



First record and redescription of *Tisbella pulchella* (Copepoda: Harpacticoida) from the eastern tropical Pacific

Primer registro y redescrición de *Tisbella pulchella* (Copepoda: Harpacticoida) del Pacífico tropical este

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Resumen. Se encontraron ejemplares del género *Tisbella* Gurney, 1927 durante una serie de muestreos de meiofauna en 2 sistemas costeros del sur de Sinaloa (noroeste de México). Los organismos fueron identificados como *Tisbella pulchella* (Wilson, 1932), una especie de copépodo harpacticoida originalmente descrita a partir de material recolectado en la región de Woods Hole (EUA) y también registrada en las islas Bermuda. Se presenta una comparación de los especímenes recolectados en sistemas costeros mexicanos del Pacífico tropical este y las redescriciones disponibles del material tipo. Se observó que las únicas diferencias observadas entre la redescrición más detallada de la especie y la presente descripción es el número de setas del artrito y palpo de la maxílula y el número de setas accesorias del maxílpedo. Finalmente se dan algunas notas acerca de su biogeografía y se concluye que *T. pulchella* es la especie con la distribución más amplia del género.

Palabras clave: Copepoda, Harpacticoida, *Tisbella*, noroeste de México, taxonomía.

Abstract. Specimens of the genus *Tisbella* Gurney, 1927 were found during a series of sampling campaigns in 2 brackish systems in southern Sinaloa (north-western Mexico). The specimens were identified as *Tisbella pulchella* (Wilson, 1932), a species of harpacticoid copepod originally described from material collected from the Woods Hole region (USA) and found also in the Bermuda Islands. A thorough comparison between the material collected in Mexican coastal systems in the eastern tropical Pacific and previous redescricions of the type material is presented. It is shown that the only differences between the most accurate and detailed redescricion available and the present description is in the number of setae of the arthrite and palp of the maxillule, and in the number of accessory setae of the maxilliped. Some notes on the biogeography of the species are presented and it is concluded that *T. pulchella* is the most widely distributed species within the genus.

Key words: Copepoda, Harpacticoida, *Tisbella*, north-western Mexico, taxonomy.

Introduction

Sediment samples were taken during 2 short-term studies regarding the effects of organic matter from natural and anthropogenic sources on the distribution and diversity of benthic copepods in 2 brackish coastal systems in southern Sinaloa (north-western Mexico). The harpacticoid fauna from Mexican coastal systems has received little attention and the diversity of these populations is largely unknown making the finds of new harpacticoid taxa as well as new records for Mexican coastal systems of great relevance. During the course of these studies, a number

of harpacticoid copepods of the genus *Tisbella* Gurney, 1927 were found and were identified as *T. pulchella* (Wilson, 1932) originally described from the Woods Hole region (Massachusetts) (Wilson, 1932) and reported also from Bermuda (Willey, 1930). Because this is the first record of the genus for Mexican coastal systems and the first record of the species for the eastern tropical Pacific, a full description of *T. pulchella* based on Mexican material is presented. This material is also compared with previous morphological data and descriptions of the species, and some notes on the biogeography of the species are given.

Material and methods

Sediment samples for meiofaunal analyses were taken

during bimonthly sampling campaigns in 2 brackish coastal systems in southern Sinaloa state (Urias system and El Verde Estuary), Mexico, during 2001 and 2005. Sediment samples were sieved through 500 µm and 40 µm sieves and benthic copepods were separated from the rest of the meiofauna using a stereomicroscope with a magnification of 40X. Specimens were fixed and stored in 70% ethanol prior to further investigation. Observations and drawings of whole and dissected specimens mounted in lactophenol were made with a Leica compound microscope equipped with phase contrast and a drawing tube at a magnification of 1000X. The material studied was deposited in the Collection of Copepoda of the Instituto de Ciencias del Mar y Limnología, Mazatlán Marine Station. The terminology proposed by Huys and Boxshall (1991) was adopted for the general description. Abbreviations used in the text and tables are: CIII, third copepodite; CIV, fourth copepodite; CV, fifth copepodite; P1-P6, first to sixth swimming legs; EXP, exopod; ENP, endopod; P1 (P2-P4) EXP (ENP) 1 (2, 3) denotes the proximal (middle, distal) exopodal (endopodal) segment of P1, P2, P3 or P4.

Description

Order: Harpacticoida Sars, 1903

Family: *Tisbidae* Stebbing, 1910

Genus: *Tisbella* Gurney, 1927

Syn. *Chappaquiddicka* Wilson, 1932 (Lang, 1948: 401)

Tisbella pulchella (Wilson, 1932) (Figs. 1-8)

Syn. *Chappaquiddicka pulchella* Wilson, 1932 (Lang, 1948: 402); *Tisbella timsae* sensu Willey (1930) (Lang, 1948: 402).

Distribution, USA: Chappaquiddick Island (Massachusetts) (Wilson, 1932), Bermuda Islands (Mangrove Lake) (Willey, 1930); México: Urias system and El Verde Estuary (Sinaloa, north-western Mexico) (present study).

Female. Body (not shown) fusiform, tapering posteriorly (as in Yeatman, 1963: 199, Fig. 1). Total body length ranges from 760 µm to 930 µm (mean, 846 µm; n, 20). Second and third urosomites (genital-double somite) completely fused (Fig. 1A); second urosomite without ornamentation; third urosomite ornamented with lateral spinules close to posterior margin, ventral surface smooth; fourth and fifth urosomites with spinules along posterior margin ventrally. Caudal rami (Fig. 1A, C) slightly longer than wide, with spinular ornamentation close to inner corner and at base of seta VI ventrally; with 7 setae; seta I located in distal quarter laterally, seta II inserted dorsally close to posterior margin, seta III arising from ventral projection, seta VI located on inner posterior corner; seta VII biarticulated and set close to posterior margin dorsally.

