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Research Article/Araştırma Makalesi

First Report of *Caligus minimus* Otto, 1821 (Copepoda: Siphonostomatoida: Caligidae) from Plankton Samples Collected from Türkiye

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Abstract: During a plankton sampling conducted off the northeastern Mediterranean coast of Türkiye, a single female copepod, *Caligus minimus* Otto, 1821 was collected from a marine plankton sample. *C. minimus* is a well-known species of the genus *Caligus* O.F. Müller, 1785 which has been previously reported as a parasite from nine marine fish species belonging to eight different families. To date, however, *C. minimus* has never been reported from plankton samples. In this study, the general morphology based on the key diagnostic characters of the planktonic *C. minimus* is presented using confocal laser scanning microscope (CLSM) images. This is the first report of *C. minimus* from plankton samples off Turkish waters and global marine environments.

Keywords: Planktonic copepod, plankton net, Mediterranean, CLSM.

Türkiye'den Toplanan Plankton Örneklerinde Deniz Biti, *Caligus minimus* Otto, 1821 (Copepoda: Siphonostomatoida: Caligidae) İle ilgili İlk Rapor

Öz: Türkiye'nin kuzeydoğu Akdeniz kıyılarında yürütülen bir plankton örneklemesi sırasında, deniz plankton örneklerinden tesadüfen tek bir dişi Caligid parazitik kopepod, *Caligus minimus* Otto, 1821 bireyi örneklendi. *C. minimus*, daha önce sekiz farklı familyaya ait dokuz deniz balığı türünden bildirilen *Caligus* O.F. Müller, 1985 cinsinin iyi bilinen bir türüdür. Ancak bugüne kadar plankton örneklerinden *C. minimus* hiç rapor edilmemiştir. Bu çalışmada, konfokal lazer taramalı mikroskobu (CLSM) görüntüleri kullanılarak planktonik *C. minimus*'un genel morfolojisi ve tür teşhisinde kullanılan belirgin karakterleri sunulmuştur. Bu çalışma, Türkiye ve dünya denizel ortamlarından *C. minimus*'un planktonik formunun ilk raporudur.

Anahtar kelimeler: Planktonik kopepod, plankton ağı, Akdeniz, CLSM.

1. Introduction

The term "sea lice" is used for ectoparasitic copepods that belong to the family Caligidae Burmeister, 1835. Represented by 277 valid species (Walter & Boxshall, 2023), the genus *Caligus* O.F. Müller, 1785, living parasitic on marine fish species, is the largest taxon within this family. In the last two decades, however, the number of *Caligus* species recorded from marine plankton samples has been increasing continuously (Venmathi Maran & Ohtsuka, 2008; Venmathi Maran et al., 2012; Suarez-Morales et al., 2012; Venmathi Maran et al., 2016; Ortega et al., 2017; Kim et al., 2019; Ohtsuka & Boxshall, 2019; Ohtsuka et al., 2020). In their review and checklist, Venmathi Maran et al. (2016) listed 32 *Caligus* species which were collected both from marine plankton samples and marine fish hosts from 38 different localities worldwide. Although more than 20 parasitic *Caligus* species were recorded from marine fishes in the Mediterranean Sea (Özak, 2020), none of them were sampled from marine plankton so far.

In the present study, a previously well-known species of *Caligus*, *C. minimus* Otto, 1821, which has been reported from nine species of marine fishes namely, *Alosa fallax* (Lacepède, 1803), *Dicentrarchus labrax* (Linneaeus, 1758), *Dicentrarchus punctatus* (Bloch, 1792), *Gadus morhua* Linnaeus, 1758, *Labrus merula* Linnaeus, 1758, *Mugil cephalus* Linnaeus, 1758, *Pagellus bogaraveo* Brünnich, 1768, *Sander lucioperca* (Linnaeus, 1758), and *Umbrina cirrosa* (Linnaeus, 1758) belonging to eight families (Alosidae, Moronidae, Gadidae, Labridae, Mugilidae, Sparidae, Percidae, Sciaenidae) (Walter & Boxshall, 2023) is collected for the first time from marine plankton samples in the northeastern Mediterranean Sea off the Turkish coast. In addition, the current account is the first report of the planktonic form of *C. minimus* both from Turkish waters and global marine environments. The general morphology of the planktonic *Caligus minimus* is presented, based on key diagnostic characters which are visualized and described using a confocal laser scanning microscope (CLSM).

2. Material and Methods

A single ovigerous female specimen was found among plankton samples collected from the northeastern Mediterranean waters off the Turkish coast, in the Gulf of Iskenderun, near Yumurtalık province at a depth of 20 m (36° 45'43''N 35°47'41''E) utilizing plankton net with a mesh size of 90 µm (mouth diameter = 45 cm) towed obliquely from near the bottom towards the sea surface. Then, plankton samples were immediately transferred in 70% ethanol. The female specimen was sorted out from the plankton samples using Nikon SMZ800N stereo zoom microscope. The preserved ovigerous specimen was cleared for about 3 hr in lactic acid. Subsequently, it was placed in a cavity slide and examined using an Olympus BX51. An ocular micrometer was used to perform measurements.

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2.1. Confocal Laser Scanning Microscope (CLSM) Examination

After conducting the measurements, the specimen was washed in distilled water to remove lactic acid for about 1 hr. Then it was transferred into Congo red solution for staining for about 2 hr. Further preparation and scanning methods were applied following Kamanli et al. (2017). The stained specimen was scanned using a Zeiss LSM 700. The right maxilliped and right leg 2 were dissected and scanned separately using CLSM. After obtaining maximum intensity projection images from CLSM, the images were processed using the combination of ImageJ and Drishti (Limaye, 2012, Schneider et al., 2012; Kamanli et al., 2017). Unless otherwise stated, all measurements in the present study are given in millimeters. The scientific and common names of fishes provided in this paper follow Fish Base (Froese & Pauly, 2023) and the morphological terminology for the copepods follows Boxshall (1990) and Huys & Boxshall (1991). The specimen was described and identified to the species level based on Kabata (1979).

3. Results and Discussion

Family: Caligidae Burmeister, 1835

Genus: *Caligus* O.F. Müller, 1785

Species: *Caligus minimus* Otto, 1821

Material examined. Single female ovigerous specimen sampled on 20.iii.2021 by plankton net (mesh size ø: 90µm) from a depth of 20 m in İskenderun Bay, near Yumurtalık, Türkiye; fixed in ethanol. The sample is stored in the collections of the Aquatic Parasitology Museum at the Faculty of Fisheries, University of Çukurova, Adana-Türkiye (CUMAP-COP/2021-1).

