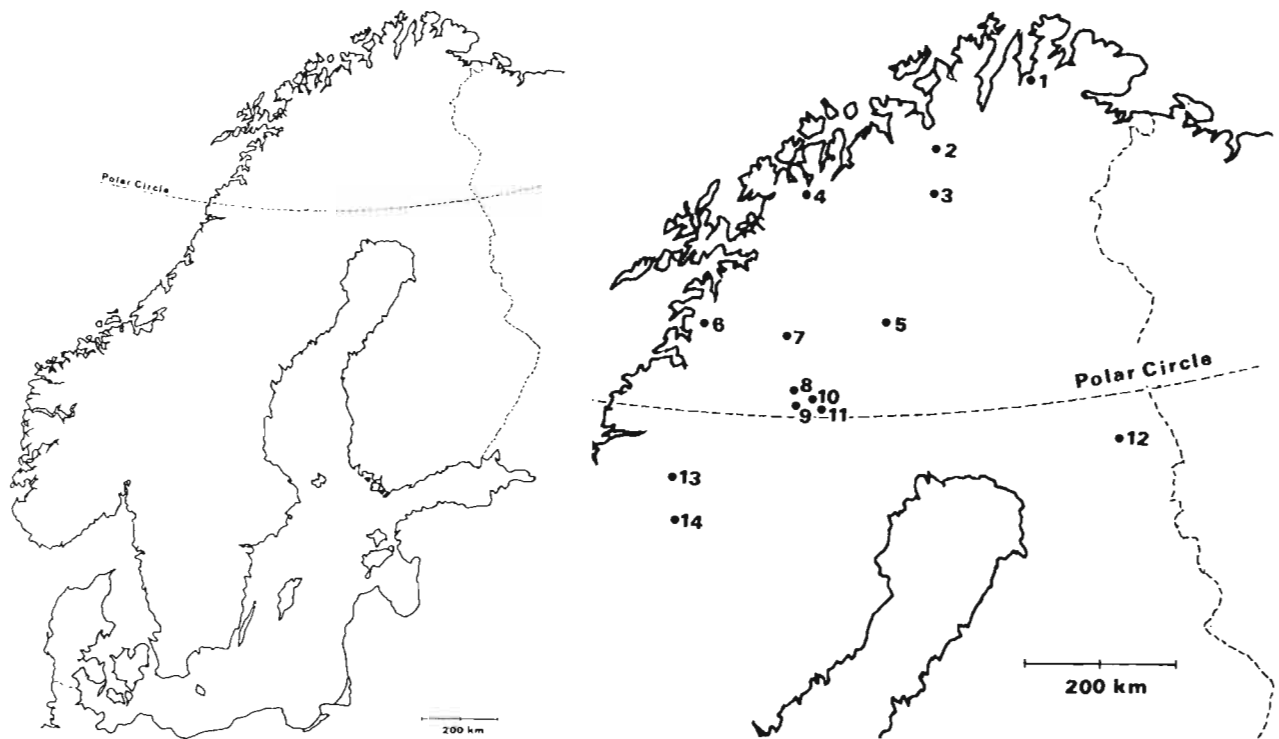


Fig. 1. Map of Scandinavia with localities of *Boreolaimus* species. 1: Lake Kuvvatn, Prov. Finnmark, Norway; 2: Lake Övre Trangvatn, Prov. Finnmark, Norway; 3: Lake Mieron, Prov. Finnmark, Norway; 4: Lake Sagelvvatn, Prov. Troms, Norway; 5: River Torneälv, Prov. Lappland, Sweden; 6: Bonnassjön, Prov. Nordland, Norway; 7: Lake Satisjaure, Prov. Lappland, Sweden; 8: Lake Peuraure, Prov. Lappland, Sweden; 9: Lake Karats, Prov. Lappland, Sweden; 10: River Pärlälven, Prov. Lappland, Sweden; 11: Lake Juonajaure, Prov. Lappland, Sweden; 12: Lake Ylikitka, Prov. Lappi, Finland; 13: Lake Laisan, Prov. Lappland, Sweden; 14: River Vojm n, Prov. Lappland, Sweden.

species. They shared, among others, the "empty" posterior part in the tail already observed in *E. enckelli*. As a result of further examinations, it became evident that these empty-tailed nematodes are part of a special group differing from all other types of *Eudorylaimus* species, and even from representatives of related genera. This group of species is here proposed as a separate genus, *Boreolaimus* gen. n.

It is hardly questionable that this new genus is a natural unit of closely related sister-species which, however, can well be differentiated from each other. *Boreolaimus* gen. n. can very well be outlined or characterized not only morphologically but also in mode of life and distribution.

***Boreolaimus* * gen. n.**

Qudsianematidae. Body moderately slender to slender, 1.5 to 2.4 mm long. Cuticle thin, smooth, excep-

tionally with superficial structure. Head offset by depression, lips separate, angular. Stoma lining around spear unusually wide and reaching well behind the spear. Odontostyle straight and cylindrical, longer than cephalic diameter; its aperture occupying about one-third of its length. Guiding apparatus a long tube with widened anterior ring. Oesophagus muscular, expanding before or near middle in more steps. Oesophageal nuclei distinct, with the exception of the anterior subventral nucleus. Intestine generally folded, with enlarged cells at junction with prerectum. Prerectum with short caudal sack. Anal musculature very strong. Vulva transverse, located near middle of body. Female genital system amphidelphic; reproduction by automixis. Males absent. Tail conoid, straight to ventrally arcuate with rounded tip, as long as two to five anal diameters. Distal part of tail "empty" with very thin cuticle.

TYPE SPECIES

Boreolaimus borealis sp. n.

* Boreo-" is from the Greek word βόρειος = northern, of the north.

OTHER SPECIES

B. arcticus sp. n.

B. encelli (Andrássy, 1967) comb. n.

= *Eudorylaimus encelli* Andrásy, 1967

B. lapponicus sp. n.

B. norvegicus sp. n.

B. septentrionalis sp. n.

In general habitus and organization, the new genus corresponds to the criteria of the family Qudsianematidae and of its type subfamily (*sensu* Andrásy, 1992). It resembles the genus *Eudorylaimus* Andrásy, 1959 in some morphological features, it differs, however, not only from that and the other genera of the family but also from all known members of the suborder Dorylaimina. The uncommonly wide lining of stoma, tubular guiding sheath, (seemingly?) lacking anterior subventral nucleus in oesophagus, "empty" posterior region of tail are the main morphological characteristics of the *Boreolaimus* species. In addition, they are notable for the complete absence of males. Moreover, their occurrence also is distinctive: all of them inhabit groundwater biotopes and are distributed, as far as known, in the Arctic region of Europe.

MAJOR MORPHOLOGICAL AND BIOLOGICAL FEATURES AND THEIR TAXONOMIC VALUE

In order to present the most important morphological characters of *Boreolaimus* and to point at their constancy or variability, let us inspect the new genus more in detail.

Body shape: The members of the genus are of middle length, between 1.5 and 2.4 mm. The body length may fluctuate only a little within one species; there are smaller species, under 2 mm, species of medium length, about 2 mm, and bigger ones, above 2 mm. The figure is moderately slender to slender, the value of "a" varies between 23 and 62. Two of the species are comparatively stout ($a < 30$), two moderately thin ($a = 30$ to 40) and two definitely slender ($a = 40$ to 60). In fixed state the body remains more or less straight or becomes slightly bent ventrad.

Cuticle: The cuticle is definitely thin, 1 to a maximum of 2 μm over the entire body, thicker, up to 3–5 μm , only on the anterior part of tail. Optically, the cuticle consists of two layers: a thinner, more refractive outer layer and a thicker inner layer. The cuticle is smooth, at most the inner surface may show some fine annulation in the neck region (Figs 7A; 9A). Only one species shows a superficial structure of cuticle: in the anal area a very fine transverse striation and indistinct punctation can be seen (Fig. 4C). In all species, the cuticle at the level of the mouth spear is conspicuously thinner than the spear itself.

Cephalic region: The head is well separated from the adjacent region of the body by a depression. Its

appearance is very similar in every species. The six lips are distinct and more or less angular, and bear rounded or somewhat conoid papillae. The diameter of the lip region varies only slightly: it measures 16 to 19 μm . The amphids open just behind the lips; they are cup-shaped and at least half as wide as the corresponding body diameter.

Buccal region: One of the principal distinguishing features of *Boreolaimus* can be seen in the mouth cavity: its lining or contour is wider (more spacious) than in other genera of Qudsianematidae. It begins with a wide atrium, then turns into a jug-shaped medial part and ends well behind the basis of the spear. The shape of the dorylaimid odontostyle is constant and there is also little variation in length: 22 to 28 μm in the genus. In each species, the variation of the stylet length does not exceed 2 μm . The spear is always longer than the diameter of head (1.2 to 1.5 times). The aperture occupies one-third of spear length or so. The structure of the guiding sheath around the spear is similar in every species: it is not a simple ring but a comparatively long tube with somewhat divergent proximal walls and widened anterior end (Figs 3A; 7A; etc.).