Antennule (Figs. 2A, 3A-E) 7-segmented. Surface of segments smooth. Segment 1 small, nearly as long as wide, segments 2, 3 and 4 elongate, segment 2 about 3 times as long as wide, segment 3 about 5 times longer than wide, segment 4 about 6 times longer than wide, segment 5 small about as long as wide, segment 6 and 7 about 4 times longer than wide. All setae smooth. Armature formula as follows: 1-(1), 2-(15), 3-(10), 4-(4+ae), 5-(1), 6-(8), 7-(4+acrothek). Acrothek consisting of 2 setae basally fused to aesthetasc.

Antenna (Fig. 2B, D, E). Basis without spinular ornamentation; with well developed distal seta. Exopod 3-segmented; first and second segment with 1 seta each; third segment with row of spinules and armed with 1 lateral and 3 apical smooth setae. First endopodal segment without spinular ornamentation and armed with 1 small and naked seta subdistally. Outer margin of second endopodal segment with row of spinules; with 3 lateral and 7 apical elements (1 of them small and bipinnate).

Mandible (Fig. 2C). Coxa-basis without spinular ornamentation. Gnathobase with uni-, bi- and multicuspidate teeth, and 1 spinulose seta; with a row of small spinules at base of teeth. Basis unarmed, without ornamentation. Exopod 1-segmented, with transverse rows of spinules and armed with 2 smooth setae apically. Endopod 1-segmented, with rows of spinules and armed with 3 lateral and 6 apical smooth setae.

Maxillule (Fig. 4B). Arthrite of praecoxa with few spinules, with 2 surface setae, 2 lateral strong spines and 3 strong spines and 2 smooth setae apically. Homologization of setae of the palp difficult to define, but most likely as follows: exopod represented by 1 well developed seta; endopod 1-segmented, with 2 setae; with 2 basal endites, distal endite with 4 setae, proximal endite represented by 1 well developed seta; coxa with 3 setae (2 of them fused basally).

Maxilla (Fig. 5B). Syncoxa with some spinules close to outer margin, with 1 endite represented by slender seta. Allobasis drawn out into strong claw with hook-like process at about 2/3 of claw, with 1 accompanying spatulate seta.

Maxilliped (Fig. 6B) subchelate. Syncoxa and basis without spinular ornamentation. Endopod 1-segmented, with long claw and 1 anterior and 1 posterior seta.

P1 (Fig. 4A). Coxa ornamented with transverse spinular rows as figured. Basis ornamented with transverse spinular rows as shown, with inner and outer small seta. Endopod shorter than exopod. Exopod 3-segmented; first segment with outer seta-like element and without inner seta, second segment with outer spine and inner seta; third segment armed with 6 setae/spines. Endopod 2-segmented; first segment robust, about 1.5 times as long as wide, with 1

