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Choreftria shiranui, a new genus and species of cyclopoid copepod (Crustacea: Copepoda) associated with the worm goby from southern Japan, with the proposal of a new family

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Abstract A new genus and species of cyclopoid copepod, *Choreftria shiranui* **n. g.**, **n. sp.** (Crustacea: Copepoda) is described based on an adult female found from the worm goby, *Taenioides snyderi* Jordan & Hubbs (Actinopterygii: Perciformes: Gobiidae), from mud flats in the Yatsushiro Sea, southern Japan. The new genus is characterized by bearing the following characters in the female: body distinctly segmented cyclopiform with 4-segmented prosome and 6-segmented urosome; genital somite clearly separated from first abdominal somite; antennule 7-segmented; antenna 4-segmented with one fused serrated claw and long claw on second endopodal segment; mandible reduced with one serrated blade; maxillule rod-like with one element; maxilla 2-segmented with recurved terminal claw; maxilliped 2-segmented; legs 1 to 4 biramous with 3-segmented rami. Since the copepod is not attributable to any of the known cyclopoid families, a new family, Choreftriidae **n. fam.** is established to accommodate *Choreftria* **n. g.** LSID urn:lsid:zoobank.org:pub:C1FB9F60-9871-4D4B-A1BF-3202BA24189F.

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Introduction

Marine fishes are the major hosts of parasitic copepods (Crustacea: Copepoda). Of the order Cyclopoida, members of the following seven families are known to inhabit marine fish: Bomolochidae Claus, 1875, Chondracanthidae Milne Edwards, 1840, Makrostrotidae Huys et al., 2012, Philichthyidae Vogt, 1877, Shiinoidae Cressey, 1975, Taeniacanthidae Wilson C.B., 1911, and Telsidae Ho, 1967 (Boxshall & Halsey, 2004; Huys et al., 2012). Several members of the two families Ergasilidae Burmeister, 1835 and Lernaeidae Cobbold, 1879, of which members are commonly found from fresh- to brackish waters, also occur on marine fishes. Additionally, one species from each of the following families, Anthessiidae Humes, 1986, Pseudanthessiidae Humes & Stock, 1972, and Macrochironidae Humes & Boxshall, 1996, was found from marine fishes, while other members of those families were found on invertebrate hosts (Avdeev, 1975; Avdeev & Kazachenko, 1986; Boxshall & Halsey, 2004; Uyeno & Rain, 2021).

In this study, a new genus and species of cyclopoid copepod that is not attributable to the known families is described based on an adult female attached to the worm goby *Taenioides snyderi* Jordan & Hubbs (Actinopterygii: Perciformes: Gobiidae) collected from the Yatsushiro Sea, southern Japan. A new family is established to accommodate this new genus.

Materials and methods

A fish was collected from at low tide on the mud flats in the Yatsushiro Sea using a yabby pump. A specimen of copepod was removed from the host's anal fin in the laboratory, fixed and preserved in 80% ethanol. Subsequently, the copepod specimen was soaked in lactophenol for 24 h, dissected with a sharpened insect pin under a dissecting microscope (Leica M80), and observed, based on a modified procedure of the wooden slide method of Humes & Gooding (1964), under a biological microscope (Olympus BX53). Illustrations were made with the aid of a drawing tube attached to the biological microscope. The copepod's body was measured using an ocular micrometer; measurements are given in μm. The type specimen of the copepod and its host fish are deposited in the crustacean collection of the Natural Museum of Nature of Science, Tsukuba, Japan (NSMT-Cr) and The Kagoshima University Museum, Kagoshima City, Japan (KAUM–I), respectively. The scientific and common names of fishes used in this paper follow FishBase (Froese & Pauly, 2021).

Results

Choreftria n. g.

LSID urn:lsid:zoobank.org:act:37FF9F26-96F1-444B-B344-F88FE691FDB5

New Japanese name: Oshiri-kajiri-mushi-zoku.

Diagnosis

Adult female. Body cyclopiform. Second to fifth pedigerous somites, genital somite and four abdominal somites free. Genital somite with genital opening on ventral surface. Abdomen composed of four free somites. Caudal ramus with one outer, one inner, and four apical setae.