Description. Adult female: Body (Fig. 1A) (total body length 3.60 mm) caligiform, comprising cephalothorax incorporating first to third pedigerous somites, free fourth pedigerous somite, genital complex and 1-segmented abdomen. Frontal plate large bearing pair of large lunules (Fig. 1B). Dorsal cephalothoracic shield oval, longer than wide 1.88 × 1.53, with convex lateral margins. Length of cephalothorax slightly longer than half of total body length. Thoracic zone of shield as long as wide, 1.05 × 1.04 comprising almost half of total length (55%) of cephalothorax. Fourth pedigerous somite subrectangular, distinctly separate from genital complex, wider than long 0.19 × 0.47. Genital complex (Fig. 1A) subquadrangular, about as long as wide 0.83 × 0.84, lateral margins slightly convex and with slightly lobate posterolateral corners, genital complex comprising about 44% of length of cephalothorax. Abdomen (Fig. 1A) 1-segmented; longer than wide 0.50 × 0.35, genital complex 1.7 times longer than abdomen. Cephalothorax 1.4 times longer than combined length of genital complex and abdomen (excluding caudal rami). Caudal rami (Fig. 1C) about 1.5 times longer than wide, 0.20 × 0.13, bearing 6 pinnate setae.

Antenna (Fig. 2A) 3-segmented, proximal segment with rounded, posterolaterally-directed process at inner distal corner (Fig. 2A white arrowhead); middle segment subrectangular and unarmed; distal segment produced into strongly curved claw armed with spine-like seta

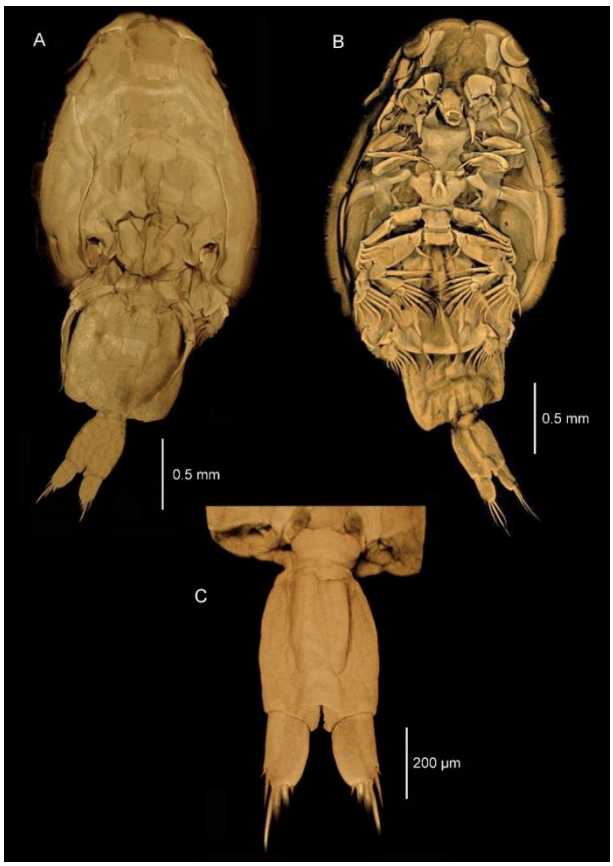

Figure 1. *Caligus minimus* Otto, 1821 female. A. Habitus (dorsal). B. Habitus (ventral). C. Abdomen and caudal rami.

proximally plus another tiny seta in mid-section (Fig. 2A white arrows). Postantennal process (Fig. 2A) with strongly curved tine; 2 sensillate papillae present on basal part, and trisensillate papilla located on body surface adjacent to process (Fig. 2A black arrows). Maxillule (Fig. 2A) comprising dentiform posterior process with tapering tip and prominent anterior papilla carrying 3 unequal setae (Fig. 2A black arrowhead). Maxilla (Fig. 2B) 2-segmented, brachiform; proximal segment (lacertus) large, unarmed; slender distal segment (brachium) bearing small subterminal hyaline membrane (flabellum) (Fig. 2B arrow) on inner margin plus short canna and long calamus distally, distal segment 1.2 times longer than proximal segment (excluding length of calamus); calamus about 2 times longer than canna, both calamus and canna ornamented with hyaline membrane along inner and outer margins. Maxilliped (Fig. 2C) comprising slender proximal segment (corpus) and distal subchela representing fused endopodal segments plus claw; corpus bearing proximal rounded myxal process mediolaterally; slender subchela armed with small seta at base of short claw. Sternal furca (Fig. 3A) with subrectangular box and parallel tines; tines spatulate, with convex outer margin and prominent flanges along inner and outer margins.

Leg 1 (Fig. 3B, C) biramous with 2-segmented exopod and slender vestigial endopod. First exopodal segment with row of setules along inner margin and minute spine on outer distal corner (Fig. 3C). Distal exopodal segment (Fig. 3C) with 3 plumose setae posteriorly plus 4 terminal elements; first 3 spines about equal in length, innermost element (seta 4) simple and slightly longer than first 3 spines. All 4 terminal elements

distinctly shorter than length of distal segment.

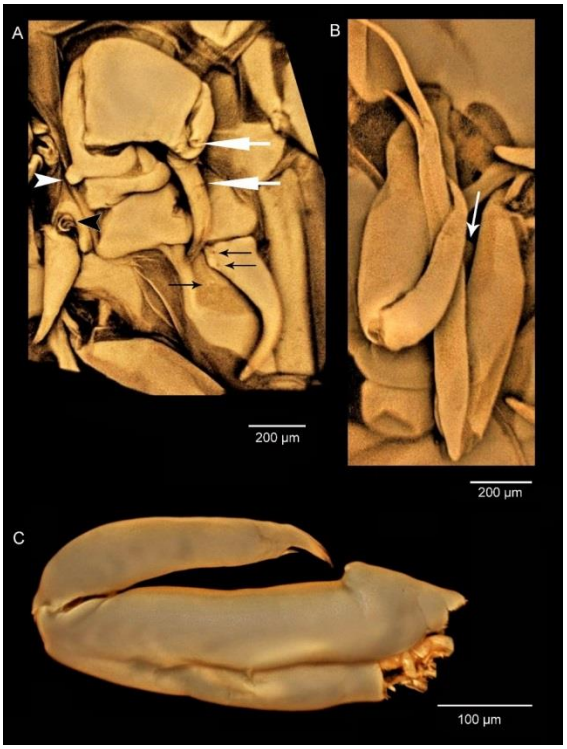

Figure 2. *Caligus minimus* Otto, 1821 female. A. Antenna (posterolaterally-directed process at inner distal corner, white arrowhead); postantennal process (2 sensillate papillae present on basal part, and trisensillate papilla located on body surface adjacent to process, black arrows); maxillule (prominent anterior papilla carrying 3 unequal setae, black arrowhead). B. Maxilla (slender distal segment (brachium) bearing small subterminal hyaline membrane (flabellum) (arrowed), on inner margin plus short canna and long calamus distally). C. Maxilliped.

