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THE SEA OF MARMARA: NEW LOCALITY FOR TWO CALIGIDS AND ONE LERNANTHROPID IN TURKEY

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Abstract: The aim of this study was to determine the parasitic copepods of marine fish from Turkey. *Caligus minimus* Otto, 1821, *Caligus apodus* Brian, 1924 (Copepoda, Siphonostomatoida, Caligidae) and *Lernanthropus kroyeri* Van Beneden, 1851 (Copepoda, Siphonostomatoida, Lernanthropidae) were reported for the first time in the Sea of Marmara Coasts of Turkey. Also, some morphological characters of these parasitic copepods are described using photographs and drawings. *Caligus minimus* and *Lernanthropus kroyeri* were found on the gill filaments of the wild sea bass, *Dicentrarchus labrax* while *Caligus apodus* on the flathead grey mullet, *Mugil cephalus*. The prevailing values of *Caligus minimus*, *Lernanthropus kroyeri* and *Caligus apodus* are 100% for the former two, 6.25%.

Keywords: *Caligus*, *Lernanthropus*, morphology, Sea of Marmara, Turkey

Introduction:

The European sea bass is eurythermic and euryhaline; thus it is able to frequent coastal inshore waters, and occurs in estuaries and

brackish-water lagoons. Sometimes they venture upstream into freshwater. It is found in (or inhabits ?) the North eastern Atlantic (from Norway to Senegal), the Mediterranean Sea, and the Black Sea. The sea bass is among the foremost fish, especially in the Mediterranean aquaculture (Tortonese 1986). Flathead mullet is a cosmopolitan fish species, widely distributed in coastal waters, lagoons, and estuaries between latitudes 42°N and 42°S (Thomson 1966).

Copepods of the family Caligidae (Siphonostomatoida) are commonly known as sea lice among the fish culturists. It is the largest family of marine copepods comprising over 450 species (Ho 2004). Lernanthropidae Kabata, 1979 is a large family of siphonostomatoid copepods comprising over 150 species. They are exclusively parasitic on gill filaments of marine teleosts (Ho et al. 2011).

Caligus minimus, *Lernanthropus kroyeri* (Copepoda), *Ceratothoa oestroides* (Isopoda), *Diplectanum aequans*

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(Monogenea) are the most reported ectoparasites in the wild and cultured sea bass (Poquet 1979; Fernandez et al. 1989; Caillot et al. 1999; Sterud 2002; Özel et al. 2004; Merella et al. 2006; Vagianou et al. 2006; Özak 2007; Uluköy and Kubilay 2007; Tokşen et al. 2008; Canli 2010; Öktener et al. 2010; Özer and Öztürk 2011; Antonelli and Marchand 2012; Tanrikul and Perçin 2012; Yalım et al. 2014).

Although *Caligus minimus*, *Caligus apodus* and *Lernanthropus kroyeri* were reported from Coasts of the Aegean Sea, Mediterranean Sea; we aimed to present new locality for geographical distribution of them in Turkey and also their morphological characters are issued with drawings and photos.

Materials and methods:

Eigth of the wild sea bass, *Dicentrarchus labrax* Linnaeus, 1758 (Pisces; Moronidae) and 64 of the flathead grey mullet, *Mugil cephalus* Linnaeus, 1758 (Pisces; Mugilidae) were collected by local gears from Bandırma Bay of Turkey in 2014. The parasites collected were fixed in 70% ethanol. Some of specimens were later cleared in lactic acid before dissection of the appendages of copepods. The drawings of appendages were carried through with the aid of camera lucida (Olympus BH-DA) and the photos were taken by means of Canon EOS 1100D connected to a microscope. Measurements were taken in millimetres (mm), with a micrometric programme (Pro-way). The scientific names, synonyms of parasite and host were checked with WoRMS (2015), Froese and Pauly (2015). Kabata (1979) was consulted for terminology. The parasites were deposited in the collections of the Muséum National d'Histoire Naturelle (MNHN) of Paris, France.

Results and discussion:

Subclass Copepoda Milne Edwards, 1840
Order Siphonostomatoida Thorell, 1859
Family Caligidae O.F. Müller, 1785

Caligus minimus Otto, 1821 (Figs. 1-5, Annexes)

Host: *Dicentrarchus labrax* (wild sea bass);
Museum number: MNHN-IU-2014-12869,
Total parasite: 24; Dissected material: 5.

All parasites were firmly attached to the gill filaments, the walls of operculum, vomer, mouth base of the host. The prevalence, mean intensity of parasite was 100%, 3 respectively.

Female morphology: The body length varies from 4.5 to 5 mm; antennule is two-segmented; the distal segment is shorter than proximal, distal segment provided with 12 setae on distal margin and 1 subterminal seta on ventral margin, the proximal segment is armed with 23 plumose setae. Antenna is 3-segmented; first segment features small, tapering proximal process; the second segment nearly quadrangular; third segment forms long, distally strongly bent curved claw; subchela with small seta. Postantennal process weakly curved, carrying 3 papillae each with 3 sensillae; similar multi-sensillate papilla are located on body surface adjacent to postantennal process. Maxillule consisting of papilla bears 3 unequal setae. Maxilla is two-segmented and brachiform; proximal segment (lacertus), large and unarmed; slender distal segment (brachium) with subterminal hyaline membrane on outer margin and is tipped distally with 2 unequal processes (calamus and canna). Maxilliped 3-segmented; proximal segment (corpus) is the largest with a seta; distal two segments fused to form a claw and are carrying a small seta at base of claw. Mandible within mouth tube, tip with 12 teeth. Tines of sternal furca slightly curved inward. Caudal rami consisted of 3 long and 3 short setae. Fifth leg is represented by 3 short plumose setae.

The setal and spinal formula from first to fourth leg are as follows (Tab. 1).

Table no. 1 The setal and spinal formula first to fourth leg

Legs	Endopod	Exopod
First leg		I-0; IV-3
Second leg	1-0; 2-0; 6-0	I-1; I-1; III-5
Third leg	1-0; 6-0	I-0; I-1; III-4
Fourth leg		I-0; I, II

Distribution: North Atlantic Ocean, Mediterranean, Adriatic, Brasil (Radujkovic and Raibaut 1989; Fonseca et al. 2000; Boxshall 2015a).

Hosts: *Dicentrarchus labrax* (Bassett-Smith and Surgeon 1896; Brian 1906; Delamare Deboutteville 1950; Boxshall 1974; Raibaut and Ben Hassine 1977; Caillet 1979; Poquet 1979; Essafi et al. 1984; Fernández et al. 1989; Radujkovic and Raibaut 1989; Theocharis et al. 1997; Raibaut et al. 1998; Nawel 2005; Fioravanti et al. 2006); *Dicentrarchus punctatus* (Grabda 1977); *Gadus morhua* (Palm et al. 1999; Hemmingsen and MacKenzie 2001); *Mugil cephalus* (Raibaut and Ben Hassine 1977; Kabata 1979; Ragias et al. 2004); *Pagellus bogaraveo* (Brian 1935); *Sander lucioperca* (Palm et al. 1999); *Labrus merula* (Tanrikul and Percin 2012); *Mugil curema*, *Mugil liza* (Fonseca et al. 2000). Kabata (1979) listed this parasite with *Umbrina cirrosa*.

Caligus apodus Brian, 1924 (Figs. 6-10, Annexes)

Host: *Mugil cephalus* (the flathead grey mullet); Museum number: MNHN-IU-2013-18734, Total parasite: 5; Dissected material: 3.

