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VERSITA

Redescription of *Caligus serratus* Shiino, 1965 (Copepoda: Caligidae) parasitic on eleven fish species from Chamela Bay in the Mexican Pacific

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Abstract

Caligus serratus Shiino, 1965 (Copepoda: Caligidae), a parasite on 11 fish species caught in Chamela Bay off the Pacific Coast of Mexico, is redescribed based on material found on Pacific agujon needlefish *Tylosurus pacificus* (Steindachner, 1876). *Caligus serratus* can be distinguished from its congeners by the combination of the following characters: i) short abdomen (approximately 0.2 times as long as cephalothorax), ii) pointed posteromedial process on the first segment of the antenna, iii) sternal furca with bluntly pointed, diverging tines, and iv) leg 4 exopod bearing 3 unequal, distal spines (the shortest 0.2 times the length of the longest). Microphotographs of female and illustrations of both female and male are provided. The redescription of this species might be useful given its low host specificity.

Keywords

Siphonostomatoida, parasitic crustaceans, marine fish, tropical Pacific, Mexico

Introduction

The Caligidae Burmeister, 1834 is a family in the copepod order Siphonostomatoida Thorell, 1859 that includes the genus *Caligus* Müller, 1785. This is the largest genus of parasitic copepods, containing more than 250 species predominantly found on marine fishes (Ho and Lin 2004). Only 19 species of *Caligus* have been recorded from Mexican systems. Thirteen of these are known from the Pacific coast (Morales-Serna *et al*. 2012). However, during recent surveys for parasitic copepods on marine fishes of commercial importance from Chamela Bay, Jalisco State (Mexican Pacific), another 10 species hitherto unknown to occur in Mexico were found (Morales-Serna *et al*. submitted).

Previous surveys in Chamela Bay revealed the presence of 16 species of *Caligus*, with *Caligus serratus* Shiino, 1965 being the most common; this species was found on 11 fish species belonging to 9 families (Morales-Serna *et al*. submitted). *Caligus serratus* has been reported earlier on the bullseye puffer *Sphoeroides annulatus* (Jenyns, 1842) from Santa María La Reforma lagoon, another locality in the Mexican Pacific (Morales-Serna *et al*. 2011). Before those findings, *C. serratus* had not been sighted since its original description from the jack silverside *Atherinopsis californiensis* Girard, 1854 caught near La Jolla, California, U.S.A. almost 50 years ago (Shiino 1965).

Given that some taxonomically important details were not mentioned in the original description of *C. serratus*, which seems to be a common parasite of marine fishes from the Mexican Pacific, a full redescription of the species is provided here in. Considering that some species of *Caligus* are causing problems in aquaculture worldwide (Ho 2000; Johnson *et al*. 2004; Costello 2006), a more precise taxonomic description of the species is needed given the promotion of cage aquaculture in the Mexican Pacific, including Chamela Bay.