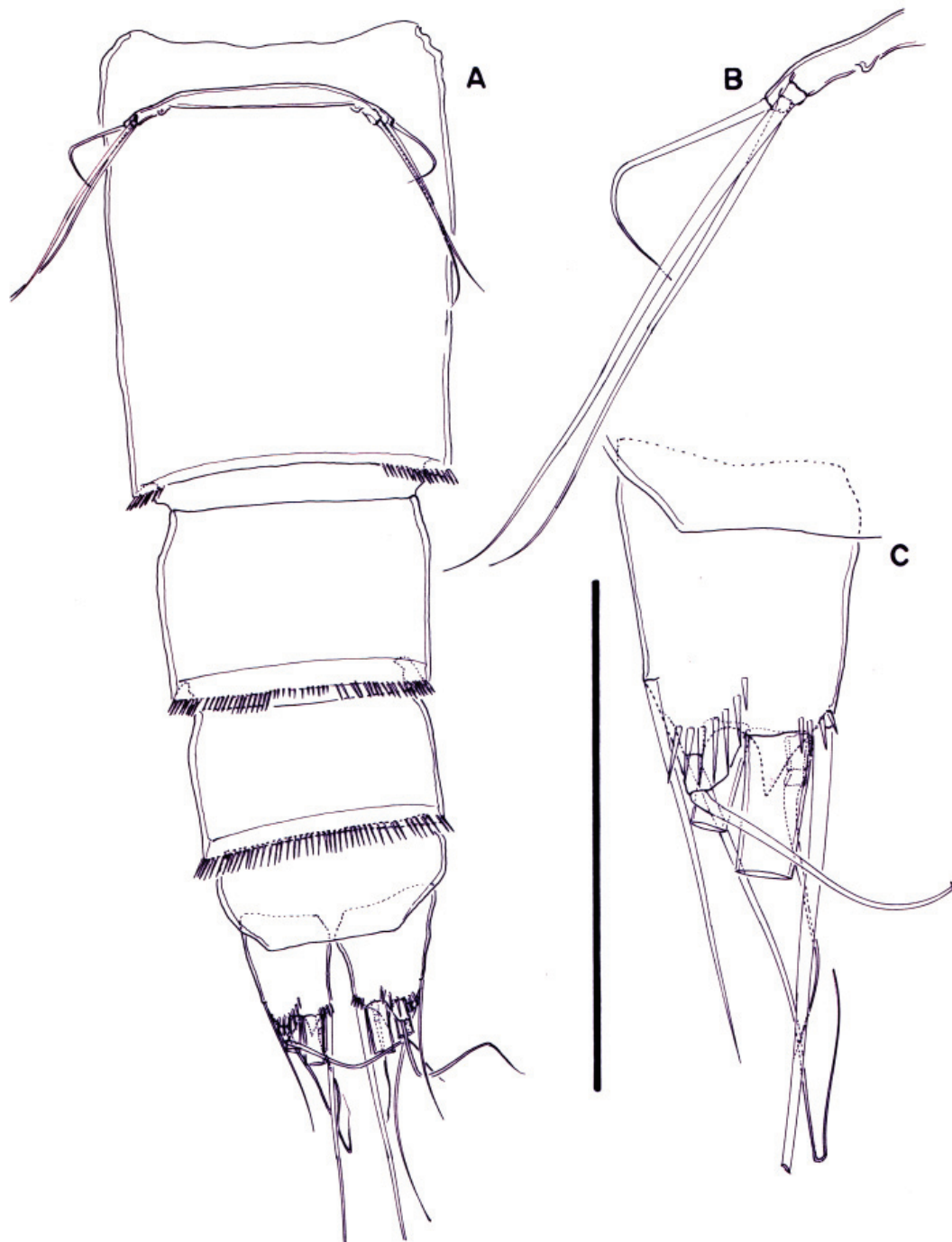


Figure 1. *Tisbella pulchella* (Wilson, 1932), female. A, urosome, ventral (P5-bearing somite omitted); B, P6; C, right caudal ramus, ventral. Scale bar: A, 183 μ m; B, C, 64 μ m.

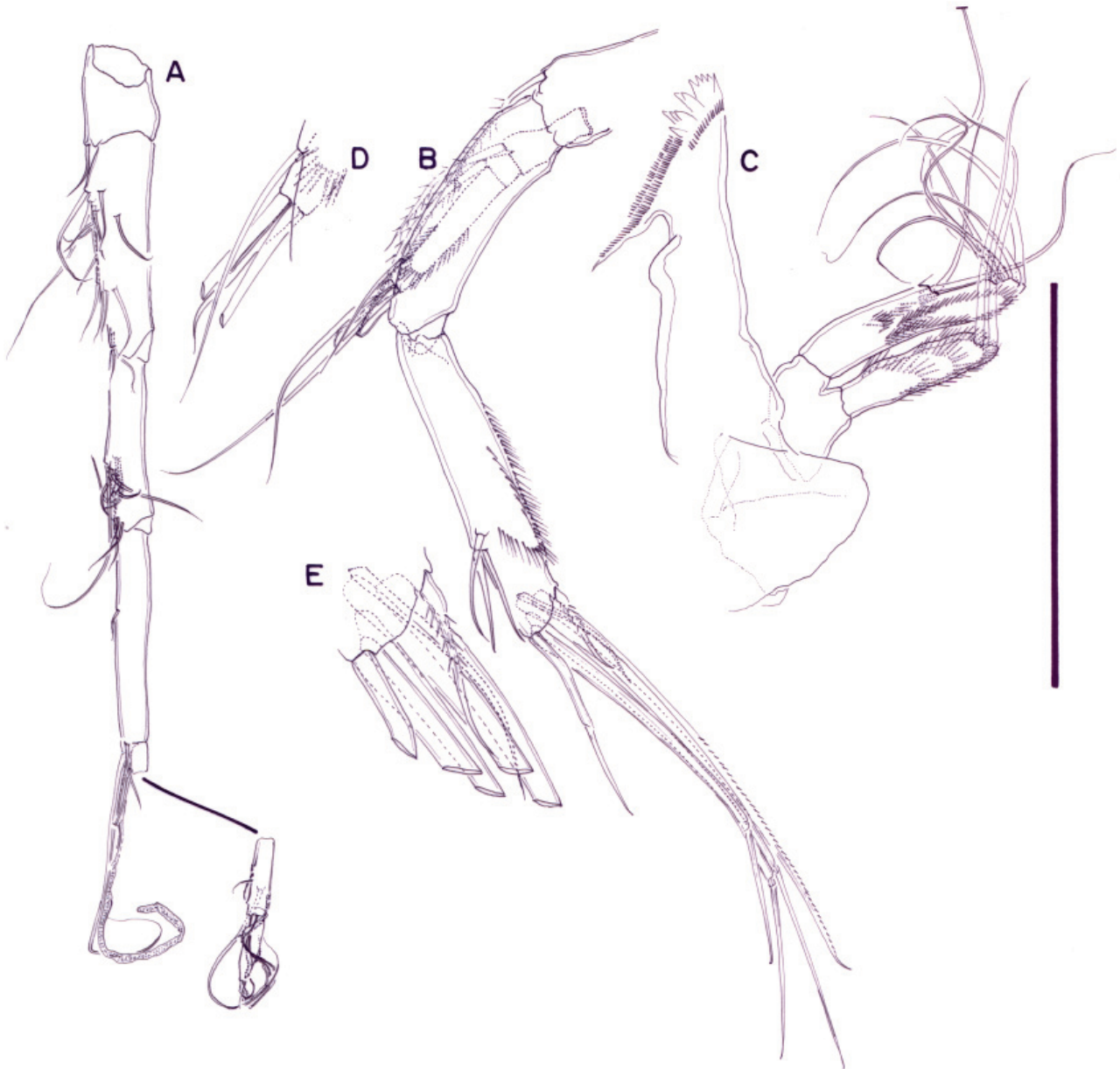


Figure 2. *Tisbella pulchella* (Wilson, 1932), female. A, antennule; B, antenna; C, mandible; D, distal part of antennal exopod; E, distal part of antennal endopod. Scale bar: A, 200 μm ; B, C, 100 μm ; D, E, 50 μm .