Oesophagus: The oesophagus consists of a slender but muscular anterior part and an extended, well muscular posterior portion, the cylindrus (see Andrásy, 1995). The length of the oesophagus is always measured from the anterior margin of the lip region to the posterior margin of the cylindrus. The length of the cylindrus cannot be defined exactly, owing to the gradual or stepwise widening of the oesophagus, but the cylindrus occupies at least half the length of the distance between anterior body end and cardia. Its posterior region is not regularly cylindrical: it starts with an anterior widening and shows a conspicuous expansion in its posterior third/fourth (e.g., Figs 9B; 10B). In addition, a slight medial swelling is also present. The oesophageal gland nuclei are refractive and well visible, except for the anterior subventral nucleus (AS_1), which is completely invisible (and there is no gland opening at the place where there would be one if the nucleus was present). Whether the nucleus is truly absent or so minute as to be indistinguishable from the oesophageal tissue, cannot be decided with certainty. Whatever the case may be, this nucleus could not be observed or localized with certainty in more than one hundred specimens studied for this purpose (in some specimens of a single species, a minute, more or less nucleus-like granule could be seen at 28–30 % of the distance between dorsal nucleus and posterior end of cylindrus, well anterior to the AS_2 . Was it an AS_1 indeed?) *. The

* In dorylaimid nematodes, the AS_1 nucleus is usually smaller than its partner (AS_2), but this small nucleus is generally visible.

dorsal nucleus (D) is essentially larger than the other nuclei, round-oval (*e.g.*, Fig. 8D), generally lying parallel with the body axis and rarely at a right angle to it. It is located in the proximal part of the anterior widened region of the cylindrus at a fairly constant position, near 60 % (57 to 62 %) of the distance between head and hind end of oesophagus. The visible anterior subventral nucleus (AS₂) and the two posterior subventral nuclei (PS₁ and PS₂) are similar in shape, *i.e.*, mostly round, exceptionally ovoid (Fig. 10B); in some cases AS₂ is a little bigger than each PS (Fig. 12B). Their position can be described as constant. AS₂ is located at about 40 % (36 to 44 %) of the distance between dorsal nucleus and posterior end of cylindrus, PS₁ and PS₂ are located at about 65 % (61-70 %) and 67 % (63-71 %) of the same distance, respectively. PS₁ and PS₂ are located at the beginning of the posterior expansion of the cylindrus. In one of the species, an unusual phenomenon was observed: at the level of the dorsal nucleus or a little before it, one or two 'accessory' nuclei were present (Figs 7B; 8E). They were elongate, transversely directed, and well visible in half the specimens. What are they actually and what are they used for? This remains an unanswered question for the moment.

Since the study of Loof and Coomans (1970), it has been generally accepted that the location of oesophageal gland nuclei in dorylaimid nematodes is useful in the characterization of families, genera, and even species. Of the five nuclei, the dorsal nucleus is the biggest and the most anterior. The other four nuclei are arranged in two pairs, one located in the middle, and the other one at the posterior third/fourth of the cylindrus. Their position may be measured in diverse ways: either in absolute distances in μm from anterior or posterior end of cylindrus, or in percentage of the cylindrus length or of the entire length of the oesophagus. Percentage values for nucleus positions are easier to visualize and compare at a glance than absolute measurements, but they also may cause some difficulties for the observer. Thus, percentages of oesophagus length can be relatively imprecise, *e.g.*, in terms of distance between closely spaced nuclei, while percentages of cylindrus length are often subjective as the anterior end of the cylindrus is often difficult to determine precisely (it begins by a gradual widening and not at a definite point). To avoid these problems, a new method is suggested here which is essentially a combination of old ones: the position of the dorsal nucleus is determined as a percentage of the total length of the oesophagus (from head to posterior end of cylindrus). This nucleus is big enough to be observed even under lower magnification and its location is easily specified in relation to the entire oesophageal length. However, the other four nuclei

should be localized as a percentage of the distance from the dorsal nucleus (from the centre of it) to the posterior end of the cylindrus. These data give a good picture of the position of the posterior four nuclei, whether to compare them with the dorsal nucleus, or with one another. In the following descriptions of the *Boreolaimus* species, this method is applied (Fig. 2); in parentheses, the 'old' values according to Loof and Coomans (1970) are also added. Unfortunately, the openings of the oesophageal glands were in most cases so indistinct that their positions could not be measured.

Intestine: The cardia is muscular, tongue-shaped, medium long. The intestine consists of one layer of large cells; it has a wide lumen and is often folded. Compact contents can frequently be observed in the digestive tract; they may be colourless, yellowish, or greenish, occasionally quite dark. Some enlarged cells are visible in the intestine just before the intestine-rectum junction, which is offset (*e.g.*, Figs 4A; 6C; 8C). The prerectum also possesses a wide lumen, as well as a short but distinct dorso-caudal sack due to the ventrally displaced origin of the rectum. The prerectum is 1.5 to 4.5 times, the sack 1 to 1.5 times as long as anal body diameter, but their lengths may vary within the same species. The rectum is practically straight.

Female genital system: Amphidelphic nematodes with equally developed gonads. The vulva is transverse (Fig. 12D), with sclerotized (Figs 5D; 10D) or non-sclerotized (Figs. 3C; 7C; 9D) inner lips; presence or absence of sclerotization is constant for a species and constitutes a good taxonomic character. The female genital aperture can be found near mid-body. The arrangement of the gonads can vary within one species: any of them may be seen either on the right or the left side of the intestine, but they are generally on opposite sides of the intestine in the same animal. Both ovaries are of similar length, reflexed, often reaching to the vulva; they consist of a moderate number of cells. No more than one or two mature eggs occur at the same time; they are longer than the body diameter. The oviduct is a slender and transversely striated tube lying on the ventral side; in young females, it is subterminally connected with the ovary (Figs 5E; 7E; 10E), in mature females the distance between the proximal end of ovary and the connection with oviduct is considerably longer (Figs 3D; 12E). At the junction of oviduct with uterus, a small chamber is present which may contain a few sperm-like elements, or fine granules only. No spermatozoa were ever seen in the uterus, even in gravid females. This means that males are actually lacking - a very remarkable feature of the genus *Boreolaimus* gen. n.!

Reproduction: Reproduction most probably occurs by self-fertilization (automixis). In younger females, a

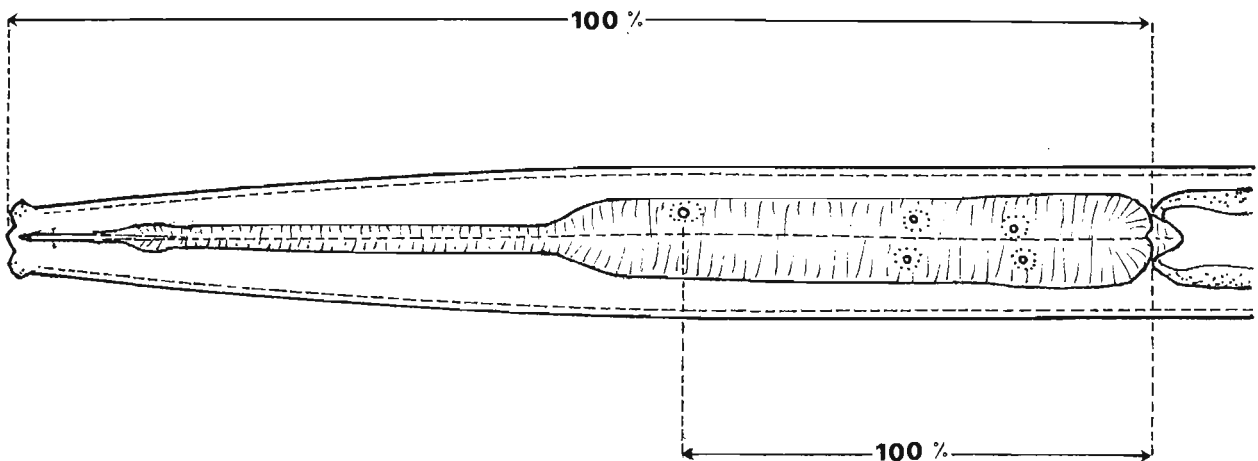


Fig. 2. How to determine the location of the pharyngeal nuclei: The position of the dorsal nucleus is expressed as a percentage of the distance between head and posterior end of oesophagus; the positions of the subventral nuclei are given as the percentage of the distance between dorsal nucleus and posterior end of cylindrus. In the example shown here, D (dorsal nucleus) = 59%; AS₁ (anterior subventral nucleus, first) = 48%; AS₂ (anterior subventral nucleus, second) = 50%; PS₁ (posterior subventral nucleus, first) = 70%; PS₂ (posterior subventral nucleus, second) = 72 %.)

few refractive cells or nuclei may be observed in the germinal zone of both ovaries, close to the ovary-oviduct junction. These are presumably spermatozoa (Figs 5E; 7E). Similar sperm-like elements, few in number as well, can sometimes be seen in the proximal widened end of the oviduct. Therefore, it is suggested that the ovaries - more exactly: ovotestes - first produce a limited number of male genital cells (spermatocytes), then change their function to produce oocytes (proterandry). Whether reproductively functional male specimens still occur from time to time could not be ascertained. No male specimens were ever found in the very rich Scandinavian material collected during various seasons. Thus, we may suppose that the representatives of the genus *Boreolaimus* are all monosexual, females in appearance, but in fact hermaphrodites. In theory, monosexual (autotokous) reproduction results in loss of genetic variability and, as a consequence, diminishes the ability for adaptation, which makes it seem to be less viable than bisexual (amphimictic) reproduction. When, however, the environment is constant enough - as is the case in our *Boreolaimus* species: they occur in a definite type of habitats, and in addition, in the same climatic zone of the Earth - hermaphroditic reproduction may be successful and sufficient for preserving the race. The great constancy in morphological characters within the whole genus *Boreolaimus* may thus be interpreted as an outcome of both mode of life and type of reproduction.