Rostrum absent. Antennule 7-segmented; aesthetascs present on sixth and distal segments. Antenna 4-segmented, composed of coxobasis and 3-segmented endopod; coxobasis large, bearing single naked distal seta; proximal endopodal segment bearing naked seta on inner median margin; second endopodal segment bearing one serrated fused distal claw, one long apical claw, and one pectinate and one naked setae; distal endopodal segment slightly laterally displaced, bearing one subterminal and six terminal setae. Labrum with serrated median linguiform process on posterior margin. Mandible composed of robust basal part and elongate curved distal part bearing blade with three posterior denticles. Paragnath ovoid with smooth margin. Maxillule represented by small rod with one apical blunt element. Maxilla 2-segmented; proximal segment unarmed; distal claw recurved. Maxilliped 2-segmented; proximal segment rod-shaped without armature; distal segment rod-shaped bearing small apical element.

Legs 1 to 4 biramous, each with 3-segmented rami. Intercoxal sclerite present on legs 1 to 4. Leg 5 2-segmented; proximal segment bearing dorsal seta and row of fine spinules on distal margin; distal segment bearing one outer and two distal naked setae and rows of fine spinules near bases of setae. Leg 6 represented by three long setae at genital opening.

Adult male. Unknown.

Type-species: *Choreftria shiranui* **n. sp.**, by original designation.

Etymology: The new generic name is derived from the Greek noun, χορεύτρια, which means "dancer", making reference to the well-developed long leg 4 of the new genus which is reminiscent of a dancer's leg. The gender is feminine.

Remarks

Choreftria **n. g.** has the following unusual characters on the cephalothorax: 1) the second endopodal segment of the antenna is armed with one fused claw and one long claw, and distal endopodal segment is laterally displaced; 2) the elongate mandible is reduced with a serrated apical blade; and 3) the maxilla is robust with a curved terminal claw. Of cyclopoid copepods, three genera, *Leptinogaster* Pelseneer, 1929, *Pholadicola* Ho & Wardle, 1992, and *Teredicola* C. B. Wilson, 1942 which are defined as members of the *Teredicola*-group by Boxshall & Halsey (2004) share the similar form of antenna and maxilla (see Wilson, 1957; Bocquet & Stock, 1958; Humes & Turner, 1972; Ho & Wardle, 1992; Kim, 2009). Especially, *Leptinogaster* is similar to the new genus in sharing an untransformed body with four well

developed pairs of swimming legs composed of coxae, bases, and both rami 3-segmented (e.g. Humes & Cressey, 1958; Kim & Ho, 1991; Kim, 2009). However, *Choreftria* **n. g.** is distinguished by the possession of a reduced mandible with only the terminal blade while those three other genera each bear two more elements in addition to the apical blade. *Gadilicola* Boxshall & O'Reilly, 2015, the type genus of the monotypic family Gadilicolidae Boxshall & O'Reilly, 2015 shares the similar antenna, mandible, and maxilla with the new genus (see Boxshall & O'Reilly, 2015). However, the body and swimming legs of *Gadilicola* are highly transformed while those of the new genus are not transformed, without distinct reduction.

Choreftria shiranui n. g., n. sp.

LSID urn:lsid:zoobank.org:act:589A498B-96B5-4043-BADF-9D6ACD189D95

New Japanese name: Oshiri-kajiri-mushi.

Type-host: *Taenioides snyderi* Jordan & Hubbs (Actinopterygii: Perciformes: Gobiidae) (KAUM–I–156767, 158.6 mm SL).

Type-locality: Off the mouth of the Kojiro River (32°06'23.9"N, 130°18'23.4"E), Izumi, Kagoshima, the Yatsushiro Sea, Japan.

Attachment site: Surface of the fin membrane of the anal fin (Fig. 1).

Type-material: Holotype, adult female (NSMT-Cr 30590), collected by Reo Koreeda from tidal flat at a depth of 0 m, 1 May 2021.