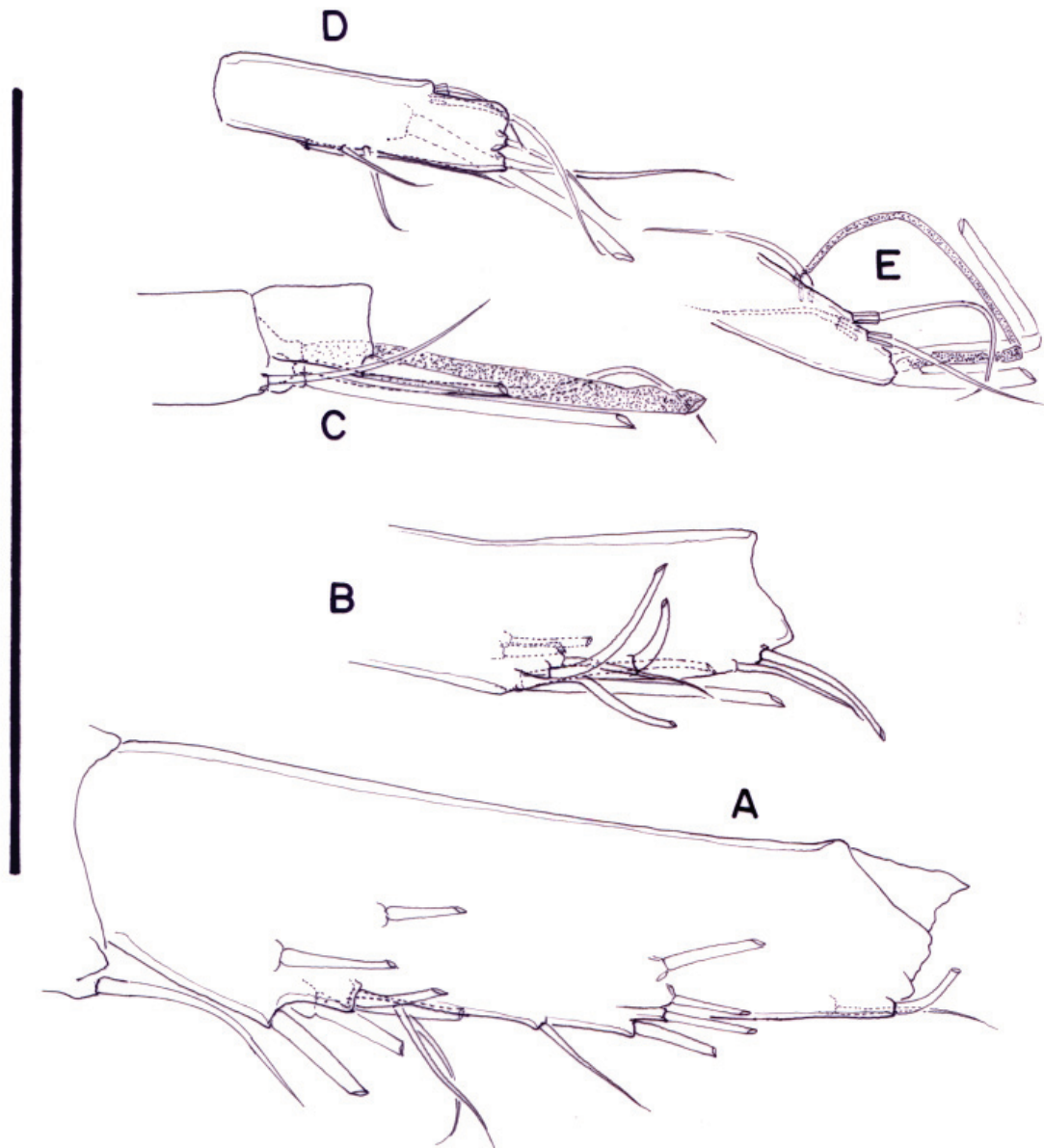


Figure 3. *Tisbella pulchella* (Wilson, 1932), female. A, second antennary segment; B, distal part of third antennary segment; C, distal part of fourth and fifth antennary segment; D, sixth antennary segment; E, distal part of seventh antennary segment. Scale bar: A-D, 100 μ m; E, 70 μ m.



Figure 4. *Tisbella pulchella* (Wilson, 1932), female. A, P1; B, maxillule. Scale bar: A, 200 μm ; B, 70 μm .

long inner seta; second about 2 times as long as wide, with 4 elements.

P2-P4 (Figs. 5A, 6A, 7A). Coxa with some spinules as figured. Basis with small spinules close to inner distal corner and at base of exopod; with very small outer seta. Rami 3-segmented; P2EXP and P3EXP shorter than endopod, P4EXP slightly longer than endopod. First and second exopodal segments with inner seta, P2EXP3 with 7, P3 and P4EXP3 with 8 setae/spines. First endopodal segment with 1, second segment with 2 inner setae; P2 and P4ENP3 with 5, P3ENP3 with 6 setae/spines.

Armature formula of female P1-P4 as follows:

	EXP	ENP
P1	1-0;I-1;1,4,1	0-1;1,2,1
P2	I-1;I-1;III,I1,2	0-1;0-2;0,I2,2
P3	I-1;I-1;III,I1,3	0-1;0-2;0,I2,3
P4	I-1;I-1;III,I1,3	0-1;0-2;0,I2,2

P5 (Fig. 7B). Inner baseoendopodal lobe with 1 inner small and bare seta and 1 long pinnate element, the latter about 2.5 times longer. Exopod about 4 times as long as wide, with spinules along inner and outer margins and at base of innermost seta; with 5 setae in all.

P6 (Fig. 1A, B) on second urosomite (proximal half of genital-double somite) and represented by symmetrical plate bearing on each side 2 inner long setae and 1 small outer element.

Male. General body shape as in female except for genital double-somite (Fig. 8A). Total body length ranges from 510 µm to 590 µm (mean, 533 µm; n, 8).

Antennule (Fig. 8B) haplocer, 10-segmented, with aesthetasc on last segment. Relative size of segments as figured.

Antenna, mandible, maxillule, maxilla, and maxilliped (not shown) as in female.

P5 (Fig. 8C). As in female, except for baseoendopodal lobe with only 1 smooth seta.

P6 (Fig. 8A) represented by 2 large plates partially fused, with 1 short outer seta and 2 long inner elements.