Figure 3. *Caligus minimus* Otto, 1821 female. A. Sternal furca. B. Leg 1. C. Distal exopodal segment of leg 1.

Leg 2 biramous with 3-segmented rami (Fig. 4A). First two exopodal segments (Fig. 4B) each with pinnate seta on inner margin and spine at outer distal corner. First exopodal spine finely serrated along outer margin and longer than slightly curved spine on second exopodal segment, extending over half of third segment. Third exopodal segment with 5 inner plumose setae plus 3 outer spines; first outer spine (smallest) slightly curved and naked; second spine with hyaline membrane on inner margin, third spine with hyaline membrane along outer margin and row of setules along inner margin (Fig. 4B). First endopodal segment (Fig. 4C) with inner plumose seta plus row of fine setules around outer distal corner; second endopodal segment armed with two inner plumose setae; outer and inner margins ornamented with rows of setules; third segment with 6 plumose setae and bearing tuft of setules at outer distal corner (Fig. 4C).

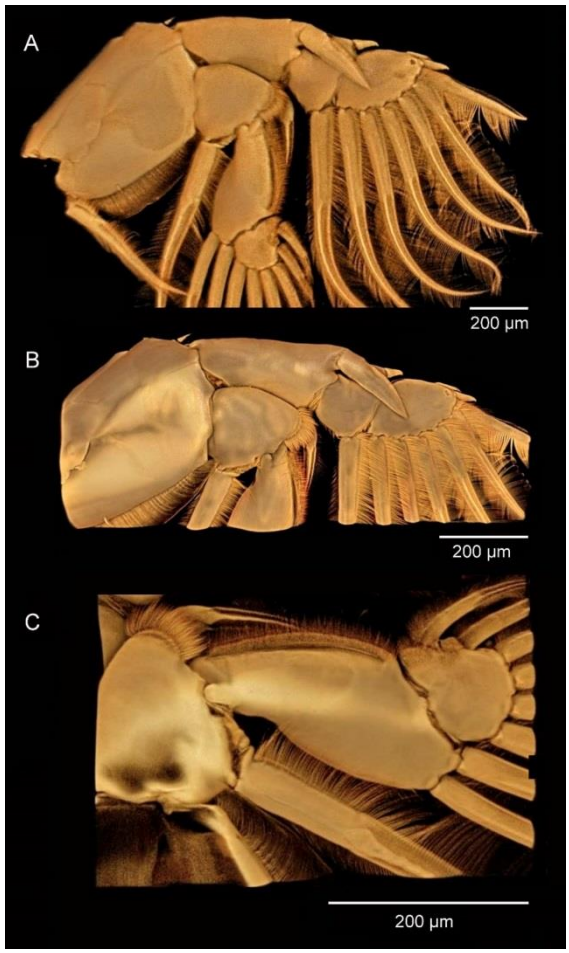

Figure 4. *Caligus minimus* Otto, 1821 female. A. Leg 2. B. Leg 2 exopod. C. Leg 2 endopod.

Leg 3 (Fig. 5A). Exopod 3-segmented, first segment with markedly curved outer spine, extending over second exopodal segment, spine reaching almost distal margin of second segment, outer margin of spine ornamented with hyaline membrane; second segment with outer spine, inner plumose seta and setules along outer margin; third segment with outer row of setules and 3 outer spines (first and second spines almost equal in length, third spine slightly longer than first 2) plus 4 pinnate setae. Endopod (Fig. 5A) 2-segmented; first segment with row of fine setules along free posterior margin and long, inner pinnate seta; second segment with 6 pinnate setae and bearing row of long setules along outer margin.

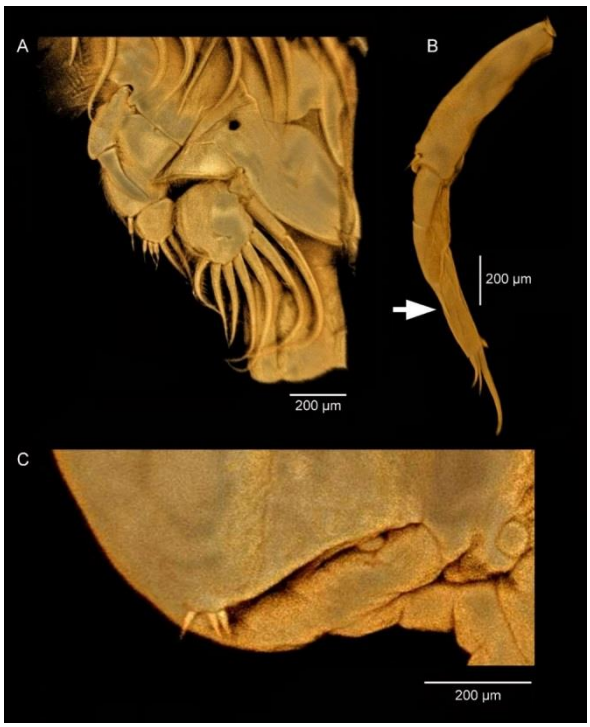

Figure 5. *Caligus minimus* Otto, 1821 female. A. Leg 3. B. Leg 4, 2-segmented exopod bearing a slender distal spine (arrowed) on first segment. C. Leg 5.

Leg 4 (Fig. 5B) uniramous; protopodal segment with outer pinnate seta. Exopod 2-segmented; first segment with slender distal spine (Fig. 5B arrow); second segment with 3 apical spines, inner spine markedly longer than other 2 subequal spines and 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, I, 5	0–1; 0–2; 6
Leg 3	I-0; I-1; III, 4	0–1; 6
Leg 4	I–0; III	absent

Leg 5 (Fig. 5C) located at posterolateral corner of genital complex, represented by 2 papillae; outer (protopodal) papilla bearing single plumose seta; inner (exopodal) papilla bearing 2 plumose setae.

