



Caligus mulli n. sp. (Copepoda: Caligidae) parasitic on two Mullid fishes from the eastern Mediterranean and adjacent Atlantic waters

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Abstract

A new species of caligid copepod, *Caligus mulli* n. sp., is described based on specimens collected from surmullet *Mullus surmuletus* Linnaeus from Atlantic waters off the Azores, Portugal, and from red mullet *Mullus barbatus barbatus* (Linnaeus) caught in the Mediterranean Sea, off the south-eastern coast of Turkey. Sixteen specimens (both sexes) were collected from the gill cavity of *M. surmuletus*, and one female was collected from the gill cavity of *M. barbatus barbatus*. The new species is described from both fish hosts. Detailed comparisons are presented with two closely related species, *C. ocyurus* Cressey, 1991 and *C. biaculeatus* Brian, 1914: the former can be distinguished by differences in shape of the dorsal cephalothoracic shield and postantennal process, while the latter differs in relative size of the distal spines on leg 4 and in the shape of the sternal furca. The new species can easily be distinguished from its congeners by a combination of the following additional characteristics: (1) the corpus of the female maxilliped bears a prominent projection proximally and the myxal area is ornamented with a hyaline flange and two sensillae, and (2) the male maxilliped has a conical proximal projection on the corpus and a bifid myxal process opposing the claw.

Keywords *Caligus* · Parasite · Copepod · Mullidae · Taxonomy

Introduction

The genus *Caligus* O.F. Müller, 1785 was first established to accommodate *Caligus curtus* Müller, 1785, the type species. Since then, it has grown to become the most speciose genus in the family Caligidae, currently comprising 266 valid species (Boxshall 2018) which are, with rare exceptions, parasitic on marine and brackish water fishes. During the twentieth century, the number of known species increased significantly, with the recognition of 177 additional species, an average of 1.77 new species per year (Fig. 1). Since the beginning of the twenty-first century, the rate of discovery of new species has increased,

with the description of another 40 new species, at a rate of 2.22 per year. This includes the recent addition of a further nine new species of *Caligus* plus the transfer of four other species into *Caligus* from other caligid genera (Boxshall 2018).

The parasite fauna of Mediterranean fishes has been intensively studied and is better known than other regional faunas. Raibaut et al. (1998) reviewed historic records and reported the presence of 26 species of *Caligus* within the Mediterranean, although this number included at least six *nomina nuda* listed by Richiardi (1880) but never described. Since Raibaut et al.'s excellent review, another nine species have been reported and these represent a mix of new species (e.g., *C. solea* Demirkale, Özak, Yanar & Boxshall 2014), invasives from the Red Sea (e.g. *C. lagocephali* Pillai, 1961 (as *C. fugu* Yamaguti & Yamasu, 1959) and first reports of Atlantic species hitherto unreported from the Mediterranean (e.g. *C. temnodontis* Brian, 1924 and *C. macrurus* Heller, 1865) (Demirkale et al. 2014; Özak et al. 2010, 2012, 2017). Currently, there are 29 valid species of the genus *Caligus* reported from Mediterranean fish species (Özak et al. 2017).

Surmullet, *Mullus surmuletus* (Linnaeus) and Red mullet, *Mullus barbatus barbatus* (Linnaeus), are common and commercially important fishes of the family Mullidae along the eastern Atlantic coast and in the Mediterranean basin. Their

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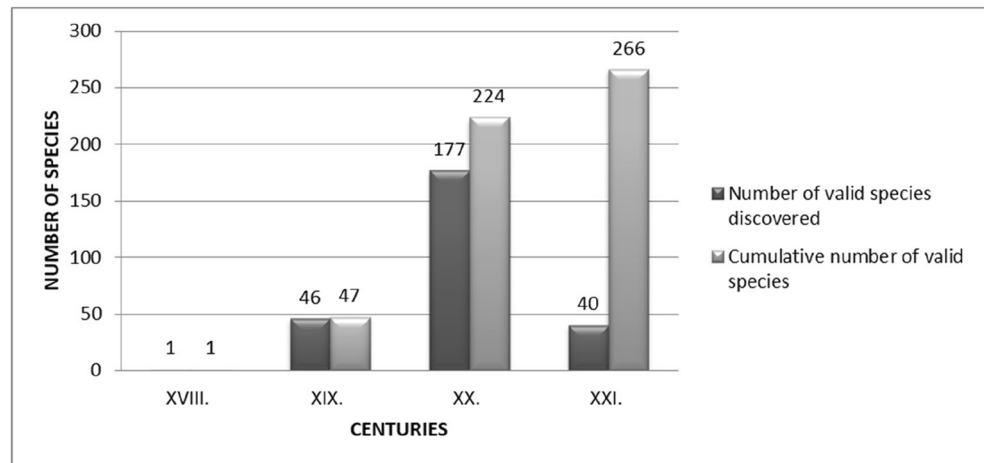
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Fig. 1 The accumulation of valid species of the genus *Caligus* from 1785 to the present



parasites have been repeatedly surveyed and, to date, a total of only eight species of parasitic copepods have been reported from these two mullid species (Table 1).

