

INVERTEBRATE
ZOOLOGY

***Foxtosognus rarus* gen. n., sp. n.—A New Genus and Species
of Copepods (Copepoda: Calanoida) from the Abyssopelagic
Zone of the Kuril–Kamchatka Trench**

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Accepted May 17, 2007

Abstract—A female of *Foxtosognus rarus* gen. n., sp. n., a new genus and species of copepods, is described from the abyss of the Kuril–Kamchatka Trench. The new genus is placed in the family Arctokonstantinidae, whose diagnosis is emended and supplemented with the following characters: mandibular basis with one to two setae; mandibular endopod one without setae; maxillular distal basal endite plus endopod with two to four setae or without setae. The features that distinguish *Foxtosognus* gen. n. from other representatives of this family are as follows: mandibular palp with a long endopod segment one, endopod segment two with seven setae, and exopod segment five with two setae; maxillula with distal basal endite lacking setae and separated from endopod bearing three setae; maxillular precoxal arthrite with seven to eight setae and exopod with four setae; maxilliped syncoxa without setae on precoxal endites and endopod of three segments. The genera *Sognocalanus* and *Foxtonia* earlier included in the Spinocalanidae are herein transferred to the Arctokonstantinidae.

Key words: copepods, Calanoida, Arctokonstantinidae, new genus and species, Kuril–Kamchatka Trench

DOI: 10.1134/S1063074008010021

The deep-sea copepods (Calanoida) are still rather poorly studied, especially with respect to the abyssopelagic fauna of the World Ocean. However, the results of investigations that have been carried out demonstrate that this fauna is rich and diverse. Therefore, the finding of a new genus and species belonging to the superfamily Spinocalanoidea from the lower ultraabyssal zone of the Kuril–Kamchatka Trench is of obvious interest. *Foxtosognus rarus* sp.n. was found in samples collected during an expedition of the P.P. Shirshov Institute of Oceanology (Moscow), performed in the 39th cruise of RV *Vityaz* in 1966.

One female of the new species selected from samples fixed with 4% formaldehyde solution was stained with 70% alcohol solution of chlorazol black E. For detailed morphological study, the mouth appendages and swimming legs of the crustacean were detached and placed into glycerol, then they were sketched using a drawing tube, and finally placed into permanent preparations.

The specimens of *Foxtonia* Hulsemann et Grice, 1963 were obtained from the materials of a Russian expedition to the Kuril–Kamchatka Trench aboard the RV *Vityaz* (39th cruise) and also from the collections of a German expedition into the Northern Atlantic aboard RV *Meteor* (sixth and seventh cruises).

Free segments of antennules and ancestral segments are designated in the text by Arabic and Roman numerals respectively [18]. One seta and one aesthetasc of an antennular segment are designated as 1s + 1ae; the first to fourth pairs of swimming legs—as P1–P4.

The type material is deposited in the Zoological Institute RAS (St. Petersburg).

Subclass Copepoda Milne–Edwards, 1830

Order Calanoida G.O. Sars, 1903

Superfamily Spinocalanoidea Vervoort, 1951

Family Arctokonstantinidae Markhaseva et. Kosobokova, 2001

Diagnosis. Rostrum is in shape of a plate or absent. Caudal rami and their inner setae are either symmetrical or asymmetrical. Proximal segment of antennal exopod is lacking the seta. Mandibular palp: basis bears one to two setae, first segment of the endopod has no setae. Maxillula: distal endite of basis is fused to endopod; rarely they are separated from each other (*Foxtosognus*), both the segments together bear two to four setae, or no setae is present (*Foxtonia*). Maxilla: Proximal coxal endite bears one to two setae. Maxilliped: terminal segment of endopod has two to three setae. P1: on basal segment the seta is absent; endopod consists of a single segment and has no inner lobe, bears four to five setae; exopod consists of one or three segments. P2: endopod consists of one or two segments; exopod

is three-segmented. P3–P4: both exopods and endopods are three-segmented. In exopods P2–P4 the third segment bears 5 inner setae. P5 is absent.

The genera *Foxtonia* Hulsemann et Grice, 1963 and *Sognocalanus* Fosshagen, 1967, as well as the new genus *Foxtosognus* correspond to the diagnosis of the family Arctokonstantinidae. Therefore, it is suggested to transfer the genera *Foxtonia* and *Sognocalanus*, which were earlier on referred to as members of the family Spinocalanidae Vervoort, 1951, into the family Arctokonstantinidae, which until now remained monotypic, as it comprised a single genus *Arctokonstantinus* Markhaseva et Kosobokova, 2001; also it is proposed to include the new genus *Foxtosognus* into this family.