Fig. 1 Fresh coloration of holotype adult female of *Choreftria shiranui* **n. g., n. sp.** (NSMT-Cr 30590) attached on the anal fin of *Taenioides snyderi* Jordan & Hubbs (KAUM–I–156767, 158.6 mm SL), photographed by Reo Koreeda

Etymology: The specific name "*shiranui*" refers to the name of both the natural phenomenon and folklore creature around the type locality, the Yatsushiro Sea. Further, the alias of the type locality is also the Shiranui Sea.

Description (Figs. 2–4)

Adult female

Body (Fig. 2A) cyclopiform, 1370 long, with greatest width at cephalothorax and second pedigerous somite. Cephalosome and first pedigerous somite forming cephalothorax. Cephalothorax wider than long, 334 × 436. Second to fifth pedigerous somites, genital somite, and four abdominal somites free. Prosome 664 long. Genital somite oval, wider than long, 137 × 248, slightly constricted at anterior third; genital opening situated on ventral surface (Fig. 2B). Abdomen composed of four free somites, 86 × 96, 75 × 98, 69 × 95, and 112 × 85, respectively. Caudal ramus (Fig. 2A, C) 4.84 times longer than wide, 188 × 39, with vertical dorsal ridge near posterior end and one outer, one inner, and four apical setae.

Rostrum absent. Antennule (Fig. 2D) 7-segmented; armature formula 4, 13, 4, 3, 4, 2 + 1 aesthetasc, 7 + 1 aesthetasc; all setae naked, except one plumose seta on posterior margin. Antenna (Fig. 2E) 4-segmented, composed of coxobasis and 3-segmented endopod; coxobasis large, bearing single naked distal seta; proximal endopodal segment bearing naked seta on inner median margin; second endopodal segment bearing one serrated fused distal claw, one long apical claw, and one pectinate and one naked setae; distal endopodal segment slightly laterally displaced bearing one subterminal and six terminal setae. Labrum (Fig. 3A, B) with serrated median linguiform process on posterior margin. Mandible (Fig. 3A, C, D) composed of robust basal part and elongate curved distal part bearing blade with three posterior denticles (Fig. 3D). Paragnath (Fig. 3A, E) ovoid with smooth margin. Maxillule (Fig. 3A, F) represented by small rod with one apical blunt element. Maxilla (Fig. 3A, G) 2-segmented; proximal segment unarmed; distal claw recurved. Maxilliped (Fig. 3A, H) 2-segmented; proximal segment rod-shaped without armature; distal segment rod-shaped bearing small apical element.

Legs 1 to 4 (Figs. 4A–D) biramous, each with 3-segmented rami. Armature formula as follows

