

# *Euryphorus suarezi* n. sp. (Copepoda: Caligidae) parasitic on an elasmobranch from the Gulf of Mexico

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Received: 8 August 2015 / Accepted: 8 October 2015  
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**Abstract** Currently, the caligid genus *Euryphorus* Milne Edwards, 1840 contains two valid species. A new species, *Euryphorus suarezi*, is described based on adult females and males collected from the spotted eagle ray *Aetobatus narinari* (Euphrasen) (Elasmobranchii: Myliobatidae), captured off Campeche and Tabasco, Mexico (southern coast of the Gulf of Mexico). The new species is mainly distinguished from its congeners by the absence of dorsal plates, the presence of postantennal process, bifurcated maxillule, maxilliped with slender corpus, and leg 4 with 3-segmented endopod. Leg 6 is conspicuous in the male. Additional differences are described. This is the first record of a species of *Euryphorus* from an

elasmobranch host, which may provide insight into the evolutionary relationships within the Caligidae.

## Introduction

Parasitic copepods of the family Caligidae Burmeister, 1835 (order Siphonostomatoida), the so-called sea lice, are common on marine fishes. This is a large family that includes 31 genera and more than 450 described species (Dojiri & Ho, 2013), most of which are grouped in only two genera (*Caligus* Müller, 1785 and *Lepeophtheirus* Nordmann, 1832) whereas most caligid genera (90%) contain less than ten valid species. Particularly, the genus *Euryphorus* Milne Edwards, 1840 currently consists of two accepted species (Dojiri & Ho, 2013; Walter & Boxshall, 2015): *E. brachypterus* (Gerstaecker, 1853) reported mostly from large scombrids, and *E. nordmanni* Milne Edwards, 1840 reported mostly from the dolphinfish *Coryphaena hippurus* Linnaeus. According to Kabata (1979) and Dojiri & Ho (2013), these two caligid species have accumulated numerous synonyms due to their morphological plasticity, the use of juveniles for descriptions, and their wide geographical distribution.

During a recent examination of marine fishes landed at various fishing ports on the southern coast of the Gulf of Mexico, specimens of *Euryphorus* spp. were collected from spotted eagle rays captured off Campeche and Tabasco. Detailed and careful

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examination of this material revealed the presence of a new species described herein.

## Materials and methods

During October 2013, eight spotted eagle rays were caught by local fishermen from three localities, off Champotón and Seybaplaya in Campeche State, and off San Pedro in Tabasco State, Mexico, on the southern coast of the Gulf of Mexico. Copepods were collected from the surfaces of the hosts and preserved in 70% ethanol. Observations and drawings were made from whole and dissected specimens mounted in lactophenol using a series of magnifications up to 1,000× with a Leica DMLB compound microscope equipped with a drawing tube. Measurements given in the text were taken after soaking the specimens in lactophenol, and are given in millimeters as the range followed by the mean in parentheses. Terminology of the body parts and appendages follows Dojiri & Ho (2013).

### Order Siphonostomatoida Thorell, 1859

#### Family Caligidae Burmeister, 1835

#### Genus *Euryphorus* Milne Edwards, 1840

### *Euryphorus suarezi* n. sp.

*Type-host*: *Aetobatus narinari* (Euphrasen) (Elasmobranchii: Myliobatidae), spotted eagle ray.

*Type-locality*: Off San Pedro (18°38'39"N, 92°28'7"W), Gulf of Mexico, in the state of Tabasco, Mexico.

*Material examined*: 35 females and 2 males collected from the body surface of *A. narinari* captured in October 2013 off San Pedro, Tabasco, Mexico; 2 females and 2 males collected from the body surface of *A. narinari* captured in October 2013 off Seybaplaya, Campeche, Mexico; 1 female collected from the body surface of *A. narinari* captured in October 2013 off Champotón, Campeche, Mexico. All isolated parasite specimens were adults, most females being ovigerous.

*Type-material*: Holotype female (CPPNP 1359), allotype (CPPNP 1360) and 40 paratypes (CPPNP 1361–1366), all stored in alcohol, plus a dissected specimen (CPPNP 1367), are deposited in the Colección de Parásitos de Peces del Noroeste del Pacífico (CPPNP) held at the Centro de Investigación en Alimentación y Desarrollo (CIAD), Unidad Mazatlán, Sinaloa, Mexico.

