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New record for the deep-sea genus *Tripoplax* (Mollusca: Polyplacophora) in the eastern Pacific

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Abstract

Background: Most species of Polyplacophora are found in shallow, coastal water, and their distribution and ecology is generally well known. On the contrary, information related with distribution, biology and ecology of deep-sea chitons is scarce.

Methods: Specimens of the deep-sea mollusks fauna were obtained during sampling operations of western Mexico (TALUD project) aimed at the study of invertebrate fauna occurring under the Oxygen Minimum Zone (OMZ). The material reported herein is part of the Polyplacophora fauna collected with a benthic sledge off the west coast of the Baja California Peninsula, in the eastern Pacific, Mexico.

Results: The deep-sea chiton *Tripoplax* cf. *balaenophila* Schwabe & Sellanes 2004 was collected in 530–625 m depth, in the following environmental conditions: dissolved oxygen, <0.25 ml/l; temperature, 6.44 °C; salinity, 34.47. It represents a range extension of 63° of latitude (ca 8280 km) to the north for this species previously known only from the type locality, off Concepción, Chile.

Conclusions: *Tripoplax* cf. *balaenophila* is associated with the lower boundary of the Minimum Oxygen Zone occurring off western Mexico, an habitat characterized by severe hypoxic conditions and colonized by well-adapted species that are generally abundant. Assignment of species to *Tripoplax* or *Lepidozona* is still a conflictive issue. The existing discrepancy in slit number and the assignment of "*balaenophila*" to *Tripoplax* cannot be solved without a more thorough review of both genera. The disjunct distribution of the genera *Tripoplax* in the eastern Pacific is also an interesting biogeographical issue.

Keywords: Polyplacophora, *Tripoplax* cf. *balaenophila*, Eastern Pacific, Mexico

Background

Polyplacophora include about 900 extant species worldwide, most living in shallow water on rocky substrates (Schwabe & Sellanes 2010; Ávila & Sigwart 2013). In addition, about 430 fossil species have been described (Puchalski et al. 2008). About 24 species have been recorded from the abyssal and hadal zones (Schwabe 2008).

Information dealing with chitons from the Mexican Pacific is available in several contributions (e.g., Reyes-Gómez & Salcedo-Vargas 2002; Reyes-Gómez 2004; Flores-Campaña et al. 2007; Galeana-Rebolledo et al. 2012; Hendrickx et al. 2014; Ramírez-Álvarez et al. 2014). On the contrary, studies related to deep-water (>200 m depth) species are few and very little is known on their distribution and biology (Stebbins & Eernisse 2009; Galeana-Rebolledo et al. 2012). Most information on deep-water chitons is found in taxonomic and monographic studies that often provide interesting information related to geographic and bathymetric ranges (Dall 1919; Ferreira 1979; Kaas & Van Belle 1985, 1987, 1990; Clark 2008), but very few data are provided regarding ecological aspects.

At deep-sea bottom soft substrates predominate and this habitat is not adequate for chitons. Hence, their occurrence is generally linked to the presence of hard

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substrates like rocks and rocky structure (Stebbins & Eernisse 2009), dead wood (Sirenko 2004), and unusually osseous remains of dead whales (Schwabe & Sellanes 2004). Chitons have also been recorded from hot-vents and cold-seeps (Saito et al. 2008), canyons (Clark 2008), and seamounts (Stocks 2004).

During an exploratory cruise off western Mexico, specimens of a species of the deep-sea genus *Tripoplax* were collected. This material is reported here and represents a significant range extension for a species described for Chile.

Results and discussion

SYSTEMATICS

Class Polyplacophora Gray, 1821
Order Chitonida Thiele, 1909
Suborder Chitonina Thiele, 1909
Family Ischnochitonidae Dall, 1889
Genus *Tripoplax* Berry, 1919
Tripoplax cf. *balaenophila* (Schwabe & Sellanes, 2004)
Fig. 1

Material examined

TALUD XV, St. 23, 27°08′11″N, 114°32′54″W, August 1, 2012, 5 specimens (TL 6.82–13.76 mm), benthic sledge, 530–625 m depth (EMU-10816 and 10817).