Foxtosognus gen. n.

Diagnosis. Rostrum is in shape of a rounded short plate. Caudal rami are symmetrical, their inner setae are arranged symmetrically. Antennules are short, somewhat longer than cephalosome. Antenna: endopod is longer and thicker than exopod; second segment of the exopod bears a seta. Mandible: basis of palp has two setae; first segment of endopod is longer than second segment, which is provided with seven setae; terminal segment of exopod has two setae; gnathobase is provided with three teeth and two setae. Maxillula: precoxal arthrite has seven to eight setae; both coxal and proximal basal endites are reduced; distal basal endite has no setae and is separated from endopod that bears three setae; exopod bears four setae. Maxilla: proximal and distal endites of precoxa bear three and two setae respectively; proximal and distal endites of coxa are provided with two and three setae respectively; those of basis—with three and two setae respectively; endopod has four setae. Maxilliped: precoxal endites of syncoxa are lacking setae; coxal endite has one seta; allobasis bears one seta arising in the middle part of segment and two setae located distally; endopod is three-segmented, its segments have one, three, and two setae respectively. P1: exopod is three-segmented, each the segment bears an external spine. P2: endopod is two-segmented. P3–P4: endopods are three-segmented, third segment bears six setae.

Male is unknown.

Remarks. *Foxtosognus* gen. n. differs from all other genera of the family Arctokonstantinidae in the following structural peculiarities: (1) second segment of antennal exopod bears a seta (it is absent in all members of other genera of the family); (2) first segment of endopod of mandibular palp is longer than the second segment, which is provided with seven setae (in the members of other genera of the family the first segment of endopod is shorter than the second segment, which bears five to six setae); (3) fifth segment of exopod has two setae (there is one seta in the members of other genera); (4) distal endite of the basis of maxillula is lacking

setae and separated from endopod (in members of other genera distal endite of basis and endopod are fused together); (5) endopod of maxillula has three setae (in *Foxtonia* it is lacking setae; in *Sognocalanus* and *Arctokonstantinus* it is not possible to determine where the setae arise from, as basis and endopod are fused together; in the latter case the fused basis and endopod together bear two and four setae respectively); (6) precoxal arthrite of maxillula has seven–eight setae (there are 12 setae in *Arctokonstantinus*, three setae in *Foxtonia*, and four setae in *Sognocalanus*); (7) exopod of maxillula has four setae (there are nine setae in *Arctokonstantinus* and three setae in *Foxtonia* and *Sognocalanus*); (8) there are no setae on precoxal endites of syncoxa of maxilliped (in the members of other genera precoxa bears at least one seta); and (9) endopod of maxilliped consists of three segments (there are five segments in *Arctokonstantinus* and *Foxtonia* and four segments in *Sognocalanus*).

The new genus differs from *Foxtonia* and *Arctokonstantinus* by the presence of a rostrum, which is absent in the above mentioned genera, and symmetrical caudal rami with symmetrically arranged setae (the setae are asymmetrically arranged in both *Foxtonia* and *Arctokonstantinus*). The new genus shows more morphological similarities to genera *Foxtonia* and *Sognocalanus* (reduction of coxal and proximal basal endites of maxillula, structure of maxilla, presence of setae on coxal endite of syncoxa of maxilliped, and armament of P1 endopod) than to the genus *Arctokonstantinus*.

Type species. *Foxtosognus rarus* sp. n., by monotypy.

Etymology. The name of the genus was composed from the names of two closely related genera, *Foxtonia* and *Sognocalanus*.

Foxtosognus rarus sp. n.

Materials. A female, 2.7 mm long, the holotype, reference number 91087; RV *Vityaz*, 39th cruise; August 24, 1966; Stn. 5626, 8750 m deep; Kuril–Kamchatka Trench, 45°11'N, 152°28'E, from a horizon of 5020–6140 m deep; Bogorov–Rass plankton net with mouth area of 1.0 m².

Description. Prosome is 2.9 times longer than urosome. Somite bearing the first pair of swimming legs is separated from cephalosome; fourth and fifth somites of prosome are separated from each other (Figs. 1a, b). Fifth somite of prosome is rounded. Genital somite is symmetrical; spermathecae are elongated–oval in shape (Figs. 1b, g, h). Caudal rami are symmetrical, with four terminal setae and one inner seta (Fig. 1i); the setae are arranged symmetrically. Rostrum has the shape of a rounded plate (Fig. 1c). Labrum is densely set with hairs (Fig. 1e).