All parasites were firmly attached to the gill filaments of the host. The prevalence, mean intensity of parasite was 6.25%, 1.25 respectively.

Female morphology: Body length varies from 4.2 to 5 mm. Antennule two-segmented; distal segment is shorter than proximal, distal segment with 13 setae on distal margin, proximal segment is armed with 18 plumose setae. Antenna, 3-

segmented; first segment small, tapering proximal process; second segment is nearly quadrangular; third segment displays curved claw; subchela with small seta. Postantennal process weakly curved, carrying 3 papillae each with 3 sensillae; Maxillule consisting of papilla bears 3 unequal setae. Maxilla is two-segmented and brachiform; proximal segment (lacertus) large and unarmed; slender distal segment (brachium) with subterminal hyaline membrane on outer margin and tipped distally with 2 unequal processes (calamus and canna). Maxilliped 3-segmented; proximal segment (corpus) is the largest; distal has two segments fused to form a claw and is carrying a small seta at the base of the claw. Mandible within mouth tube, tip with 12 teeth. Tines of sternal furca slightly parallel. Caudal rami consisted of 3 long and 3 short setae. Fourth leg is absent, fifth leg being represented by 3 short plumose setae

The setal and spinal formula from first to third leg are as follows (Tab. 2).

Table no. 2 The setal and spinal formula first to third leg

Legs	Endopod	Exopod
First leg		I-0; IV-3
Second leg	1-0; 2-0; 6-0	I-1; I-1; II-6
Third leg	1-0; 6-0	I-0; I-1; III-4

Distribution: The Mediterranean Sea, the Atlantic Ocean (Brian 1906; Radujkovic and Raibaut 1989; Raibaut et al. 1998; Boxshall 2015b).

Hosts: *Chelon labrosus* (Raibaut et al. 1971; Raibaut and Ben Hassine 1977; Radujkovic and Raibaut 1989; Raibaut et al. 1998; Merella and Garippa 2001); *Dicentrarchus labrax* (Ragias et al. 2004); *Liza aurata* (Raibaut et al. 1971; Raibaut et al. 1998); *Liza ramada* (Raibaut et al. 1971; Raibaut and Ben Hassine 1977; Raibaut et al. 1998; Merella and Garippa 2001); *Liza saliens* (Raibaut et al. 1971; Radujkovic and

Raibaut 1989; Raibaut et al. 1998; Merella and Garippa 2001); *Liza carinata* (Raibaut et al. 1998); *Mugil cephalus* (Brian 1935; Raibaut et al. 1971; Raibaut and Ben Hassine 1977; Raibaut et al. 1998; Merella and Garippa 2001); *Oedalechilus labeo* (Radujkovic and Raibaut 1989; Raibaut et al. 1998); *Solea solea* (Özak et al. 2013).

Subclass Copepoda Milne Edwards, 1840

Order Siphonostomatoida Thorell, 1859

Family Lernanthropidae Kabata, 1979

Lernanthropus kroyeri Van Beneden, 1851 (Figs. 11-13, Annexes).

Host: *Dicentrarchus labrax* (sea bass);
Museum number: MNHN-IU-2013-18746;
Total parasite: 21; Dissected material: 10.

All parasites were firmly attached to the gill filaments of the host. The prevalence, mean intensity of parasite was 100%, 2.6 respectively.

Female morphology: Body length varies from 4 to 6 mm. Antennule seven-segmented; first segment with one seta, second segment two setae, third segment displays one setae, fourth segment two setae, fifth segment with one seta; sixth segment with one long and one short seta; seventh segment with nine setae. Parabasal flagellum as large as the antennule. Antenna is robust, two-segmented; large corpus with small papilliform process; subchela without arms presents a strongly curved claw, claw with a small spinule at the base. Mandible with seven teeth. Maxillule bilobate, endopod subcylindrical, slightly tapering with three subequal terminal processes, exopod much smaller with inflated base and short process. Maxilliped is two-segmented; robust corpus, myxal area without arm; subchela appears elongated and smooth; claw provided with a short robust spinule at base. Maxilla two-segmented, brachiform; lacertus is robust, unarmed, brachium is distally long with sharp process on inner margin; terminal claw with one short spiniform process and row of sharp denticles on inner margin. First leg two segmented; tapering endopod, with one

apical seta and denticles on distal half of surface on both margins; exopod is larger broader distally with five short spines; a plumose seta lateral to the base of endopod and exopod. Second leg smaller than first leg, four spines on exopod and short apical seta on endopod; a lateral plumose seta to the base of endopod and exopod. Third leg protruding posteroventrally, parallel to each other. Fourth leg is slender, with bifid lobes. Fifth leg, blunted, shorter with a short seta. Uropod with two short setae distally; two long seta and one short setae medially.

Distribution: North Atlantic Ocean, Mediterranean, Adriatic, Brasil (Rodriguez 2004; Boxshall 2015c).

Hosts: *Dicentrarchus labrax* (Bassett-Smith and Surgeon 1896; Brian 1906; Delamare Deboutteville 1950; Raibaut et al. 1971; Boxshall 1974; Kabata 1979; Diebakate 1994; Benmansour and Ben Hassine 1998; Raibaut et al. 1998; Bahri et al. 2002; Manera and Dezfuli 2003; Ramdane and Trilles 2007; Koyuncu et al. 2012); *Lutjanus griseus* (Bere 1936; Rodriguez 2004).

The morphological characters of *Caligus minimus* found in this study are compared with mainly Brian (1935), Raibaut and Ben Hassine (1977); Caillet (1979); Kabata (1979). The general morphology - mouth parts (antenna, mandible, maxillule, maxilla, maxilliped), setal and spinal formula from first to fourth leg, exopod of first leg with two middle setae carrying narrow flanges at apices - in this study are compatible according to these literatures except for antennule. We found 23 setae on proximal segment and 13 setae on distal segment; while Raibaut and Ben Hassine (1977) and Caillet (1979) found 25 setae on proximal segment and 14 setae on distal segment.

This species was reported on sea bass, *Dicentrarchus labrax* from the Aegean Sea (Uluköy and Kubilay 2007; Tokşen et al. 2008), Çamlık Lagoon Lake connected to the Mediterranean Sea (Özak 2007); Hurmaboğazı Lagün Lake also connected to the Mediterranean Sea (Canli 2010); the Black Sea (Özer and Öztürk 2011); on

Labrus merula from the Aegean Sea of Turkey (Tanrıkuş and Percin 2012). The Sea of Marmara is the new locality for this species in Turkey according to literatures.

Concerning the low infestation values of *Caligus minimus* Fernandez et al. (1989) found 15% prevalence on *Dicentrarchus labrax*; 13% prevalence on wild *Dicentrarchus labrax* by Caillot et al. (1999); 5-45% prevalence on wild *Dicentrarchus labrax* by Yalim et al. (2014); 16% prevalence on wild *Dicentrarchus labrax* by Canli (2010). Regarding the high infestation values of *Caligus minimus*: Fonseca et al. (2000) found 80% prevalence on *Mugil liza*, *Mugil curema*; 4% prevalence on *Dicentrarchus labrax* by Fioravanti et al. (2006); 85.7-97.9% prevalence on *Dicentrarchus labrax* by Ragias et al. (2004); 75.2% prevalence on *Dicentrarchus labrax* by Theocharis et al. (1997); 45.45, 52.17, 97.77% prevalence on *Dicentrarchus labrax* by Bahri et al. (2002); 90% prevalence on wild *Dicentrarchus labrax* by Er and Kayış (2015). The high prevalence found in this study is compatible with the findings in these studies.