That male individuals are infrequent or very scarce is not unusual in nematodes, but a perfect and con-

sistent absence of males is an extremely rare phenomenon in free-living forms. We know of only a few genera, that are rich in species and fairly frequent in certain biotopes, where males have never been found (e.g., *Bunonema*, *Drepanodorylaimus* *).

The material described here was interesting in another respect. When investigating the fine structure of the female genital system in Dorylaimida, Geraert *et al.* (1980) wrote: "As we never found oocytes in the oviduct, oocytes must pass quickly through each of these cells although under the light microscope a lumen is never seen". In two specimens of *Boreolaimus*, I could observe how a half-mature egg (oocyte) goes through the oviduct by actually flowing through this very tight tube, which does have a lumen. The oocytes are practically liquid in content and covered by a very thin and elastic membrane. When the most mature oocyte is ready to start from the ovary towards the uterus, it simply flows through the oviduct (Fig. 7F). Once in the uterus, it regains its concrete shape, develops a thick shell, and becomes a true egg. Whether fertilization happens in the ovary, or elsewhere on the way towards the genital opening - most probably in the receptaculum-like chamber of the oviduct - could not be ascertained in fixed material.

* I have an exceptionally rich collection of *Drepanodorylaimus* species as well as of other relative genera of the dorylaimid subfamily Afrodorylaiminae; whereas they were collected in various parts of the Earth, male specimens do not exist among any of them.

Tail: In addition to the shape of buccal cavity and guiding sheath, and to the probable lack of anterior subventral nucleus in the oesophagus, the unique structure of the tail is another important feature of *Boreolaimus*. The tail is conical, narrowing quickly at first then more slowly, straight (Figs 4A, C; 6A) or ventrally arcuate (Figs 8A; 9F, G; 13A, B), and always with a regularly rounded tip. Its length varies between two and five anal body diameters within the genus, but it is very typical and constant for each species. There are species with short tail ($c' = 1.8-2.6$), medium tail ($c' = 3.1-3.5$), and long tail ($c' = 4.3-5.2$). The posterior region of the tail always seems to be empty. The body tissue which fills the anterior half rapidly ends with a sharp contour, which leaves the posterior part free. The comparatively thick cuticle of the anterior tail portion suddenly becomes very thin at the level where the tail tissues end or a little before (Figs 6D; 9H; 11D; 13C). It may be that the 'empty' portion of tail is filled up with air or some crystal-clear liquor; certainly, no solid elements were seen in it. In some other dorylaimids, the posterior part of tail is sometimes also apparently empty; however, this portion may contain traces of tissues or be packed with the thickened – but transparent – cuticle. Still, if there is some actual void in the tail, it is limited in extension and called 'core'. In *Boreolaimus* species, the posterior part of tail is covered by a very thin layer of cuticle and the whole interior is apparently empty. It may be supposed that this emptiness at the hind end of body plays some role in the life of our animals – but what is that role? The length of the 'empty' section in relation to the entire length of tail is fairly constant within the same species. In the genus, it varies from 21 to 54 %. In some species it measures 1/4 (Fig. 13A, B), in other species 1/3 (Fig. 11A, B) or 1/2 (Fig. 4A-C) of tail length. It should be noted that two species of *Boreolaimus* are characterized in having distinct 'bubbles' or 'saccate bodies' in the subventral cuticle on the anterior half of the tail; these structures are constant (Figs 4A-C; 11A-C). It is furthermore characteristic for the tail that the anal musculature is stronger and wider than usual in dorylaimids.

Habitat and distribution: As far as known, the mode of life and the distribution of representatives of the genus *Boreolaimus* seem to be unique. All six members of the group have come to light from one series of collections in Scandinavia. Although the species of this genus are terricolous, they do not inhabit soil types covered by plants and interwoven with roots but they live in groundwater along river banks or lake shores. In these interstitial habitats, they have been found associated with other nematodes which are generally known to occur in such biotopes. Thus, the samples studied also contained members of the following genera: *Theristus*, *Plectus*, *Hemicyclophora*, *Prismatolaimus*,

Ironus, *Tobrilus*, *Neotobrilus*, *Trischistoma*, *Tripyla*, *Mononchus*, *Prionchulus*, *Mylonchulus*, *Eudorylaimus*, and *Discolaimoides*. However, it should be emphasized that, while these other genera of Nematoda may occur in various other habitats as well, the species of *Boreolaimus* only inhabit groundwater biotopes – as far as is known at present.

As for their distribution, all six species were discovered in Scandinavia, close to or beyond the Arctic Circle. Whether our animals also occur in other regions of the Arctic remains unknown. The nematode communities of interstitial biotopes in North Russia, North Canada, Alaska, or Greenland have not been investigated yet; the fauna of other biotopes of these territories are also hardly known.

It is of interest that no species of the genus *Boreolaimus* has been discovered in Spitzbergen, the northernmost isles of the European mainland. Although a rich nematode collection from those islands has been studied by Loof (1971), nematodes similar to *Boreolaimus* were not mentioned in this paper. One species, *Eudorylaimus maksymovi* Altherr, 1963, seems to be a little *Boreolaimus*-like as described by Loof (1971). Dr Loof kindly sent me two female individuals for comparison with my Arctic animals. However, the specimens sent by Dr Loof are typical members of *Eudorylaimus* in every respect (head practically not offset, spear weak, cuticle as thick as spear, guiding ring as usual in dorylaimids, buccal cavity moderately large, intestine not folded, vulva roundish, posterior part of tail not 'empty', tail tissue, if very thin, reaching to tail tip, cuticle not thinned on hind end, etc.). However, Loof did not examine nematodes from groundwater habitats in Spitzbergen. On the other hand, it is also worth mentioning that no other investigators of interstitial biotopes – particularly Altherr – has ever described nematodes similar to *Boreolaimus*. Altherr (1972) did study groundwater samples from Sweden but his collection originated predominantly from southern regions of the country. Summa summarum: groundwater and far north, both these criteria are necessary to meet *Boreolaimus* – at least to our present knowledge.

THE SPECIES OF THE GENUS *BOREOLAIMUS*

The genus *Boreolaimus* consists of six species. One of them, *B. enckelli*, is known, the other five are new to science. The members of the genus share a great number of common morphological features (generic characters), that is, they are strongly similar to one another, but they are easily distinguished by specific morphological features.

It should be noted that other *Boreolaimus* species may be present in the European Arctic. In the material examined, I found individuals – not one or two but several – which undoubtedly belonged to *Boreo-*

laimus, but could not be identified with any of the six described species. They were in poor condition or in small numbers and could not be described as new species. Therefore, they are not included in this paper.

***Boreolaimus borealis* * sp. n.**

(Figs 3, 4)

MEASUREMENTS

Holotype (female): L = 2.17 mm; a = 39; b = 3.8; c = 31; V = 55; c' = 2.0.

Females (n = 10): L = 2.00-2.38 mm; a = 39-45; b = 3.8-4.3; c = 31-34; V = 53-55; c' = 1.8-2.2.

DESCRIPTION

Females: Body long and slender, 49-54 μm wide at mid-region. Cuticle 1.8-2.0 μm thick, at spear level only about 2/3 as thick as this, thicker (4-5 μm) on anterior region of tail; smooth excepted on the anal region where fine transverse striation or punctation (the striae may show anastomoses) present. Labial region well offset by depression, 17-18 μm wide; lips angular with finely rounded papillae. Body at posterior end of oesophagus 2.6-3.0 times as wide as head. Amphids caliciform, broader than half the corresponding body diameter. Buccal cavity wide, especially at level of guide ring where it is wider than half the corresponding body diameter; reaching far behind posterior end of spear. Odontostyle straight, well developed, 24-26 μm long and about 3 μm thick, 1.3-1.5 times as long as labial diameter, 1/20-1/22 of entire length of oesophagus. Aperture shorter than 1/3 spear length. Guiding sheath long, tubular, its anterior ring-like expansion located behind spear aperture. Protractor and retractor muscles of spear well developed. Oesophagus muscular in its entire length, 500-565 μm long, widening gradually or in several steps at about 40-45 % of its length. Cylindrus somewhat expanded on both ends. Dorsal nucleus 4-5 μm , rounded-oval to oval, directed parallel with body axis, distinctly bigger than other nuclei; three sub-ventral nuclei round, conspicuous. Two posterior nuclei generally lying at the same level; closer to AS₂ than to posterior end of cylindrus. Locations of oesophageal gland nuclei given in Table 1; location following Loof and Coomans (1970): D: 57-60 %, AS₂: 75-78 %, PS₁: 85-87 %, PS₂: 85-88 %. Distance between posterior end of oesophagus and vulva longer (1.1-1.3 times) than oesophagus. Cardia wide, tongue-shaped. Intestine with wide lumen, folded, with enlarged cells just before prerectum. Prerectum 1.3-2.2 anal diameters long, with a short dorsal caudal sack; rectum straight, 1.1-1.2 anal diameters long. Vulva trans-

* The specific name *borealis* (Greek/Latin) means: northern, north-inhabiting.