Considering the intensity of sampling of these hosts, it was surprising to discover a species of *Caligus* that was previously unknown from the Atlantic and the Mediterranean. The new species described below was first collected from *M. b. barbatus* captured during a parasitological survey of the fishes of Iskenderun Bay, Turkey in 2014. However, only a single female was collected from the gill cavity of its host after the examination of a large sample of 3000 specimens of this commercially important fish. Two years later, 16 specimens were collected from *M. surmuletus* captured during a research project on “Developing methods for capture, husbandry and live transportation of aquarium fishes” conducted in oceanic waters off Faial Island, in the Azores archipelago. Five (three females and two males) of the 16 specimens collected were sent to the first author for identification. Comparative morphological examination of the *Caligus* specimens collected from the two different mullid hosts revealed that the single female *Caligus* collected from *M. b. barbatus* from the Mediterranean was identical with the Atlantic specimens collected from

M. surmuletus. The discovery of the new species of *Caligus* on these two hosts raises the number of parasitic copepods reported from *M. barbatus barbatus* from five to six and from *M. surmuletus* from seven to eight. In addition, it raises the number of species of *Caligus* known from the Mediterranean to 30.

Materials and methods

Sixteen specimens were collected from *Mullus surmuletus* ($n = 14$; total body length range 8–10 cm) caught in oceanic waters off Faial Island, in the Azores archipelago, and one female was sampled from the gill cavity of *Mullus barbatus barbatus* ($n = 3000$; total body length range 15–22 cm) caught in Iskenderun Bay, Turkey. The Atlantic specimens were collected from the host by applying the freshwater treatment method of Wildgoose (2001) as follows: the fish was initially placed in a 5-L tank containing 36 ppt seawater; the salinity was then decreased to 9 ppt within 35 min; the fish was kept at 9 ppt for 30 min, after which time the salinity was increased slowly from 9 to 36 ppt. After the osmotic shock, a total of 16

Table 1 Species of parasitic copepods reported from *Mullus surmuletus* and *Mullus barbatus barbatus*

Parasites	<i>M. surmuletus</i>	<i>M. barbatus barbatus</i>	References
<i>Caligus brevicaudatus</i> A.Scott, 1901	—	+	Ramdane et al. (2010)
<i>Caligus centrodoni</i> Baird, 1950	+	—	Raubaut et al. (1998)
<i>Colobomatus mulli</i> Essafi, Raibaut & Boudaoud-Krissat, 1983	+	+	Essafi et al. (1983); Radujkovic and Raibaut (1987); Raibaut et al. (1998)
<i>Colobomatus steenstrupi</i> (Richiardi, 1876)	+	+	Essafi et al. (1983); Raibaut et al. (1998)
<i>Hatschekia mulli</i> (Van Beneden, 1851)	+	+	Papoutsoglou (1976); Raibaut et al. (1998)
<i>Lernaeocera lusci</i> (Basset-Smith, 1896)	+	—	Kabata (2003)
<i>Peniculus fistula fistula</i> Nordmann, 1832	+	—	Cordero del Campillo (1978); Raibaut et al. (1998)
<i>Peniculus fistula mulli</i> Delamare Deboutville & Nunes-Ruivo, 1952	+	+	Nuñez-Ruivo (1954)

specimens of a parasitic copepod were collected from the bottom of the tank by filtering the water through a plankton net (mesh size 100 μ). The Mediterranean specimen was collected during the macroscopic examination of the fishes. The parasitic copepods were immediately preserved in 70% ethanol. Atlantic and Mediterranean specimens were cleared in lactic acid for 2 h prior to examination using a Nikon SMZ 800N dissecting microscope and an Olympus BX51 compound microscope. Subsequently, the specimens were mounted as temporary preparations in a drop of lactic acid on a cavity slide. Measurements were made using an ocular micrometre and drawings were made with the aid of a drawing tube. All measurements are in millimetres unless otherwise stated. The scientific and common names of fishes follow Froese and Pauly (2018) and the morphological terminology for the copepods follows Boxshall (1990) and Huys and Boxshall (1991). The holotype female (CUMAP-COP/2017-29) and holotype male (CUMAP-COP/2017-30) are stored in the collections of the Aquatic Parasitology Museum at the Faculty of Fisheries, University of Çukurova, Adana-Turkey.