The morphological characters of *Caligus apodus* revealed in this study are compared mainly to those illustrated by Brian (1935), Özak et al. (2013). The general morphology - mouth parts (antenna, mandible, maxillule, maxilla, maxilliped), setal and spinal formula from first to third leg, absence of the fourth leg - in this study are compatible according to these literatures except for the antennule. We found 18 setae on proximal segment and 13 setae on distal segment; while Brian (1935) discovered 12 setae on proximal segment 8 setae on distal segment. This species was reported on the gill filaments of *Mugil cephalus*, *Liza saliens*, *Liza ramada*, *Chelon labrosus* from Aegean (Altunel 1983); on the body surface of *Solea solea* from the Mediterranean Sea (Özak et al. 2013) of Turkey. The Sea of Marmara is also the new locality for this species in Turkey according to literatures.

With regard to the infestation values of *Caligus apodus* Raibaut and Ben Hassine

(1977) found 30.1% prevalence on *Mugil cephalus*, 16.5% prevalence on *Liza ramada* and *Chelon labrosus*, 11.4% prevalence on *Liza aurata* and 9.4% prevalence on *Liza saliens*; 2-10.7% prevalence on *Dicentrarchus labrax* by Ragias et al. (2004); 63% on *Chelon labrosus*, 64% on *Liza ramada*, 37% on *Liza saliens*, 55% on *Mugil cephalus* by Merella and Garippa (2001); 3.2% on *Chelon labrosus* and 2% on *Liza saliens* by Radujkovic and Raibaut (1989); 3% prevalence on *Solea solea* by Özak et al. (2013).

There are several studies about morphology concerning *Lernanthropus kroyeri* (Kabata 1979; Diebakate 1994; Tokşen et al. 2008; Koyuncu et al. 2012). The findings about the general morphology - mouth parts (antenna, mandible, maxillule, maxilla, maxilliped), spines on first and segment legs, vestigial of the fifth leg - in this study comply with Kabata (1979), Diebakate (1994), Tokşen et al. (2008) apart from spine number on segments of antennule. The seta on first segment of antennule is compliant with Kabata (1979) and Tokşen et al. (2008); two setae on second segment with Diebakate (1994) and Tokşen et al. (2008); two setae on fourth segment (Kabata 1979; Tokşen et al. 2008); one seta on fifth segment with Kabata (1979), Diebakate (1994) and Tokşen et al. (2008); two setae on sixth segment with Diebakate (1994) and Tokşen et al. (2008); nine setae on seventh segment with Kabata (1979) and Tokşen et al. (2008).

This species was reported on sea bass, *Dicentrarchus labrax* from the Aegean Sea (Özel et al. 2004; Tokşen et al. 2008; Akbaş 2011; Bulut 2011), within the Mediterranean Sea (Koyuncu et al. 2012) and from Black Sea (Öktener et al. 2010). The Sea of Marmara is as well the new locality for this species in Turkey according to literatures.

As regards the infestation values of *Lernanthropus kroyeri* Theocharis et al. (1997) found 96.4-100% prevalence on *Dicentrarchus labrax*; 12.9, 38.63, 63.04, 100% prevalence on *Dicentrarchus labrax* by Bahri et al. (2002); 61% prevalence on

Dicentrarchus labrax from Turkey by Koyuncu et al. (2012); 35% prevalence from Greece on *Dicentrarchus labrax* by Manera and Dezfuli (2003); 20% prevalence on wild *Dicentrarchus labrax* by Caillot et al. (1999); 7.41% prevalence on wild *Dicentrarchus labrax* by Boualleg et al. (2010); 44% prevalence on wild *Dicentrarchus labrax* by Fernandez et al. (1989); 10% prevalence on wild *Dicentrarchus labrax* by Ramdane and Trilles (2007). The high prevalence found in this study is compliant with the findings in these studies.

Conclusions:

Although *Caligus minimus*, *Caligus apodus* and *Lernanthropus kroyeri* were known as proper to the Coasts of the Aegean Sea, the Mediterranean Sea of Turkey, there are some taxonomical deficiencies. The more detailed studies must be undertaken for the parasitic copepods. This study was aimed to confirm the Sea of Marmara as the new locality for the geographical distribution of these parasitic copepods in Turkey and also their morphological characters are conveyed with drawings and photos.

Rezumat:

MAREA MARMARA: O NOUĂ LOCAȚIE PENTRU DOUĂ CALIGIDE ȘI UN LERNANTHROPID ÎN TURCIA

Scopul acestui studiu a fost determinarea copepodelor parazite ale peștilor marini din Turcia. *Caligus minimus* Otto, 1821, *Caligus apodus* Brian, 1924 (Copepoda, Siphonostomatoida, Caligidae) și *Lernanthropus kroyeri* Van Beneden, 1851 (Copepoda, Siphonostomatoida, Lernanthropidae), au fost semnalate pentru prima dată în zona litorală a Turciei din Marea Marmara. De asemenea, unele dintre caracterele morfologice ale acestor copepode

parazite au fost descrise prin folosirea fotografiilor și a desenelor. *Caligus minimus* și *Lernanthropus kroyeri* au fost găsiți pe branhiile filamentoase ale lupului de mare, *Dicentrarchus labrax*, în timp ce *Caligus apodus* pe chefal, *Mugil cephalus*. Valorile dominante la *Caligus minimus*, *Lernanthropus kroyeri* sunt de 100%, iar pentru *Caligus apodus* de 6,25%.

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Annexes:

Figure no. 1 *Caligus minimus* ♀ habitus (Scale 1 mm).



Figure no. 2 *Caligus minimus* ♀. a) antennule (0.23 mm); b) distal of antennule; c) antenna and postantennal process (0.15 mm); d) maxillule (0.08 mm); e) maxilliped (0.18 mm); f) maxilla (0.23 mm); g) mandible (0.04 mm); h) caudal ramus (0.25 mm).