*Etymology*: The species is named in honour of Dr. Eduardo Suárez-Morales (ECOSUR, Chetumal, Quintana Roo, Mexico) for his many contributions to our knowledge of the Copepoda.

Description (Figs. 1–4)

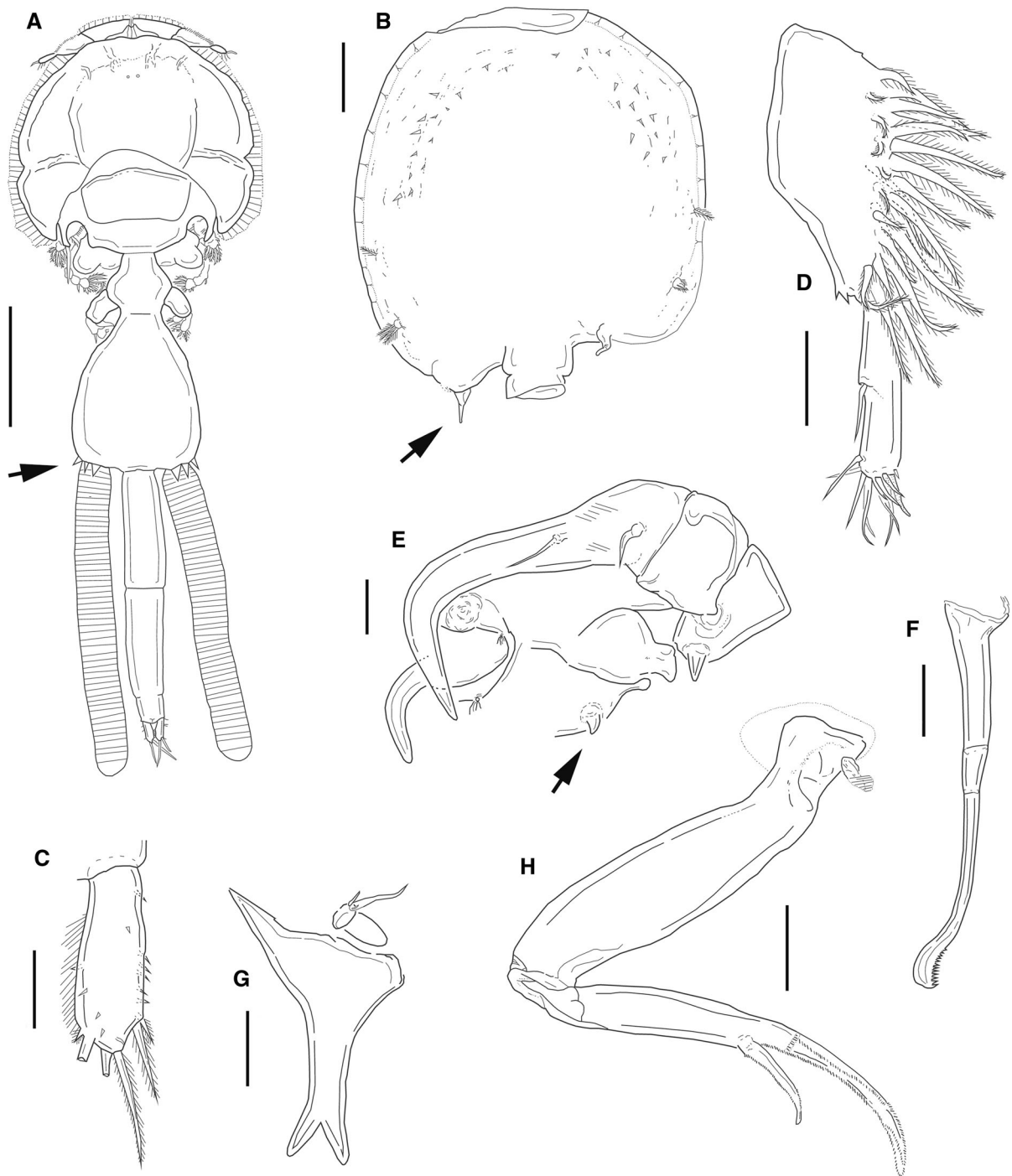
#### *Adult female*

Body (Fig. 1A) 3.97–5.92 (5.49) long, excluding setae on caudal ramus. Cephalothoracic shield subcircular, 1.73–2.25 (1.94) long, 1.70–1.98 (1.83) wide, with distinct indentation at mid-length of lateral zone; frontal plate without lunules, and shallow posterior sinuses. Tip of antennule within lateral border of cephalothorax. Free margin of thoracic zone extending only slightly beyond tip of lateral zone. Fourth pedigerous somite distinctly wider than long (without dorsal plates). Genital complex (Fig. 1A) flask-shaped, longer than wide; ventral surface with an arc of denticles (Fig. 1B); posterolateral region rounded, bearing vestigial leg 5 and 3 dorsal and 1 ventral spinelike processes (arrowed in Fig. 1A, B), covering extrusion area of each egg-sac.

