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Trebius benzi n. sp. (Siphonostomatoida: Trebiidae) infecting *Squalus acutipinnis* Regan off South Africa

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Abstract *Trebius* Krøyer, 1838 currently consists of 15 accepted species all infecting elasmobranchs. Apart from two species, i.e. *T. caudatus* Krøyer, 1838 and *T. latifurcatus* Wilson, 1921, that have been reported from ten and eight host species, respectively, the other 13 species have each been reported from only one or two host species. *Trebius benzi* n. sp., collected from *Squalus acutipinnis* Regan, is described and illustrated after examination through stereo- and compound microscopes. This species can be distinguished from the other known species by a combination of characters including an abdomen that is shorter than the genital complex, a maxillule with an endite that consists of a single-tined dentiform process, sternal furca tines that are blunt and as long as the base, and the innermost spine of the last exopodal segment of leg 1 the shortest.

Introduction

Representatives of the family Trebiidae C.B. Wilson, 1905 differ from the members of the Caligidae Burmeister, 1835 in the presence of free third and fourth pedigerous somites between the cephalothorax and genital complex (Kabata, 1979) and a biramous fourth leg (similar to *Avitocaligus* Boxshall & Justine, 2005 and *Euryphorus* Milne Edwards H., 1840 in Caligidae) (Boxshall & Halsey, 2004; Boxshall & Justine, 2005). Even though there is great morphological similarity between the members of the two families they differ vastly in their life cycles (Trebiidae lacking a chalimus phase *vs* Caligidae with four chalimus stages) and reproductive behaviour [copulation in Trebiidae taking place in copepodid III and/or IV females (according to Izawa's interpretation), but only in the adult females in Caligidae] (Izawa, 2013).

Trebiidae currently consists of *Kabataia ostorhinchi* Kazachenko, Korotaeva & Kurochkin, 1972 described from a teleost [probably *Oplegnathus woodwardi* Waite (see Froese & Pauly, 2016)] and 15 accepted species of *Trebius* all described from elasmobranchs (Kabata, 1979; Deets & Dojiri, 1989; Nagasawa et al., 1998). No records could be found on the validity of *T. cyclopteri* (Beneden, 1870) and *T. soleae* (Beneden, 1861) (see Walter & Boxshall, 2015). *Trebius caudatus* Krøyer, 1838 seems to be the most generalist species being reported from both rays (eight species) and sharks (two species) followed by *T. latifurcatus* Wilson, 1921 reported from eight species of rays while other species seem to be specialists being reported from only one or two host species (Boxshall & Halsey, 2004). Species of *Trebius* are mostly ectoparasites on the body surface or inside the brachial chambers of their hosts (see Nagasawa

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et al., 1998) while *T. shiinoi* Nagasawa, Tanaka & Benz, 1998 was reported as an endoparasite inside the uteri and on the body surface of embryos (Nagasawa et al., 1998) as well as an ectoparasite on the body surface, brachial lamellae, and buccobranchial cavity of *Squatina japonica* Bleeker (see Izawa, 2013). The only report of a *Trebius* species from a host species of *Squalus*, is *T. caudatus* from *S. acanthias* Linnaeus (Boxshall & Halsey, 2004).

Materials and methods

Copepods were collected from the gill filaments of *Squalus acutipinnis* Regan taken as bycatch in demersal trawls conducted during commercial hake and sole fishing off Mossel Bay, Western Cape, South Africa. The heads of caught sharks were cut off and frozen and later defrosted and examined for infection by copepods. Collected copepods were preserved in 70% ethanol, cleared, and stained in lactic acid with a small amount of dissolved lignin pink before being dissected. They were studied using both stereo- and light microscopes with the wooden slide technique (Humes & Gooding, 1964) and drawn with the aid of a drawing tube. Measurements were done using a stage micrometer. Anatomical terminology used conforms mostly to that of Huys & Boxshall (1991) and Kabata (1979) while host nomenclature is according to Ebert & Van Hees (2015).

Family Trebiidae Wilson C.B., 1905
Genus *Trebius* Krøyer, 1837

Trebius benzi n. sp.