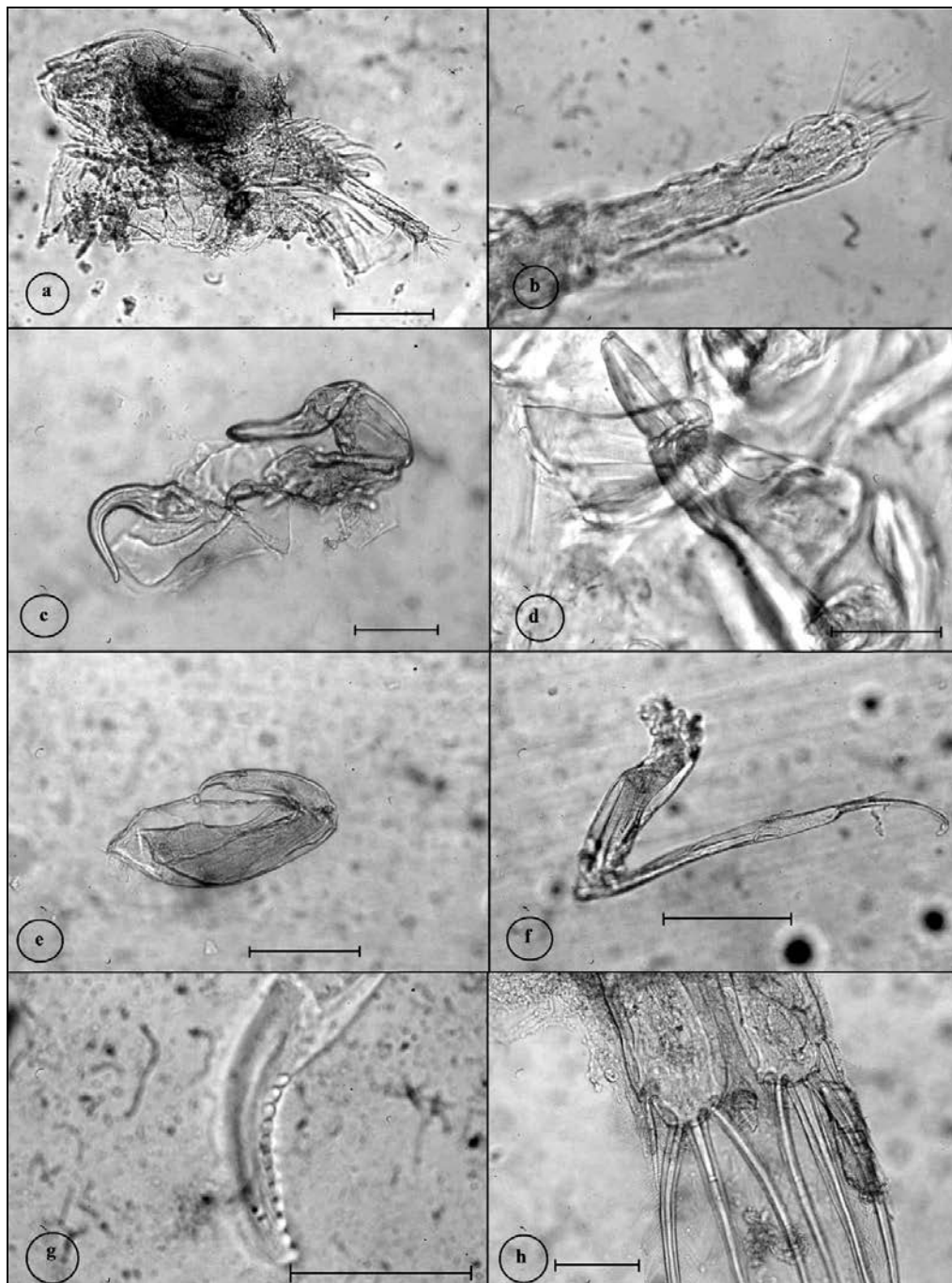


Figure no. 3 *Caligus minimus* ♀. a) sternal furca (0.06 mm); b) first leg (0.14 mm); c) exopod of first leg; d) second leg (0.10 mm); e) third leg (0.11 mm); f) fourth leg (0.27 mm).

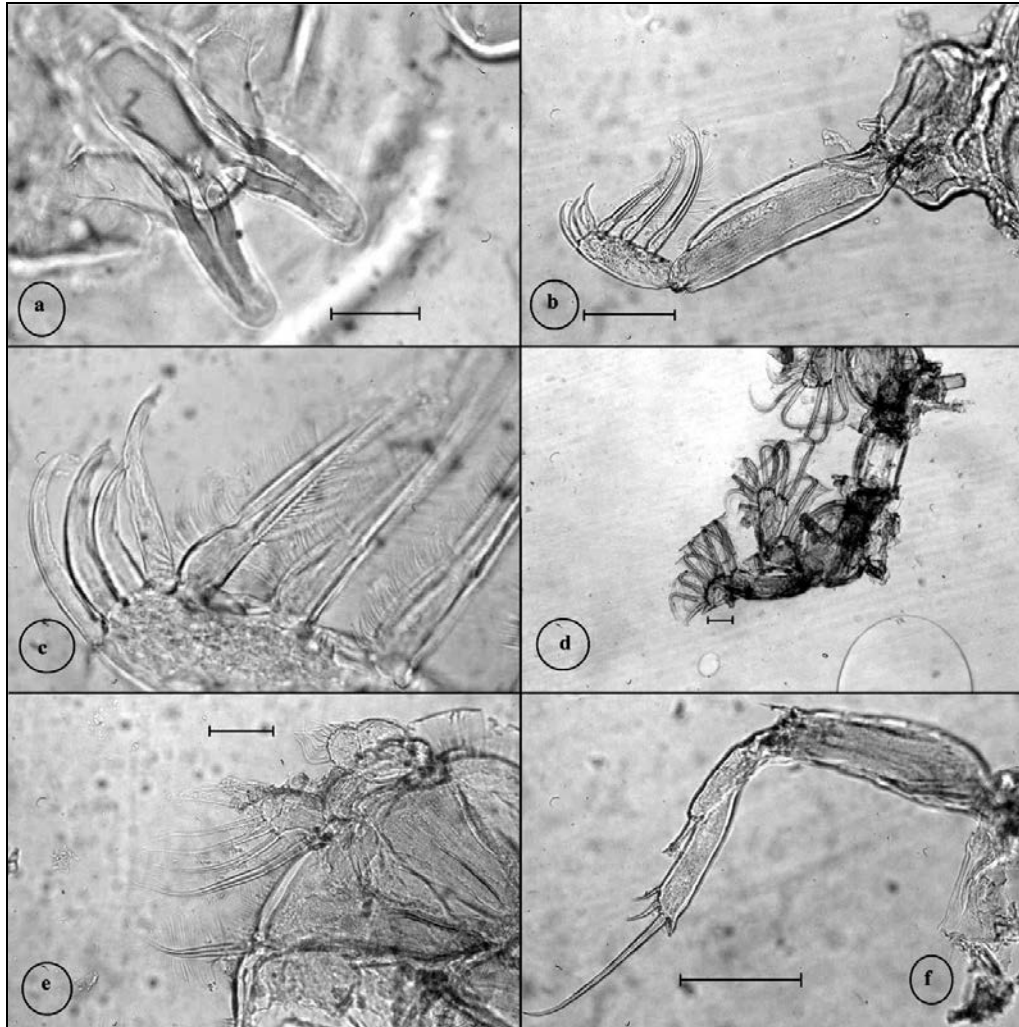


Figure no. 4 *Caligus minimus* ♀. a) antennule (0.23 mm); b) antenna; c) postantennal process (0.15 mm); d) maxillule (0.08 mm); e) mandible (0.05 mm); f) maxilliped (0.18 mm); g) maxilla (0.23 mm); h) caudal ramus (0.25 mm); i) sternal furca (0.06 mm); j) fifth leg (0.10 mm).