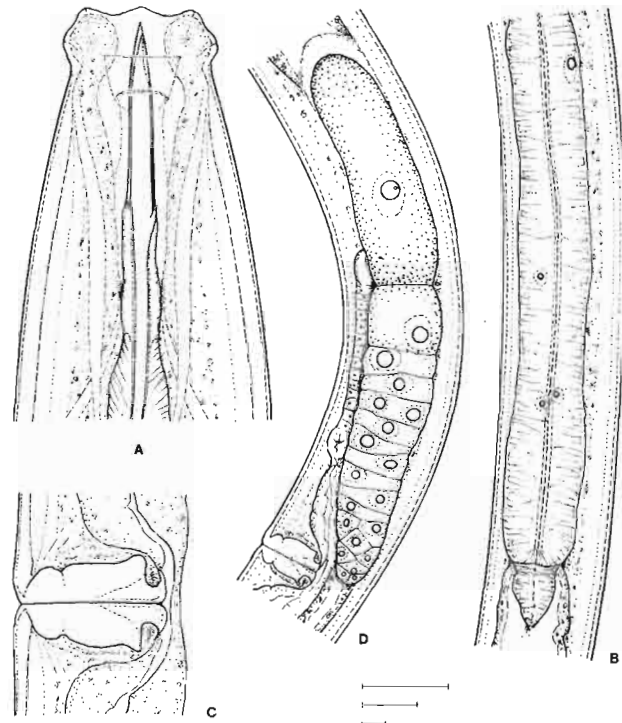


Fig. 3. *Boreolaimus borealis* sp. n. A: Anterior end; B: Cylindrus with nuclei; C: Vaginal region; D: Anterior female gonad. (Scale bars = 10 μm each; upper: A, middle: C, lower: B, D).

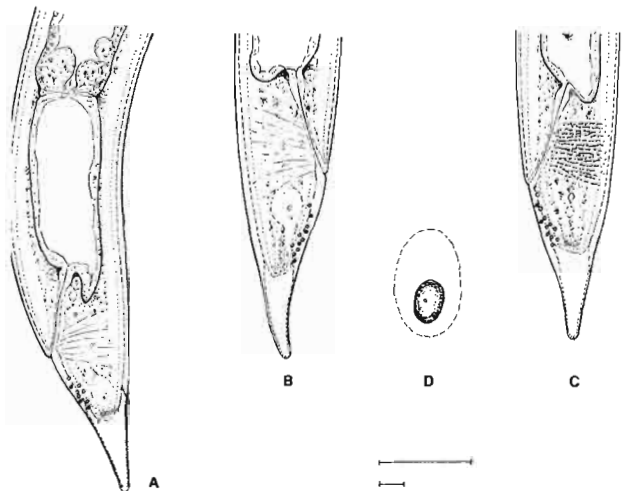


Fig. 4. *Boreolaimus borealis* sp. n. A-C: Tails; D: Dorsal oesophageal nucleus. (Scale bars = 10 μm each; upper: D, lower: A-C).

verse, with non-sclerotized inner lips. Vagina 27-31 μm long, as long as or longer than half the corresponding body diameter. Female genital organ 20-

23 % of body length in mature females; each branch four to five times as long as body diameter. Anterior gonad mostly on the left, posterior gonad on the right side of intestine. Ovaries reflexed to vulva. Oviduct with a proximal receptaculum-like chamber; junction oviduct uterus with a sphincter. Uterus never containing sperm. Mature eggs not observed. Distance between vulva and anus 13 to 15 times as long as tail. Tail short, 64-75 μm , 1.8-2.2 anal diameters long, or 3.0-3.2 % of body length; conoid, straight or with posterior part slightly bent ventrally, with rounded tip. Three features characteristic for the tail: *i*) on its anterior region cuticle finely but distinctly striated, and with a very fine punctation as well; transverse striae best visible on the dorso-lateral side of the tail and sometimes with anastomoses; *ii*) on the anterior region, but at some distance from the anal opening, small but distinct subventral 'saccate bodies' ('bubbles') sometimes present; *iii*) distal 'empty' region measuring 30-39 μm , *i.e.*, about half length of tail (47-54 %).

Males: not found.

TYPE MATERIAL

Holotype: Female, slide No. 7/Sk-B. Paratypes: fourteen females and two juveniles. All in the nematode collection of the Eötvös Loránd University, Budapest, Hungary.

LOCALITY AND HABITAT

Lake Övre Trangvatn in the Alta-elv river system, Prov. Finnmark, the northernmost region of Norway, well north of the Arctic Circle, groundwater, August 1965; collected by P.H. Enckell (Fig. 1, loc. 2).

DIAGNOSIS AND RELATIONSHIPS

The main characters are: longest species in the genus, body slender, spear long, vulva not sclerotized, tail short with striated-dotted cuticle and subventral bubbles.

Boreolaimus borealis sp. n. belongs to the short-tailed representatives of the genus, resembling in this respect *B. enckelli* (Andrásy, 1967) and *B. lapponicus* sp. n. It clearly differs from *B. enckelli* in having a body longer (2.0-2.4 *vs* 1.5-1.6 mm) and more slender ($a = 39-48$ *vs* 27-29), unsclerotized vulval lips, and finely ornate cuticle on tail; from *B. lapponicus* in having cuticular ornamentation on/in the tail and a longer percentage of 'empty' portion in relation to tail length. In the ornamentation of the tail, *B. borealis* is unique within the genus.

Boreolaimus enckelli (Andrásy, 1967) comb. n. = *Eudorylaimus enckelli* Andrásy, 1967 (Figs 5, 6)

MEASUREMENTS

Holotype (female)*: L = 1.56 mm; a = 29; b = 3.1; c = 21; V = 51 %; c' = 2.4.

Females (n = 6): L = 1.50-1.61 mm; a = 27-29; b = 3.2-3.5; c = 22-26; V = 52-56; c' = 2.3-2.6.

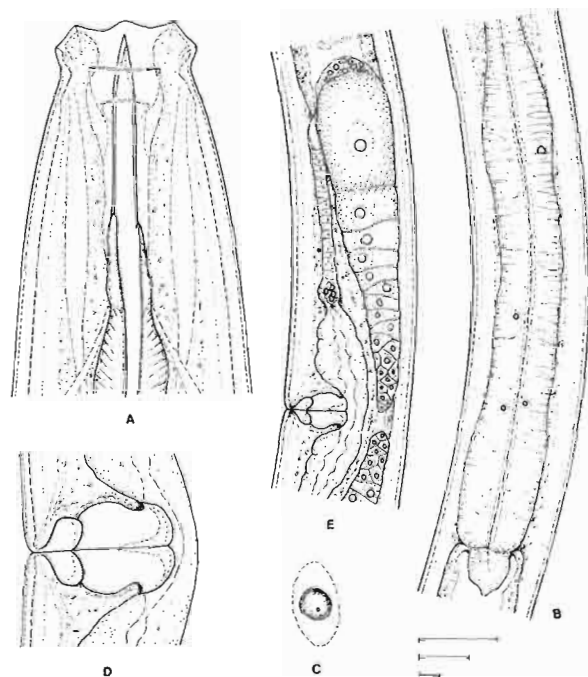


Fig. 5. *Boreolaimus enckelli* (Andrásy, 1967) comb. n. A: Anterior end; B: Cylindrus with nuclei; C: Dorsal pharyngeal nucleus; D: Vulva and vagina; E: Anterior female gonad; germinal end with spermatozoa. (Scale bars = 10 μm each; upper: A, C, middle: D, lower: B, E).

DESCRIPTION

Females: Body shorter and stouter than in other species of the genus, 52-56 μm wide at middle. Cuticle thin and smooth, 1.7-1.8 μm , somewhat thicker (2.5 μm) on anterior part of tail; half as thick as spear itself at level of spear. Cephalic region offset by depression, 17-19 μm wide, with well separated lips; papillae conoid. Body at posterior end of oesophagus about 2.5 times as wide as head. Amphids caliciform, half as wide as corresponding body diameter. Buccal

* In the original paper (1967), the measurements of the young female – still surrounded by the last larval cuticle – were mistakenly given instead of those of the mature female; the measurements of the holotype are to be found here.

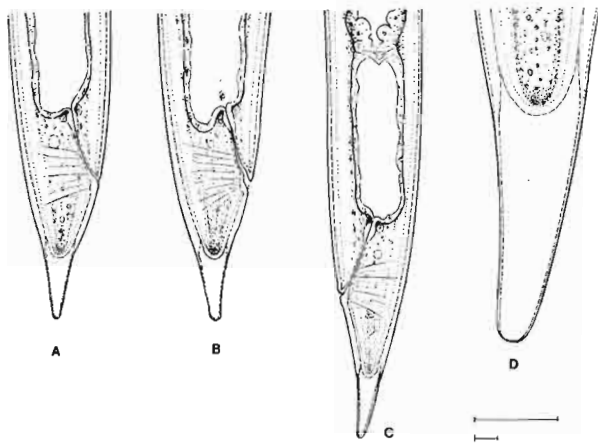


Fig. 6. *Boreolaimus encckelli* (Andrássy, 1967) comb. n. A-C: Tail forms; D: Posterior half of tail with 'empty' region. (Scale bars = 10 μ m each; upper: D, lower: A-C).

cavity wide and long. Odontostyle 23-24 μ m long and about 3 μ m thick, 1.3-1.4 times as long as cephalic diameter, or 1/20-1/22 of oesophageal length. Aperture somewhat shorter than 1/3 spear length. Oesophagus 463-498 μ m long, 29-32 % of entire length of body, gradually widening at middle. Cylindrus typical for the genus: somewhat widened on both ends. Distance between posterior end of oesophagus and vulva considerably shorter (0.6-0.7 times) than oesophagus. Dorsal nucleus oval, 4 μ m, longitudinally directed; subventral nuclei round, distinctly smaller than dorsal nucleus. AS₂ much closer to the two PS than to D. Average distance between dorsal nucleus and posterior nuclei somewhat shorter than in other species of the genus. Locations of oesophageal gland nuclei given in Table 1; location following Loof and Coomans (1970): D: 60-62 %, AS₂: 76-78 %, PS₁: 84-86 %, PS₂: 85-87 %. Cardia short but fairly broad. Intestine with wide lumen and folds. Prerectum offset by constriction, 2.0-2.5 times as long as anal body diameter, with a caudal sack. Rectum 1.2-1.5 anal diameters long, straight. Vulva transverse with strongly sclerotized drop-shaped inner lips. Vagina strong, 25-28 μ m, nearly half as long as body diameter. Female genital organ 22-24 % of body length; each gonad 2.8-3.5 body diameters long. Anterior gonad on the left, posterior gonad on the right side of intestine. Ovaries long, mostly reaching to vulva. One or two eggs in uterus: 80-83 \times 49-51 μ m, 1.4-1.5 times as long as body diameter. Distance between vulva and anus 9-10 times as long as tail. Tail 60-74 μ m, 2.3-2.6 anal diameters long, or 4-5 % of body length, conoid, straight or slightly bent; tip of tail regularly rounded. 'Empty' portion 23-30 μ m long,

40-50 % of tail length. Anal muscles strongly developed.