Taxonomic abstract

Material examined. Twenty females and 8 males preserved in alcohol (EMUCOP- 060605-11), 3 dissected females (EMUCOP- 080405-12, EMUCOP- 080405-13, EMUCOP- 170801-05) and 1 dissected male (EMUCOP- 170801-58). El Verde estuary (April 8, 2005, stn. 1

(23°24'55"N, 106°32'28"W); salinity 21‰; temperature, 24.9° C; organic carbon content, 2.6%; dissolved oxygen, 2.7 mg/l; BOD₅, 0.6 mg/l; sand, 3.38%; silt, 37.21%; clay, 64.41%) and Urías system (August 17, 2001, stn. 3 (23°10'34"N, 106°20'57"W); salinity 33‰; temperature, 32.1° C; organic carbon content, 3.4%; sand, 62.57%; silt, 29.6%, clay, 7.8%; December 2, 2005, stn. 1 (23°09'06"N, 106°18'46"W); salinity 39‰; temperature, 22.4° C; organic carbon content, 4.19%; dissolved oxygen, 6.52 mg/l; BOD₅, 5.52 mg/l; sand, 71.61%; silt, 21.3%; clay, 7.09%). Coll. S. Gómez, F. N. Morales-Serna, I. M. Bustos-Hernández, and F. E. Vargas-Arriaga.

Taxonomic comments

Gurney (1927) found a single female of an unknown species of harpacticoid copepod in samples taken from Ismaïlia (Egypt) during the Cambridge Expedition to the Suez Canal in 1924. For this new species Gurney (1927) created the genus *Tisbella* Gurney, 1927 and coined the name *Tisbella timsae* Gurney, 1927. Because Gurney (1927) had only 1 female at hand, he decided not to dissect it and was not able to give a detailed description of the mouthparts. However, he suggested a close relationship of his new genus with *Tisbe* Lilljeborg, 1853. Later on, Willey (1930) reported *T. timsae* from Mangrove Lake (Bermuda), and Wilson (1932) created the genus *Chappaquiddicka* Wilson, 1932 for *Chappaquiddicka pulchella* Wilson, 1932 from Chappaquiddick Island (Woods Hole region).

In his monograph, Lang (1948) considered *Chappaquiddicka* as a synonym of *Tisbella*, and suggested that *T. timsae sensu* Willey (1930) from Bermuda is in fact a synonym of *T. pulchella*, thus recognizing 2 species within *Tisbella*, *T. timsae* and *T. pulchella*.

Yeatman (1963) redescribed Willey's (1930) material of *T. timsae* from Mangrove Lake (1 female collected in August 4, 1955) and Wilson's (1932) material of *C. pulchella* from Massachusetts (3 female paratypes –USNM No. 60409- collected in July 20, 1925, and 5 females and 1 male collected in June 25, 1959), and supported Lang's (1948) view.

Later, in her revision of the genus *Tisbella*, Volkmann (1979), probably unaware of Yeatman's (1963) paper, redescribed in detail *T. pulchella* from material collected by Wilson in 1925 from Chappaquiddick Island (USNM No. 60409, the same material on which Yeatman (1963) based his redescription), and noted that most of Wilson's (1939) drawings were incorrect. Also in that revision, Volkmann (1979) recognized 4 species of *Tisbella* worldwide, *T. rosea* Volkmann, 1979 known from Bermuda, *T. alba* Volkmann, 1979 known from Bermuda and Florida, *T. pulchella*