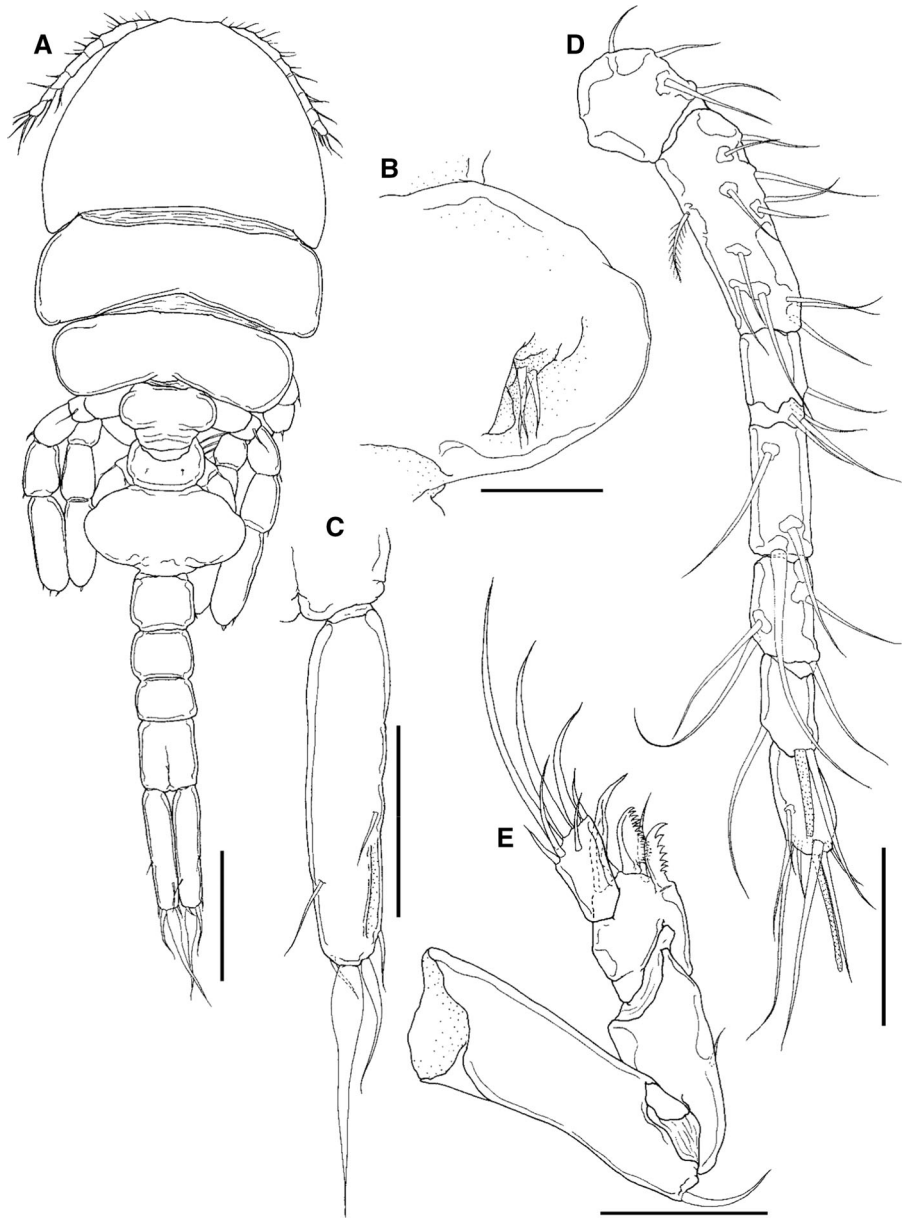

Fig. 2 *Choreftria shiranui* **n. g., n. sp.**, adult female, holotype, NSMT-Cr 30590. A, habitus, dorsal; B, partial genital somite, left side, ventral; C, right caudal ramus, dorsal; D, left antennule, posterior; E. right antenna, posterior. Scale bars: A, 200 μm; B, D, 50 μm; C, 100 μm; E, 30 μm

(Arabic numbers = number of seta, Roman numbers = number of spines):

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-I	I-0; I-1; III, 1, 4	0-1; 0-1; I, 2, 3
Leg 2	0-1	1-0	I-0; I-1; III, 2, 4	0-1; 0-2; II, I, 3
Leg 3	0-1	1-0	I-0; I-1; II, 1, 4	0-1; 0-2; I, 2
Leg 4	0-0	1-0	1-0; 1-1; 1, 2	0-1; 0-1; 1