Morphological remarks

Small-sized animal (TL, 13.76, 11.21, 10.22, 6.98 and 6.82 mm) (Fig. 1i, j). Color yellowish-beige, girdle of the same ground color, with slightly darker bands. Tegmentum. General valve sculpture consisting of very fine granules arranged in quincunx (Fig. 1a, c, e), readily visible on the head valve, lateral areas and postmucronal area. Articulamentum consisting of a thin translucent white layer. Insertion plates short, with broad, sharp teeth (Fig. 1b, f). Slit formula: 10/1-2/17 (vs. 10/1-2/12 in the holotype), slit rays present. Ctenidia (or gills) in a holobranchial arrangement, left and right series of ctenidia counting 17–18 (Fig. 1j). Perinotum. Girdle rather small, covered with larger rectangular scales (>100 μm), the later sculptured with about 10 radial ribs (Fig. 1g, h). Radula (Fig. 1k, l). Central tooth slender, narrower in its middle part, provided with a small, upper fold inclined downwards. First lateral tooth shorter than central; turbercule-like structure in the corner of the blade directed outward. Second lateral tooth with inner denticle sharp, nearly twice as long as outer one; outer denticles obtuse. Major uncinal tooth slender, a lateral fold at mid-third, tip flattened, round, paddle-like.

General features of the examined material fit well with the original description (Schwabe & Sellanes 2004). However, although quite similar, girdle scales are proportionally larger and more rectangular in the Mexican specimens. The central tooth of the radula shows a distinctly different shape compared to these tooth in the original description of *T. balaenophila*, i.e., rectangular with a forward and downward bent single blade. The first lateral tooth is shorter in relation to the central one in our specimen and the tubercule-like structure in the corner of the blade is directed outward vs. inward directed in *T. balaenophila*.

Photographs of one specimen (TL, 11.21 mm; Fig. 1i, j) of *T.* cf. *balaenophila* were sent to Boris Sirenko who suggested that it could belong to that species (B. Sirenko, pers. comm., January 2015). SEM photographs of the radula and the girdles scales were sent to Enrico Schwabe who emphasized the similarity between *T. balaenophila* and our material, but suggested that the variations observed in the radula and in the girdles scales might indicated that the material reported herein represents a species very close yet distinct to *T. balaenophila* (E. Schwabe, pers. comm., September 2015). The differences observed might be significant, but a more profound revision is needed, including comparing the material with other species in the context of a thorough revision of *Tripoplax* (and *Lepidozona*), both morphologically and using molecular markers.

Environmental conditions

The species was collected at 530–625 m depth in the following environmental conditions: dissolved oxygen, <0.25 ml/l; temperature, 6.44 °C; salinity, 34.47.

Type locality

Off Concepción, Chile, 36°29.9′S; 73°40.8′W (Fig. 2), in 240 m depth, just beneath the shelf break, mostly attached to bones of dead whales and rocks.

Distribution and habitat

The presence of *T. balaenophila* off western Mexico would considerably extends its geographic range by over 63° of latitude (ca 8280 km) to Baja California (27°08′ 11″N; 114°32′54″W) (Fig. 2), and its bathymetric range to 530–625 m. There was no evidence of osseous remains in the sample and we believe that the specimens were probably attached to the rocks found in the net, and that were accidently collected. There was no indication that the sample was obtained from a chemosynthetic environment, as hypothesized earlier (Schwabe & Sellanes 2004). It is clear, however, that our material was collected just below the Oxygen Minimum Zone (OMZ) in severe hypoxic conditions (<0.25 ml/l O_2). The OMZ has long been recognized as an ecologically important feature of the eastern Pacific, including western Mexico (Diaz & Rosenberg 1995; Hendrickx & Serrano 2010; Serrano 2012). According to published information (Schwabe & Sellanes 2004; Sellanes et al. 2010), the