4. Remarks & Discussion

Caligus minimus Otto, 1821 has been reported so many times from different geographical localities in the world seas and oceans. It has been recorded from the Atlantic coasts, the North Sea, the whole Mediterranean Sea, the Black Sea, Sea of Marmara, Aegean Sea, and North Sea collected from a fish host (see Table 1). *C. minimus* was also reported from cultured *Dicentrarchus labrax* (Linnaeus, 1758) in the Mediterranean Sea and Aegean Sea (Table 1). In all previous reports, *C. minimus* was collected from a fish host. Although other Caligid copepods were also reported from zooplankton samples (see Venmathi Maran et al., 2016) in different marine parts of the world, presently reported specimen of *C. minimus* is collected for the first time among the marine plankton samples. The first reported caligid in the planktonic form was *Caligus hyalinus* Cherniavsky, 1868, which was reported from the Black Sea, one and a half centuries ago (Czerniavski, 1868; Venmathi Maran et al., 2016). In their broad checklist and review, Venmathi Maran et al. (2016), three genera, *Caligus*, *Lepeophtheirus* and *Metacaligus*, from the family Caligidae were listed from both fish hosts and plankton samples in some localities such as Japan, Gulf of Thailand, Mexico, Florida, Black Sea (Russia), California, China, and India. 32 planktonic caligid species were reported from 38 localities around the world (see Tables 1 and 2 in Venmathi Maran et al., 2016); however, there were no data available from the Mediterranean Sea. 13 caligid species among 32 were reported only from plankton samples from different localities around the globe (Venmathi Maran et al., 2016); *C. aduncus* Shen & Li, 1959 and *C. costatus* Shen & Li, 1959 from China (Shen & Li, 1959), *C. evelynae* Suárez-Morales, Camisotti & Martín, 2012 from Venezuela (Suárez-Morales et al., 2012a), *C. hyalinae* Heegaard, 1966 from the USA (Heegaard, 1966), *C. ilhoikimi* Suárez-Morales & Gasca, 2016 from Mexico (Suárez-Morales & Gasca, 2016), *C. longiramus* Venmathi Maran, Ohtsuka & Jitchum, 2012 (Venmathi Maran et al., 2012a), *C. ogawai* Venmathi Maran, Ohtsuka & Shang, 2012 and *C. quadrigenitalis* Venmathi Maran, Ohtsuka & Shang, 2012 from Japan (Venmathi Maran et al., 2012b), *C. tripedalis* Heegaard, 1972 from New Zealand (Heegaard, 1972), *C. undulatus* Shen & Li, 1959 from Brazil, China, India, Japan, Korea and Mexico (Shen & Li, 1959; Pillai, 1985; Venmathi Maran & Ohtsuka, 2008; Suárez-Morales et al., 2012b); *Caligus* sp.1 and *Metacaligus yucatanensis* Suárez-Morales, Kim & Escamilla, 2012 from Mexico (Suárez-Morales et al., 2012b), and *Lepeophtheirus alvaroi* Suárez-Morales & Gasca, 2012 from Costa Rica (Suárez-Morales & Gasca, 2012). The other species mentioned in their study were both from fish hosts and plankton samples. In addition to the species listed in the study of Venmathi Maran et al. (2016), *C. chinglonglini* Ohtsuka and Boxshall, 2019 from the Japanese coast of the Sea of Japan (Ohtsuka & Boxshall, 2019), *C. epidemicus* Hewitt, 1971 from the Mitchell River (Hewitt, 1971), *C. littoralis* Luque and Cezar, 2000 and *C. praetextus* Bere, 1936 from the coast of Venezuela western Caribbean (Kim et al., 2019), *C. longicaudatus* Brady, 1899 from New Zeland (Hewitt & Hine, 1972), and *C. tetrodontis* Barnard, 1948 from Brazil (Montú, 1982) were also reported from different studies. Although, *C. minimus* was reported only from a fish host so far, the current examination provides information on the planktonic occurrence of the species.

The presence of the planktonic caligids was explained by many reasons in different studies (Kabata, 1979; Ocaña-Luna & Álvarez-Silva 2001; Ohtsuka et al. 2004; Hayward et al., 2008, 2011; Venmathi Maran & Ohtsuka, 2008; Suárez-Morales et al., 2012a; Venmathi Maran, 2012a; Suárez-Morales & Gasca 2016; Venmathi Maran et al., 2016, 2018; Ohtsuka et al., 2018; Kim et al., 2019). These are generally gathered under 5 main headings; (1) accidental occurrence, (2) escape from host, (3) host-switching or searching for a new host, (4) change the mode of life (alternative life cycle or ontogenetic behavior), and (5) behavioral or accidental detachment from the host (Venmathi Maran et al., 2012a, 2016; Ohtsuka et al., 2018). The free-living chalimus and adult stages of caligids in plankton samples were encountered

in many studies (Ho & Lin 2004; Ohtsuka et al. 2004; Venmathi Maran & Ohtsuka 2008; Venmathi Maran et al. 2012a, b, 2016; Suarez-Morales et al. 2012a, Ohtsuka et al., 2018). In the current study, *C. minimus* was found with egg sacs attached to the body which shows that it was an ovigerous adult female specimen. During clearing using lactic acid for about 3 hours; however, the egg sacs were detached from the body.

Table 1. Geographical report of *Caligus minimus*, Otto 1821 recorded from their fish hosts.