Type-host: *Squalus acutipinnis* Regan (Chondrichthyes: Squaliformes: Squalidae).
Type-locality: Off Mossel Bay, Western Cape, South Africa.
Site in host: Gill filaments.
Material studied: Three adult females (somewhat contracted and shrivelled) from three different hosts on the 3rd of April 2013.
Type-material: One adult female (holotype) (SAMC-A085806) deposited in the Iziko South African Museum, Cape Town, South Africa. Remaining females (1 dissected) have been retained in the personal collection of the author.
Etymology: The species epithet, *benzi*, is in honour of Dr George Benz in recognition of his major contribution to our knowledge and understanding of siphonostomatoids infecting elasmobranchs.

Description (Figs. 1, 2)

Adult female
Cephalothorax (Figs. 1A, B) wider than long with well-developed frontal plates; tips of antennules not extending beyond lateral margins of cephalothorax bearing thin marginal membranes; posterior sinuses conspicuous, fringed by marginal membranes. Third pedigerous somite (Fig. 1A) wider than long, slightly shorter than posterior lobe of cephalothorax. Fourth pedigerous somite (Fig. 1A) narrowed anteriorly, posteriorly about half width of third pedigerous somite. Genital complex (Fig. 1A) elongated, about as long as cephalothorax (no spinules or spinulated processes observed posterolaterally, maybe due to contraction?). Abdomen (Fig. 1A) 3-segmented, about two thirds length of genital complex; first somite almost twice length of each of second and third somites. Caudal rami (Fig. 2G) about twice as long as wide, posterior margin pointed, medial margin with setules, distally bearing 6 pinnate setae; 3 long setae terminally; 2 shorter, unequal setae distolaterally; 1 small ventral seta distomedially. (No measurements taken due to contracted state of specimens, but female about 3.7 mm including caudal rami).

Antennule (Fig. 1C) 2-segmented (3rd segment, see, Izawa, 2013, not observed); first segment with numerous (probably 27) pinnate setae; second segment seemingly 2-segmented, much narrower than first with one seta halfway along length, distally with cluster of setae of varying lengths (none with branched tips observed) and at least one aesthetasc. Antenna (Fig. 2A) subchelate, unciform claw, 4-segmented; first segment broad with 3 small processes; second segment slightly narrower with conspicuous indent on distolateral margin, third segment with large corrugated process laterally; claw with proximal naked seta and another about mid-length on inner margin. Postantennal process (Fig. 2A) an inflated base with finger-like projection longer than base. Mandible (Fig. 1D) stylet with 12 small teeth distomedially. Maxillule (Fig. 1E) bilobed; palp (anterior lobe) papillate, bearing 3 naked seta, 1 long (extending to about mid-length of endite) and 2 very short; endite