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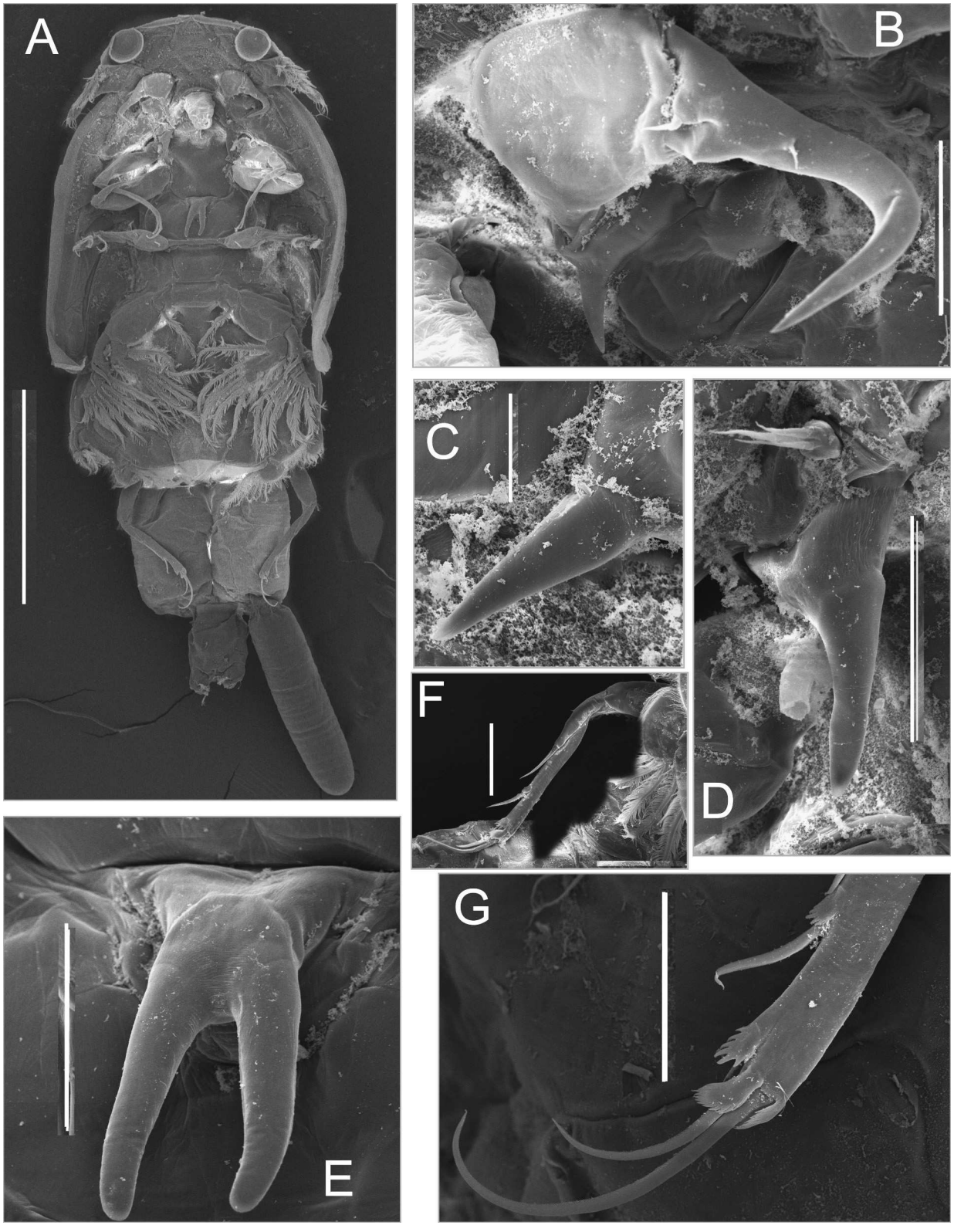

Fig. 1. *Caligus serratus* Shiino, 1965, female. **A**. Habitus, ventral; **B.** Antenna, ventral; **C.** Pointed posteromedial process of the first segment of antenna; **D.** Maxillule, ventral; **E.** Sternal furca, ventral; **F.** Leg 4, ventral; **G.** Tip of leg 4, ventral. Scale-bars: 1 mm in A; 100 µm in B, D, E and G; 20 µm in C; 200 µm in F

Materials and Methods

Fishes were collected in Chamela Bay (19°31´N, 105°4´W), located in the state of Jalisco, on the Pacific coast of Mexico. The parasitic copepods were removed from the fish and preserved in 100% ethanol. For the morphological study, copepods were mounted on semi-permanent slides and cleared with lactic acid to facilitate observation under the light microscope. Drawings were made with the aid of a drawing tube attached to an Olympus BX40 compound microscope. Three specimens were dehydrated through a graded series of ethanol, subjected to critical point drying with carbon dioxide, sputter-coated with gold, and then examined at 15 kV in a Hitachi Scanning Electron Microscope S-2460N (Hitachi Ltd., Tokyo, Japan). Measurements are documented as the mean followed by the range in parentheses. The description of the female is given in full but that of the male is confined only to those parts showing sexual dimorphism. Voucher specimens were deposited in the Colección Nacional de Crustáceos (CNCR 27696–27722), Instituto de Biología, Universidad Nacional Autónoma de México.

Results

Order Siphonostomatoida
Family Caligidae Burmeister, 1835
Genus *Caligus* Müller, 1785

***Caligus serratus* Shiino, 1965** (Figs 1–5)

Material examined: 3 females and 2 males (CNCR 27722), body surface of *Tylosurus pacificus* (Steindachner, 1876) (Belonidae), from Chamela Bay, Jalisco, Mexico, February 2011, specimens undissected, ethanol preserved.