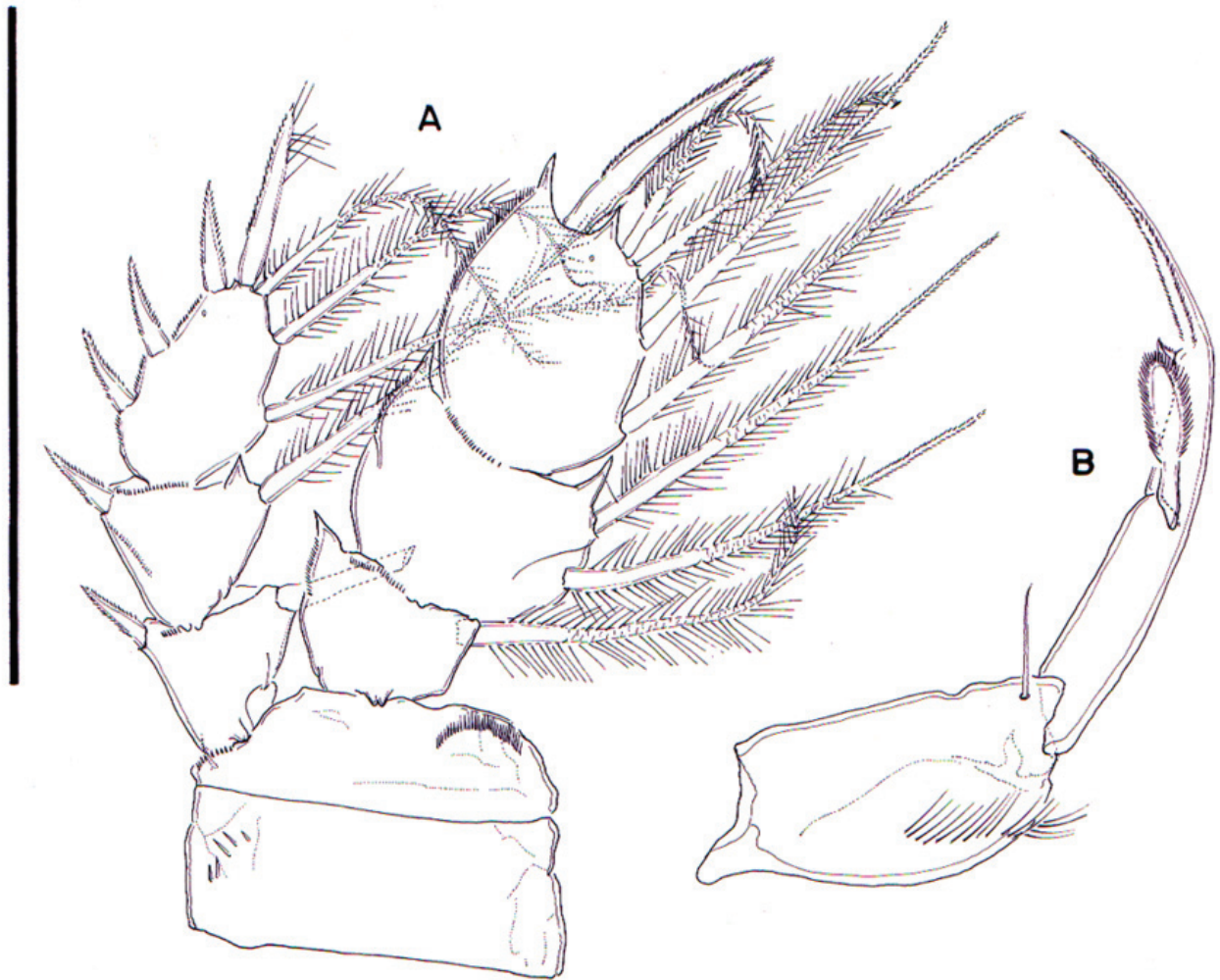


Figure 5. *Tisbella pulchella* (Wilson, 1932), female. A, P2; B, maxilla. Scale bar: A, 200 μm ; B, 140 μm .



Figure 6. *Tisbella pulchella* (Wilson, 1932), female. A, P3; B, maxilliped. Scale bar: A, 200 µm; B, 140 µm.

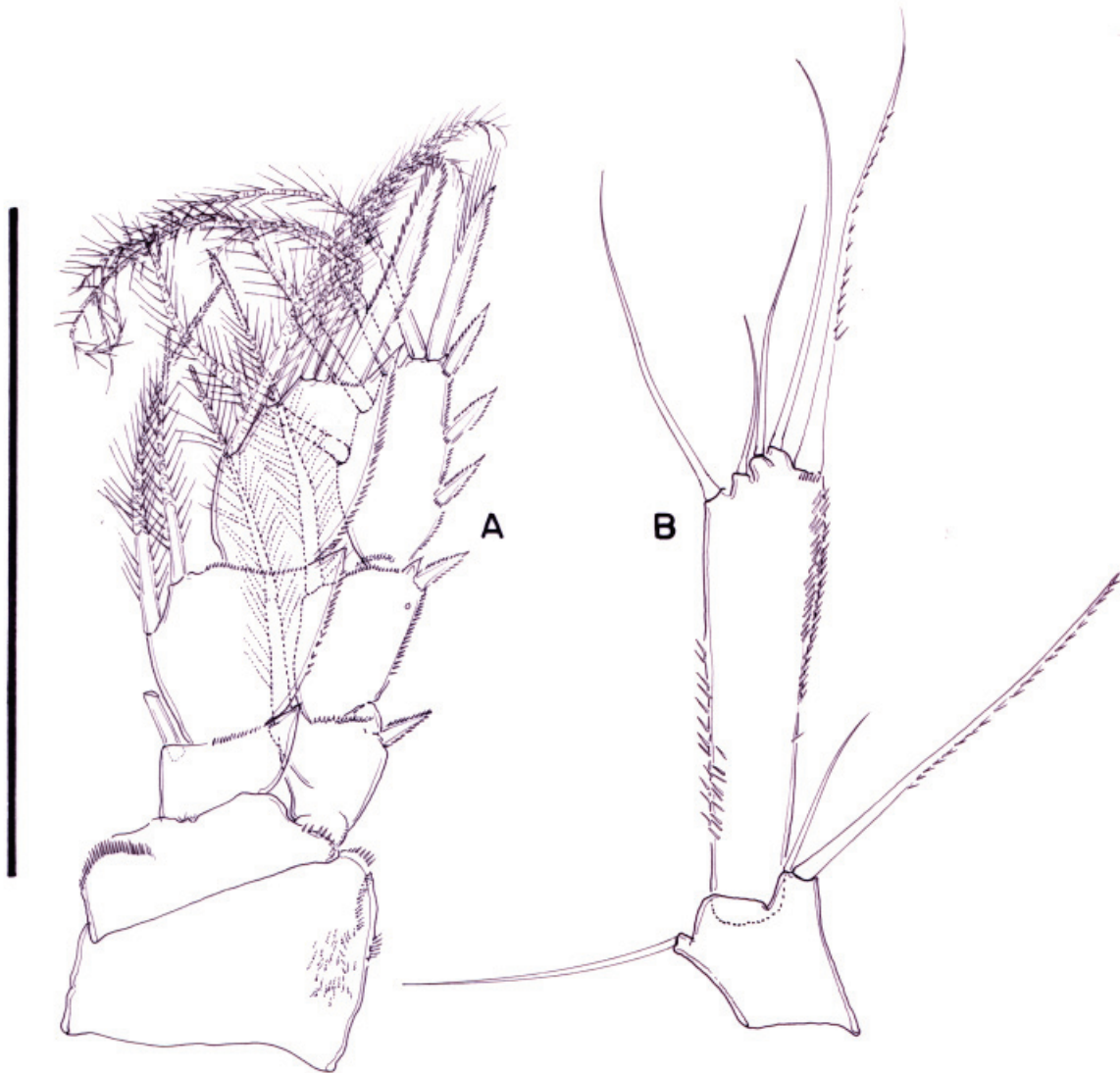


Figure 7. *Tisbella pulchella* (Wilson, 1932), female. A, P4; B, P5. Scale bar: A, 200 μm ; B, 140 μm .