Antennules are short, somewhat longer than cephalosome (Fig. 1b), and consist of 23 segments (segments I–

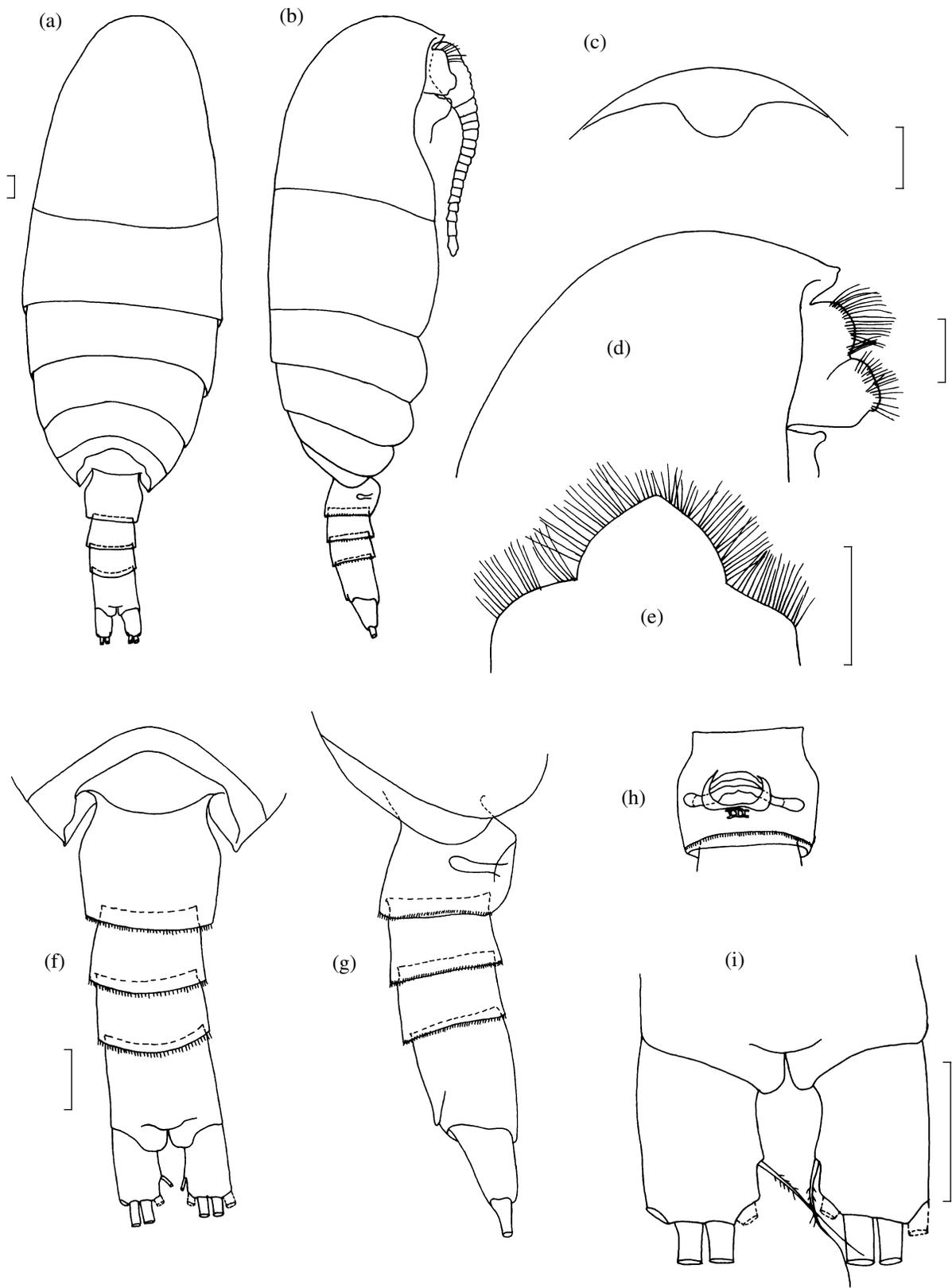


Fig. 1. *Foxtosognus rarus* sp.n. Female (the holotype): (a) general view, dorsal; (b) general view, lateral; (c) rostrum, ventral aspect; (d) anterior part of cephalosome, lateral aspect; (e) labrum; (f) posterior angles of prosome and urosome, dorsal aspect; (g) posterior angles of prosome and urosome, lateral aspect; (h) genital segment, ventral aspect; (i) caudal rami, dorsal aspect. Scale bar: 0.1 mm.