Female: Body shape as for the genus (Figs 1A, 2A), total body length measured from anterior part of cephalothoracic shield to posterior margin of caudal rami, ranging from 2.91 to 3.41 mm (mean 3.22 mm; n = 3). Cephalothoracic shield almost as long as wide (Fig. 2A). Frontal plates bearing a tiny setule situated midway between each lunule and median line. Lateral margins of cephalothoracic shield carrying a single setule just behind the middle. Fourth pedigerous somite wider than long, fused with genital complex (Fig. 2A). Genital complex (Fig. 2A) suborbicular, as long as it is wide. Abdomen (Fig. 2B) short, 1-segmented, slightly longer than wide, approximately 0.2 times as long as cephalothorax. Caudal rami (Fig. 2B) almost as long as wide, ornamented with inner row of setules subterminally, and armed with 3 short and 3 long distal setae.

Antennule (Fig. 2D) 2-segmented; proximal segment with 25 plumose and 2 naked setae; distal segment armed with 1 naked subdistal seta on posterior margin, and 11 naked setae and 2 aesthetascs distally.

Antenna (Figs 1B, C; 3A (A1)) 3-segmented; proximal segment smallest, with short, pointed posteromedial process; middle segment subrectangular and unarmed; distal segment forming curved, sharp claw bearing 1 small proximal seta, and 1 small seta in middle region. Postantennal process (Fig. 3A (A2)) a small claw bearing 2 basal papillae with 2 setules each, another similar papilla nearby on sternum.

Maxillule (Figs 1D, 3A (A3)) comprising dentiform process and basal papilla with 3 unequal setae.

Mandible (Fig. 3B) 4-segmented; with 12 teeth on medial margin of distal blade.

Maxilla (Fig. 3C) 2-segmented, brachiform; proximal segment (lacertus) unarmed; distal segment (brachium) carrying small, subdistal outer hyaline membrane (flabellum), and 2 unequal elements distally (a short canna, and a long calamus).

Maxilliped (Fig. 3D) 3-segmented; proximal segment (corpus) largest, with small subterminal denticle; middle segment (shaft) shortest, with subterminal denticle; distal segment (claw) with short medial seta.

Sternal furca (Figs 1E, 3E) with bluntly pointed, diverging tines.

Leg 1 (Fig. 4A, B). Coxa with 1 plumose outer seta and 1 plumose inner seta. Endopod vestigial, as a small process tipped with 1 tiny setule. Exopod 2-segmented; first segment with a row of posterior setules and with small, spiniform, subapical seta; second segment with 4 apical and 3 outer elements, of which medial two apical elements with accessory process (arrowed in Fig. 4B), outermost apical element about twice as long as innermost apical element.

Leg 2 (Fig. 4C). Coxa small, with large plumose inner seta on distal edge and a setule-bearing papilla on anterior surface. Basis robust, with small outer seta in addition to long setule-bearing papilla on anterior surface, close to base of inner marginal membrane. Exopod 3-segmented, first exopodal segment with spine across and slightly beyond second segment; second exopodal segment with short spine reaching middle of last segment; third exopodal segment with two small outer spines, one apical spine (as long as last two segments combined) and five outer elements. Endopod 3-segmented; first segment with 1 inner seta; second segment with outer row of setules, and armed with 2 inner setae; third segment with 6 setae.

Leg 3 (Fig. 4D). Protopod (apron) with large marginal membrane on outer and inner margins. Setae as in figure and typical for the genus. Exopod 3-segmented; first segment with 1 outer setule and 1 stout, slightly recurved spine with thin flange along outer margin; second segment with 1 outer spine and 1 inner seta. Endopod 2-segmented; first segment with 1 inner seta; second segment with 6 elements.

Leg 4 (Figs 1F, G, 5A, B). Protopod with 1 plumose outer seta. Exopod 2-segmented; first segment with 1 apical element reaching base of middle lateral seta of second segment; second segment with 1 outer element and 3 unequal apical spines, outermost shortest (arrowed in Fig. 5B). Pectens at insertion of each of 4 elements of second exopodal segment.

Armature of legs 1–4 as follows (Roman numerals indicating spines and Arabic numerals setae)