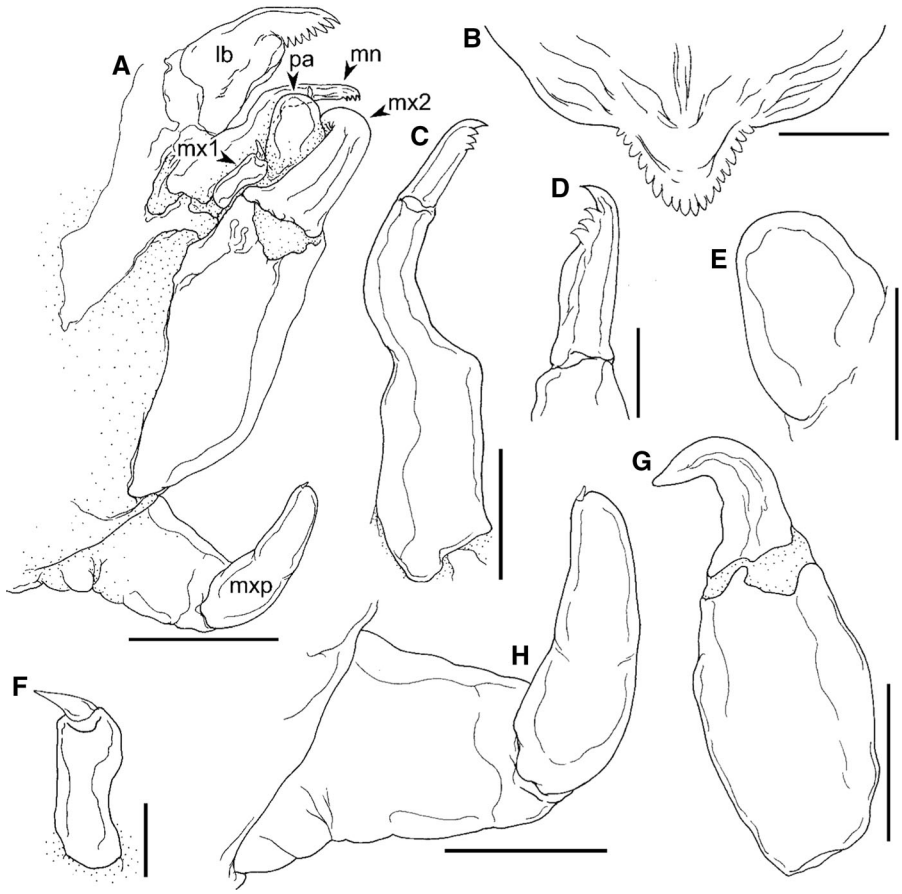

Fig. 3 *Choreftria shiranui* **n. g., n. sp.**, adult female, holotype, NSMT-Cr 30590. A, oral region, right side, lateral, lb = labrum, mn = mandible, pa = paragnath, mx1 = maxillule, mx2 = maxilla, mxp = maxilliped; B, labrum, anterior; C, right mandible, outer; D, distal tip of right mandible, inner; E, right paragnath; F, right maxillule, anterior; G, left maxilla, posterior; H, right maxilliped, outer. Scale bars: A, G, 50 μm; B, C, E, 20 μm; D, F, 10 μm; H, 30 μm

Intercoxal sclerite of leg 1 (Fig. 4A) with pair of marginal rows of hairs. Intercoxal sclerites of legs 2 to 4 (Figs. 4B–D) with pair of posterior rows of spinules. Coxae, bases, and rami of legs 1 to 4 bearing row of spinules on posterior margins. Middle endopodal segments of legs 1 to 3 each armed with pointed distal projection on outer margin. All setae on legs 1 to 3, except on bases, plumose. Leg 5 (Fig. 4E) 2-segmented; proximal segment bearing dorsal seta and row of fine spinules on distal margin; distal segment bearing one outer and two distal naked setae and rows of fine spinules near bases of setae. Leg 6 (Fig. 2B) represented by three long setae at genital opening.

Discussion

As commented in the Remarks section of this paper, *Choreftria* **n. g.** shares several characters with three genera of the *Teredicola*-group. The genera of the *Teredicola*-group were previously placed in the families Clausidiidae Embleton, 1901 or Clausiidae Giesbrecht, 1895 (see Wilson & Illg, 1955; Bocquet & Stock, 1958; Kim & Ho, 1991; Ho & Wardle, 1992; Kim, 2001). The taxonomic affinities of these genera are still controversial but they are often recognized as members of the family Clausidiidae. While the mandibles of the *Teredicola*-group genera, with three or four elements, are similar to that of Clausidiidae (see Humes, 1987; Kim & Stock, 1996; Ho & Kim, 2004; Kim, 2007, 2015; Moon & Kim, 2014; Hwang et al., 2016), that of *Choreftria* **n. g.** is reduced and bears only one apical serrated blade. Humes & Boxshall (1996) consider that the mandible is diagnostic at the family level in their revision of the lichomolgoid complex. Boxshall & O'Reilly (2015) recognized the similarity between the genus *Gadilicola* Boxshall & O'Reilly, 2015 and the genera of *Teredicola*-group but the independent family Gadilicolidae was established to accommodate the genus