XXVIII are ancestral); however, seven proximal segments (ancestral segments I–IX) are incompletely separated from each other. The armament of the left antennules is as follows: (I) 1s; (II–IV) 5s + 1ae; (V–VI) 2s; (VII) 2s + 1ae; (VIII–IX) 2s; (X–XI) 4s + 1ae; (XII–XIV) 2s; (XV) 1s; (XVI) 1s + 1ae; (XVII–XX) 1s; (XXI) 2s; (XXII–XXIII) 1s; (XXIV) 2s; (XXV) 1s + ?; (XXVI–XXVIII) 7s + 1ae. The armament of the right antennules differs in the following details: (XVI) 1ae; (XX) 0; (XXI) 1ae; (XXIII) 0; (XXVII–XXVIII) 5s.

Antenna (Fig. 2a): endopod is wider and longer than exopod; coxa bears one seta; basis has one seta; first segment of endopod is provided with one seta, second segment bears six setae on outer lobe and seven setae on inner lobe; exopod consists of eight segments, the armament of the latter is as follows: 0, 1, 1, 1, 1, 1, 1, 3.

Mandible (Figs. 2b, c): basis has two setae; first segment of endopod is longer than second one, lacking setae, second segment bears seven setae; exopod is five-segmented, its armament is as follows: 1, 1, 1, 1, and two setae; gnathobase is provided with three teeth and two lateral setae.

Maxillula (Fig. 2d): precoxal endite of right and left appendages bears seven and eight setae respectively; coxal and proximal basal endites are reduced; distal basal endite is lacking setae and separated from endopod; endopod has three setae; exopod bears four setae; epipod of right and left appendages is provided with five and four setae respectively.

Maxilla (Fig. 2e): proximal and distal precoxal endites are provided with three and two setae respectively; proximal and distal coxal endites have two and three setae respectively (one setae is strongly chitinized); proximal basal endite is provided with three setae (two setae are strongly chitinized), distal endite has two setae (one seta is strongly chitinized); endopod is provided with four strongly chitinized setae.

Maxilliped (Fig. 2g): precoxal endites of syncoxa are lacking setae, outer part of syncoxa has a proximal tubercle; coxal endite bears one seta; allobasis has one medial and two distal setae; endopod is three-segmented (although weak signs of demarcation between two penultimate segments could still be observed); the armament of segments is as follows: 1, 2 + 1, and 2 setae respectively.

P1 (Fig. 3b, c): coxa and basis are lacking setae; endopod has no lobe, has three chitinous pores arranged along the inner edge of the segment and five setae; all three segments of exopod are provided with outer spines; third segment also has a terminal spine and four inner setae.

P2 (Fig. 3d): coxa has one inner seta; basis is lacking setae; endopod is two-segmented, its first segment has one inner seta, second segment is provided with two inner, two terminal, and one outer setae, at the base of

each inner seta there are two small denticles; first and second segments of exopod have one inner seta and outer spine each; third segment of exopod bears five inner setae, one terminal spine, and three outer spines.

P3–P4 (Figs. 3e, f, g): coxa has one inner seta; basis is lacking setae; first and second segments of endopod bear one inner seta each; third segment has two inner, two terminal, and two outer setae; first segment of exopod is provided with one inner and one outer spines; second and third segments of exopod are broken off.

P5 is absent.

Etymology. The species name “*rarus*” means “rare or unusual” and characterizes the specific structural pattern of mouthparts in the new species.

DISCUSSION

Superfamily Spinocalanoidea includes family Spinocalanidae, which earlier comprised 11 genera (see table) and monotypic family Arctokonstantinidae (*Arctokonstantinus*). The following characters were listed earlier as diagnostic for Arctokonstantinidae ([12]: 319–320): (1) the armament of proximal coxal endite of maxilla, having less than three setae (the presence of three setae is characteristic of Spinocalanidae); (2) the armament of terminal segment of maxillipedal endopod, bearing less than four setae (the presence of four setae is typical for Spinocalanidae); (3) the absence of seta on the basal segment of P1 (it is present in Spinocalanidae); and (4) the absence of lobe on the endopod of P1 (it is present in Spinocalanidae). Boxshall and Halsey referred to *Arctokonstantinus* as advanced members of the family Spinocalanidae, and proposed to consider the family Arctokonstantinidae itself as a junior synonym of Spinocalanidae (see [4]). However, we consider this opinion to be unreasonable.