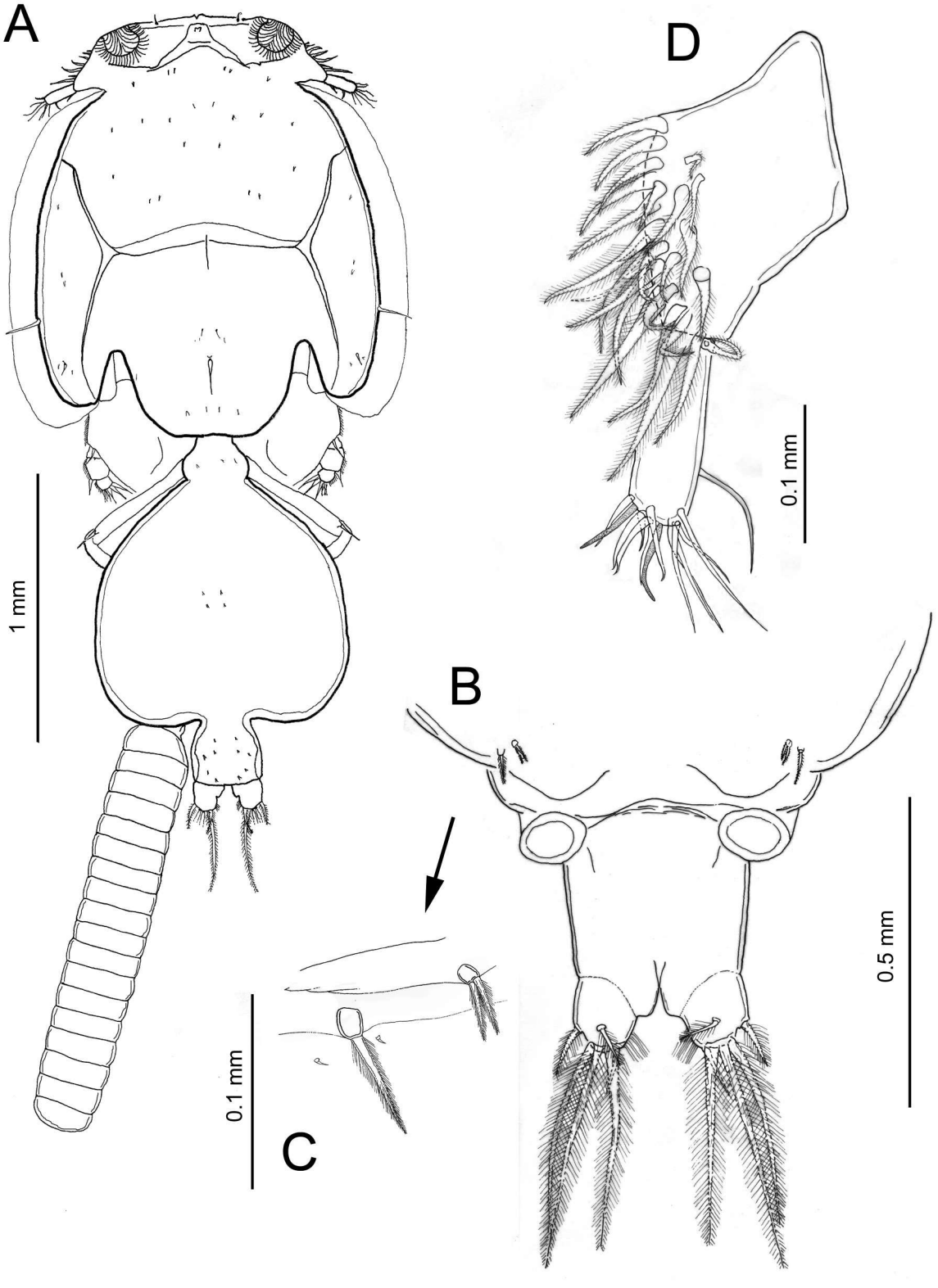

Fig. 2. *Caligus serratus* Shiino, 1965, female. **A.** Habitus, dorsal; **B.** Abdomen, ventral; **C.** Leg 5, ventral; **D.** Antennule, ventral