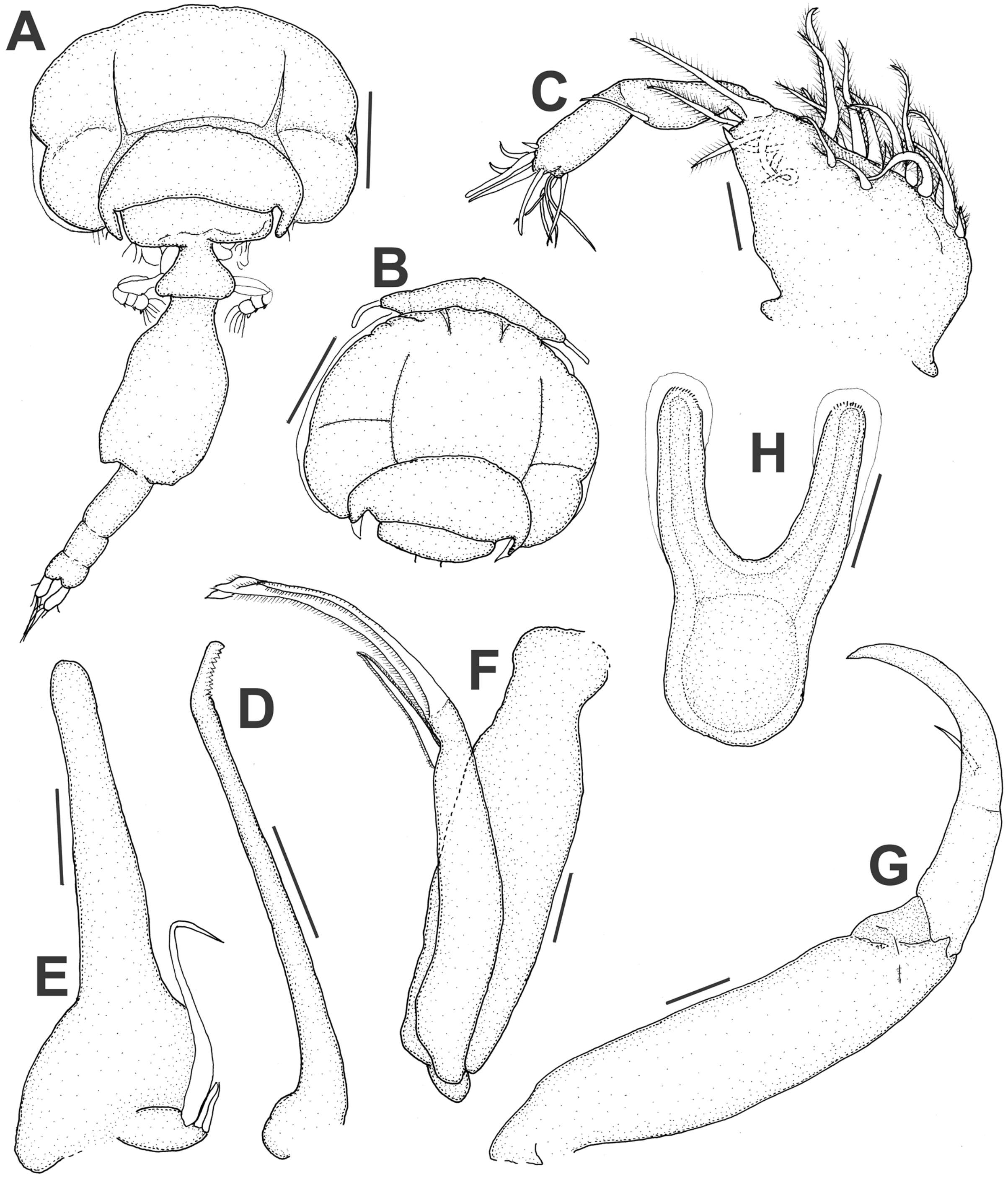

Fig. 1 *Trebius benzi* n. sp. ex *Squalus acutipinnis* Regan. Adult female. A, Habitus, dorsal view of contracted specimen with frontal plates and antennules curled ventrally; B, Cephalothorax with frontal plates and antennules, dorsal view; C, Antennule; D, Mandible; E, Maxillule; F, Maxilla; G, Maxilliped; H, Sternal furca. *Scale-bars*: A, B, 0.5 mm; C–H, 50 µm