Family Caligidae Burmeister, 1835

Genus *Caligus* Müller, 1785

Caligus mulli n. sp.

Atlantic specimens: ($n = 16$; 14 females, 2 males)

Type host: *Mullus surmuletus* Linnaeus, 1758 (Mullidae)

Type locality: Atlantic waters off Faial Island, Azores, Portugal; collected by Alfredo M.V. Rodrigues on 19 Oct. 2016.

Site on host: Dorsal body surface.

Prevalence: 85.7% (12 fish infected of a total of 14 examined)

Mediterranean specimen: ($n = 1$, 1 female)

Host: *Mullus barbatus barbatus* (Linnaeus, 1758) (Mullidae)

Locality: Northeastern Mediterranean waters off Karatas, Iskenderun Bay, Turkey; collected by A. A.Özak (15 Feb. 2014).

Depth range: 30–50 m; mean surface water temperature 13.5 °C; salinity 35 ppt.

Site on host: Gill cavity

Prevalence: 0.0003% (1 fish infected of a total of 3000 examined)

Type material: holotype female [CUMAP-COP/2017-29]; holotype male [CUMAP-COP/2017-30] stored in the collection of the Aquatic Parasitology Museum of the Faculty of Fisheries, University of Çukurova (CUMAP), Adana, Turkey.

Etymology: The species name refers to the host genus.

Adult female Body caligiform, comprising cephalothorax incorporating first to third pedigerous somites, free fourth pedigerous somite, genital complex and 1-segmented abdomen (Fig. 2a). Body length 2.72 (2.68–2.77) ($n = 4$) excluding caudal setae. Dorsal cephalothoracic shield subtriangular,

longer than wide, 1.44 (1.34–1.49) \times 1.25 (1.20–1.31); thoracic zone of shield 0.75 (0.7–0.79) \times 0.97 (0.9–1.1), comprising slightly more than half total length (52%) of cephalothorax; posterior margin of thoracic zone extending beyond posterior margins of lateral zones. Fourth pedigerous somite distinctly separate from genital complex, wider than long, 0.13 (0.09–0.15) \times 0.30 (0.24–0.36). Genital complex (Fig. 2b) 1.36 times longer than wide, 0.94 (0.91–0.97) \times 0.69 (0.63–0.74); with slightly rounded anterior angles, parallel sides and with rounded posterolateral corners; about 4.95 times longer than 1-segmented abdomen. Abdomen slightly longer than wide, 0.19 (0.15–0.22) \times 0.18 (0.14–0.2). Combined length of genital complex and entire abdomen (excluding caudal rami) approximately 78% of length of cephalothorax. Caudal rami longer than wide, 0.11 (0.09–0.13) \times 0.08 (0.05–0.1), armed with 6 pinnate setae.

Antennule (Fig. 2c) 2-segmented, proximal segment distinctly wider than distal, armed with 25 plumose setae on anterior and antero-ventral surfaces plus 2 unarmed setae

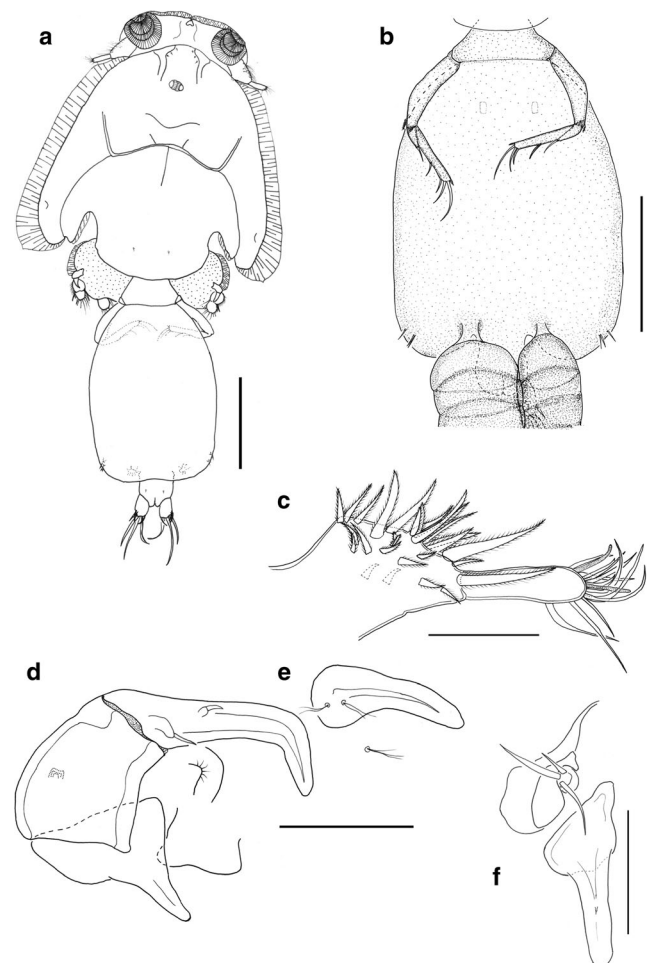


Fig. 2 *Caligus mulli* n. sp. holotype female. **a** Habitus, dorsal view; **b** genital complex, ventral view; **c** antennule; **d** antenna; **e** postantennal process; **f** maxillule. Scale bars: **a** and **b**, 0.5 mm; **c–f**, 100 μ m