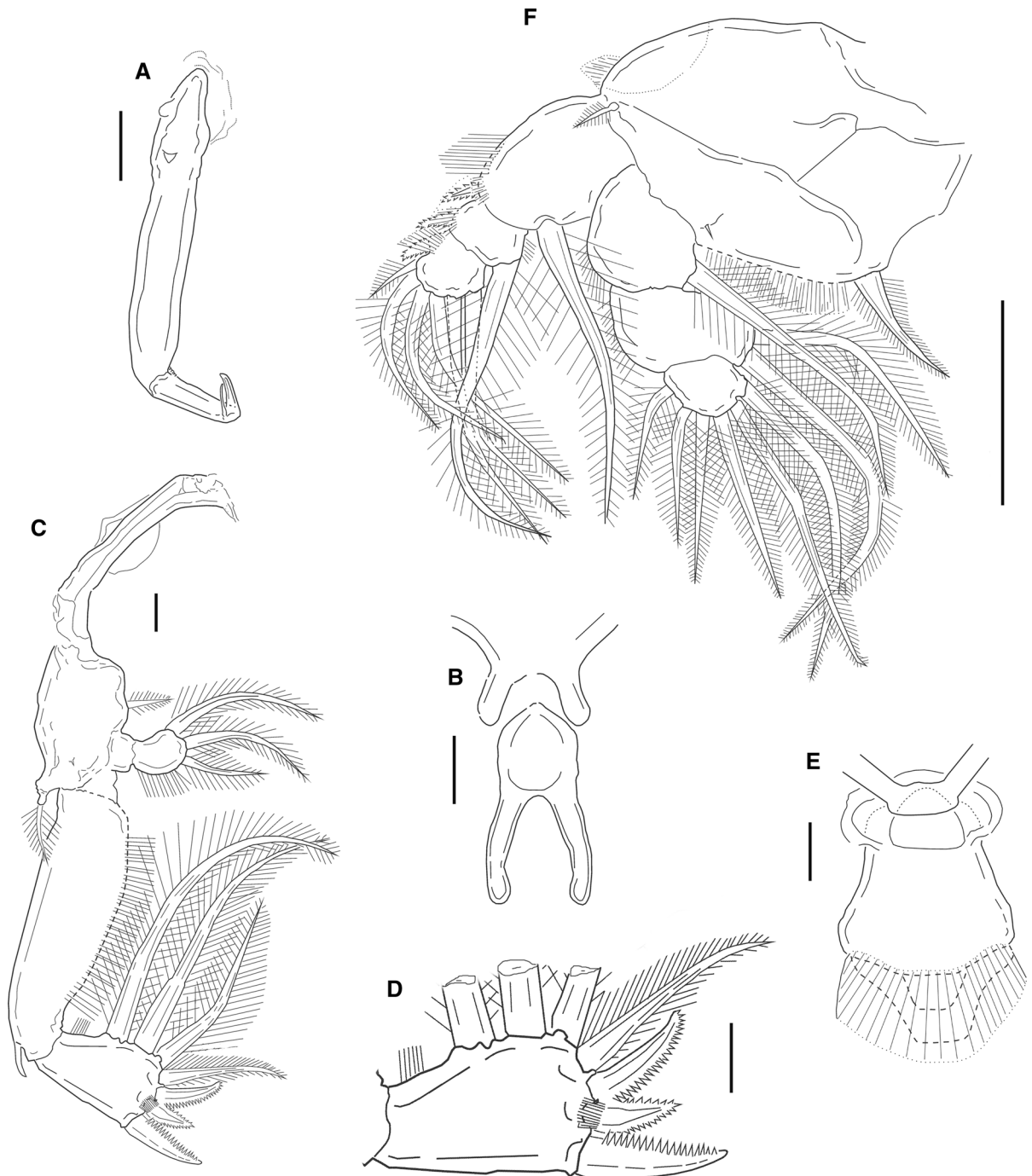
Abdomen (Fig. 1A) 1.65–1.97 (1.85) long, almost as long as cephalothorax, apparently 3-segmented; proximal and middle segments subequal, each 3× as long as wide; distal segment smallest, about as long as wide, and not clearly delimited from middle segment. Caudal ramus (Fig. 1C), approximately 2.5× as long as wide, bearing 2 small and 4 large plumose setae. Egg-sacs (Fig. 1A) uniseriate extending only slightly beyond tip of caudal rami.