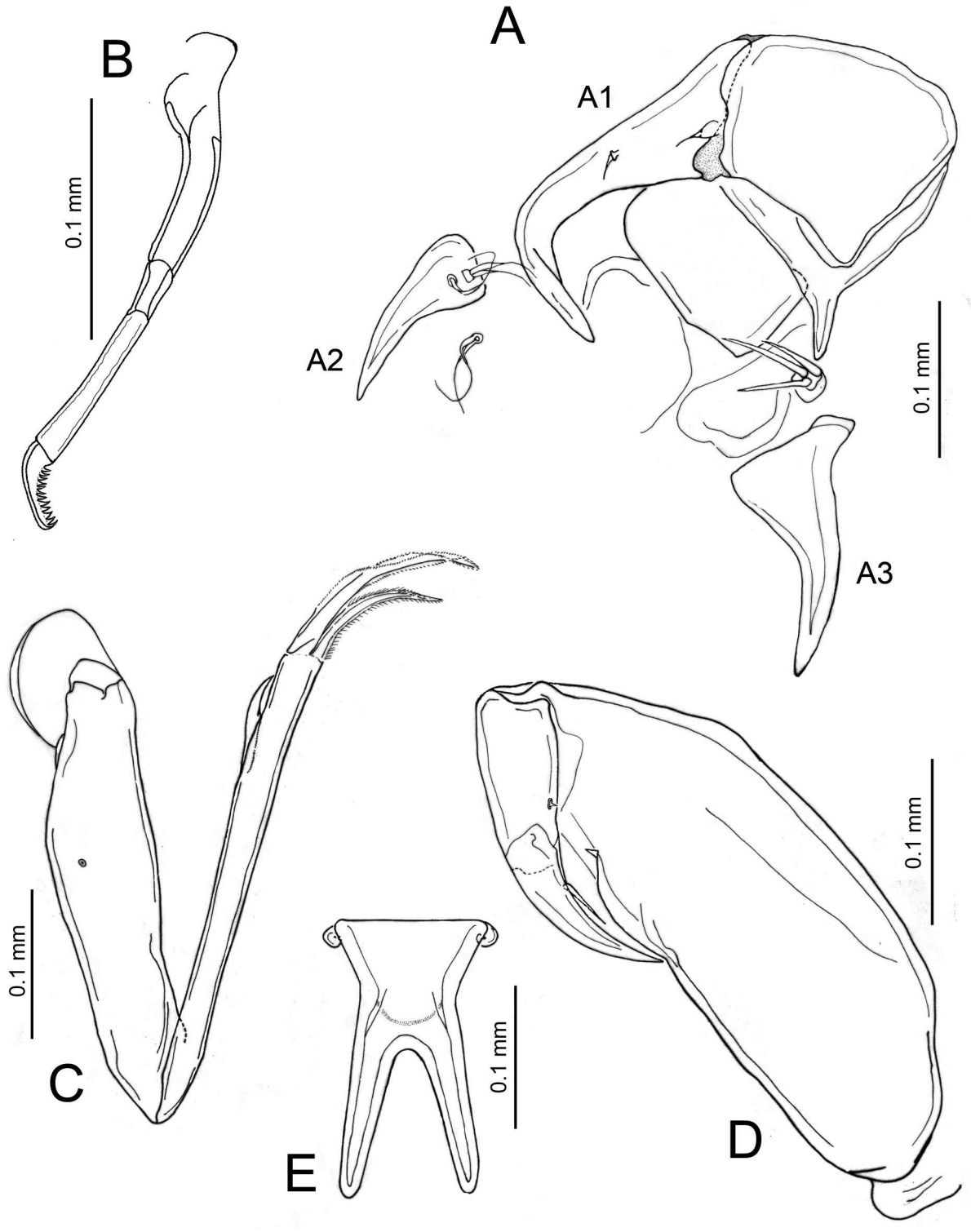

Fig. 3. *Caligus serratus* Shiino, 1965, female. **A.** Antenna (A1), postantennal process (A2), and maxillule (A3); **B.** Mandible, ventral; **C.** Maxilla, ventral; **D.** Maxilliped, ventral; **E.** sternal furca, ventral