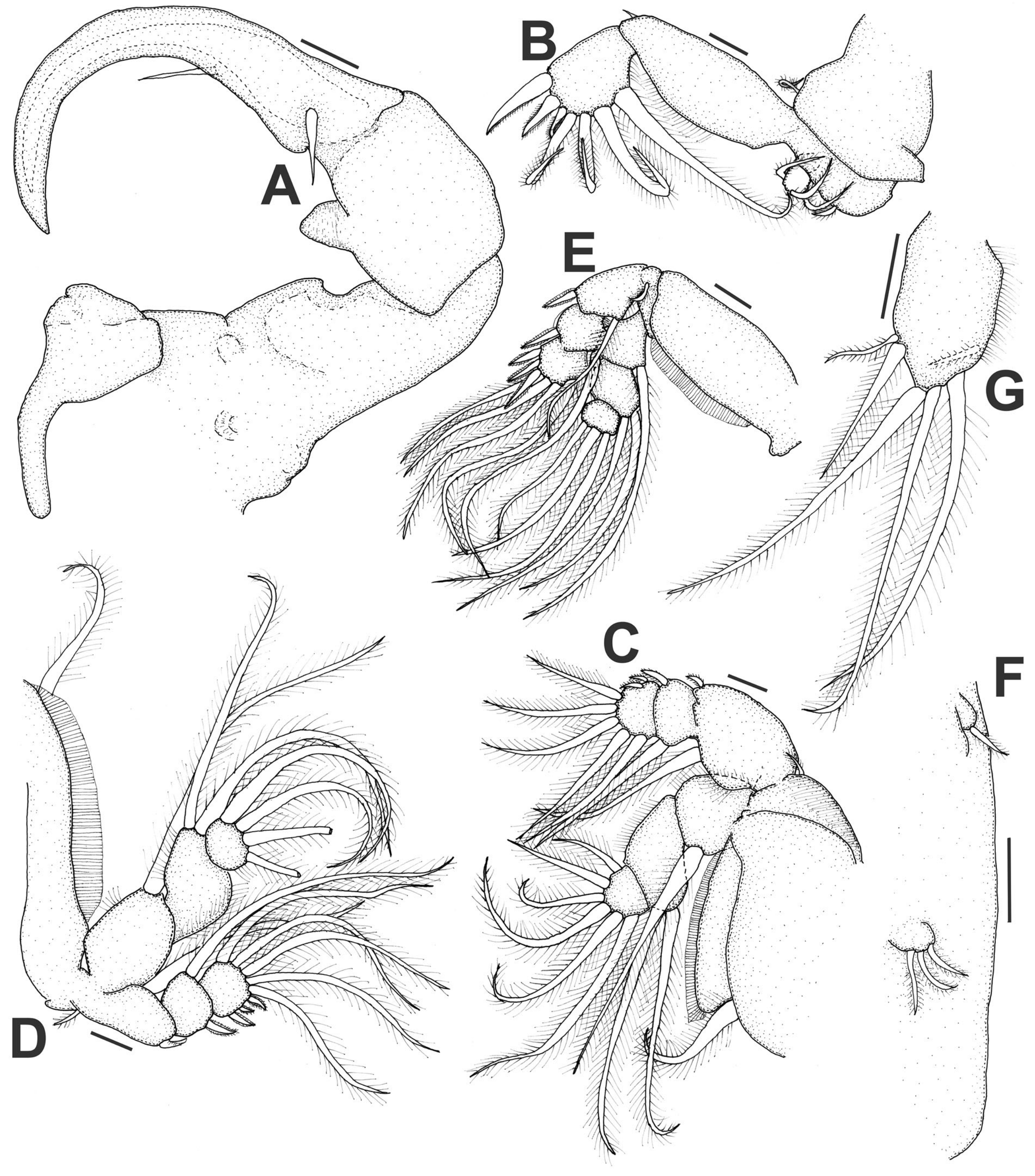

Fig. 2 *Trebius benzi* n. sp. ex *Squalus acutipinnis* Regan. Adult female. A, Antenna and postantennal process; B, Leg 1; C, Leg 2; D, Leg 3; E, Leg 4; F, Leg 5, ventral on genital complex; G, Caudal ramus. *Scale-bars*: 50 µm

(posterior lobe) dentiform process. Maxilla (Fig. 1F) brachiform; lacertus unarmed; brachium with calamus and canna both fringed by serrated membranes. Maxilliped (Fig. 1G) 2-segmented, subchelate; corpus maxillipedis slender, unarmed with few denticles distomedially; subchela slightly shorter than corpus, tapering with naked seta near base of claw. Sternal furca (Fig. 1H) with divergent, blunt tines (longer than box) fringed by narrow flanges.