Antennule (Fig. 1D) 2-segmented; proximal segment with 2 tooth-like elements on posterodistal corner, in addition to 2 anterodorsal and 25 anteroventral plumose setae; distal segment with suture and smooth seta on posterior margin near mid-length, in addition to 12 smooth setae plus 1 aesthetasc around apex.

Antenna (Fig. 1E) apparently 4-segmented; first segment unornamented; second segment with posteriorly directed sharply-pointed process; third segment robust and unarmed; fourth segment a large claw with robust seta in basal region and slender seta in middle region. Postantennal process (Fig. 1E) a stocky hook, with basal protuberance and branched setules. A small conical projection located between bases of antenna and postantennal process (arrowed in Fig. 1E).



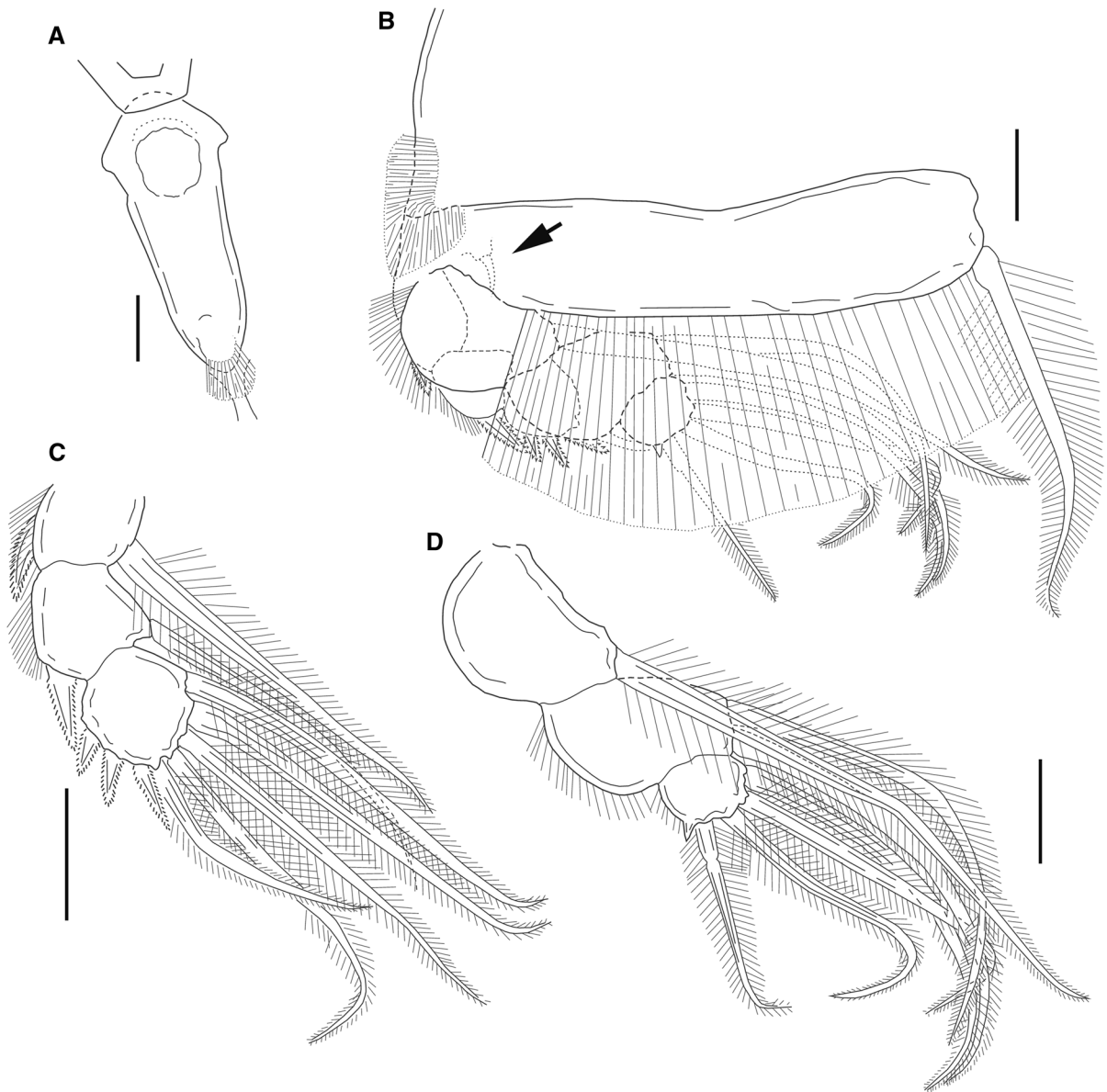
**Fig. 1** *Euryphorus suarezi* n. sp., adult female. A, Habitus, dorsal view (arrow indicates the spine-like processes); B, Genital complex, ventral view (arrow indicates the spine-like process); C, Caudal ramus (2 terminal setae broken), dorsal view; D, Antennule, ventral view; E, Antenna and postantennal process, ventral view (arrow indicates the conical projection); F, Mandible; G, Maxillule, ventral view; H, Maxilla, ventral view. Scale-bars: A, 1 mm; B, 0.2 mm; C–H, 0.1 mm