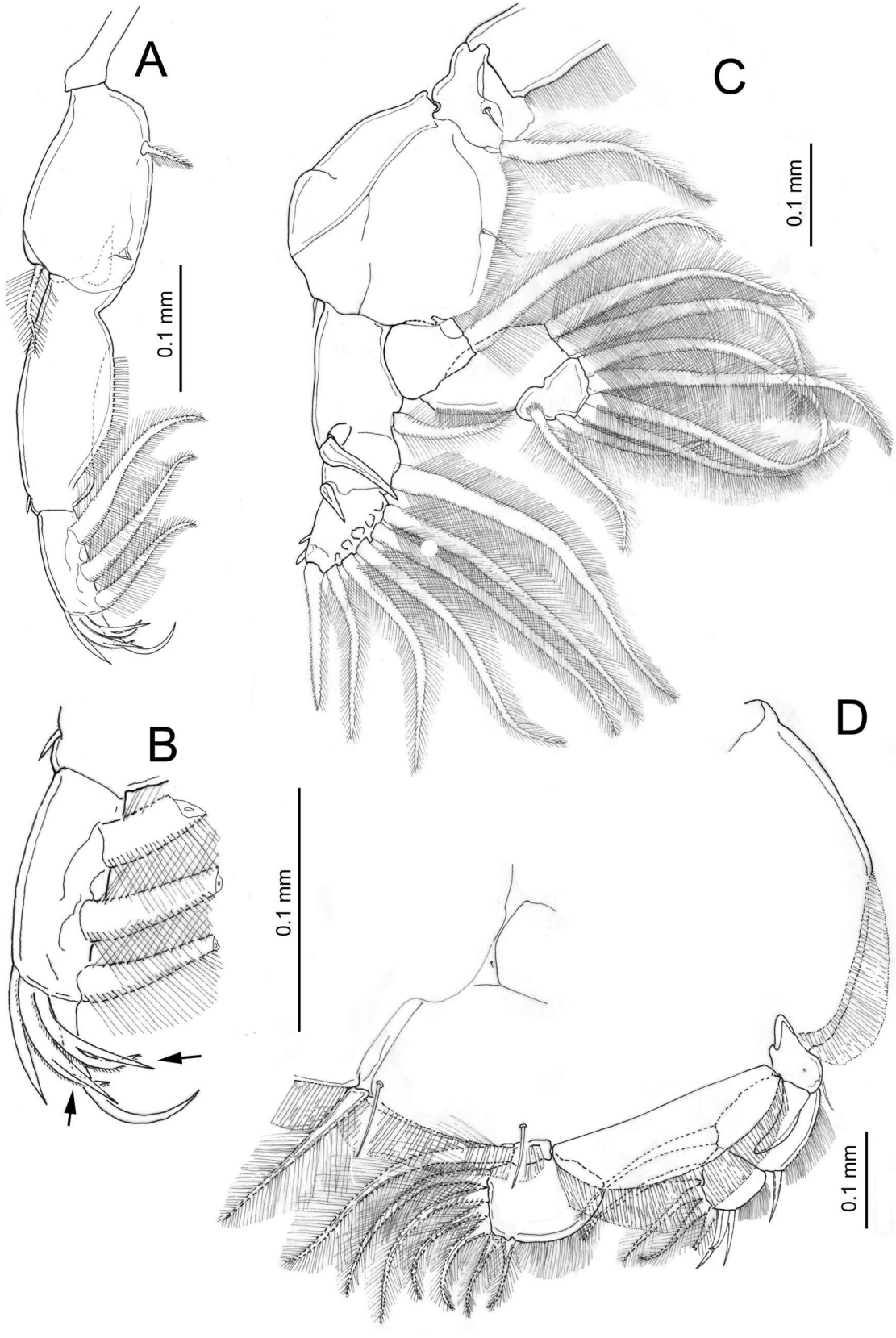

Fig. 4. *Caligus serratus* Shiino, 1965, female. **A.** Leg 1, anterior; **B.** Tip of leg 1 [arrows showing medial two apical elements with accessory process]; **C.** Leg 2, anterior; **D.** Leg 3, anterior