located dorsally; distal segment armed with 1 subterminal seta on posterior margin and 11 setae plus 2 aesthetascs around distal margin. Antenna (Fig. 2d) uniramous, 3-segmented; proximal segment produced posteriorly into blunt spinous process; middle segment with small adhesion pad on dorsal surface; distal segment forming recurved claw with small setae proximally and distally. Postantennal process (Fig. 2e) weakly curved, carrying 2 bi-sensillate papillae and similar sensillate papilla located on body surface adjacent to process. Maxillule (Fig. 2f) comprising dentiform posterior process with a minute denticle on medioventral surface and rounded tip, anterior papilla bearing 3 setae, 1 long and 2 small. Mandible (Fig. 3a) curved inward distally and with 12 teeth on one side near apex. Sternal furca (Fig. 3b) with small box and bluntly pointed, divergent tines curved inward distally, each with large flange along outer margin. Maxilla (Fig. 3c) brachiform and 2-segmented; proximal segment (lacertus) unarmed, distal segment (brachium) slender bearing subterminal hyaline membrane on outer margin, plus short canna and long calamus distally (Fig. 3d). Maxilliped (Fig. 3e) comprising large proximal segment (corpus) and distal subchela representing fused endopodal segments plus claw; outer

margin of corpus with small subtriangular process proximally; subchela armed with small seta at base of claw; claw extending about to mid-length of corpus.

Swimming leg 1 (Fig. 3f) biramous, with 2-segmented exopod and unsegmented vestigial endopod. Sympod armed with lateral plumose seta and inner seta. First exopodal segment ornamented with row of setules along free posterior margin and bearing small spine at outer distal corner. Distal exopodal segment (Fig. 3g) with 3 plumose setae posteriorly plus 4 distal margin elements; spine 1 (outermost) simple, spines 2 and 3 about equal in length and each bearing single accessory process, seta 4 (innermost) longer than spines but shorter than segment.

Leg 2 (Fig. 4a) biramous with 3-segmented rami. Coxa small with large pinnate seta on posterior margin. First and second exopodal segments (Fig. 4b) each with pinnate seta on inner margin and long spine at outer distal corner reflexed obliquely back across surface of segment; both spines finely bilaterally serrated. Third exopodal segment (Fig. 4b) with five inner plumose setae plus three outer spines; proximal outer spine (smallest) naked, middle spine rounded, extending over base of distal spine; distal spine ornamented with hyaline

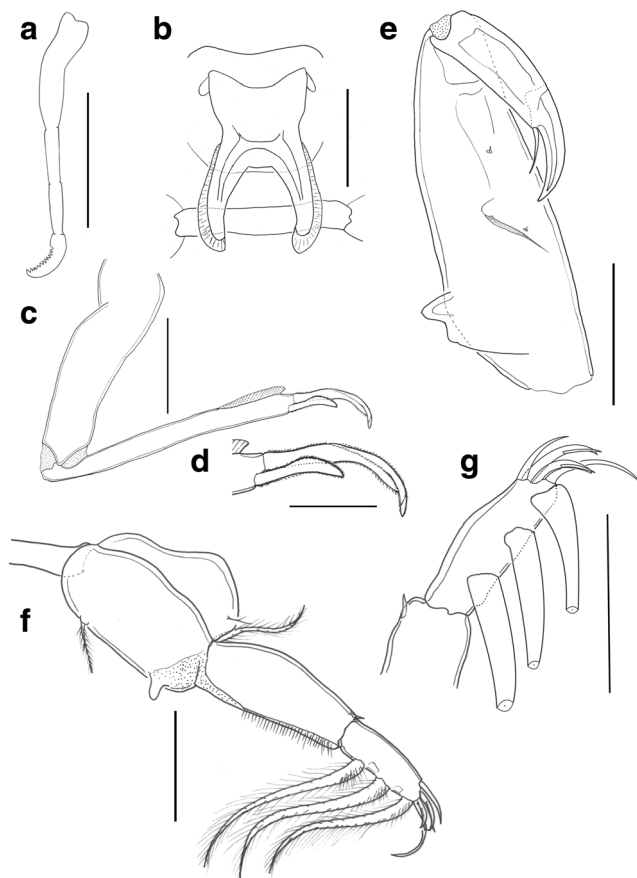


Fig. 3 *Caligus mulli* n. sp. holotype female. **a** Mandible; **b** sternal furca; **c** maxilla; **d** calamus and canna of maxilla; **e** maxilliped; **f** leg 1; **g**, distal exopodal segment of leg 1. Scale bars: **a–c, f, g** 100 µm; **d**, 50 µm