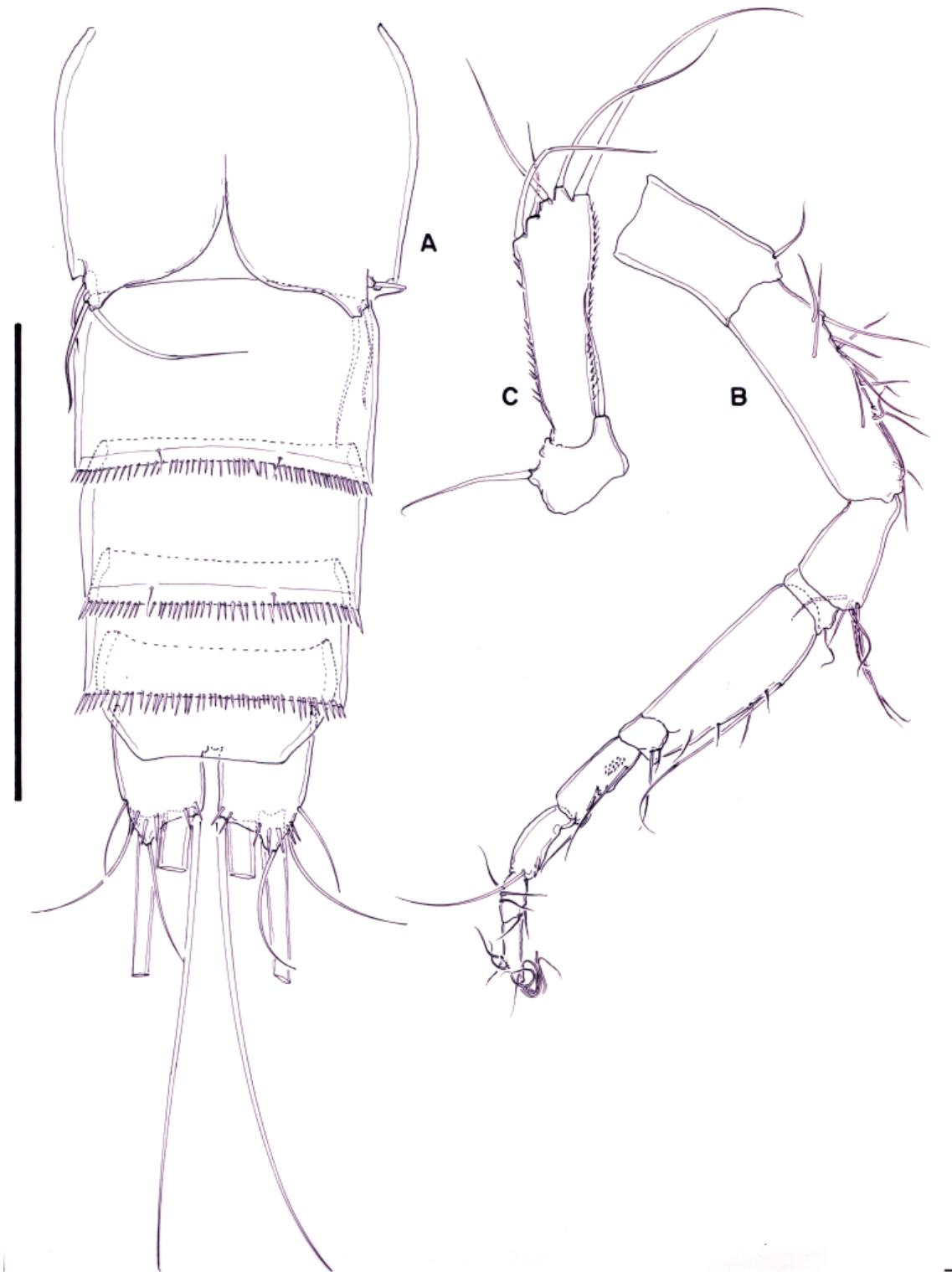


Figure 8. *Tisbella pulchella* (Wilson, 1932), male. A, urosome, ventral (P5-bearing somite omitted); B, antennule; C, P5. Scale bar: A, C, 100 µm; B, 140 µm.

(Wilson, 1932) known from Massachusetts and Bermuda, and *T. timsae* known from Egypt. Also, Volkmann (1979: 93) noted that the interpretation of possible relationships within *Tisbella* species is rather speculative.

The Mexican material agrees with the redescription of the species given by Volkmann (1979). A comparison between the previous redescriptions of the type material and the Mexican specimens are given below.

Willey (1930) omitted any comment on the total number of segments of the female antennule but noted that the "sixth and seventh joints are imperfectly divided". Wilson (1932) described the female antennule as 8-segmented with an aesthetasc arising from the fourth segment. Yeatman (1962) described an 8-segmented female antennule, observed 1 aesthetasc arising from the fourth segment and noted that the "sixth and seventh segments- are often imperfectly separated by a joint", suggesting that Willey (1930) also observed an 8-segmented female antennule. Volkmann (1979) observed that the female antennule of the species is 7-segmented, and that the division observed by Willey (1930) and Yeatman (1962) is in fact the base of insertion of a relatively large seta situated in the middle of the segment. The same was observed in the Mexican material.

Willey (1930) noted that "the fourth joint of the outer branch of the second antenna is considerably elongated". The 4-segmented condition of the exopod of the antenna was erroneously corrected by Wilson (1932) and Yeatman (1962) who described this appendage as 2-segmented. In her redescription, Volkmann (1979) accurately described the antennary exopod as 3-segmented, having the first, second and third segments 1, 1 and 3 setae, respectively. The same condition was observed in the Mexican material, being the middle segment very small in both Volkmann's (1979) and in the present description. The first and second endopodal segments of the antenna observed in the Mexican material agrees perfectly with the illustrations given by Volkmann (1979) (the descriptions/drawings presented by the other authors lack detail and it is of little use to compare them).

The description of the mandible given by Willey (1930) is very poor. In his illustration he presented the mandibular gnathobase with a large seta and the mandibular palp with 1-segmented rami, the exopod being armed with 2 setae and the endopod with 6 apical and 2 lateral setae. The description of the mandible given by Wilson (1932) differs from Willey's (1930) in the number of setae of the endopod (with 1 lateral and 4 apical seta in Wilson's (1932) description). Yeatman's (1962) description is different from Willey's (1930) and Wilson's (1932) in that Yeatman (1962) described the endopod with 2 lateral and 3 apical setae. The description of the mandible given by

Volkmann (1979) matches perfectly that of the Mexican material.