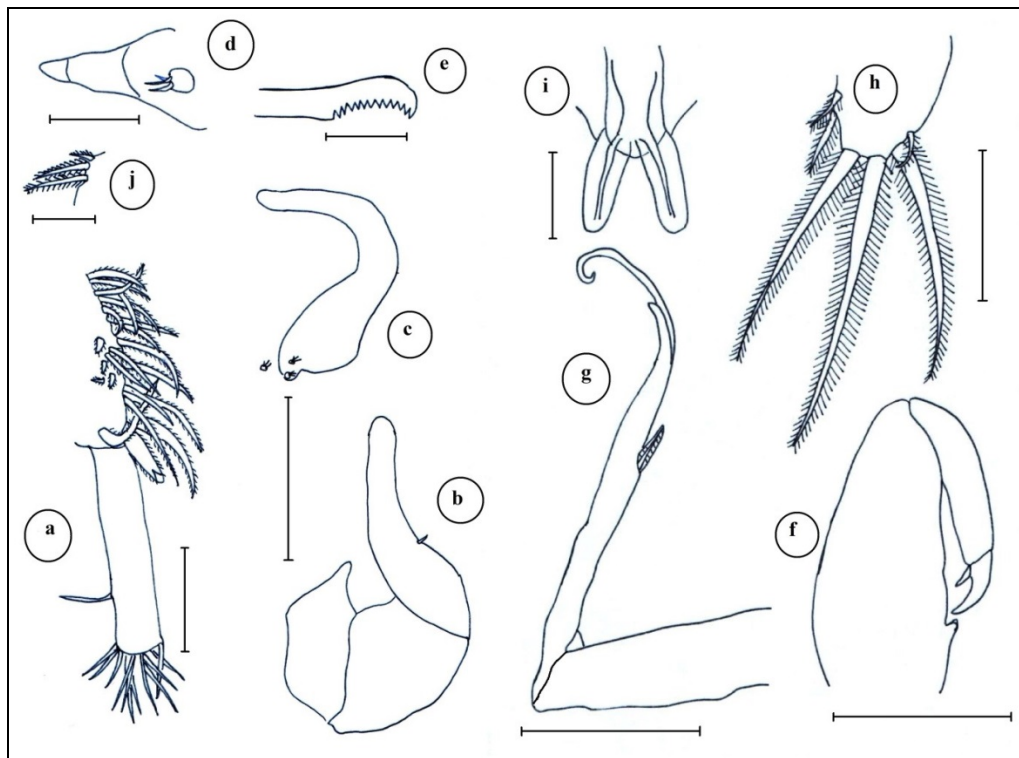


Figure no. 5 *Caligus minimus* ♀. a) first leg (0.14 mm); b) second leg (0.10 mm); c) third leg (0.11 mm); d) fourth leg (0.17 mm).

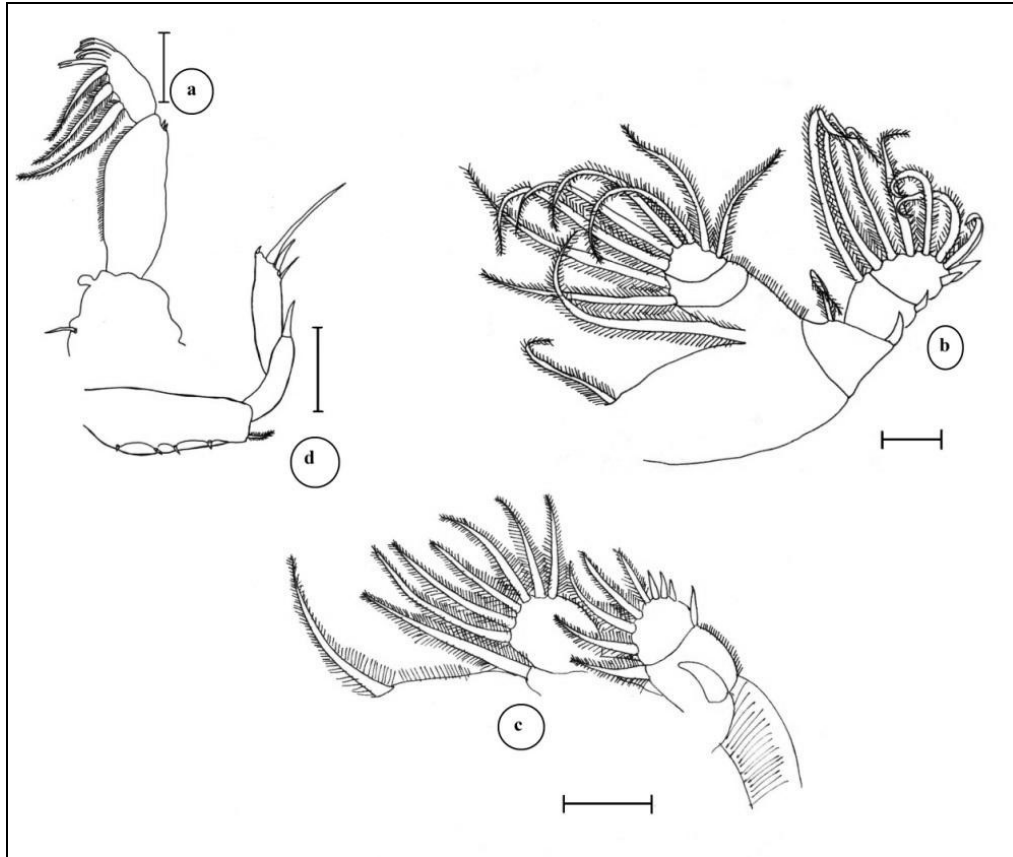


Figure no. 6 *Caligus apodus* ♀ habitus (Scale 1 mm)