**Fig. 2** *Euryphorus suarezi* n. sp., adult female. A, Maxilliped, ventral view; B, Sternal furca and anterior process, ventral view; C, Leg 1 and intercoxal plate, ventral view; D, Second segment of leg 1 exopod, ventral view; E, Sclerotised area between legs 1 and 2; F, Leg 2, ventral view. Scale-bars: A–F, 0.1 mm

Mouth tube with intrabuccal stylet and strigil; mandible (Fig. 1F) with 3 sections (third and fourth sections fused), bearing 12 apical teeth. Maxillule

(Fig. 1G) comprising long, bifurcated, dentiform process and small basal papilla tipped with 3 setae (1 larger than other 2). Sclerotised rounded process



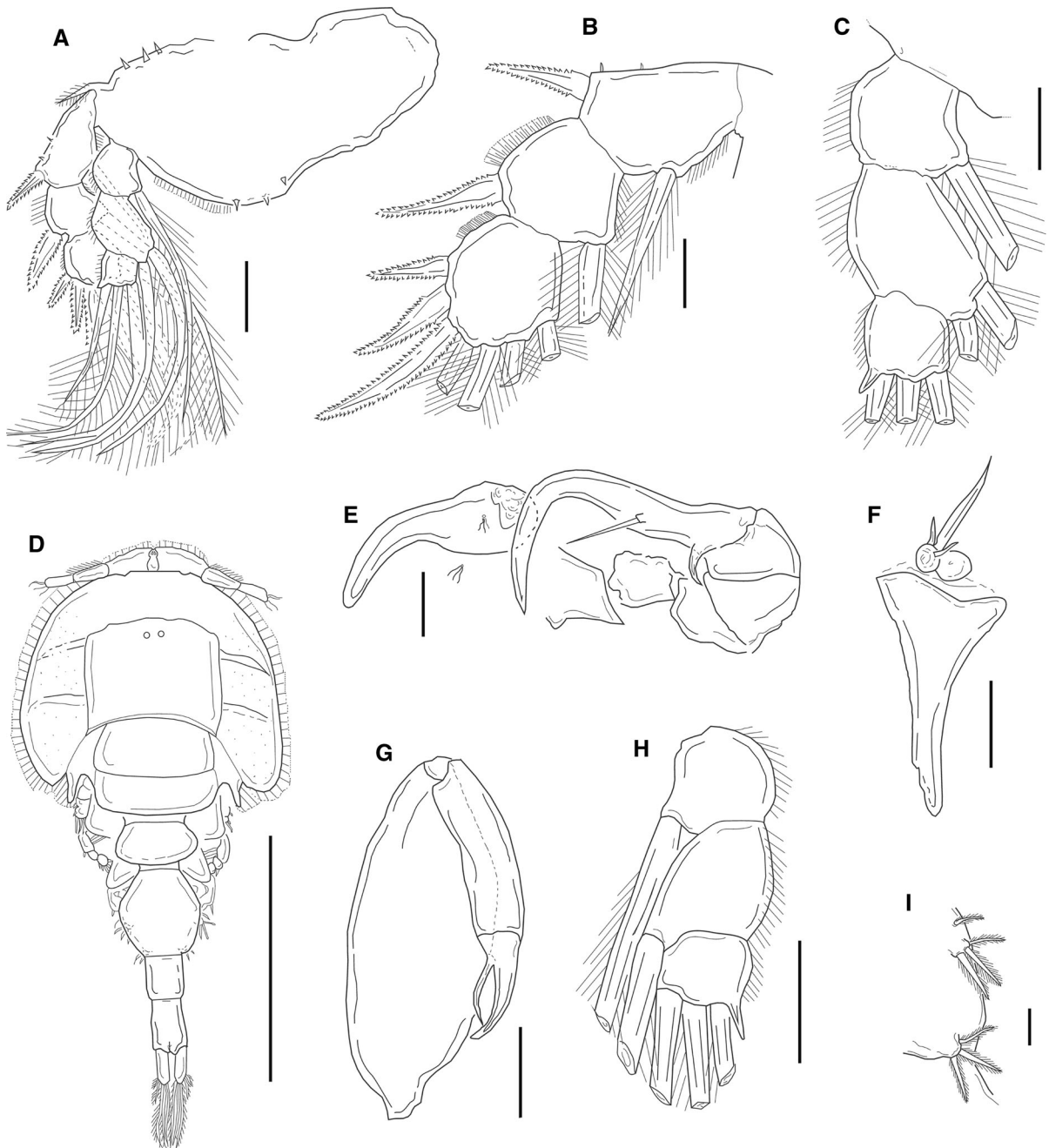
**Fig. 3** *Euryphorus suarezi* n. sp., adult female. A, Sclerotised area between legs 2 and 3; B, Leg 3, ventral view (arrow indicates the seta near outer margin); C, Exopod of leg 3, ventral view; D, Endopod of leg 3, ventral view. Scale-bars: A–D, 0.1 mm