The maxillule has received little attention. Willey (1930) omitted any comment on it, Yeatman (1962) only presented a small illustration of it, and the description given by Wilson (1932) and Volkmann (1979) differ in the number of elements on the praecoxal arthrite and palp. The description herein is by far the most accurate presented to date.

The written descriptions of the maxilla presented by Willey (1930), Wilson (1932) and Yeatman (1962) are also very poor and the illustrations are very similar, the only difference being the lack of the inner seta on the syncoxa in Willey's (1930) illustration. The description given by Volkmann (1979) is, by far, the most detailed, and matches perfectly the maxilla observed in the Mexican material.

The maxilliped likewise received little attention in Willey's (1930) and Yeatman's (1962) descriptions and nothing is said about the accessory setae of the endopodal segment. The maxilliped presented by Willey (1930) was described as possessing an extremely long syncoxa. On the other hand, the maxilliped presented by Wilson (1932) has been erroneously described as possessing an accompanying spine instead of a seta at the base of claw and with 6 hair-like setae on syncoxa. The maxilliped presented by Volkmann (1979) resembles that of the Mexican material except for 1 accessory seta at the base of claw (with 1 seta in Volkmann's (1979) description, but with 2 setae in the Mexican specimens).

Willey (1930: 86) omitted the description of the armature formula and shape of the setae/spines and noted that using Gurney's (1927) table for the armature formulae "one may disregard the distinction between flexible bristles and rigid spines, making the table purely numerical", but presented the same type of table as in Gurney's (1927). This is important since it seems as if Willey (1930) was not sure about the shape of the outer element of P1EXP1. Gurney (1927) omitted any comment on this point, but Willey (1930: 87, Fig. 9) showed the outer element of P1EXP1 as a seta-like element. The same shape of this outer element was observed by Yeatman (1962) and Volkmann (1979), and has been observed also in the Mexican specimens. Noteworthy, Willson (1932: 200) described this element as a "small acuminate outer spine". The armature formula and/or shape of the elements (setae and spines) are the same in the description and illustrations presented by Willey (1930), Wilson (1932), Yeatman (1962) and Volkmann (1979), except for Wilson's (1932) illustration of P3ENP3 with 2 inner setae instead of 3 inner elements. The Mexican material entirely matches the armature formulae as presented by Willey (1930),

Yeatman (1962) and Volkmann (1979).

Willey (1930) omitted any comment about the female P5. Wilson (1932) was right in the number of setae of the female baseopod but his written description is not completely accurate in the number of setae of the baseopodal lobe. The general shape and number of setae of the baseopod and exopod observed in the Mexican material agrees completely with those described by Yeatman (1962) and Volkmann (1979).

Furthermore, the female P6 has received little attention. Willey (1930) and Wilson (1932) omitted any comment on it, and Yeatman (1962) observed only 1 long inner seta and 1 short outer seta. In her revision of the genus, Volkmann (1979) observed that each female P6 is represented by a short, outer seta and 2 long, inner elements. The armature of the female P6 observed in the Mexican material matches completely Volkmann's (1979) observations.

Willey (1930) remained silent about the shape, length:width ratio and number of setae of the caudal rami, and Wilson (1932) only noted that the caudal rami are half the length of the anal segment and that the rami were "tipped with 2 long setae". The shape, length:width ratio, and number of setae of the caudal rami observed in the Mexican material matches completely the ones observed by Yeatman (1962) and Volkmann (1979).

Regarding sexual dimorphism, Willey (1930) and probably Wilson (1932) (the latter noted that the "last 4 segments –are- turned forward", suggesting from his plate 4, Fig. c, that he observed an 8-segmented male antennule) described the male antennule as being 8-segmented. Yeatman (1962) did not present the description of the male antennule and Volkmann (1979) accurately described the male antennule as 10-segmented, which matches completely the male antennule observed in the Mexican material.

Willey (1930) did not describe the male P5. The shape and number of baseopodal and exopodal setae of the male P5 observed in the Mexican specimens agree completely with the descriptions by Wilson (1932), Yeatman (1962) and Volkmann (1979).

Willey (1930) remained silent about the number of setae of the male P6, and Wilson (1932) and Yeatman (1962) described this limb with 4 setae. The condition of the male P6 matches completely with the description given by Volkmann (1979) (with 3 setae only).

Volkmann (1979) suggested that *T. alba* could be the "most primitive species" within the genus, and at that time, this species had the largest known distribution among *Tisbella* species, being known from Bermuda and Florida (Volkmann, 1979). Ours is the first report of *T. pulchella* from the Tropical Eastern Pacific, and represents a range extension of the species from Massachusetts and Bermuda

to Sinaloa (north-western Mexico), being the species within *Tisbella* with the widest distribution so far. The presence of the same species in the Atlantic coast of USA and north-western Mexico is not unusual as evidenced by the presence of *Tisbe monozota* Bowman, 1962 (Gómez et al., 2004). Volkmann (1979) suggested that the genus *Tisbella* may have evolved on the shores of the Tethys Sea during the Miocene (about 14 Myr BP). However, it has been suggested that some other species of benthic copepods from the Western Atlantic (e.g. *Darcythompsonia fairliensis* T. Scott, 1899, *Cyclopina caissara* Lotufo, 1994, *Enhydrosoma lacunae* Jakubisiak, 1933) might have reached the Eastern Pacific before the consolidation of the Central American Isthmus sometime during the Early Tertiary period (about 65 Myr BP) (Gómez, 2000; Gómez and Martínez-Arbizu, 2004; Gómez, 2003). Of course these species might have been transported in ballast water and their historical biogeography remains speculative.

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