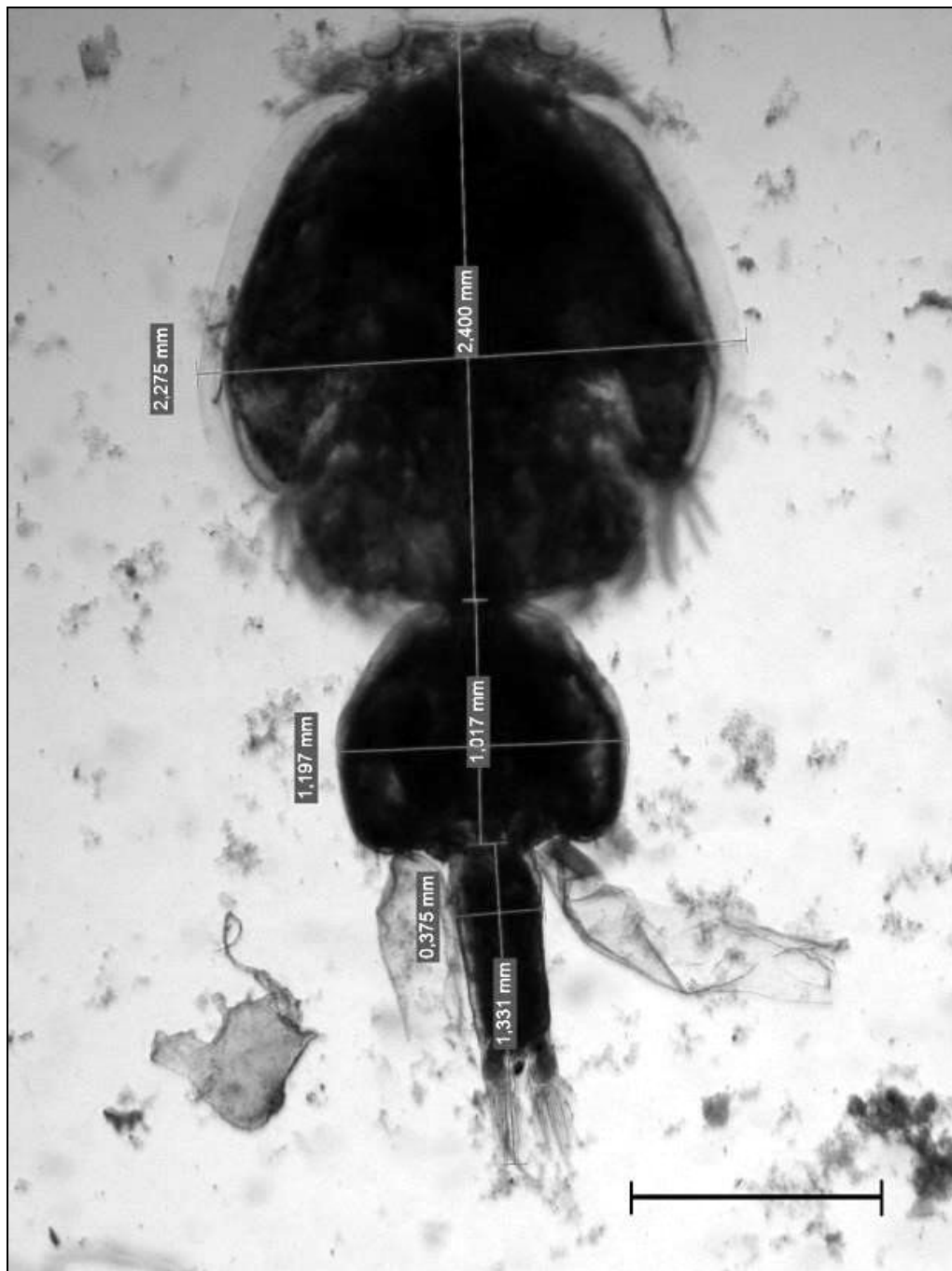


Figure no. 7 *Caligus apodus* ♀. a) antennule (0.16 mm); b) antenna (0.13 mm); c) maxilliped (0.18 mm); d) distal of maxilliped; e) maxilla (0.16 mm); f) mandible (0.05 mm); g) caudal ramus (0.14 mm); h) setae on caudal ramus.

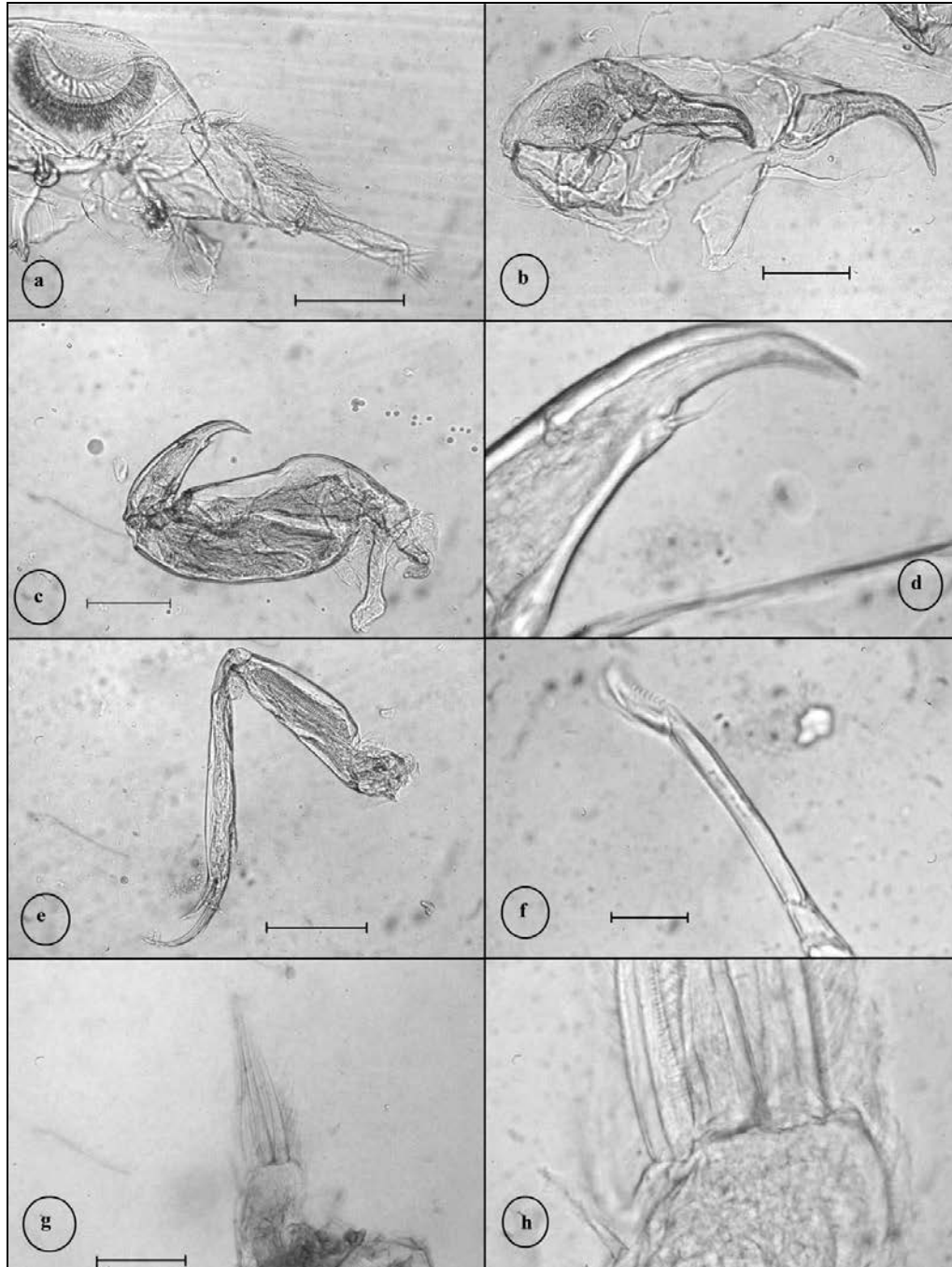


Figure no. 8 *Caligus apodus* ♀. a) sternal furca (0.05 mm); b) first leg (0.23 mm); c) second leg (0.14 mm); d) third leg (0.14 mm); e) fifth leg (0.05 mm).