Male: not found.

LOCALITY AND HABITAT

This species was first found in groundwater near River Torne-älv, Prov. Lappland, Sweden, north of the Arctic Circle, July 1962 (Fig. 1, loc. 5). Recently it was observed in samples from Lake Satisjaure at Vietasjokk, Lule-älv water system, Prov. Lappland, Sweden, north of the Arctic Circle, in groundwater, 440 m above sea-level, July 1963 (six females and two juveniles; Fig. 1, loc. 7).

REMARKS

The main characters are: smallest species of the genus, body comparatively stout, distance between posterior oesophagus end and vulva shorter than in the other species, vulval lips sclerotized, tail short with comparatively long 'empty' portion.

I described this species as *Eudorylaimus encckelli* Andr ssy, 1967 but I noted then that it differed from every member of the genus *Eudorylaimus* in the structure of its tail. There is no question that *encckelli* is a true *Boreolaimus*. In having a short tail, this species resembles *B. borealis* sp. n. and *B. lapponicus* sp. n., but it can be very easily distinguished from them by the well sclerotized vulval lips (see the descriptions of *B. borealis* and *B. lapponicus* for other differences.) In sclerotization of vulva, *B. encckelli* is similar to *B. septentrionalis* sp. n., but the tail of the present species is much shorter (60-74 vs 160-168 μ m; c' = 2.3-2.6 vs 4.8-5.2) and there are no 'saccate bodies' in the cuticle.

It shall be noted that in a sample collected in Sweden, I found three females closely resembling *B. encckelli*. However, they were longer (1.7-2.0 mm), more slender (a = 33-38), the dorsal nucleus was directed transversely in the cylindrus, and the egg was longer, i.e., two body diameters. Whether this form was a variant of *B. encckelli* or a separate species could not be determined because of the small number of specimens.

Boreolaimus lapponicus * sp. n.

(Figs 7, 8)

MEASUREMENTS

Holotype (female): L = 2.06 mm; a = 42; b = 4.0; c = 30; V = 52; c' = 2.1.

Females (n = 24): L = 1.73-2.17 mm; a = 35-42; b = 3.6-4.1; c = 26-30; V = 52-58; c' = 2.0-2.3.

* The specific name of this nematode refers to Lappland, the region of both Finland and Sweden where our species was collected.

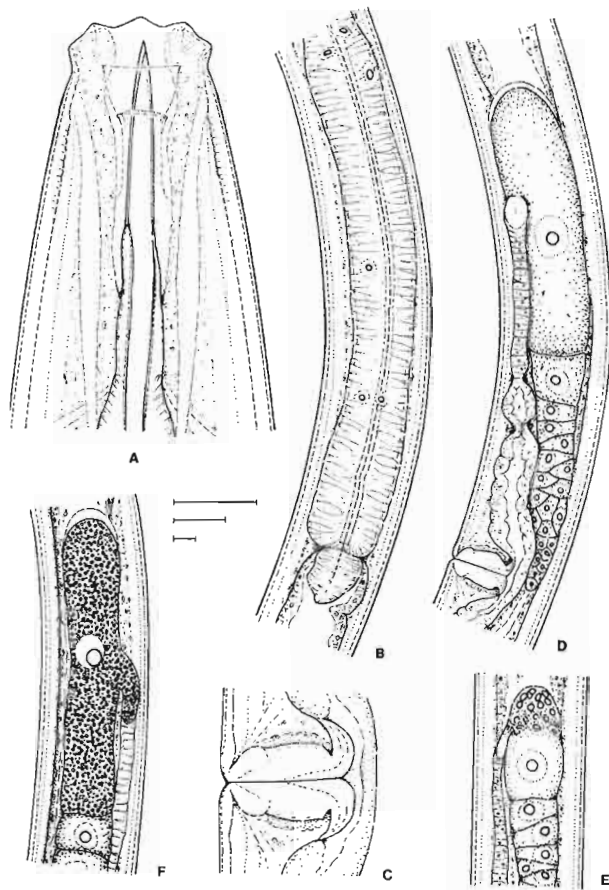


Fig. 7. *Boreolaimus lapponicus* sp. n. A: Anterior end; B: Cylinder with nuclei; C: Vulva and vagina; D: Anterior female gonad; E: Ovary-oviduct junction; germinal end of ovary (= oviestis) showing half-mature and mature spermatozoa; F: An oocyte just pouring into the oviduct. (Scale bars = 10 μ m each; upper: A, middle: C, lower: B, D-F).

DESCRIPTION

Females: The longest species of the genus. Body fairly slender, 50-57 μ m in mid-region. Cuticle thin, 1.5-1.7 μ m, thicker (3-4 μ m) on anterior part of tail, only half as thick as the spear at level of spear; smooth or very finely annulated on inner surface of neck region. Labial region offset, 17-19 μ m wide, lips separate with conoid-rounded papillae. Body at posterior end of oesophagus 2.6-2.8 times as wide as head. Amphids dorylaimid, half as wide as corresponding body or a little wider. Buccal cavity very spacious and long. Odontostyle straight, 23-25 μ m long and 3 μ m wide, 1.2-1.4 times as long as cephalic diameter, 1/22-1/24 of oesophageal length. Aperture nearly 1/3 of spear. Guiding apparatus tubular with widened anterior end and diverging posterior walls. Oesophagus

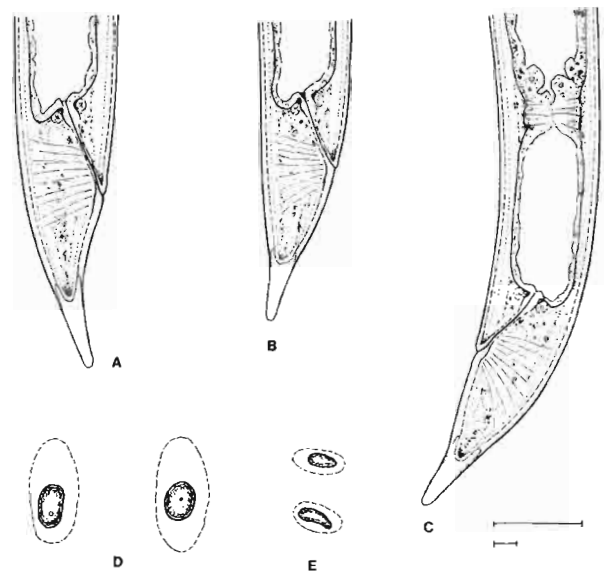


Fig. 8. *Boreolaimus lapponicus* sp. n. A-C: Tail shapes; D: Forms of dorsal nuclei; E: "Accessory" nuclei in the vicinity of the dorsal nucleus. (Scale bars = 10 μ m each, upper: D-E, lower: A-C).

500-575 μ m long, muscular in its entire length, gradually expanding near middle; cylindrus 50-52 % of oesophagus length. Dorsal nucleus 3.5-5.5 μ m, longitudinally directed. Anterior subventral nucleus (AS₂) round or oval, at 83-87 μ m from dorsal nucleus. Posterior subventral nuclei (PS₁ and PS₂) globular, close to one another, 134-152 and 137-153 μ m behind the dorsal nucleus, respectively. In about half of the specimens, one or two quite distinct oval, or slightly irregular 'accessory' nuclei present at level of the dorsal nucleus or somewhat (2-16 μ m) anterior to it, larger than the subventral nuclei but smaller than the dorsal nucleus. In some specimens, a minute refractive particle also present at about one body diameter before the AS₂, possibly representing AS₁. Locations of oesophageal gland nuclei given in Table 1; location following Loof and Coomans (1970): D: 58-60 %, AS₂: 74-77 %, PS₁: 85-88 %, PS₂: 86-88 %. Cardia broad, tongue-shaped. Intestine often folded, with wide lumen. Prerectum offset, its lumen also wide, short, as long as 1.2-2.2 anal diameters, rectum 0.9-1.3 anal diameters long. Intestine with enlarged cells anterior to junction with prerectum. Posterior dorsal end of prerectum sack-like. Vulva transverse, inner lips not sclerotized; vagina 26-30 μ m, half as long as corresponding body diameter or a little shorter. Female genital apparatus 20-24 % of body length. Each gonad 4.0-4.4 times as long as body diameter. Ovaries short in young females, longer in old females, reaching to

vulva. Oviduct ventral, with small receptaculum-like proximal chamber but not containing sperm. One or two eggs present at the same time, $102-107 \times 47-49 \mu\text{m}$, 1.8-2.0 body diameters long. No spermatozoa observed in the uterus. In young females eight to fifteen refractive cells observed at the distal ends of the ovaries, most probably spermatozoa produced by the proterandric germinative glands. Vulva-anus distance ten to fourteen times as long as tail. Tail $65-76 \mu\text{m}$, 2.0-2.2 times as long as anal body diameter, or 3.4-3.8 % of total length of body; conical, straight or slightly bent, with regularly rounded tip. 'Empty' section $27-30 \mu\text{m}$ long, 37-44 % of tail length. Cuticle thinning suddenly a little before the beginning of this empty part. Anal muscles very strong.