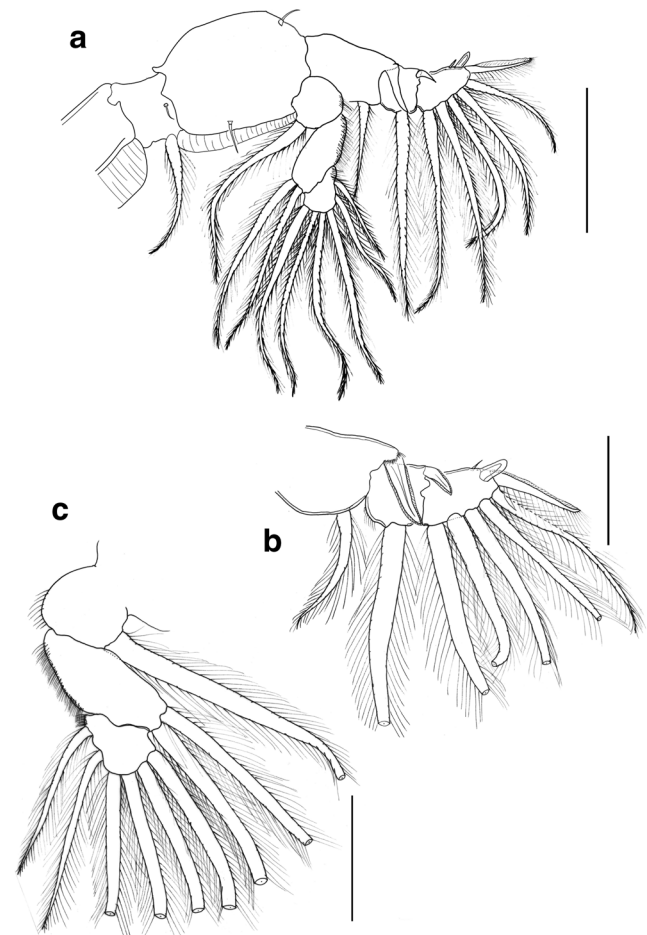


Fig. 4 *Caligus mulli* n. sp. holotype female. **a** Leg 2; **b** exopodal segments of leg 2; **c** endopodal segments of leg 2. Scale bars: **a**, 200 µm; **b** and **c**, 100 µm

membrane along outer margin and row of setules along inner margin. First endopodal segment (Fig. 4c) armed with inner plumose seta and ornamented with row of setules along outer margin; second endopodal segment with two inner plumose setae plus dense ornamentation of setules along outer margin; third segment with six plumose setae (Fig. 4c).

Leg 3 (Fig. 5a) forming flattened plate closing posterior part of cephalothoracic sucker as typical for genus. Protopodal part flattened and joined by plate-like intercoxal sclerite, forming apron ornamented with marginal membrane posteriorly and along lateral margin anterior to exopod: bearing inner plumose seta at junction with intercoxal plate and outer plumose seta dorsal to base of exopod; sensillae located adjacent to inner coxal seta and adjacent to origin of endopod. Exopod (Fig. 5a) 3-segmented; first segment armed with straight outer claw directed over ventral surface of ramus, slightly shorter than segment; second segment with slender outer spine and inner plumose seta; third with three outer spines and four inner plumose setae; middle spine shorter than proximal or distal; outer margins of segments 2 and 3 ornamented with row of slender setules. Endopod 2-segmented (Fig. 5a); first segment forming flap-like velum