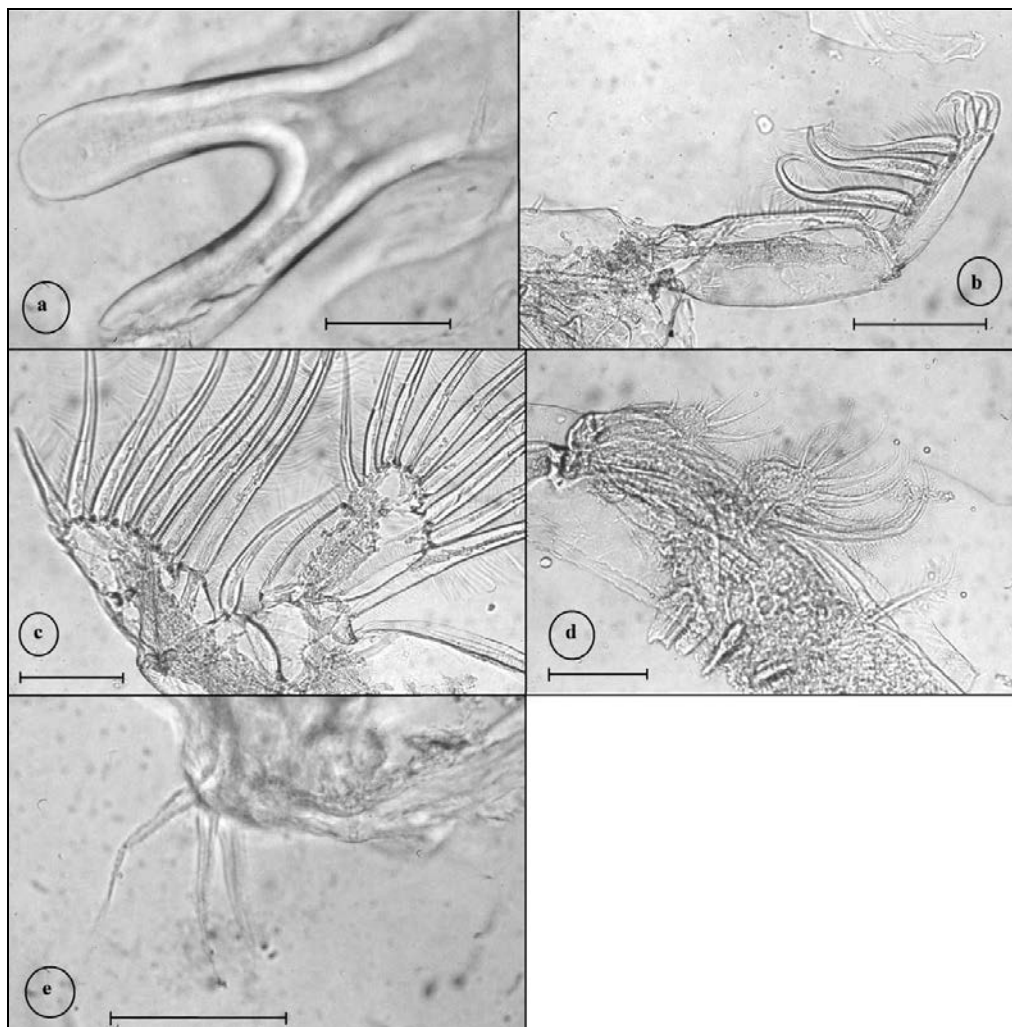


Figure no. 9 *Caligus apodus* ♀. a) antennule (0.16 mm); b) maxilliped (0.18 mm); c) sternal furca (0.05 mm); d) antenna and postantennal process (0.13 mm); e) maxilla (0.16 mm); f) caudal ramus (0.14 mm); g) fifth leg (0.05 mm); h) maxillule (0.05 mm).

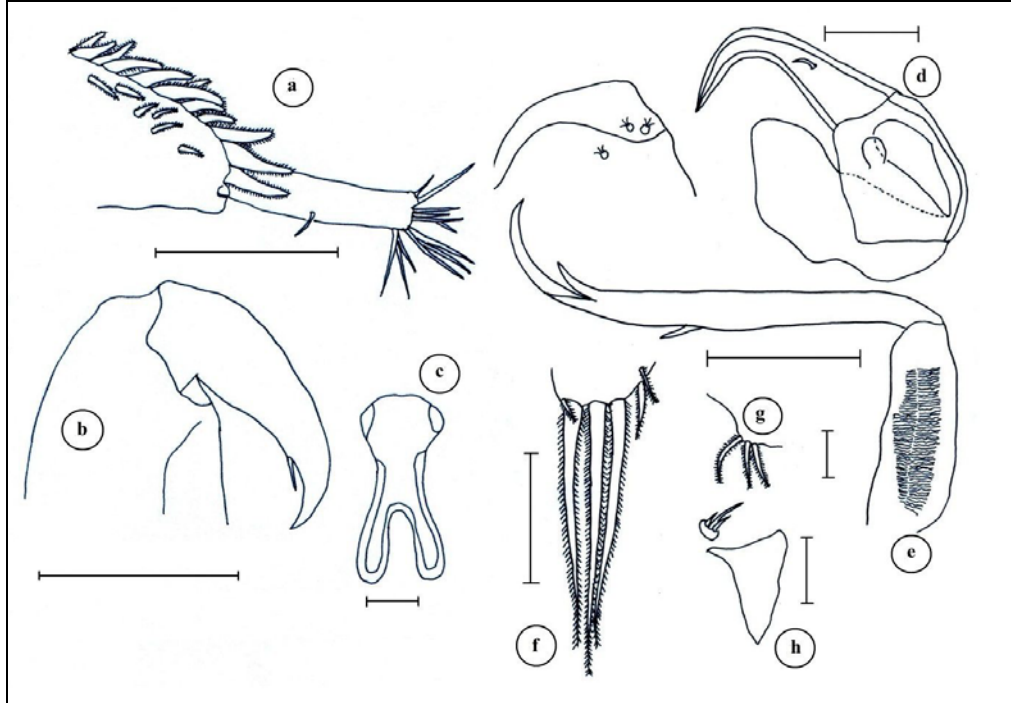


Figure no. 10 *Caligus apodus* ♀. a) first leg (0.23 mm); b) second leg (0.14 mm); c) third leg (0.14 mm).

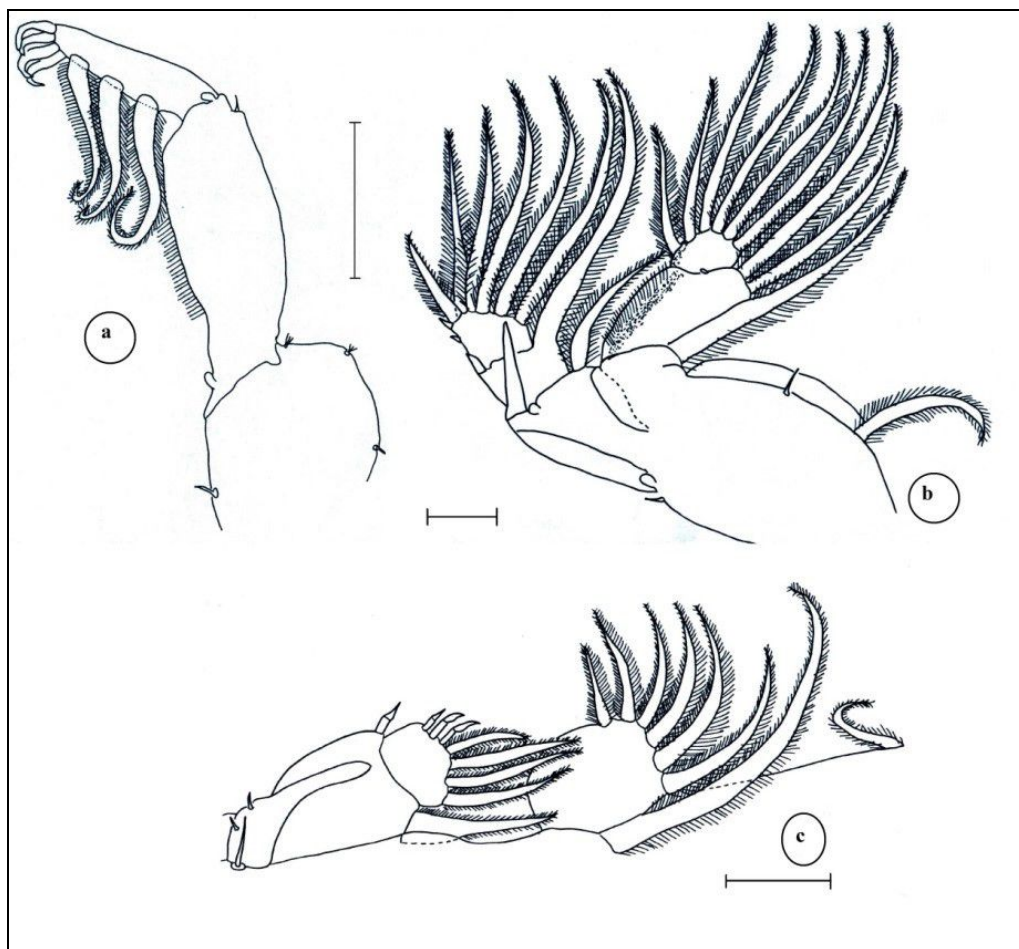


Figure no. 11 *Lernanthropus kroyeri* ♀ (Scale 1.25 mm)