Males: not found.

TYPE MATERIAL

Holotype: Female, slide No. 41/Sk-B. *Paratypes*: 40 females and three juveniles. All deposited in the nematode collection of the Eötvös Loránd University. Further paratype specimens: Three females sent to the collection of the Landbouwhogeschool, Wageningen, The Netherlands, and three females and three juveniles to the collection of the Muséum National d'Histoire Naturelle, Paris, France.

LOCALITIES AND HABITAT

Type locality: Lake Ylikitka at Hyväniemi, Oulankajoki water system, Prov. Lappi, Finland, close to the Arctic Circle, groundwater at 2 m from the lake, July 1960, collected by P.H. Enckell (47 females and 6 juveniles, Fig. 1, loc. 12).

Other localities: Lake Peuraure, Lule-älv water system, Prov. Lappland, Sweden, near the Arctic Circle, 440 m above sea-level, groundwater, July 1964 (three females, three juveniles; Fig. 1, loc. 8). Lake Karats, Lule-älv water system, Prov. Lappland, Sweden, on the Arctic Circle, 410 m above sea-level, groundwater, July 1964 (one female, one juvenile; Fig. 1, loc. 9). River Pärälven at Pärän, Lule-älv river system, Prov. Lappland, Sweden, quite close to the Arctic Circle, groundwater, July 1964 (one female; Fig. 1, loc. 10). Lake Juonajaure, Lule-älv river system, Prov. Lappland, Sweden, on the Arctic Circle, July 1964 (two females; Fig. 1, loc. 11). Lake Mieron, Alta-elv water system, Prov. Finnmark, Norway, well north of the Arctic Circle, groundwater, August 1965 (three females, two juveniles; Fig. 1, loc. 3).

DIAGNOSIS AND RELATIONSHIPS

The main characters are: comparatively large species with slender body, unsclerotized vulval lips, short tail and plain caudal cuticle.

Boreolaimus lapponicus sp. n. belongs to the short-tailed species of the genus. It is close to *B. borealis* sp. n. and *B. enckelli* (Andrássy, 1967). It can be distin-

guished from *B. borealis*: the cuticle of the tail is simple (striated and with 'saccate bodies' in *B. borealis*), the 'empty' part in proportion to tail length is shorter; from *B. enckelli*: the vulval lips are not sclerotized, the body is longer (1.7-2.2 vs 1.5-1.6 mm). If the presence of 'accessory' nuclei in front of the cylindrus were a constant feature, it would be an additional distinguishing feature for *B. lapponicus*.

Boreolaimus arcticus * sp. n.

(Fig. 9A-H)

MEASUREMENTS

Holotype (female): L = 1.64 mm, a = 33; b = 3.7; c = 18; V = 51; c' = 3.5.

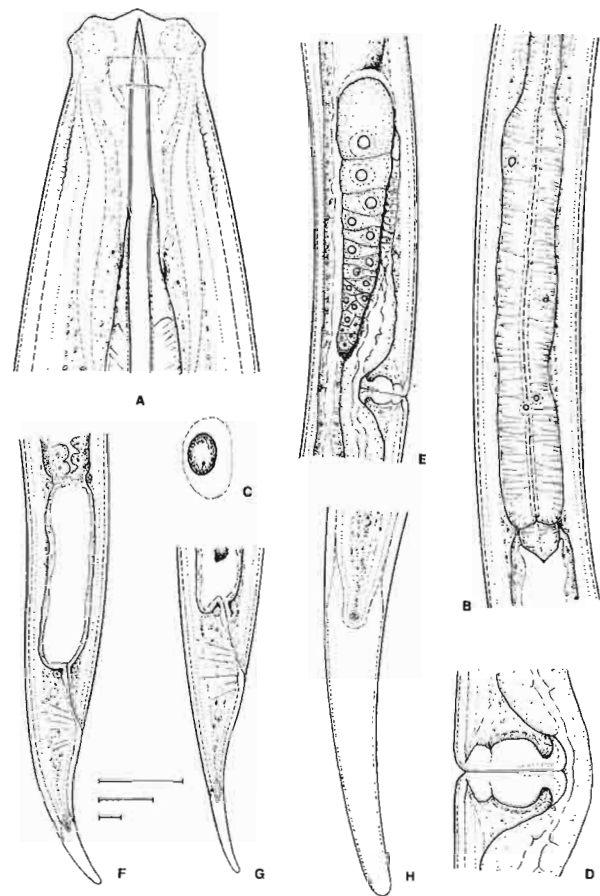


Fig. 9. *Boreolaimus arcticus* sp. n. A: Anterior end; B: Cylindrus with nuclei; C: Dorsal nucleus; D: Vulva and vagina; E: Anterior female gonad; F-G: Tails; H: Posterior 'empty' half of tail. (Scale bars = $10 \mu\text{m}$ each; upper: A, C, H, middle: D, lower: B, E, F-G).

* The specific name *arcticus* (Latin) means: arctic, originating from the Arctic.

Females (n = 18): L = 1.50-1.79 mm; a = 28-36; b = 3.6-3.9; c = 15-19; V = 44-51; c' = 3.1-3.5.

DESCRIPTION

Females: Body moderately long and slender, 42-56 μm in mid-region. Cuticle thin, 1.5-1.7 μm , hardly thicker (2 μm) on anterior region of tail, about 2/3 as thick as spear at level of spear; smooth, only subcuticle showing fine striation at neck region. Cephalic region offset by depression, 16-17 μm wide, lips separate with rounded papillae. Body at proximal end of pharynx 2.5-2.8 times as wide as head. Amphids caliciform, half as wide as body at the same level. Lining of buccal cavity wide and long as in other representatives of the genus. Odontostyle 22-24 μm long and about 2.5 μm thick, 1.2-1.3 times as long as labial diameter. Aperture shorter than 1/3 spear length. Guiding ring tubular, widened at both ends. Oesophagus 397-460 μm long, expanded over 50-55 % of its length, more rapidly than in other species. Nuclei distinct. Dorsal nucleus 4-5 μm , oval, longitudinally directed. Other nuclei round and equal in shape. Anterior subventral nucleus at 63-66 μm from dorsal nucleus, posterior nuclei at 106-112 μm and 107-114 μm from dorsal nucleus. Locations of oesophageal gland nuclei given in Table 1; location following Loof and Coomans (1970): D: 60-62 %, AS₂: 75-77 %, PS₁: 86-87 %, PS₂: 87-88 %. Cardia short, tongue-shaped. Distance between posterior end of oesophagus and vulva 0.7-0.9 times shorter than oesophagus. Intestinal lumen wide, often with greenish-blue contents; walls of intestine widened inwards just before prerectum. Prerectum 2.1-3.2 times as long as anal body diameter, with a short caudal sack; rectum 1.0-1.2 times as long as anal body diameter. Vulva transverse, not sclerotized; vagina roundish, 20-21 μm long, about 40 % of corresponding body diameter. Female genital apparatus as long as 14-20 % of body length. Anterior gonad generally to the left, posterior to the right from intestine; each 2.4-4.0 times as long as body diameter. Ovaries reflexed almost to vulva. Eggs not observed. No spermatozoa in uterus observed. Distance vulva-anus 7-9 times as long as tail. Tail long, 80-110 μm , 3.1-3.5 anal diameters, 5.5-7.0 % of body length; conoid, mostly slightly bent ventrally, rounded on tip. 'Empty' portion 26-40 μm long or 28-38 % of tail length. Cuticle narrowing suddenly before the beginning of the 'empty part'.

Males: not found.

TYPE MATERIAL

Holotype: Female, slide No. 31/Sk-B. Paratypes: 22 females and sixteen juveniles. All specimens deposited in the nematode collection of the Eötvös Loránd University, Budapest, Hungary.

LOCALITIES AND HABITAT

Type locality: A short unnamed river at Bonnassjöen, Prov. Nordland, Norway, above the Arctic Circle, groundwater, August 1965; coll. P.H. Enckell (Fig. 1, loc. 6).

Other locality: Lake Kuvatn, Prov. Finnmark, Norway, far north of the Arctic Circle, groundwater, July 1965 (three females, three juveniles, Fig. 1, loc. 1).

DIAGNOSIS AND RELATIONSHIPS

The main characters are: body moderately long and slender, vulva not sclerotized, vagina comparatively short, lying more anterior than usual, tail long, empty portion about 1/3 of tail length.