Fish Host	Locality	Reference
Alosa fallax (Lacepède, 1803) reported as *Clupea finta* Cuvier, 1829	Mediterranean Sea (Italy)	Brian (1935)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea	Heller (1865)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea	Brian (1906)
Dicentrarchus labrax (Linnaeus, 1758) reported as *Labrax lupus* (Lacepède, 1802)	Mediterranean Sea (Italy)	Brian (1935)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (France)	Delamare Deboutteville (1950)
Dicentrarchus labrax (Linnaeus, 1758)	North Sea	Boxshall (1974)
Dicentrarchus labrax (Linnaeus, 1758)	British waters	Kabata (1979)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Spain)	Poquet (1979)
Dicentrarchus labrax (Linnaeus, 1758)	Atlantic (France)	Paperna & Baudin Laurencin (1979)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Tunisia)	Raibaut & Ben Hassine (1977)
Dicentrarchus labrax (Linnaeus, 1758)	Baltic Sea (Poland)	Grabda (1977)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea	(Paperna 1977; 1980)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Tunisia)	Essafi et al. (1984)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Spain)	Fernández et al. (1989)
Dicentrarchus labrax (Linnaeus, 1758)	Adriatic Sea (Montenegro)	Radujkovic & Raibaut (1989)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Greece)	Papoutsoglou et al. (1996)
Dicentrarchus labrax (Linnaeus, 1758)	North Atlantic Ocean (Portugal)	Santos (1996)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Tunisia)	Benmansour & Ben Hassine (1998)
Dicentrarchus labrax (Linnaeus, 1758)	North Atlantic (Ireland)	Holmes (1998)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Italy)	Pavoletti et al. (1999)
Dicentrarchus labrax (Linnaeus, 1758)	Aegean Sea	Tokşen (1999)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Tunisia)	Bahri et al. (2002)
Dicentrarchus labrax (Linnaeus, 1758)	North Sea (Norway)	Sterud (2002)
Dicentrarchus labrax (Linnaeus, 1758)	Tunisia	Yamak & Ben Hassine (2002)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Türkiye)	Özak (2007)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Türkiye)	Canlı (2010)
Dicentrarchus labrax (Linnaeus, 1758)	Black Sea (Türkiye)	Özer & Öztürk (2011)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Türkiye)	Yalım et al. (2014)
Dicentrarchus labrax (Linnaeus, 1758)	Black Sea (Türkiye)	Er & Kayış (2015)
Dicentrarchus labrax (Linnaeus, 1758)	Sea of Marmara	Öktener et al. (2017)
Dicentrarchus labrax (Linnaeus, 1758)	Mediterranean Sea (Egypt)	Abou Zaid et al. (2018)
Dicentrarchus labrax Linnaeus, 1758) (Cultured)	Mediterranean Sea (France)	Cabral & Raibaut (1986)
Dicentrarchus labrax (Linnaeus, 1758) (Cultured)	Mediterranean Sea (Türkiye)	Cengizler et al. (2001)
Dicentrarchus labrax (Linnaeus, 1758) (Cultured)	Aegean Sea (Greece)	Ragias et al. (2004)
Dicentrarchus labrax (Linnaeus, 1758) (Cultured)	Aegean Sea (Türkiye)	Ulukoy & Kubilay (2005)
Dicentrarchus labrax (Linnaeus, 1758) (Cultured)	Italy	Fioravanti et al. (2006)
Dicentrarchus labrax (Linnaeus, 1758) (Cultured)	Mediterranean Sea (Greece)	Vagianou et al. (2006)
Dicentrarchus labrax (Linnaeus, 1758) (Cultured)	Aegean Sea (Türkiye)	Ulukoy & Kubilay (2007)
Dicentrarchus labrax (Linnaeus, 1758) (Cultured)	Mediterranean Sea (Egypt)	El-Deen et al. (2013)
Dicentrarchus labrax (Linnaeus, 1758) (Cultured)	Portugal	Saraiva et al. (2015)
Dicentrarchus labrax (Linnaeus, 1758) (Cultured)	Mediterranean Sea (Egypt)	Salama & Yousef (2020)
Dicentrarchus punctatus (Bloch, 1792)	Baltic Sea (Poland)	Grabda (1977)
Gadus morhua Linnaeus, 1758	North Atlantic	Hemmingsen & MacKenzie (2001)
Gadus morhua Linnaeus, 1758	Baltic Sea (Germany)	Palm et al. (1999)
Gadus morhua Linnaeus, 1758	North Sea - Baltic Sea	Möller (1975)
Labrus merula Linnaeus, 1758	Aegean Sea (Türkiye)	Tanrikul & Percin (2012)
Mugil cephalus Linnaeus, 1758	British waters	Kabata (2003)
Pagellus bogaraveo (Brünnich, 1768)	Mediterranean Sea	Raibaut et al. (1998)
Sander lucioperca (Linnaeus, 1758) reported as *Stizostedion lucioperca* (Linnaeus, 1758)	Baltic Sea (Germany)	Palm et al. (1999)
Umbrina cirrose (Linnaeus, 1758) reported as *Umbrina cirrhata* (Linnaeus, 1758)	Mediterranean Sea (Italy)	Brian (1935)

Considering the distribution of the caligid species in planktonic form, they either were found as abundant or single specimen. In the study of Kim et al. (2019), several specimens of 4 species of Caligus Müller, 1785 in a zooplankton survey lasted in one year were collected on the northern coast of Venezuela, western Caribbean, whereas a single male specimen of Caligus (*Caligus chinglonglini* Ohtsuka & Boxshall, 2019) was recorded in study of Ohtsuka & Boxshall (2019) from the Sea of Japan. In the present study, there was only one single female, *C. minimus*, was collected among other planktonic samples in an ongoing project held in the area. Therefore, the number of the specimen may increase in the future. Apart from the *C. hyalinus* which was reported from the Russian Black Sea coast, there was no Caligus species in planktonic form was reported in and around Türkiye including the Mediterranean Sea until the current study. The reported specimen of *C. minimus*, however, is collected for the first time among the marine plankton samples.

Although *C. minimus* has been reported numerous times previously, the most accurate description of the species was provided by Kabata (1979) based on the material collected from British waters. Therefore, the present material was compared with the description presented by Kabata (1979). The main similarities between the presently collected material of *C. minimus* and the British material identified by Kabata (1979) are as follows: (1) the oval shape of the cephalothorax; (2) the slightly lobate posterolateral corners of the genital complex; (3) 1-segmented abdomen 1.42 times longer than wide whereas 1.30 times longer than wide in Kabata's specimen; (4) the shape of the female sternal furca with subrectangular box and its parallel, rounded tines; (5) the general form and the relative lengths of the terminal elements of the distal exopod segment of leg 1; (6) the spine and setal formula of legs 1–4; the setular ornamentation on outer margin of the three endopodal segments of leg 2; (7) the number of setae on female leg 5.

However, slight differences were also observed between the present material and Kabata's specimen: (1) The total length of the present material slightly shorter than the female reported by Kabata (3.6 vs. 4-5 mm); and (2) the cephalothorax about 1.41 (vs. 1.24 times in Kabata) times longer than the combined length of genital complex and abdomen. Although slight differences were observed between the present material and the British material, the adult female *Caligus* specimen collected among the ichthyoplankton samples was identified as *C. minimus* due to the close similarities given above.

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References

Abouzaid, A.A., Bazh, K.E., Desouky, A.Y., & Abo-Rawash, A.A. (2018). Metazoan parasite fauna of wild sea bass; *Dicentrarchus labrax* (Linnaeus, 1758) in Egypt. *Life Science Journal*, 15(6), 48-60. https://doi.org/10.7537/marslsj150618.06

Bahri, L., Ben Hamida, J., & Ben Hassine, O.K. (2002). Use of parasitic copepod, *Lernanthropus kroyeri* (Van Beneden, 1851) (Lernanthropidae) as a bio-indicator of two fish populations, *Dicentrarchus labrax* Linnaeus (1758) and *Diplodus punctatus* (Bloch, 1792) (Moronidae) in Tunisian inshore areas. *Crustaceana*, 75, 253-267.

Benmansour, B., & Ben Hassine, O.K. (1998). Preliminary analysis of parasitic copepod species richness among coastal fishes of Tunisia. *Italian Journal of Zoology*, 65, 341-344.

Boxshall, G.A. (1974). Infections with parasitic copepods in North Sea marine fishes. *Journal of the Marine Biological Association of the United Kingdom*, 54, 355-372. https://doi.org/10.1017/S0025315400058598

Boxshall, G.A. (1990). The skeletomusculature of siphonostomatoid copepods, with an analysis of adaptive radiation in structure of the oral cone. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*. 328, 167-212. https://doi.org/10.1098/rstb.1990.0113

Bragoni, G., Romestand, B., & Trilles, J.P. (1983). Parasitism by cymothoids among sea bass in rearing. *Annales de Parasitologie Humaine et Comparée*, 58(6), 593-609. https://doi.org/10.1051/parasite/1983586593

Brian, A. (1906). Copepodi parassiti dei Pesci d'Italia. Stabilimento Tipo-Litografico Regio Istituto Sordomuti, Genova, 187 pp.

Brian, A. (1935). I Caligus parassiti dei pesci del Mediterraneo (Copepodi). *Annali del Museo Civico di Storia Naturale 'Giacomo Doria', Genova*, 57, 152-211.