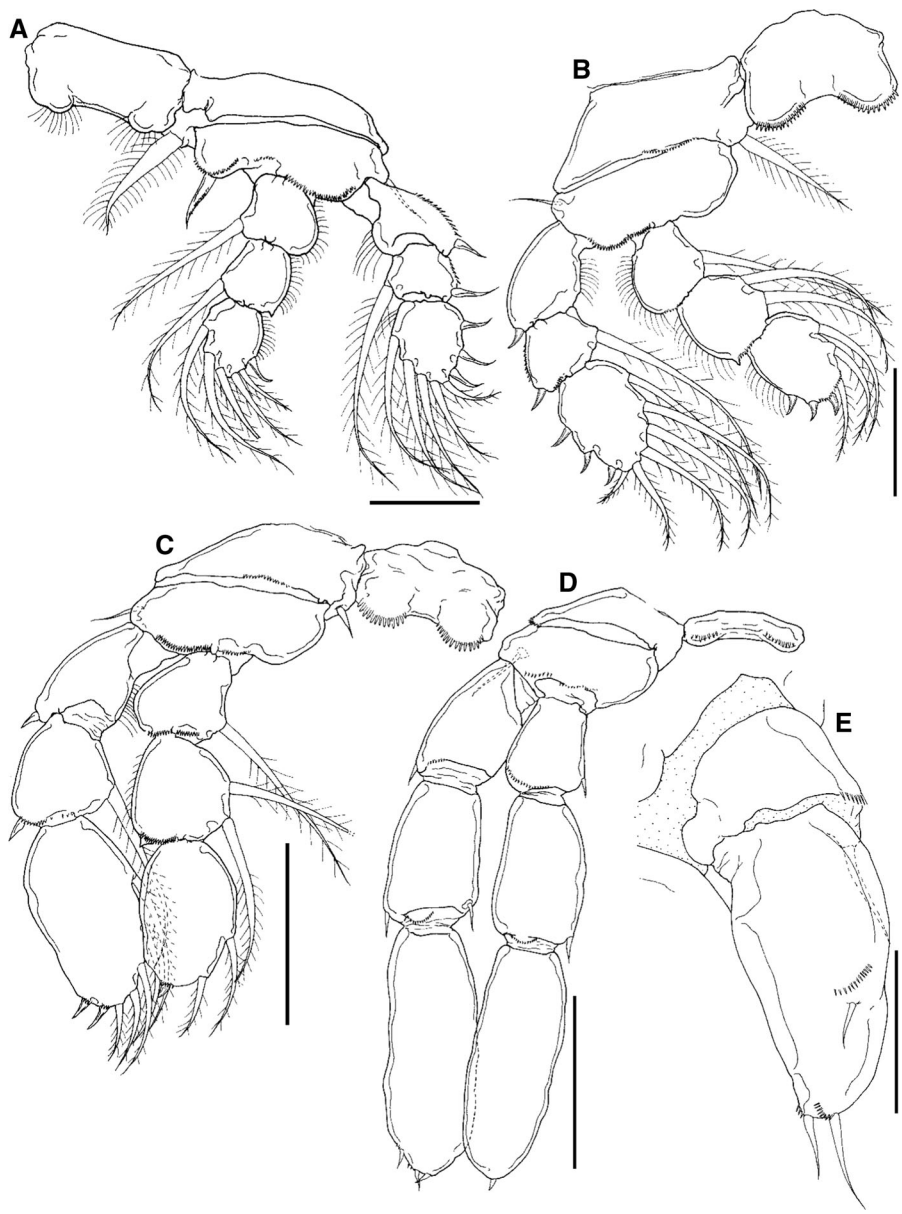

Fig. 4 *Choreftria shiranui* **n. g.**, **n. sp.**, adult female, holotype, NSMT-Cr 30590. A, left leg 1, anterior; B, right leg 2, anterior; C, right leg 3, anterior; D, right leg 4, anterior; E, left leg 5, ventral. Scale bars: A, 50 µm; B, 70 µm; C, D, 100 µm; E, 40 µm