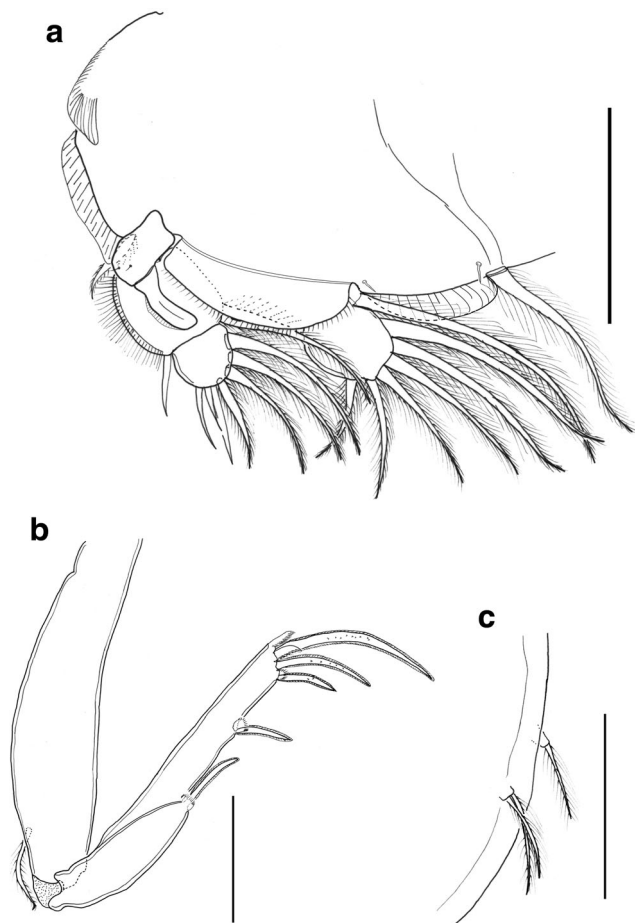


Fig. 5 *Caligus mulli* n. sp. holotype female. **a** Leg 3; **b** leg 4; **c** leg 5. Scale bars: **a** 200 μ m; **b** and **c** 100 μ m

ornamented with row of fine setules along free margin, closing space between rami and armed with inner plumose seta; compound distal segment expanded laterally, armed with six setae increasing in length from outermost to innermost.

Leg 4 (Fig. 5b) uniramous, comprising long protopodal segment armed with outer pinnate seta plus 2-segmented exopod; first exopodal segment with one short distal spine, not quite reaching middle of margin of second exopodal segment; compound second segment with one lateral spine plus three apical spines along oblique distal margin, longest spine about twice as long as shortest; each spine with pecten at base.

Spine (Roman numerals) and seta (Arabic numerals) formula of legs 1–4 as follows:

	Exopod	Endopod
Leg 1	I-0; III,1,3	Vestigial
Leg 2	I-1; I-1; II,1,5	0-1; 0-2; 6
Leg 3	I-0; I-1; III,4	0-1; 6
Leg 4	I-0; I,III	Absent

Leg 5 (Fig. 5c) located at posterolateral corner of genital complex, represented by two papillae; outer (protopodal) papilla bearing single pinnate seta; inner (exopodal) papilla bearing two plumose setae.

Adult male. Body (Fig. 6a) 1.37–1.39 mm ($n = 2$) long, excluding caudal setae. Cephalothoracic shield subtriangular, slightly longer than wide, $0.8\text{--}0.9 \times 0.72\text{--}0.77$, excluding marginal hyaline membranes. Free thoracic zone of shield wider than long, $0.43\text{--}0.48 \times 0.56\text{--}0.59$. Fourth pedigerous somite $0.09\text{--}0.12 \times 0.17\text{--}0.19$, indistinctly divided from genital complex. Genital complex (Fig. 6a) $0.17\text{--}0.19 \times 0.17\text{--}0.19$, with convex sides and subtriangular posterolateral corners. Abdomen (Fig. 6f) comprising two somites; first free abdominal somite $0.07\text{--}0.09 \times 0.1\text{--}0.1$, shorter than anal somite, $0.18\text{--}0.2 \times 0.16\text{--}0.18$; ventral surface of anal somite ornamented with sensillae. Caudal rami (Fig. 6f) longer than wide, $0.1\text{--}0.09 \times 0.07\text{--}0.06$, bearing six pinnate setae.

Antennule as in female. Antenna (Fig. 6b) 3-segmented; proximal segment long, narrow, with corrugated adhesion pad on outer surface proximally; middle segment largest, with corrugated pads proximally and on outer and medial distal surfaces; distal segment of antenna forming recurved claw consisting of three overlapping triangular plates and armed with two slender basal setae. Postantennal process (Fig. 6c) more strongly curved than that of female, inner margin with small protuberance on mid-part, carrying two bi-sensillate papillae; similar bi-sensillate papilla located on body surface near postantennal process. Maxillule (Fig. 6d) with small deniform knob located medially on posterior spinous process plus an anterior papilla carrying two medium-length and one long setae; deniform process corrugated at base. Mandible and maxilla as in female. Maxilliped (Fig. 6e) with massive corpus