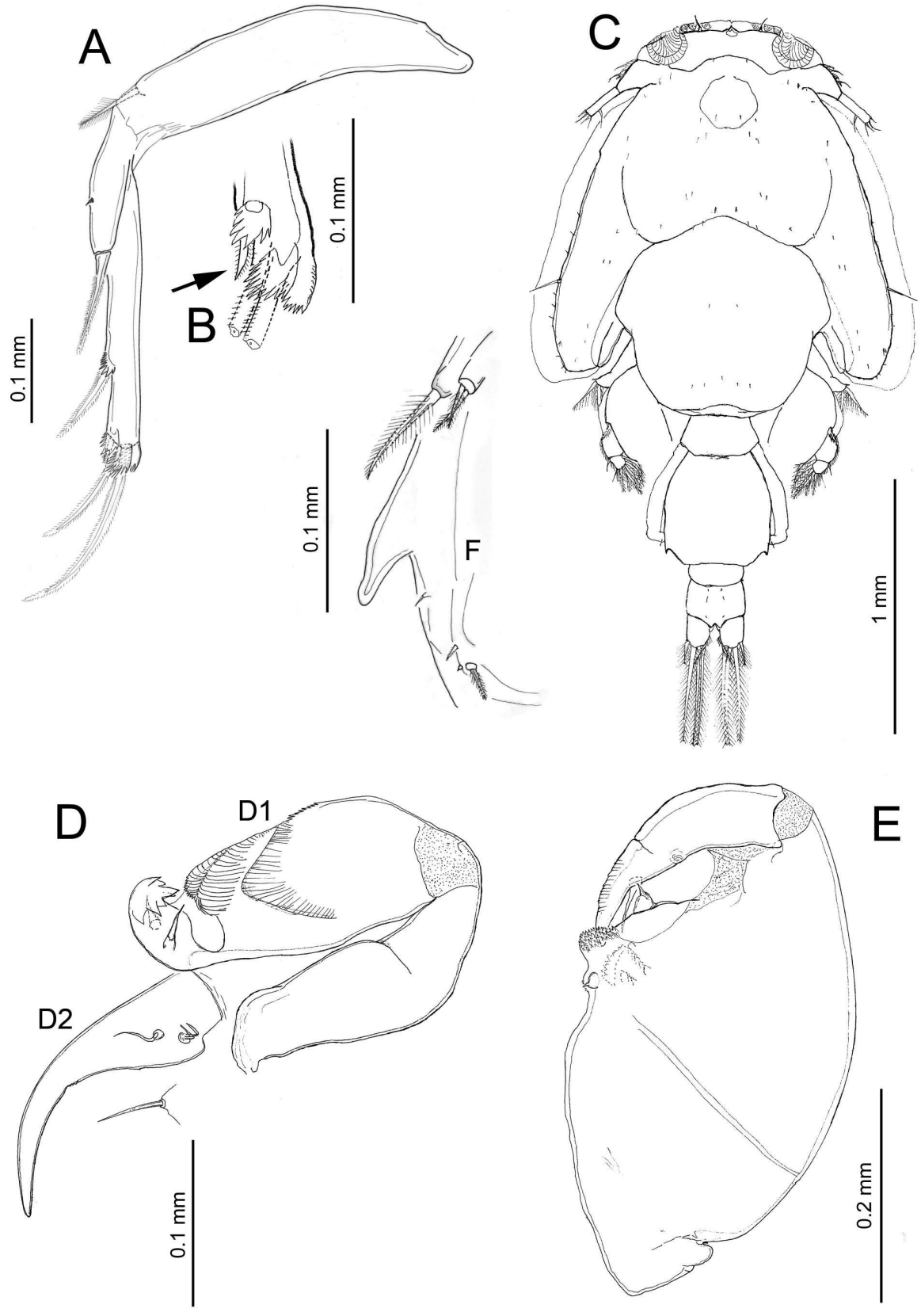

Fig. 5. *Caligus serratus* Shiino, 1965, female. **A.** Leg 4, anterior; **B.** Tip of leg 4 [arrow showing the shortest spine]; Male. **C.** Habitus, dorsal; **D.** Antenna (D1) and postantennal process (D2); **E.** Maxilliped, ventral; **F.** Legs 5 and 6, ventral

	Exopod	Endopod
Leg 1	1–0; 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; I, III	(absent)

Leg 5 (Fig. 2C) represented by 2 small papillae on posterolateral margin of genital complex, one tipped with small 1 plumose seta, other with 2 setae of about the same length.

Male: Body as in Fig. 5C. Total body length of the two males examined, 2.68 mm and 3.29 mm, measured from anterior part of cephalothoracic shield to posterior margin of caudal rami. Fourth pediger separated from genital complex, about 1.8 times as wide as long. Cephalothoracic shield roughly triangular in shape. Genital complex subquadrate and truncate posteriorly, with small pointed process on posterolateral margin. Abdomen 2-segmented; second segment about twice as long as first segment.

Antenna (Fig. 5D (D1)) 3-segmented; proximal segment slender and unarmed; middle segment largest, with 1 large, median and 2 distal corrugated pads; last segment smallest, armed with 2 basal setae and 2 overlapping cuticular flaps with pointed tips. Postantennal process (Fig. 5D (D2)) comparatively longer than in female.

Maxilliped (Fig. 5E) 3-segmented, robust. Myxal region of first segment with 2 protuberances ornamented with denticles and 2 small processes tipped with 1 tiny setule. Middle and distal segment as in female, except for claw with outer corrugated part in male.

Leg 5 (Fig. 5F) located at basis of protruded process on posterolateral margin of genital complex, comprising 2 papillae, one tipped with 1 long plumose seta and the other with 2 shorter plumose setae.

Leg 6 (Fig. 5F) located on posterolateral corner of genital complex, represented by 1 anterior small seta and 1 posterior papilla tipped with 1 plumose seta.