located near papilla. Maxilla (Fig. 1H) 2-segmented and branchiform; proximal segment (lacertus) broader than terminal segment (brachium); lacertus with small process in basal region; brachium with 2 unequal elements (a short cana, and a long calamus) apically. Maxilliped (Fig. 2A) with long and slender corpus, about 6 times as long as wide, carrying 2 small processes in basal region; shaft slender, unarmed; claw shorter than shaft, relatively straight, with 1 smooth seta near base.

Sternal furca (Fig. 2B) with subquadrate box and bluntly-pointed tines. Process with divergent, short tines (secondary furca?) located anteriorly to sternal furca (Fig. 2B).

Leg 1 (Fig. 2C) biramous; sympod with large, pinnate outer seta and another pinnate inner setae. Exopod 2-segmented; first segment with outer distal spine and inner row of setules; second segment with small row of setules proximally and 3 large pinnate setae on inner margin, in addition to 1 large pinnate seta





**Fig. 4** *Euryphorus suarezi* n. sp., adult female. A, Leg 4, ventral view; B, Exopod of leg 4, ventral view; C, Endopod of leg 4, ventral view. Adult male, D, Habitus, dorsal view; E, Antenna and postantennal process, ventral view; F, Maxillule, ventral view; G, Maxilliped, ventral view; H, Endopod of leg 4, ventral view; I, Legs 5 and 6, ventral view. Scale-bars: A–C and F–I, 0.1 mm; D, 1mm; E, 0.05 mm

and 3 serrate spines on distal margin, of which spine 2 smaller than spines 1 and 3. Base of spine 2 with pectinate membrane (Fig. 2D). Endopod 2-segmented;

first segment shortest, unarmed; second segment with outer row of setules and 3 large pinnate setae terminally. Area between legs 1 and 2 sclerotised (Fig. 2E).

Leg 2 (Fig. 2F) biramous; sympod with short, pinnate outer seta and large, pinnate inner seta, in addition to tiny seta on anterior surface close to inner marginal membrane. Exopod 3-segmented; first segment largest, with serrate spine on outer distal corner and long, pinnate inner seta; second segment with serrate spine on outer distal corner and long, stout, pinnate inner seta; third segment with serrate spine and 6 pinnate setae terminally. All 3 outer spines of exopodal segments with large pectinate membrane at base. Endopod 3-segmented; first segment with long pinnate seta on inner margin; second segment with 2 long, pinnate inner setae; third segment with 6 long pinnate setae terminally, which decrease in length towards outer margin. Area between legs 2 and 3 sclerotised (Fig. 3A).