Cabral, P. (1983). Morphologie, biologie et écologie des Copépodes parasites du Loup Dicentrarchus labrax (Linné, 1758) et du Sar rayé *Diplodus sargus* (Linné, 1758) de la région languedocienne. Thèse de 3ème cycle, Université Montpellier, Montpellier, 221 pp.

Cabral, P., & Raibaut, A. (1986). Discovery of a new caligid copepod, parasite of the wolf's seed coat, *Dicentrarchus labrax* (L., 1758) (Pisces, Moronidae) in breeding and in a natural environment. *Bulletin of the Zoological Society of France*, 111(1-2), 123-130.

Canlı, M. (2010). Ectoparasite research on economic fish species which is caught from Hurmabogazı Lagoon (Adana). Dissertation. Cukurova University (in Turkish with English abstract).

Cengizler, İ., Erdem, Ü., Özak, A.A., Genç, E., & Şahan, A. (2001). Caligiosis in Sea Bass (*Dicentrarchus labrax*) cultured in coast of Yumurtalık (Adana). In: XI National Symposium on Aquatic Products, 4-6 September 2001, Hatay, Turkey (in Turkish).

Czerniavski, V. (1868). Materialia ad zoographiam Ponticam comparatam. *Travaux de la Societe des naturalistes de St. Petersbourg*, 1, 19-136.

Delamare-Debouteville, C. (1950). Copépodes parasites des poissons de Banyuls (1ère série). *Vie et Milieu*, 3, 305-309.

El-Deen, A.I.E.N., Mahmoud, A.E., & Hassan, H.M. (2013). Field studies of Caligus parasitic infections among cultured seabass (*Dicentrarchus labrax*) and mullet (*Mugil cephalus*) in marine fish farms with emphasis on treatment trials. *Global Veterinaria*, 11(5), 511-520. https://doi.org/10.5829/idosi.gv.2013.11.5.76168

Er, A., & Kayış, Ş. (2015). Intensity and prevalence of some crustacean fish parasites in Turkey and their molecular identification. *Turkish Journal of Zoology*, 39, 1142-1150. https://doi.org/10.3906/zoo-1409-35

Essafi, K., Cabral, P., & Raibaut, A. (1984). Parasitic copepods of fish from the Kerkennah Islands (southern Tunisia). *Les Archives de l'Institut Pasteur Tunis*, 61(4), 475-523.

Fernández, J.P., Muñoz, M.V., Orts, M.E., & Carbonell, E. (1989). Prevalencia e intensidad de parasitación por crustáceos en peces del Mar Mediterráneo, *Revista Ibérica de Parasitología*, 49(1), 75-76.

Fioravanti, M.L., Caffara, M., Florio, D., Gustinelli, A., & Marcer, F. (2006). A parasitological survey of European Sea Bass (*Dicentrarchus labrax*) and Gilthead Sea Bream (*Sparus aurata*) cultured in Italy. *Veterinary Research Communications*, 30(1), 249-252. https://doi.org/10.1007/s11259-006-0053-5

Froese, R., & Pauly, D. (2023). FishBase. Retreived from http://www.fishbase.org

Grabda, J. (1977). Crustaceans-parasites of marine fishes, Wiadomosci Parazytologiczne. 23(1-3), 171-176.

Hayward, C.J., Aiken, H.M., & Nowak, B.F. (2008). An epizootic of *Caligus chiastos* on farmed southern bluefin tuna *Thunnus maccoyii* off South Australia. *Diseases of Aquatic Organisms*, 79, 57-63. https://doi.org/10.3354/dao01890

Hayward, C.J., Svane, I., Lachimpadi, S.K., Itoh, N., Bott, N.J., & Nowak, B.F. (2011). Sea lice infections of wild fishes near ranched southern bluefin tuna (*Thunnaus maccoyi*) in South Australia. *Aquaculture*, 320, 178-182. https://doi.org/10.1016/j.aquaculture.2010.10.039

Heegaard, P. (1966). Parasitic copepods from Texas. *Videnskabelige Meddelelser fra Dansk naturhistoriske Forening, Copenhagen*, 129, 187-197.

Heegaard, P. (1972). Caliginae and Euryphorinae of the Dana Expedition (Crustacea, Copepoda, Caligidae). *Steenstrupia*, 2, 295-317.

Heller, C. (1865). Crustaceen. Reise der Oesterreichischen Fregatte Novara um die Erde in den Jahren 1857, 1858, 1859. *Zoologischer Theil*, 2, 1-280.

Hemmingsen, W., & MacKenzie, K. (2001). The parasite fauna of the Atlantic cod, *Gadus morhua* L. *Advances in Marine Biology*, 40, 1-80.

Hewitt, G.C. (1971). Two species of Caligus (Copepoda, Caligidae) from Australian waters, with a description of some developmental stages. *Pacific Science*, 25, 145-164.

Hewitt, G.C., & Hine, P. M. (1972). Checklist of parasites of New Zealand fishes and of their hosts. *New Zealand Journal of Marine and Freshwater Research*, 6(1-2), 69-114. https://doi.org/10.1080/00288330.1977.9515410

Ho, J.S., & Lin, C.L. (2004). Sea Lice of Taiwan (Copepoda: Siphonostomatoida: Caligidae). The Sueichan Press, Keelung, 388 pp.

Holmes, J.M.C. (1998) A checklist of the Siphonostomatoida (Crustacea: Copepoda) of Ireland. *Bulletin of the Irish Biogeographical Society, Dublin*, 22(2), 194-228.

Huys R., & Boxshall, G.A. (1991). Copepod Evolution, The Ray Society, London.

Kabata, Z. (1979). Parasitic Copepoda of British Fishes, The Ray Society, London, 468 pp.

Kabata, Z. (2003). Copepods Parasitic on Fishes. 2nd, revised edition. Synopses of the British Fauna, 2nd revised edition. Backhuys. No. 47, 1-274.

Kamanli, S.A., Kihara, T.C., Ball, A.D., Morritt, D., & Clark, P.F. (2017). A 3D imaging and visualisation workflow, using confocal microscopy and advanced image processing for brachyuran crab larvae. *Journal of Microscopy*, 266, 307-323. https://doi.org/10.1111/jmi.12540

Kim, I., Suárez-Morales, E., & Márquez-Rojas, B. (2019). Caligid copepods (Copepoda: Siphonostomatoida: Caligidae) as zooplankters off the Venezuelan coast, western Caribbean Sea. *Thalassas: An International Journal of Marine Sciences*, 35(2), 607-618. https://doi.org/10.1007/s41208-019-00130-w

Limaye, A. (2012). Drishti: a volume exploration and presentation tool, in: Stock SR (ed), Proceedings of SPIE Vol. 8506 SPIE. Developments in X-ray Tomography VIII Bellingham, Washington.