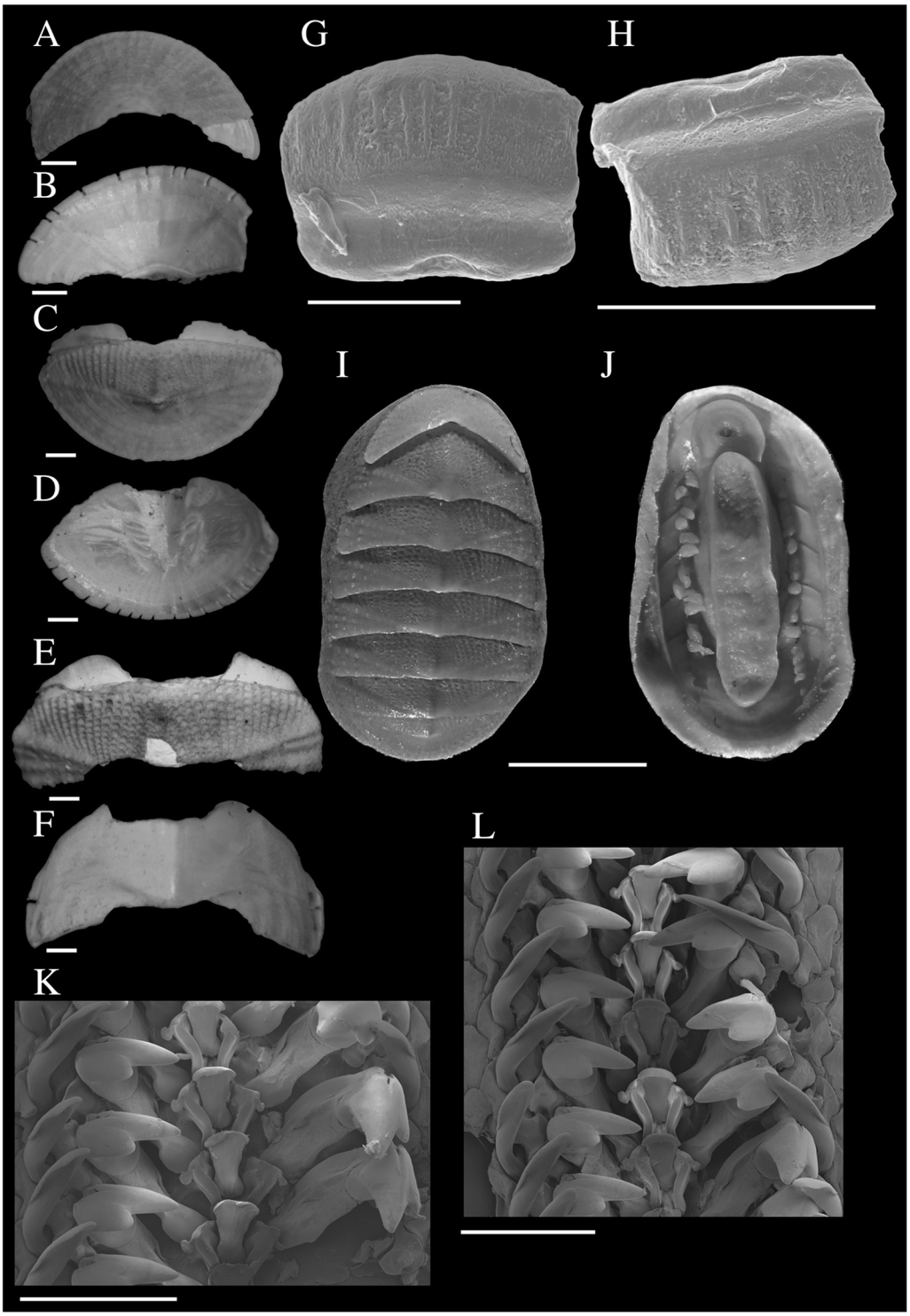

Fig. 1 *Tripoplax* cf. *balaenophila* (Schwabe & Sellanes, 2004) (EMU-10817). **a**-**f**, TL 13.76 mm; H-l, TL 11.21 mm. **a** Dorsal view of first valve, scale bar: 1 mm. **b** Ventral view of the first valve, scale bar: 1 mm. **c** Dorsal view of the tail valve, scale bar: 1 mm. **d** Ventral view of the tail valve, scale bar: 1 mm. **e** Dorsal view of valve v, scale bar: 1 mm. **f** ventral view of valve v, scale bar: 1 mm. **g** Dorsal girdle scales, scale bar: 100 μm. **h** Lateral view girdle scales, scale bar: 200 μm. **i** Dorsal view, head region on top, scale bar: 5 mm. **j** Ventral view, head region on top, scale bar: 5 mm. **k** Detail of radula, showing teeth, scale bar: 200 μm. **l** Anterior portion of radula, scale bar: 200 μm