Leg 3 (Fig. 3B) biramous (overlapped in Fig. 3B, setae of exopod not drawn); sympod with single long, pinnate inner seta and another short seta near outer margin (arrowed in Fig. 3B); additionally, bearing large marginal membrane on outer and posterior edges. Exopod (Fig. 3C) 3-segmented; first and second segments each with serrate outer spine and long, pinnate inner seta; third segment with 3 distolateral serrate spines and 5 long pinnate setae. Endopod (Fig. 3D) 3-segmented; first segment with long, stout, pinnate inner seta; second segment with 2 long, pinnate inner setae; third segment with 4 pinnate setae terminally and a spine-like process on outer distal corner.

Leg 4 (Fig. 4A) biramous; sympod with pinnate outer seta and spinules scattered near both outer and inner edges. Exopod (Fig. 4B) 3-segmented; first and second segments each with outer serrate spine and long, pinnate inner seta; third segment with 3 distolateral serrate spines and 4 long pinnate setae. Endopod (Fig. 4C) 3-segmented; first segment with long, pinnate inner seta; second segment with 2 long, pinnate inner setae; third segment with 3 long pinnate setae terminally and spine-like process on outer distal corner.

Leg 5 (Fig. 1B) represented by 2 small papillae on posterolateral corner of genital complex, 1 tipped with small pinnate seta, other with 3 similar setae.

#### Adult male

Body (Fig. 4D) 1.98–2.39 (2.24) long, excluding setae on caudal ramus. Cephalothoracic shield as in female, 0.73–1.21 (0.93) long, 0.89–1.28 (1.07) wide. Fourth

pedigerous somite twice as wide as long. Genital complex as wide as long, ovoid. Abdomen 0.34–0.41 (0.39) long, comprising 2 free somites; first somite almost as long as wide; second somite 1.7× as long as wide. Caudal ramus as in female.

Antennule as in female. Antenna (Fig. 4E) as in female, except for larger claw and unarmed second segment (without pointed process). Postantennal process (Fig. 4E), mandible, and maxilla as in female. Maxillule (Fig. 4F) with dentiform process bearing accessory tine subterminally. Maxilliped (Fig. 4G) as in female, except for robust first segment (corpus).

Legs 1–3 as in female. Leg 4 as in female except for second endopodal segment with only 1 long inner seta (Fig. 4h). Leg 5 (Fig. 4I) as in female, located on lateral margin of genital complex. Leg 6 (Fig. 4I) represented by 3 pinnate setae on posterior region of genital complex.

## Discussion

The well-developed 2-segmented endopod of leg 1 is an important criterion to distinguish *Euryphorus* from other genera of the Caligidae, except for *Alebion* Krøyer, 1863, *Avitocaligus* Boxshall & Justine, 2005 and *Pupulina* van Beneden, 1892; however, within the entire family, *Avitocaligus* and *Euryphorus* are unique by the distinctly biramous leg 4 (Boxshall & Justine, 2005; Dojiri & Ho, 2013). In general, the new species shares most of morphological characters described by Dojiri & Ho (2013) for *Euryphorus*, such as the shape of cephalothorax with indentation at mid-length, frontal plate without lunules, 2-segmented antennule, mandible with third and fourth sections fused, maxillule with dentiform process, sternal furca present, leg 1 biramous with 2-segmented rami, leg 2 biramous with 3-segmented rami, leg 3 with large ventral apron, biramous with 3-segmented rami, leg 4 biramous, and leg 5 represented by setiferous papilla. On the other hand, the dorsal plates on the fourth pedigerous somite, the posterolateral processes on genital complex, and the lateral flaps of the abdomen described for the genus were not observed in the new species. Dojiri & Ho (2013) stated that the aliform flaps of the first abdominal somite of the female remain as the single possible generic discriminant; however, this diagnosis is based on two species of *Euryphorus* and it could change as more species are described.