The same authors published some supplementary information about the structure of *Sognocalanus* ([4]: 195–196), while recently an original investigation was performed on the poorly studied genus *Foxtonia*; the structure of caudal rami and armament of maxillipeds of the members of this genus have been specified (see table). Considering this information and taking into account the finding of the new genus *Foxtosognus* closely related to *Sognocalanus*, *Foxtonia*, and *Arctokonstantinus*, we performed a taxonomical analysis of this group of genera to evaluate its position within the system of Spinocalanoidea. When estimating whether a particular characteristic is primitive or advanced we followed the criteria generally accepted among copepodologists: the evolution of copepods is characterized by oligomerization [2] and follows, primarily, the pathway of reductions, fusions, and losses [3], i.e., the condition of the greatest articulation and setation of appendages is considered to be the most primitive one.



Fig. 2. *Foxtosognus rarus* sp.n. Female (the holotype): (a) antenna; (b) mandible, the palp; (c) gnatobase of mandible; (d) maxilla; (e) maxilla; (f) maxilliped. Scale bar: 0.1 mm.

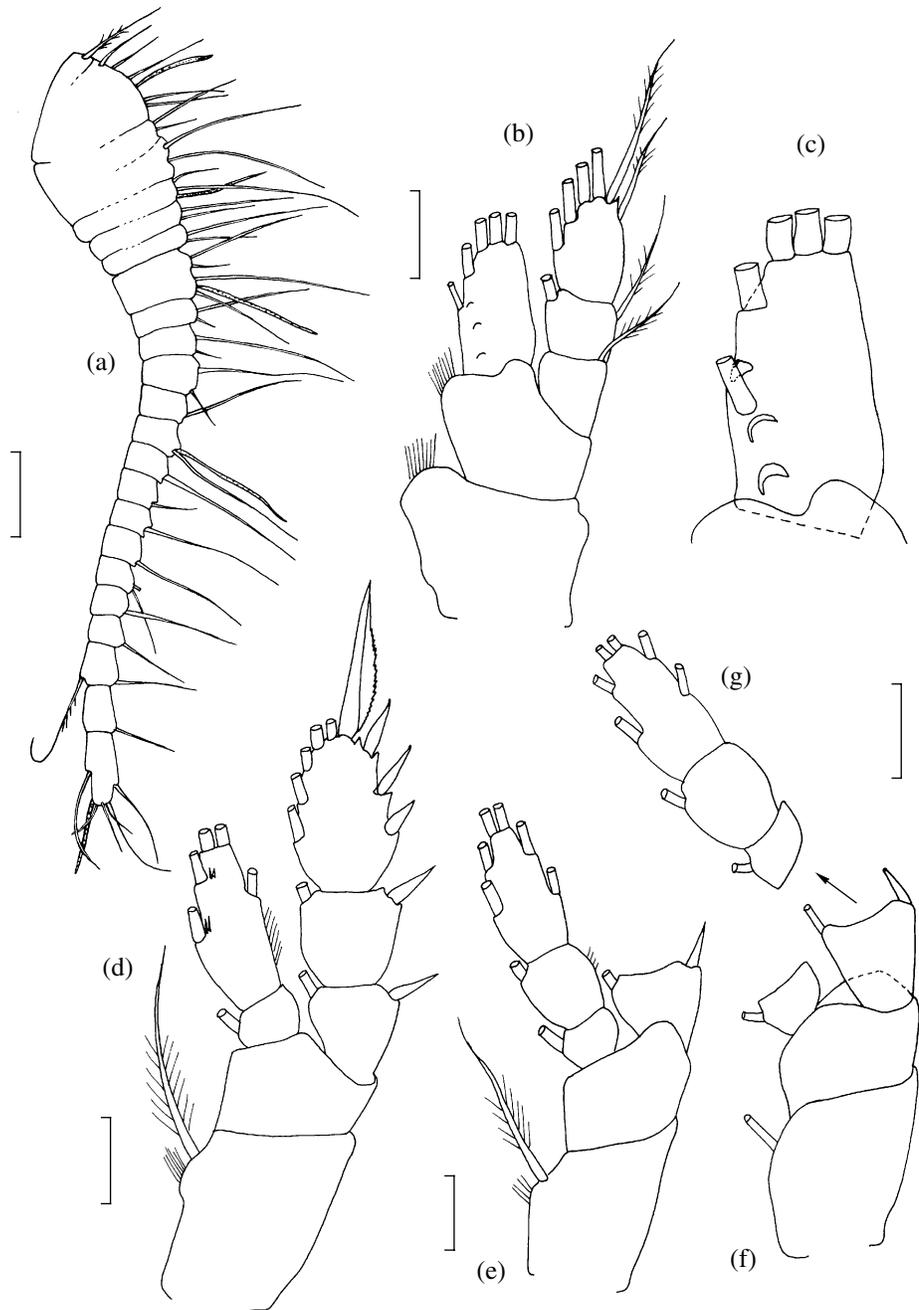


Fig. 3. *Foxtosognus rarus* sp.n. Female (the holotype): (a) antennule; (b) P1; (c) endopod of P1; (d) P2; (e) P3; (f) coxopod, basis and first segments of exopod and endopod of the left P4; (g) endopod of the right P4. Scale bar: 0.1 mm.

Finally, we have made the conclusion that *Arctokonstantinus*, *Sognocalanus*, *Foxtonia*, and *Foxtosognus* together comprise a monophyletic group of genera within the superfamily Spinocalanoidea. This group is characterized by reduction of the number of setae on the mouthparts, the loss of seta on the basis and loss of the lobe of the endopod in P1, and, often, also by fusion together of the basis and endopod of maxillula (see table). In addition to the earlier reported [12] and above listed diagnostic characters, the following apomorphies