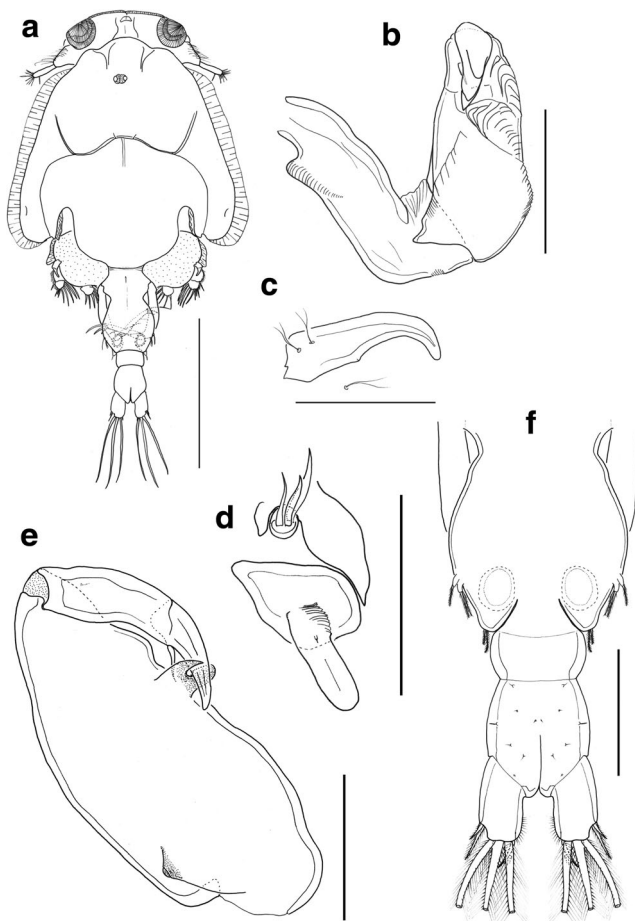


Fig. 6 *Caligus mulli* n. sp. holotype male. **a** Habitus, dorsal view; **b** antenna; **c** postantennal process; **d** maxillule; **e** maxilliped; **f** legs 5 and 6. Scale bars: **a**, 0.5 mm; **b–e**, 100 μ m; **f**, 200 μ m

carrying conspicuous bifid process on myxal margin, opposing claw; corpus with prominent conical process on outer ventral surface; subchela armed with small seta at base of claw. Sternal furca and legs 1–4 as in female. Leg 5 (Fig. 6f) represented by two papillae located on posterolateral margins of genital complex, outer papilla with 1 and inner (exopodal) papilla with two plumose setae. Leg 6 (Fig. 6f) represented by single papilla bearing two unequal setae on posteroventral side of genital complex.

Remarks

The new species belongs to a large group of species within *Caligus* that is united by the possession of a 3-segmented leg 4 in which the distal exopodal segment is compound (representing the fused second and third exopodal segments) and carries four spines. More than 90 valid species of *Caligus* share this same configuration of leg 4. Specimens of the new species also retain the three plumose setae on the posterior margin of the distal exopodal segment of leg 1. This eliminates all members of the *Caligus productus*-group which are

characterised by the loss or major reduction of these posterior margin setae (Boxshall and El-Rashidy 2009; Boxshall 2018). A total of nearly 50 species share these two character states. However, only ten of these also have a genital complex in the female that is both markedly longer than wide and more than three times longer than the free abdomen. Within this group of ten species, only two, *Caligus biaculeatus* Brian, 1914 and *C. ocyurus* Cressey, 1991, share the possession of a genital complex in the female that is about five times longer than the 1-segmented free abdomen (the anal somite).

Caligus ocyurus was described on the basis of material of both sexes collected from the yellow snapper, *Ocyurus chrysurus* Bloch, caught at Carrie Bow Cay in Belize (Cressey 1991). Estimating from the measurements provided by Cressey (1991), the genital complex of the adult female is 1.4 times longer than wide and 5.2 times longer than the 1-segmented abdomen. This species also has bisensillate papillae on the postantennal process, outer margin spines on exopodal segments 1 and 2 of leg 2 that are reflexed obliquely across the surface of the ramus and a weakly curved outer spine on the first exopodal segment of leg 3 that does not reach the distal margin of the second segment. Like most *Caligus* species, *C. ocyurus* has three outer margin spines on the third exopodal segment of leg 3 but, unusually, the middle spine is shorter than both the proximal and the distal spines. All of these features are shared with the new species. However, the new species differs in having a straight postantennal process, compared to a recurved and flanged process in *C. ocyurus*, and the dorsal cephalothoracic shield is subtriangular whereas that of *C. ocyurus* is rather elongate with nearly parallel lateral margins (in dorsal view). In addition, the sternal furca of the new species has inwardly curved, blunt tipped tines (vs. straight and sharply pointed tines), the proximal segment of the male antenna is subrectangular (vs. irregular in *C. ocyurus*) and the recurved terminal segment of male antenna comprises three overlapping subtriangular elements (vs. two subtriangular recurved elements in *C. ocyurus*).