Legs 1–4 (Figs. 2B, C, D, E) biramous; rami 2-segmented in leg 1; 3-segmented in legs 2–4. Leg 1 (Fig. 2B) sympod with small outer and inner pinnate setae; exopod first segment elongated with medial fringe of setules and small distolateral spine; second segment armed with medial setules followed by 4 pinnate setae (decreasing in length from medial to distal), 1 spiniform seta with serrated lateral margins, 1 larger spiniform seta with serrated lateral margins, and 1 large spiniform seta with serrated medial margin; endopod first segment small, unarmed; second segment armed with three pinnate setae distally. Leg 2 (Fig. 2C) sympod with pinnate outer and inner setae and medial membrane; exopod first segment with medial setules, distomedial pinnate seta and distolateral spiniform seta with serrated margins; second segment with distomedial pinnate seta and distolateral spiniform seta with serrated margins; third segment with 5 pinnate setae (decreasing in length from medial to distal) and 2 small lateral spiniform setae with serrated margins; endopod first segment with lateral setules and pinnate seta distomedially; second segment with lateral setules and 2 distomedial pinnate setae; third segment bearing 6 pinnate setae (decreasing in length from medial to lateral). Leg 3 (Fig. 2D) sympod with small pinnate outer seta, large pinnate inner seta and medial membrane; exopod first segment with medial setules, distomedial pinnate seta and distolateral spiniform seta with serrated margins; second segment with distomedial pinnate seta and distolateral spiniform seta with serrated margins; third segment with 5 pinnate setae (slightly decreasing in length from medial to distal) and 3 lateral spiniform setae with serrated margins (middle one smallest); endopod first segment with lateral setules and pinnate seta distomedially; second segment with lateral setules and 2 distomedial pinnate setae; third segment bearing 4 pinnate setae distally. Leg 4 (Fig. 2E) sympod with small pinnate outer seta and medial membrane; exopod first segment with medial setules, distomedial pinnate seta and distolateral spiniform seta with serrated margins; second segment with distomedial pinnate seta and distolateral spiniform seta with serrated margins; third segment with 4 pinnate setae (slightly decreasing in length from medial to distal) and 3 lateral spiniform setae with serrated margins; endopod first segment with lateral setules and pinnate seta distomedially; second segment with lateral setules and 2 distomedial pinnate setae; third segment bearing 3 pinnate setae distally. Leg 5 (Fig. 2F) vestigial, consisting of 2 setiferous papillae with 1 and 3 small pinnate setae, respectively.

Discussion

According to Deets & Dojiri (1989) eight of the *Trebius* species possess a maxillule in which the endite consists of a single-tined dentiform process (also see Nagasawa et al., 1998; Izawa, 2013) and seven species have an endite with a bifid dentiform process. Four of the eight species (*T. exilis* Wilson, 1906; *T. javanicus* Hameed & Pillai, 1973; *T. kirtii* Hameed & Pillai, 1973 and *T. sepheni* Hameed & Pillai, 1973) with a single-tined dentiform process were reported from rays from the Indian Ocean (Pillai, 1985). However, all four have similar sternal furca with a large base and short, pointed tines (see figure 68A in Pillai, 1985) whereas in *T. benzi* n. sp. the base and the rounded tines are about equal in length (see Fig. 1H). Additionally, three other single-tined dentiform species (*T. elongatus* Capart, 1953; *T. minutus* Capart, 1959; *T. nunesi* Capart, 1959) have more pointed tines (cf. Deets & Dojiri, 1989) while all three also have abdomens that are equal to or longer than the genital complex (Capart, 1959; Deets & Dojiri, 1989) while that of *T. benzi* n. sp. is shorter (see Fig. 1A). The last species with a single-tined dentiform process, i.e. *T. shiinoi*, has an abdomen that is much longer than the genital complex, the tine of the dentiform process has an additional small protuberance about two thirds along the medial margin as well as additional secondary tines on the sternal furca (Nagasawa et al., 1998; Izawa, 2013). Thus, *T. benzi* n. sp. can be distinguished from all the other species by the combination of an abdomen that is shorter than the genital complex (Fig. 1A), a maxillule with an endite that consists of a single-tined dentiform process (Fig. 1E), sternal furca tines that are blunt and as long as the base (Fig. 1H) and with the innermost spine of the last exopodal segment of leg 1 the shortest (Fig. 2B) (see Deets & Dojiri, 1989).

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Compliance with ethical standards

Conflict of interest The author declares that she has no conflict of interest.

Ethical approval All applicable institutional, national and international guidelines for the care and use of animals were followed.

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