because of it having a reduced mandible with an apical blade. This type of mandible is similar to that of *Choreftria* **n. g.**, and more like that of several genera of the families Clausiidae and Nereicolidae Claus, 1875, but other morphological features (e.g. body segmentation and other appendages, especially the mouth parts) are not similar between the new genus and these three families (see Kim et al., 2013; Boxshall & O'Reilly, 2015; present paper). Therefore, we herein establish a new monotypic family to accommodate *Choreftria* **n. g.** Just as Boxshall & O'Reilly (2015) mentioned with Gadilicolidae, confirming the validity of the new family is required based on further phylogenetic research. Although the enlarged female's leg 4 of *Choreftria* **n. g.** is similar to that of *Telson* Pearse, 1952, there are many differences in other appendages between those two genera (see Causey, 1960; Ho, 1967). From sharing the maxilliped of female with a sigmoid bifurcate claw, *Telson* is considerable to be related to Bomolochidae Claus, 1875 and Makrostrotidae Huys et al., 2012 rather than Clausidiidae and its allied genera (see Huys et al.,

2012). The possession of two serrated mandibular blades of *Telson* also differs from *Choreftria* **n. g.**

While almost all of the genera that are possibly related to *Choreftria* **n. g.** (i.e. species of *Teredicola*-group, Clausidiidae, Clausiidae, Gadilicolidae, and Nereicolidae) have been recorded from molluscs and polychaetes, *C. shiranui* **n. g., n. sp.** was found from a fish. There are several similar records among parasitic copepods of apparent host switching from invertebrate to vertebrate hosts. Members of the family Anthessiidae are known to be associated with molluscan hosts but *Anthessius lophiomi* Avdeev & Kazachenko, 1986 inhabits the angler fish, *Lophiomus setigerus* (Vahl) (Lophiiformes: Lophiidae) (Avdeev & Kazachenko, 1986). The family Macrochironidae is known to be associated with cnidarians but *Paramacrochiron sewelli* Reddiah, 1968, a member of the family, was recorded from the mackerel *Trachurus trachurus* (Linnaeus) (Perciformes: Carangidae) in addition to the scyphozoan jellyfish *Lychnorhiza malayensis* Stiasny (Rhizostomeae: Lychnorhizidae) (Reddiah, 1968) (Avdeev, 1975). Furthermore, in recent years, *Pseudanthessius* sp. which is a member of Pseudanthessiidae was described from the grouper *Epinephelus* sp. (Perciformes: Serranidae) while most of other known congeners have been found from various invertebrates (e.g. poriferans, turbellarians, gastropods, polychaetes, echinoids, crinoids, and ophiuroids) (e.g. Humes & Stock, 1973; Uyeno & Rain, 2021). This may be because of the extraordinary host change that occurred from invertebrates to fishes, and the finding of *C. shiranui* **n. g., n. sp.** from the worm goby *Taenioides snyderi* might be a new example. It is probably not an accidental infection because the copepod was firmly attached to the host's anal fin by the antennae when the specimen was collected. Although *C. shiranui* **n. g., n. sp.** shows some similarities in the mouthparts with the copepods associated with marine invertebrates (*i.e.*, with *Teredicola*-group, Clausidiidae, Clausiidae, Gadilicolidae, and Nereicolidae), it is difficult to define that *C. shiranui* **n. g., n. sp.** is commensal or parasitic at this stage. Since only one adult female of *C. shiranui* **n. g., n. sp.** was found in this study, it is desirable that additional specimens will be found in the future to help understand its biology.

Choreftriidae n. fam.

LSID urn:lsid:zoobank.org:act:B5F24254-6CEC-4F5F-98BD-C1DDC5BAE3DF

New Japanese name: Oshiri-kajiri-mushi-ka.

Diagnosis

As for the genus.

Type-genus: *Choreftria* **n. g.**, by original designation.

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Author contributions DU has carried out all the procedures in the preparation of the manuscript.

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Declarations

Conflict of interest The author has no competing interests to declare.

Data availability See Material Examined section.

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