By its comparatively long tail (80-110 μm), *Boreolaimus arcticus* sp. n. clearly differs from the three short-tailed species (60-77 μm : *B. borealis*, *B. encelli*, *B. lapponicus*), as well as from the longer-tailed one (160-168 μm : *B. septemtrionalis*). In the absolute length of tail (in μm) it is close to *B. norvegicus* sp. n., but its body is much plumper (a = 28-36 vs 50-62), the tail comparatively shorter (c' = 3.1-3.5 vs 4.3-5.0), and the "empty" section longer (1/3 vs 1/4 of tail length).

Boreolaimus septemtrionalis * sp. n.

(Figs 10A-E; 11A-D)

MEASUREMENTS

Holotype (female): L = 1.92 mm; a = 30; b = 3.8; c = 12; V = 50; c' = 5.0.

Females (n = 4): L = 1.62-1.95 mm; a = 23-30; b = 3.7-3.8; c = 10-12; V = 47-50; c' = 4.8-5.2.

DESCRIPTION

Females: Body moderately long and slender, 63-71 μm at middle. Cuticle smooth, 2 μm over most of body, but thicker (2.5-3.5 μm) on anterior region of tail and about 2/3 as thick as the spear at level of spear. Cephalic region offset by depression, 18-19 μm wide, lips separate with rounded papillae. Body at posterior end of oesophagus 3.4-3.5 times as wide as head. Amphids dorylaimid, half as wide as body at the same level. Mouth cavity large, in its widest part wider than half a corresponding body diameter. Odontostyle 27-28 μm long and 3.5 μm thick, 1.3-1.5 times as long as labial diameter, 1/17-1/19 of oesophagus length; straight. Aperture occupying a little less than 1/3 spear length. Guiding ring a long tube. Oesophagus 440-506 μm long, expanded in several steps. Cylindrus somewhat widened at both ends. Oesophageal gland nuclei well visible. Dorsal nucleus almost spherical with large halo, other nuclei not globular as in

* Named after its northern occurrence; "septemtriones" means 'from the North' in Latin language.

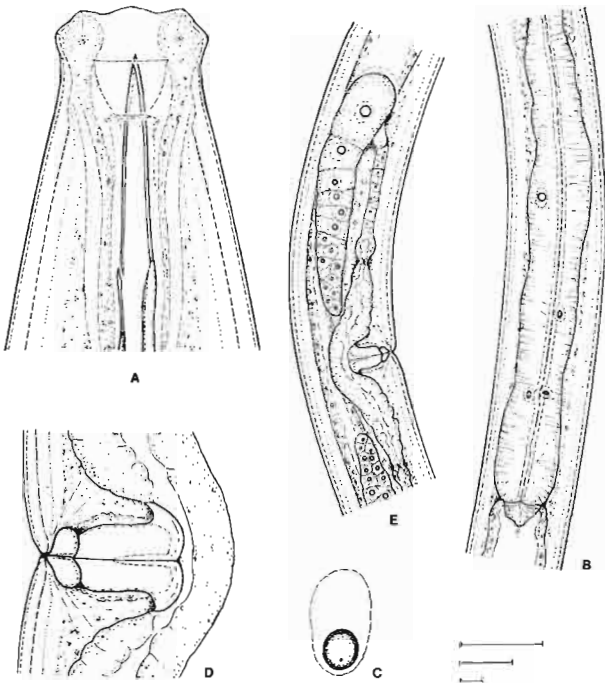


Fig. 10. *Boreolaimus septemtrionalis* sp. n. A: Anterior end; B: Cylindrus with nuclei; C: Dorsal nucleus; D: Vulva and vagina; E: Anterior female gonad. (Scale bars = 10 µm each; upper: A, C, middle: D, lower: B, E.)

the other species of the genus but plum-stone-shaped, longitudinal or transverse in direction. Anterior subventral nucleus at 65-67 µm from dorsal nucleus; posterior subventral nuclei at 117-119/118-122 µm from dorsal nucleus; average distance between AS₂ and D comparatively shorter than in other species. Locations of oesophageal gland nuclei given in Table 1; location following Loof and Coomans (1970): D : 58-59 %, AS₂: 73-75 %, PS₁: 85-86 %, PS₂: 85-87 %. Cardia and intestine typical of *Boreolaimus*. Prerectum 2.5-3.2 times as long as anal body diameter, with a short caudal sack; rectum 1.1-1.4 times as long as anal body diameter. Distance between posterior end of oesophagus and vulva 0.8-0.9 times as long as oesophagus. Vulva transverse, inner lips conspicuously sclerotized. Vagina 26-30 µm, about half of the corresponding body width. Female genital apparatus 20-21 % of body length. Each gonad 2.5-3.5 body diameter long. Ovaries not reaching to vulva. One egg: 82 × 55 µm, 1.2 times as long as body diameter. No sperm in uterus. Distance vulva-anus 4.2-5.1 times as long as tail. Tail unusually long, 160-168 µm, 4.8-5.2 times anal diameter, 8-10 % of body length; conoid, arcuately bent ventrad, with finely rounded tip. Cuticle with ovoid subventral 'saccate bodies' on the postanal

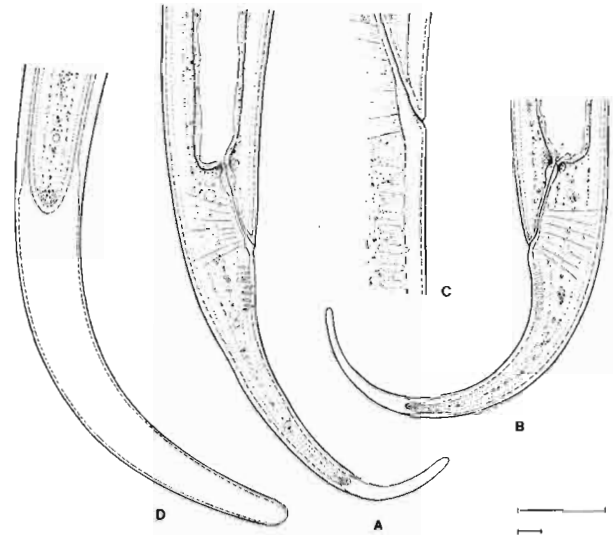


Fig. 11. *Boreolaimus septemtrionalis* sp. n. A-B: Tails; C: Oval bodies in the anterior subventral region of tail; D: "Empty" portion of tail. (Scale bars = 10 µm each; upper: C-D, lower: A-B).

region, 7-10 on each side. 'Empty' portion 26-34 % of tail length.

Male: not found.

TYPE MATERIAL

Holotype: Female, slide No. 72/Sk-B. Paratypes: one female and three juveniles. Every specimen deposited in the Nematode Collection of the Eötvös Loránd University, Budapest, Hungary.

LOCALITIES AND HABITAT

Type locality: Lake Laisan, Uma-älv water system, Prov. Lappland, Sweden, 450 m above sea-level, groundwater, July 1963; coll. P.H. Enckell (Fig. 1, loc. 13).

Other locality: Vojmån River at Henriksfjäll, Ångerman-älven water system, Prov. Lappland, Sweden, 500 m above sea-level, groundwater, August 1966 (two females and two juveniles, Fig. 1, loc. 14).

DIAGNOSIS AND RELATIONSHIPS

The main characters are: medium shape, the longest odontostyle in the genus, sclerotized vulval lips, comparatively small egg, long tail, bubbles in tail cuticle, short empty portion in body end.

Boreolaimus septemtrionalis sp. n. can easily be distinguished from every member of the genus in having an unusually long and ventrally arcuate tail (160-168 vs 60-110 µm in the other species). The vulval lips are well sclerotized, as in *B. enckelli*, but the long, ventrally bent tail with 'saccate bodies' and the comparatively short 'empty' part distinguish our species from *B. enckelli*.

***Boreolaimus norvegicus* * sp. n.**
(Figs 12A-E; 13A-C)

MEASUREMENTS

Holotype (female): L = 1.75 mm; a = 53; b = 3.8; c = 17; V = 46; c' = 4.7.

Females (n = 6): L = 1.74-2.04 mm; a = 50-62; b = 3.8-4.5; c = 16-21; V = 44-48; c' = 4.3-5.0.

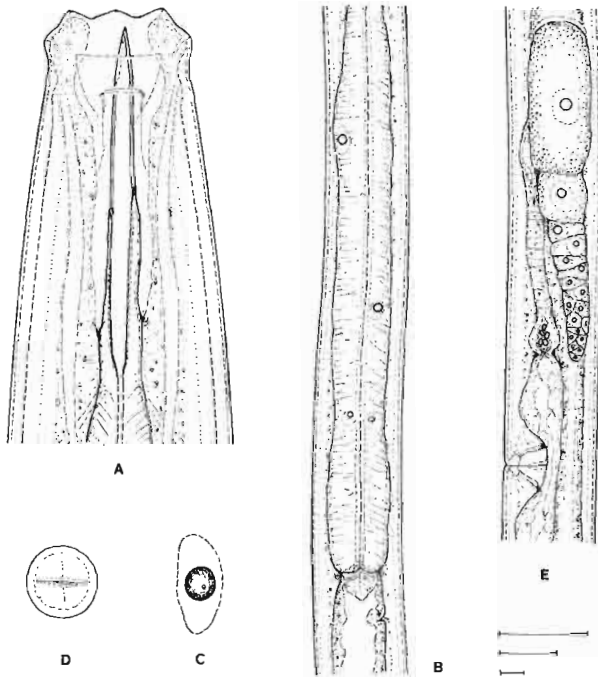


Fig. 12. *Boreolaimus norvegicus* sp. n. A: Anterior region; B: Cylindrus with nuclei; C: Dorsal nucleus; D: Vulva in frontal view; E: Anterior female gonad. (Scale bars = 10 μ m each; upper: A, C, middle: D, lower: B, E).