Discussion

The general morphology, body shape and size, as well as the segmentation and armature of maxillule, maxilla, maxilliped, sternal furca, and legs 1 to 4 of the female and male specimens of *C. serratus* from Chamela Bay and those of Shiino's (1965) specimens are identical. However, the pointed posteromedial process of the first segment of the female antenna was not mentioned in the original description of the species. This process is useful for the identification of *Caligus* species, and its description is, therefore, herein provided. Likewise, the male leg 6 was not mentioned in Shiino's (1965) original description of *C. serratus*. In addition, Shiino (1965) described the female leg 5 as a short plumose spine instead of 2 small papillae, one tipped with 1 small plumose seta and other with 2 plumose setae. In spite of these discrepancies, we are reasonably sure that the copepod species redescribed in this paper is *C. serratus*.

Since the male remains unknown for many species, comparisons among *Caligus* species are accordingly restricted to the female. The females of *C. serratus* can be readily distinguished from those of most *Caligus* species by a combination of morphological and morphometric traits, such as the length of the abdomen, presence of a pointed posteromedial process of the first segment of the antenna, shape of the sternal furca, and segmentation and armature of leg 4. According to Shiino (1965), *C. serratus* closely resembles *C. biaculeatus* Brian, 1914 and *C. teres* Wilson, 1905. However, *C. serratus* can be separated from these species by the elongated genital complex, the stout spinules on the setae of the terminal segment of leg 1 exopod and the sternal furca with diverging tines of *C. biaculeatus*, and the terminal spines of leg 1 exopod without secondary process of *C. teres*. Interestingly, a phylogenetic study of 25 species of *Caligus*, based on mitochondrial cytochrome *c* oxidase subunit I gene sequences, revealed that, in fact, *C. clemensi* Parker et Margolis, 1964 is the sister species of *C. serratus*, with a genetic divergence of 16.48 (Morales-

Table I. Fish host species and localities where *Caligus serratus* Shiino, 1965 has been found

Host	Locality	Reference
Atherinopsis californiensis Girard, 1854	La Jolla, California, U.S.A.	Shiino (1965)
Calamus brachysomus (Lockington, 1880)	Chamela Bay, Jalisco, Mexico	Morales-Serna *et al*. (submitted)
Caranx caballus Günther,1868	Chamela Bay, Jalisco, Mexico	Morales-Serna *et al*. (submitted)
Caranx caninus Günther,1867	Chamela Bay, Jalisco, Mexico	Morales-Serna *et al*. (submitted)
Cynoscion xanthulus Jordan & Gilbert, 1882	Chamela Bay, Jalisco, Mexico	Morales-Serna *et al*. (submitted)
Elops affinis Regan, 1909	Chamela Bay, Jalisco, Mexico	Morales-Serna *et al*. (submitted)
Haemulon steindachneri (Jordan & Gilbert, 1882)	Chamela Bay, Jalisco, Mexico	Morales-Serna *et al*. (submitted)
Kyphosus elegans (Peters, 1869)	Chamela Bay, Jalisco, Mexico	Morales-Serna *et al*. (submitted)
Lutjanus argentiventris (Peters, 1869)	Chamela Bay, Jalisco, Mexico	Morales-Serna *et al*. (submitted)
Microlepidotus brevipinnis (Steindachner, 1869)	Chamela Bay, Jalisco, Mexico	Morales-Serna *et al*. (submitted)
Scomberomorus sierra Jordan & Starks, 1895	Chamela Bay, Jalisco, Mexico	Morales-Serna *et al*. (submitted)
Sphoeroides annulatus (Jenyns, 1842)	Santa María La Reforma lagoon, Sinaloa, Mexico	Morales-Serna *et al*. (2011)
Tylosurus pacificus (Steindachner, 1876)	Chamela Bay, Jalisco, Mexico	Morales-Serna *et al*. (submitted)

Serna *et al*. submitted). Unfortunately, *C. biaculeatus* and *C. teres* were not included in that study.

Caligus serratus is known for its low host specificity since at least 13 fish species can serve as its host (Table I). This range of host preferences suggests that *C. serratus* could represent a risk for finfish aquaculture in the Mexican Pacific, such as that of snappers (*Lutjanus* spp.) cultured in sea cages in Chamela Bay. Currently, these snappers are being cultured to a small-scale, but an increase in the near future is expected. Other species of *Caligus* known to cause problems in aquaculture have also been characterized by their low host specificity; this trait would allow high rates of survival and development for those parasites, with each fish species being a source of infection. For instance, *C. epidemicus* Hewitt, 1971, responsible for both fish diseases and mortality, was similarly observed to be able to infect a wide range of host species in Australia and Asia (Ho 2000, 2004). Thus, it would be prudent to assess the abundance and distribution if *C. serratus* in the Mexican Pacific in order to prevent a possible epizootic episode.

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