have been revealed that distinguish the family Arctokonstantinidae (see table): the basis of mandibular palp bears one to two setae (there are three to four setae in Spinocalanidae); the first segment of endopod of mandibular palp is lacking setae (there are two to four setae in Spinocalanidae); the distal endite of basis and endopod of maxillula together bear two to four setae or are lacking setae (*Foxtonia*) (there are eight to twenty-one setae in Spinocalanidae).

Details of armament of mouthparts and P1 in Spinocalanoidea that are important for diagnostic purposes

Genus	Mandible		Maxillula, distal endite of basis + endopod	Maxilla, proximal coxal endite	Maxilliped, terminal segment of endopod	P1		Source
	basis	first segment of endopod				seta on basal segment	lobe on endopod	
<i>Monacilla</i> Sars, 1905	4	4	5 + 16	3	4	Present	Present	[15]
<i>Spinocalanus</i> Giesbrecht, 1888	4	4	5 + 16	3	4			[1, 5, 13, 15]
<i>Mimocalanus</i> Farran, 1908	3	3–4	25, 7 + 15	3	?	"	"	[1, 5, 13]
<i>Damkaeria</i> Fosshagen, 1983	3–4	4	2 + 5, 7	3	4	"	"	[8, 18]
<i>Mospicalanus</i> Schulz, 1996	4	4	4 + 8	3	4	"	"	[17]
<i>Kunihulsea</i> Schulz, 1992	4	4	2–3 + 5, 10	3	4	"	"	[16, 18]
<i>Tenerifroma</i> Grice & Hulsemann, 1967	4	3	6 + 7	3	4	"	"	[9, 15]
<i>Methanocalanus</i> Ivanenko, Defaye & Cuoc, 2007	3	3	4 + 10	3	4	"	"	[11]
<i>Isaacsicalanus</i> Fleminger, 1983	3	2	1 + 7	3	4	"	"	[6, 15]
<i>Arctokonstantinus</i> Markhaseva & Kosobokova, 2001	2	0	4	2	3	Absent	Absent	[12]
<i>Sognocalanus</i> Fosshagen, 1967	2	0	2	2	2	"	"	[4, 7]
<i>Foxtonia</i> Hulsemann & Grice, 1963	1	0	0	1	2	"	"	[10], original data
<i>Foxtosognus</i> gen. n.	2	0	0 + 3	2	2	"	"	Original data

Note: The table presents the most primitive condition of characters that has been revealed for the genus. Synapomorphies for genera placed into the family Arctokonstantinidae are shown in boldface.

Thus, the new genus *Foxtosognus* agrees with a diagnosis of Arctokonstantinidae and is hereby included into the latter; the genera *Sognocalanus* and *Foxtonia*, which earlier were considered as members of the family Spinocalanidae, are transferred into the family Arctokonstantinidae.

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