Caligus biaculeatus was originally described on the basis of material recovered free within a deep-water trawl that contained specimens of *Macrourus* Bloch and *Bathygadus* Günther taken off the Madeira Islands (Brian 1914). The assumption was, presumably, that it may have utilised such deep-sea fishes as hosts even though we now know that caligids in general are rarely found in deep water (Boxshall 1998). Cressey (1991) challenged Brian's assumption: he considered that the hosts were more likely fishes of the shallow waters surrounding the Madeira Islands. He re-examined the holotype female of *C. biaculeatus* stored in the Musée Océanographique, Monaco and compared it with 19 lots of new material collected from eight different hosts caught off the coast of Belize (Cressey 1991). The most common hosts of *C. biaculeatus* in Belize were *Aulostomus maculatus* Valenciennes, 1841, *Halichoeres bivittatus* (Bloch, 1791)

and *Sparisoma viride* (Bonnaterre, 1788)—three very different fish from three different families, Aulostomidae, Labridae and Scaridae, respectively. Cressey (1991) redescribed female *C. biaculeatus* and concluded that this parasite was “not very host specific”.

Calculating from measurements given by Cressey (1991), the genital complex of female *C. biaculeatus* is about 2.3 times longer than wide and about 4.9 times longer than the 1-segmented abdomen. This species also has bisensillate papillae on the weakly curved postantennal process, spine 1 on the distal margin of the exopod of leg 1 is distinctly shorter than spines 2 and 3, the outer margin spines on exopodal segments 1 and 2 of leg 2 that are reflexed obliquely across the surface of the ramus, and the outer spine on the first exopodal segment of leg 3 is weakly curved and does not reach the distal margin of the second segment. It also shares with *C. ocyurus*, the unusual configuration of the three outer margin spines on the third exopodal segment of leg 3 in which the middle spine is shorter than both the proximal and the distal spines. The new species also shares this configuration of spines on the distal exopodal segment of leg 3, has bisensillate papillae on the postantennal process, a short spine 1 on the distal margin of the exopod of leg 1 and reflexed outer margin spines on the first and second exopodal segments of leg 2. It is clearly closely related to *C. biaculeatus*.

The females redescribed by Cressey (1991) carried four spines on the compound distal exopodal segment of leg 4, and the outermost spine on the oblique distal margin was tiny. It appeared easy to overlook, so Cressey highlighted it in his illustrations (Cressey 1991: arrowed in his Fig. 64). In the original description, Brian (1914) figured the female leg 4 as having two large distal spines on the oblique distal margin, plus a tiny spine that was largely hidden by its associated pecten (Brian 1914: Fig. 5). In the new species, this outermost spine on the oblique distal margin is well developed and about equal in size to the spine on the lateral margin of the same segment. Given the diagnostic importance of leg 4 in the systematics of *Caligus*, this is a significant difference between the new species and both Brian’s eastern Atlantic (Madeira) females and Cressey’s Gulf of Mexico (Belize) females of *C. biaculeatus*, which share the possession of the tiny outer distal spine on leg 4. The lengths of the armature elements on leg 4 are reliable characters in *Caligus* species, showing little if any geographic variation, unlike the shape of the female genital complex which varies markedly with the reproductive state of the individual female (Parker et al. 1968). An additional minor difference is that the tines of the sternal furca are relatively longer in *C. biaculeatus* than in the new species.

The new species also resembles *Caligus suffuscus* Wilson, 1913. However, the new species differs from *C. suffuscus* in the possession of a blunt-tipped posterior dentiform process on the maxillule (vs. slender process tapering towards the tip);

the sternal furca has divergent and inwardly curved tines (vs. divergent but straight tines); the outer spine on the distal exopodal segment of leg 1 is slightly shorter than the adjacent elements (vs. distinctly shorter than other three distal elements); the middle endopodal segment of leg 2 has fine setules along the outer margin (vs. with a row of spinules) and the outer spine on the distal exopodal segment of leg 4 is more than half as long as the middle spine (vs. distinctly shorter).

Although closely related to *C. biaculeatus*, we consider that the new species described herein exhibits sufficient differences to justify the establishment of a new species to accommodate it. It can be most readily distinguished from *C. biaculeatus* by the size of the outermost distal spine on leg 4, which is equal in length to the lateral spine on the same segment.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

Ethical approval All procedures performed in studies involving animals were in accordance with the ethical standards of the University of Cukurova in Adana, Turkey and Flying Sharks, in Horta, Portugal or practice at which the studies were conducted. All applicable international, national and/or institutional guidelines for the use and care of animals were followed. Fish samples studied in Turkey and Portugal were maintained according to the guidelines of the animal facility at Faculty of Fisheries of the Cukurova University in Turkey and the Flying sharks in Portugal, respectively.

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