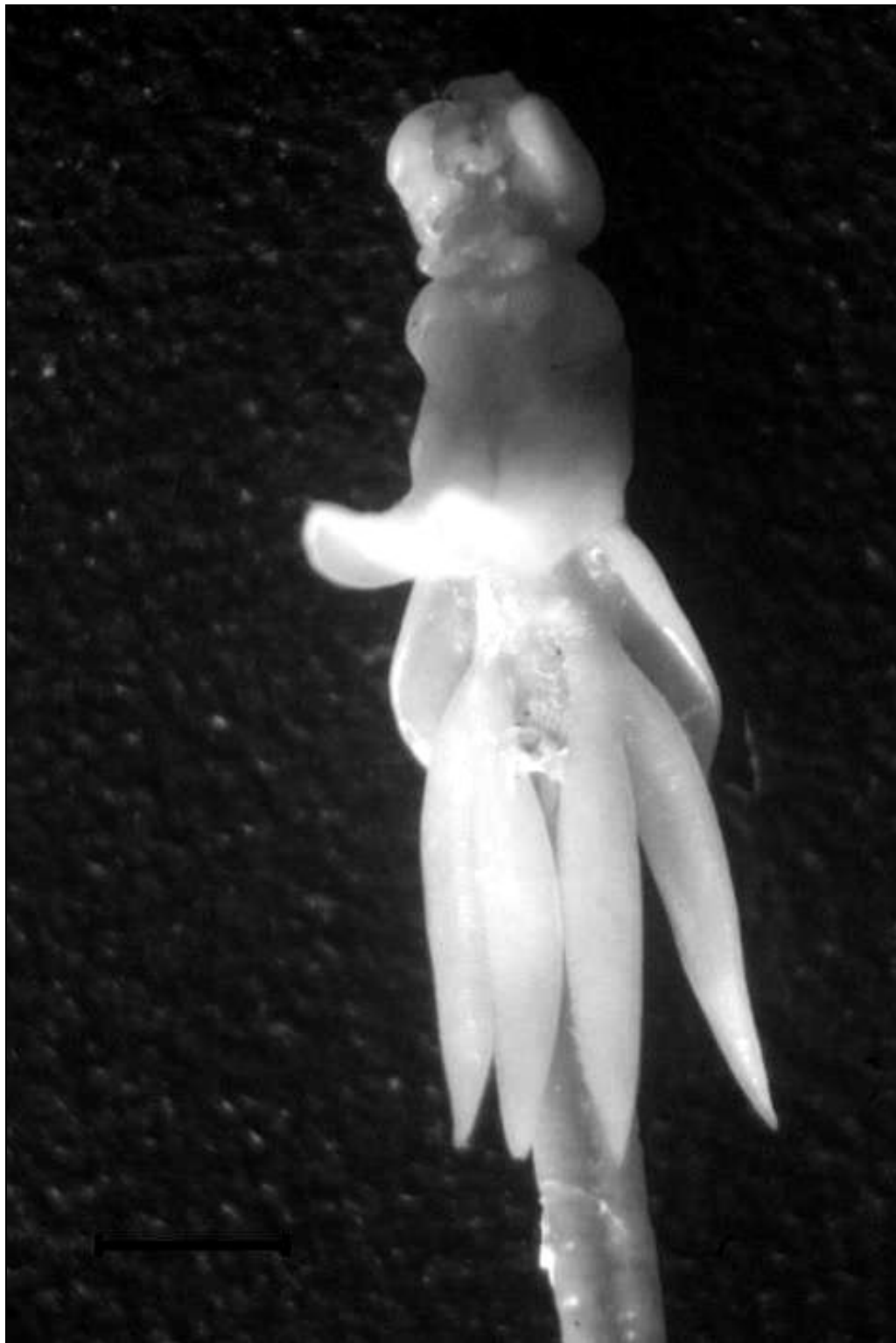


Figure no. 12 *Lernanthropus kroyeri* ♀. a) antennule (0.24 mm); b) antenna (0.12 mm); c) maxillule (0.05 mm); d) maxilla (0.09 mm); e) uropod (0.26 mm); f) maxilliped (0.19 mm); g) mandible (0.03 mm); h) first leg (0.06 mm); i) second leg (0.04 mm).

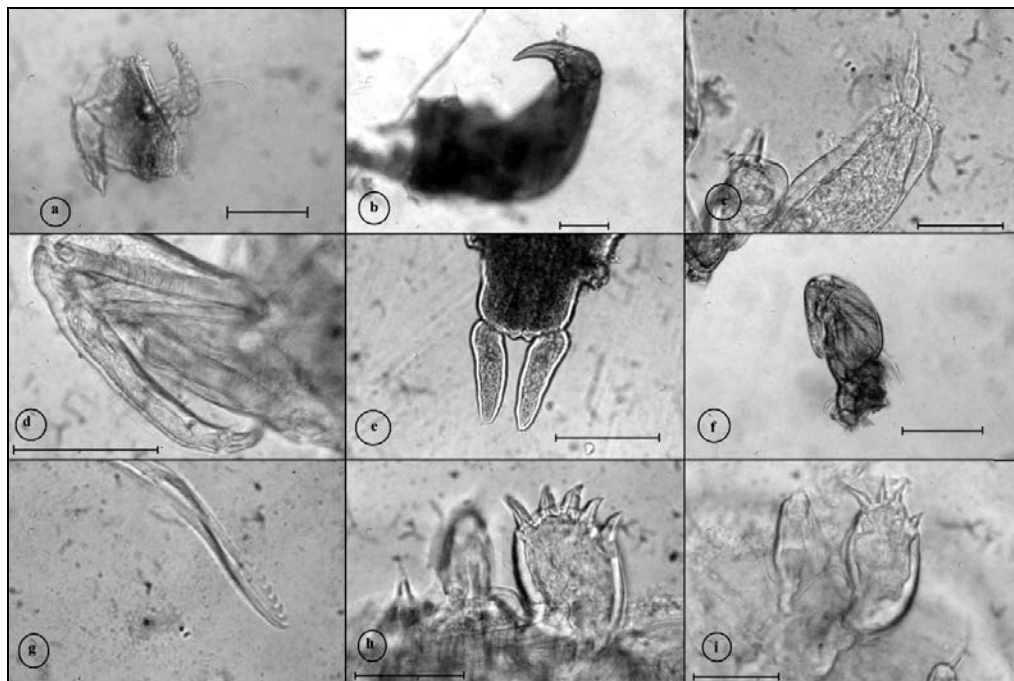


Figure no. 13 *Lernanthropus kroyeri* ♀. a) maxilla (0.09 mm); b) antennule (0.12 mm); c) maxilliped (0.22 mm); d) maxillule (0.10 mm); e) uropod (0.13 mm); f) second leg (0.04 mm); g) first leg (0.06 mm); h) antenna (0.12 mm); i) mandible (0.03 mm).