Likewise, the knowledge of *Avitocaligus* is based on two species, *A. assurgericola* Boxshall & Justine, 2005 and *A. evoxymetoponicola* Izawa, 2012, which are characterised by the absence of sternal furca, abdomen with ventral plates, and loosely coiled, uniseriate egg-sacs, concealed between the middle lamellar plates on the genital complex (Boxshall & Justine, 2005; Izawa, 2012). Therefore, the new species cannot be accommodated in the genus *Avitocaligus*.

*Euryphorus suarezi* n. sp. is the third representative of the genus in addition to *E. brachypterus* and *E. nordmanni*. The female of the new species differs from its congeners by the following characters: (i) body without dorsal plates; (ii) oviducal opening covered by four spine-like processes; (iii) distal segment of antennule with suture; (iv) postantennal process present (absent in the two known species); (v) maxillule large and bifurcated; (vi) maxilliped with slender segments; (vii) sclerotised area (secondary sternal furca?) located proximal to sternal furca; (viii) single spine (instead of two) on third exopodal segment of leg 2; (ix) distinctly 3-segmented endopod of leg 4 (indistinctly 3-segmented in the two known species); (x) single inner seta on first exopodal segment of leg 4 (absent in the other two species); (xi) spine-like process on tip of endopod of legs 3 and 4; and (xii) the average body length (5.49 mm) of *E. suarezi* n. sp. being smaller than that of *E. brachypterus* (10.22 mm) and *E. nordmanni* (10.08 mm). The male of *E. suarezi* n. sp. differs from its congeners by the following: (i) body without dorsal plates; (ii) leg 6 present (apparently absent in the two known species); and (iii) the average body length (2.24 mm) of *E. suarezi* n. sp. being smaller than that of *E. brachypterus* (7.65 mm) and *E. nordmanni* (5.38 mm).

The new species also differs from its congeners in relation to host preference. To date, *E. brachypterus* has been reported from large scombrids [*Allothunnus fallai* Serventy, *Thunnus maccoyii* (Castelnaud), *T. alalunga* (Bonnaterre), *T. obesus* (Lowe), *T. albacares* (Bonnaterre), *T. thynnus* (Linnaeus), and *T. atlanticus* (Lesson)] from the Atlantic, Indian, and Pacific Oceans, whereas *E. nordmanni* has been reported mostly from the dolphinfish (*C. hippurus*) and, to a lesser extent, from some scombrids (*T. alalunga*, *T. albacares*, and *T. obesus*), *Alepisaurus ferox* (Lowe), and *Rachycentron canadum* (Linnaeus) also from the Atlantic, Indian, and Pacific Oceans (see Dojiri & Ho,

2013). Therefore, the finding of *E. suarezi* on *A. narinari* represents the first record of a species of *Euryphorus* from an elasmobranch host.

Caligidae is one of the ten siphonostomatoid families reported from elasmobranch hosts. The other nine families are the Dichelesthidae Milne Edwards, 1840, Dissonidae Yamaguti, 1963, Eudactylinidae Wilson, 1932, Kroyeriidae Kabata, 1979, Lernaeopodidae Milne Edwards, 1840, Pandaridae Milne Edwards, 1840, Pennellidae Burmeister, 1835, Sphyriidae Wilson, 1919 and Trebiidae Wilson, 1905 (see Dippenaar, 2009). Nonetheless, of the 31 genera of the Caligidae only a few have been reported from elasmobranch hosts (Boxshall & Halsey, 2004). These hosts are descendants of one of the earliest branches of the vertebrate evolutionary tree. Therefore, the presence of *E. suarezi* n. sp. on *A. narinari* may shed light on host-parasite evolutionary relationships, supporting the phylogeny of the Caligidae proposed by Dojiri & Ho (2013) where *Euryphorus*, in addition to *Avitocaligus*, *Alebion*, *Gloiopotes* Steenstrup & Lütken, 1861 and *Pupulina*, are basal to the remaining 26 caligid genera.

In addition, the host preference for an elasmobranch and the distinctly 3-segmented endopod of leg 4 in *E. suarezi* n. sp. suggest its plesiomorphic position within *Euryphorus*.

**Acknowledgements** We are grateful to Hiley Valeria Montijo Hernández for her help with drawings. Gratitude is also due to two anonymous reviewers for their valuable comments on a previous version of the manuscript.

**Funding** FNM-S and MAR-S are supported by the program Cátedras CONACyT from the National Council for Science and Technology of Mexico.

#### Compliance with ethical standards

**Conflict of interest** The authors declare that they have 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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