Montú, M. (1982). Alguns copépodos parasites de peixes do sul do Brasil. *Arquivos de Biologia e Tecnologia*, 5, 329-339.

Möller, H. (1975). Bibliography on parasites and diseases of marine fishes from North Sea and Baltic Sea. 15. Berichte aus dem Institut für Meereskunde an der Christian-Albrechts-Universität Kiel, 015. Institut für Meereskunde Kiel. 1-35. https://doi.org/10.3289/IFM_BER_15

Ocaña-Luna, A., & Álvarez-Silva, C. (2001). Range extension of *Caligus chelifer* (Copepoda: Siphonostomatoida) to coastal lagoons. *Revista de Biología Tropical*, 49, 1277-1277.

Ohtsuka, S., Ho, J., Nagasawa, K. (2004). Ergasilid copepods (Poecilostomatoida) in plankton samples from Hokkaido, Japan, with reconsideration of the taxonomic status of Limnoncaea Kokubo, 1914. *Journal of Natural History*, 38, 471-498. https://doi.org/10.1080/0022293021000034778

Ohtsuka, S., Madinabeitia, I., Yamashita, H., Venmathi Maran, B.A., Suárez-Morales, E., & Ho, J.S. (2018). Planktonic phases in symbiotic copepods: a review. *Bulletin of the Southern California Academy of Sciences*, 117(2),104-19.

Ohtsuka, S., & Boxshall, G.A. (2019). Two new species of the genus *Caligus* (Crustacea, Copepoda, Siphonostomatoida) from the Sea of Japan, with a note on the establishment of a new species group. *ZooKeys*, 893, 91-113. https://doi.org/10.3897/zookeys.893.46923

Ohtsuka, S., Nawata, M., Nishida, Y., Nitta, M., Hirano K, Adachi K, ..., & Suárez-Morales, E. (2020). Discovery of the fish host of the 'planktonic' caligid *Caligus undulatus* Shen & Li, 1959 (Crustacea: Copepoda: Siphonostomatoida). *Biodiversity Data Journal*, 8, e52271. https://doi.org/10.3897/BDJ.8.e52271

Ortega, I., Scott-Frías, J., & Martin, A. (2017). Diversity and composition of copepods assemblage associated with hyperbenthic zone of the Venezuelan central coast sandy beaches. *Juan Antonio Bolaños Curvelo, In Memoriam, Publicación Especial del Boletín del Instituto Oceanográfico de Venezuela*, 123-132.

Öktener, A., Türker, D., & Alaş, A. (2017). The Sea of Marmara: new locality for two caligids and one lernanthropid in Turkey. *Journal of Wetland Biodiversity*,7, 109-130.

Özak, A.A. (2007). Studies on the biology of parasitic copepod, *Caligus minimus* Otto, 1821 on European Sea Bass, *Dicentrarchus labrax* L. 1758. Dissertation, Çukurova University 110 pp (in Turkish with English abstract).

Özak, A.A. (2020). Sea lice (Copepoda: Caligidae) of Turkey, with the discovery of *Caligus quadratus* Shiino, 1954 in the Mediterranean Sea and the re-description of a rare caligid copepod, *Caligus scribae* Essafi, Cabral & Raibaut, 1984. *Systematic Parasitology*, 97, 779-808. https://doi.org/10.1007/s11230-020-09953-1

Özer, A., & Öztürk, T. (2011). First report of *Ceratomyxa sp*. (Myxozoa) and *Caligus minimus* (Copepoda) on sea bass (*Dicentrarchus labrax*) from Turkey. In: 16th Symposiyum on National Aquatic Products 25–27 October 2011, Antalya, Turkey.

Palm, H.W., Klimpel, S., & Bucher, C. (1999). Checklist of metazoan fish parasites of German coastal waters. Berichte aus dem Institut für Meereskunde an der Christian-Albrechts-Universität Kiel 307. 148 pp.

Paperna, I. (1977). Copepod infection in fish in euryhaline environments. *Wiadomosci Warazytologiczne*, 23, 183–188.

Paperna, I., & Baudin Laurencin, P. (1979). Parasitic infections of sea bass, *Dicentrarchus labrax*, and gilt head sea bream, *Sparus aurata*, in mariculture facilities in France, *Aquaculture*, 16,173-175.

Paperna, I. (1980). Study of *Caligus minimus* (Otto, 1821) (Caligidae Copepoda) infections of the Sea bass *Dicentrarchus labrax* (L.) in Bardawil Lagoon. *Annales des Sciences Naturelles Zoologie*, 55(6), 687-706. https://doi.org/10.1051/parasite/1980556687

Papoutsoglou, S., Costello, M.J., Stamou, E., & Tziha, G. (1996). Environmental conditions at sea-cages and ectoparasites on farmed European sea-bass. *Dicentrarchus labrax* (L.), and gilt-head sea-bream, *Sparus aurata* L., at two farms in Greece. *Aquaculture Research*, 27, 25-34.

Pavoletti, E., Fioravanti, M.L., Prearo, M., & Ghittino, C. (1999). Osservazioni sulla Caligosi in spigole dallevamento. *Bollettino della Società Paleontologica Italiana*, 11, 2-9.

Pillai, N.K. (1985). The Fauna of India. Copepod Parasites of marine Fishes. Zoological Society of India, Calcutta, 900 pp.

Poquet, M. (1979). Aportaciones al estudio morfologico de algunas especies de copepodos parasitos de peces del litoral mediterraneo. *Miscellaneous publications (University of Michigan) Museum of Zoology*, 5, 161-171.

Radujković, B.M., & Raibaut, A. (1989). Copepodes parasites des poissons des cotes du Montenegro (Adriatique Sud). *Parassitologia*, 31(1), 1-24.

Ragias, V., Tontis, D., & Athanassopoulou, F. (2004). Incidence of an intense *Caligus minimus* Otto 1821, *C. pageti* Russell, 1925, *C. mugilis* Brian, 1935 and *C. apodus* Brian, 1924 infection in lagoon cultured sea bass (*Dicentrarchus labrax* L.) in Greece. *Aquaculture*, 242, 727-733. https://doi.org/10.1016/j.aquaculture.2004.08.019

Raibaut, A. & Ben Hassine, O.K. (1977). Les copépodes parasites des muges en Méditeranée. *Bulletin du Museum National d'histoire Naturelle. Ser. 3*, 329, 833-848.

Raibaut, A., Combes, C., & Benoit, F. (1998). Analysis of the parasitic copepod species richness among Mediterranean fish. In: Dahms, H.U., Glatzel, T., Hirche, H.J., Schiel, S., & Schminke, H.K. (eds.), Proceedings of the 6th International Conference on Copepoda. *Journal of Marine Systems, Spec*, 15(1-4), 185-206.