DESCRIPTION

Females: Body extremely slender, 33-38 μ m wide at mid-region. Cuticle thin, 1-1.5 μ m thick on most of the body, 2 μ m thick on anterior half of tail, half as thick as spear at level of spear; smooth. Cephalic region offset by depression, 16-17 μ m wide; lips separate. Anterior labial papillae conoid, lateral papillae rounded. Body at proximal end of oesophagus 2.2-2.3 times as wide as head. Amphids caliciform, broader than half the body diameter at the same level. Buccal cavity spacious and very long. Odontostyle 22-23 μ m, 1.3-1.4 labial diameter long, 18-21 % of oesophageal length, straight. Aperture about as long

* Found only in Norway, hence its specific name *norvegicus*.

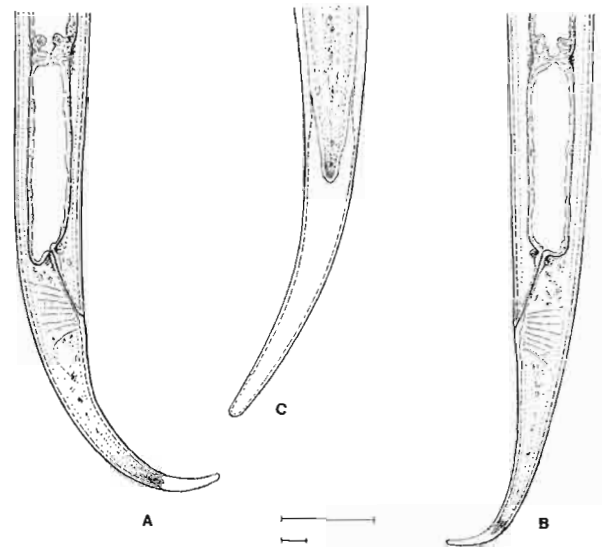


Fig. 13. *Boreolaimus norvegicus* sp. n. A-B: Tails; C: Posterior 'empty' portion of tail. (Scale bars = 10 μ m each; upper: C, lower: A-B).

as 1/3 spear. Guiding ring tubular, anteriorly expanded. Oesophagus 394-495 μ m long, widened at 44-48 % of its length. Cylindrus somewhat widened at both ends. Nuclei distinct. Dorsal nucleus rounded-oval, longitudinally directed, 4 μ m. Other nuclei round; AS₂ hardly smaller than D. Distance between dorsal nucleus and anterior nuclei 116-131 μ m and 119-131 μ m. Locations of oesophageal gland nuclei given in Table 1; location following Loof and Coomans (1970): D: 59-61 %, AS₂: 74-77 %, PS₁: 84-87 %, PS₂: 85-87 %. Cardia short, tongue-like. Intestine often with greenish contents. Prerectum 3.0-4.6 times as long as anal body diameter; rectum 1.0-1.5 times as long as anal body diameter. Distance between posterior end of oesophagus and vulva 0.8-1 times as long as oesophagus itself. Vulva transverse, inner lips not sclerotized; vagina 17-19 μ m, half the corresponding body diameter or a little longer, strongly widened proximally. Length of female genital organ equal to 13-19 % of body length. Each gonad 3.5-5.2 body diameters long. Ovaries not reaching to vulva. Anterior gonad mostly on the left, posterior on the right side of intestine. Mature egg not seen. No spermatozoa in uterus. Distance between vulva and anus 8-10 times as long as tail. Tail 95-110 μ m, 4.3-5.0 anal diameters long, 5-6 % of body length; conoid, almost straight, with rounded tip. 'Empty' portion 20-26 μ m or 21-24 % of tail length; shorter (12-17 %) in juvenile animals. Anal muscles strongly developed.

Table 1. Position (%) of oesophageal gland nuclei in species of the genus *Boreolaimus* n. gen.

	<i>B. borealis</i> sp. n.	<i>B. encelli</i> n. comb.	<i>B. lapponicus</i> sp. n.	<i>B. arcticus</i> sp. n.	<i>B. septemtrionalis</i> sp. n.	<i>B. norvegicus</i> sp. n.
D	57-60	60-62	58-60	60-62	58-59	59-61
AS ₁	—	—	—	—	—	—
AS ₂	41-44	40-42	39-42	38-40	36-38	36-40
PS ₁	65-68	62-64	64-70	64-66	64-65	61-67
PS ₂	66-69	63-66	66-71	66-67	65-66	63-67

TYPE MATERIAL

Holotype: Female, slide No. 42/Sk-B. Paratypes: five females and nine juveniles. All specimens are deposited in the nematode collection of the Eötvös Loránd University, Budapest, Hungary.

TYPE LOCALITY AND HABITAT

Lake Sagelvatn 50 km south of Tromsø, Sagelva river system, Prov. Troms, Norway, north of the Arctic Circle, groundwater, August 1965; coll. P.H. Enckell (Fig. 1, loc. 4).

DIAGNOSIS AND RELATIONSHIPS

The main characters are: body very slender and of middle length, vulva not sclerotized, vagina proximally expanded, prerectum long, tail long with empty portion measuring 1/4 of tail length.

Boreolaimus norvegicus sp. n. is the most slender species of the genus, which makes it easily recognizable. Among the species with unsclerotized vulva, *B. norvegicus* resembles *B. arcticus* sp. n., as both have medium-long tails; it can be distinguished from *B. arcticus* by slender body, comparatively longer tail ($c' = 4.3-5.0$ vs $3.1-3.5$), and shorter "empty" part of tail (1/4 vs 1/3 of tail length).

Key to the species of *Boreolaimus*

- 1 – Vulval lips conspicuously sclerotized 2
 - Vulval lips not sclerotized 3
- 2 – Tail 160-168 μm ventrally arcuate, with "saccate bodies" in its cuticle; c' about 5; $L = 1.6-1.9$ mm; $a = 23-30$; $b = 3.7-3.8$; $c = 10-12$; $V = 47-50$; Sweden *septemtrionalis* sp. n.
 - Tail 60-74 μm , practically straight, with plain cuticle; $c' = 2-2.5$, $L = 1.5-1.6$ mm; $a = 27-29$; $b = 3.2-3.5$; $c = 22-26$; $V = 52-56$; Sweden *encelli* (Andrássy, 1967) n. comb.
- 3 – Body very slender ($a = 50-62$); $c' = 4-5$ anal diameters; $L = 1.7-2.0$ mm; $a = 50-62$; $b = 3.8-4.5$; $c = 16-21$; $V = 44-48$; Norway *norvegicus* sp. n.
 - Body not so slender ($a \leq 45$), $c' = 1.8-3.5$ 4

- 4 – Tail 80-110 μm ; $c' = 3-3.5$; $L = 1.5-1.8$ mm; $a = 28-36$, $b = 3.6-3.9$; $c = 15-19$; $V = 44-51$; Norway *arcticus* sp. n.
 - Tail 64-77 μm ; $c' = 1.8-2.3$ 5
- 5 – Anal region with fine cuticular striation/punctation; ventral cuticle of tail with blisters; $L = 2.0-2.4$ mm; $a = 39-45$; $b = 3.8-4.3$; $c = 31-34$; $V = 53-55$; Norway *borealis* sp. n.
 - Anal region not striated; ventral cuticle of tail without blisters; $L = 1.7-2.2$ mm; $a = 35-42$; $b = 3.6-4.1$; $c = 26-30$; $V = 52-58$; Norway, Sweden, Finland *lapponicus* sp. n.

Acknowledgements

I would like to express my special gratitude to Dr P.H. Enckell (Lund, Sweden) for giving me a free rein in his rich and valuable nematode material. Thanks are also due to Dr P.A.A. Loof (Wageningen, The Netherlands) for loaning some nematodes from his Spitzbergen material. Last, but not least, I am grateful to Dr P. De Ley (Gent, Belgium) for his friendly assistance in putting the language of the manuscript into a better English.

References

- ALTHERR, E. (1972). Contribution à la connaissance des Nématodes rithrostygopsammiques et rithrostygopséphiques de Suède. *Revue suisse Zool.*, 79: 881-902.
- ANDRÁSSY, I. (1967). Nematoden aus interstitiellen Biotopen Skandinaviens, gesammelt von P.H. Enckell. 1. Nematoden aus der Uferregion des Vättern- und Torne-träsk-Sees (Schweden). *Opusc. Zool. Bpest.*, 7: 3-36.
- ANDRÁSSY, I. (1992). The superfamily Dorylaimoidea. Family Qudsianematidae, II. *Opusc. Zool. Bpest.*, 24: 3-55.
- ANDRÁSSY, I. (1995). Tropical nematodes of rare genera (Dorylaimida). *Opusc. Zool. Bpest.*, 27 28: 5-24.
- GERAERT, E., GROOTAERT, P. & DECRAEMER, W. (1980). Structure of the female reproductive system in some Dorylaimida and Enoplida (Nematoda). *Nematologica*, 26: 255-271.
- LOOF, P.A.A. (1971). Freelifving and plant parasitic nematodes from Spitzbergen, collected by Mr. H. van Rossen. *Meded. LandbHoges. Wageningen*, 71: 1-86.
- LOOF, P.A.A. & COOMANS, A. (1970). On the development and location of the oesophageal gland nuclei in the Dorylaimina. *Zesz. probl. Postep. Nauk roln.*, 92: 79-161.