Salama, S.S.A., & Yousef, N.S.I. (2020). The impact of co-infection of sea lice and its concurrent some bacterial diseases with field treatment trials in some marine cultured fishes. *Egyptian Journal of Aquatic Biology and Fisheries*, 24(7-Special issue), 363-381. https://doi.org/10.21608/ejabf.2020.120412

Santos, M.J. (1996). Observations on the parasitofauna of wild sea bass (*Dicentrarchus labrax* L.) from Portugal. *Bulletin of the European Association of Fish Pathologists*, 16, 77-79.

Saraiva, A., Costa, J., Serrão, J., Eiras, J.C., & Cruz, C. (2015). Study of the gill health status of farmed sea bass (*Dicentrarchus labrax* L., 1758) using different tools. *Aquaculture*, 441, 16-20. https://doi.org/10.1016/j.aquaculture.2015.02.004

Schneider, C.A., Rasband, W.S., & Eliceiri, K.W. (2012). NIH Image to ImageJ: 25 years of image analysis. *Nature Methods*, 9(7), 671-675. https://doi.org/10.1038/nmeth.2089

Shen, C.-j., & Li, H.-l. (1959). Parasitic copepods from fishes of China, IV. Caligoida. Caligidae (3). *Acta Zoologica Sinica*, 11, 12-20 (In Chinese with English summary).

Sterud, E. (2002). Parasites of wild sea bass *Dicentrarchus labrax* from Norway. *Diseases of Aquatic Organisms*, 48, 209-212. http://dx.doi.org/10.3354/dao048209

Sterud, E. (2002). Parasites of wild sea bass *Dicentrarchus labrax* from Norway. Diseases of Aquatic Organisms, 48, 209-212. https://doi.org/10.3354/dao048209

Suárez-Morales, E., Camisotti, H., & Martín, A. (2012a). A new species of Caligus (Copepoda, Siphonostomatoida) from the plankton of the Caribbean coast of Venezuela with a key to species. *Zookeys*, 201, 59-71. http://dx.doi.org/10.3897/zookeys.201.3099

Suárez-Morales, E., Kim, I.-H., & Escamilla, B.J. (2012b). On some caligids (Copepoda: Caligidae) from plankton of a coastal lagoon in the Gulf of Mexico with a description of a new species of *Metacaligus*. *Zoological Studies*, 51, 804-818.

Suárez-Morales, E., & Gasca, R. (2012). A new Lepeophtheirus (Copepoda: Siphonostomatoida: Caligidae) from Isla del Coco National Park, Costa Rica, Eastern Tropical Pacific. *Revista de Biología Tropical*, 60 (Suppl.3), 235-242.

Suárez-Morales, E., & Gasca, R. (2016). A new species of Caligus Müller, 1785 (Copepoda: Siphonostomatoida) from the coral reef plankton in the Mexican Caribbean. *Zootaxa*, 4174(1), 424-436. https://doi.org/10.11646/zootaxa.4174.1.26

Tanrikul, T.T., & Percin, F. (2012). Ectoparasitic sea lice, *Caligus minimus* (Otto 1821, Copepoda: Caligidae) on Brawn wrasse, *Labrus merula* L., in Izmir Bay, Aegean Sea. *Italian Journal of Animal Science*, 11, 38-41.

Tokşen, E. (1999). Metazoan gill parasites of culture gilthead sea bream (*Sparus aurata* L.) and sea bass (*Dicentrarchus labrax* L.) in the Aegean Sea Coast and their treatment. PhD thesis, Ege University, İzmir, Turkey.

Uluköy, G., & Kubilay, A. (2005). Ege sea lice (*Caligus minimus* Otto, 1821, Copepoda: Caligidae) infestation in cultured seabass (*Dicentrarchus labrax*, L 1758). *Turkish Journal of Aquatic Life*, 4, 256.

Uluköy, G., & Kubilay, A. (2007). *Caligus minimus* infestation on cultured European sea bass, (*Dicentrarchus labrax* L., 1758). XIV National Symposium on Aquatic Products, 4-7 September 2007, Mugla, Turkey.

Vagianou, S., Athanassopoulou, F., Ragias, V., Di Cave, D., Leontides, L., & Golomazou, E. (2006). Prevalence and pathology of ectoparasites of Mediterranean Sea bream and sea bass reared under different environmental and aquaculture conditions. *The Israeli Journal of Aquaculture – Bamidgeh*, 58, 78-88.

Venmathi Maran, B.A., & Ohtsuka, S. (2008). Description of caligiform copepods in plankton samples collected from East Asia: Accidental occurrences or a new mode of life cycle? *Plankton Benthos Research*, 3, 202-215. https://doi.org/10.3800/pbr.3.202

Venmathi Maran, B.A., Ohtsuka, S., & Jitchum, P. (2012a). Occurrence of caligid copepods (Crustacea) in plankton samples collected from Japan and Thailand, with the description of a new species. *Species Diversity*, 17, 87-95. https://doi.org/10.12782/sd.17.1.087

Venmathi Maran, B.A., Ohtsuka, S., & Shang, X. (2012b). Records of adult caligiform copepods (Crustacea: Copepoda: Siphonostomatoida) in marine plankton from East Asia, including descriptions of two new species of Caligus (Caligidae). *Species Diversity*, 17, 201-219. http://dx.doi.org/10.12782/sd.17.2.201

Venmathi Maran, B.A., Suárez-Morales, E., Ohtsuka, S., Soh, H.Y., & Hwang, U.W. (2016). On the occurrence of caligids (Copepoda: Siphonostomatoida) in the marine plankton: a review and checklist. *Zootaxa*, 4174(1), 437-447. https://doi.org/10.11646/zootaxa.4174.1.27

Venmathi Maran, B.A., Suárez-Morales, E., Ohtsuka, S., Soh, H.Y., & Hwang, U.W. (2018). Planktonic phase of symbiotic copepods: a brief review. *Bulletin of the Southern California Academy of Sciences*, 117,1-16.

Yalım, F.B., Emre, N., Emre, Y., Yazmen, H., Öztürk, M.O., Akmirza, A., & Aydoğdu, A. (2014). *Caligus minimus* (Copepoda, Caligidae) infestation of European sea bass (*Dicentrarchus labrax*) from Beymelek Lagoon Lake (Antalya, Turkey): Effects of host sex, age, size and season. *Journal of Academic Documents for Fisheries and Aquaculture*, 1, 9-16.

Yamak, S., & Ben Hassine, O.K. (2002). Impact of a fish farm on ichthyofauna and ichthyoparasitofauna of a Tunisian lagoon. In: Proceedings of the International Conference on the Environmental Problems of the Mediterranean Region, 12–15 April 2002, Nicosia, Turkish Republic of Northern Cyprus.

Walter, T.C. & Boxshall, G.A. (2023). World of Copepods Database. Retreived from http://www.marinespecies.org/copepoda