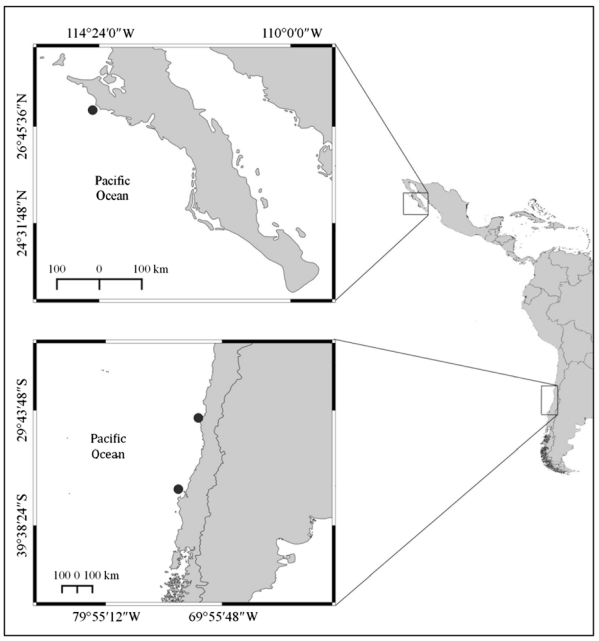

Fig. 2 Sampling localities of the deep-water chiton *Tripoplax* cf. *balaenophila* off Baja California, Mexico (upper map), off Concepción (data extracted from Schwabe & Sellanes, 2004), and off Coquimbo, Chile (E. Schwabe, pers. comm., April 2015) (lower map)

specimens from Chile were collected in bottom water with severe oxygen deficiency (<0.5 ml/l). The amplitude of the OMZ corresponding to upper and lower oxygen concentrations of 0.5 ml/l is reduced and shallower off Concepción, in southern Chile (from 50 to 150 m depth) (Helly & Levin 2004) when compared to the conditions found at the Mexican sampling locality (TALUD XV, St. 23, from 90 to >630 m depth) (D. Serrano, pers. comm., April 2015). In this area (ca 27 °N), the OMZ fringe corresponding to concentrations of 0.5 ml/l extends from 200 to 750 m (Helly & Levin 2004), a similar range as what is shown by the TALUD XV cruise data. This probably explained why the Mexican material was collected in deeper water than off Chile. On the other hand, it is reasonable to assume that *T. balaenophila* occurs in the wide latitudinal interval between Chile and western Mexico and that lack of additional records of this species is due to lack of sampling. As a matter of fact, an additional, unpublished record of *T balaenophila* is available for a second Chilean locality: off Coquimbo, 30.3815 °S, 71.9626 °W, in 140 m depth (Bavarian State Collection of Zoology, Munich, Germany, Mol 20130032, 5 specimens; Enrico Schwabe, pers. comm., April 2015: coll. J. Sellanes). According to data available for this area (Helly & Levin 2004), this material was obtained close to the lower boundary of the OMZ.

Additional comments

The subgenus *Tripoplax* was originally proposed in 1919 (Berry 1919) within the genus *Ischnochiton* Gray, 1847. *Tripoplax* and *Lepidozona* have been considered as subgenera of *Lepidozona* Pilsbry, 1892 (Kaas & Van Belle 1987; Clark 1991, 2000; Eernisse 1998). *Tripoplax* has also been considered a natural assemblage based of its morphology and biogeography and elevated to genus (Clark 2008). An expanded definition of *Tripoplax* (Clark 2008) clearly stated that "insertion plates of intermediate valves with two to four slits" are characteristic of the genus. *Tripoplax balaenophila* was originally described in the genus *Lepidozona* (Schwabe & Sellanes 2004), with a slit formula of 1–2 for intermediate valves. In 2010, however, it was transferred to *Tripoplax* (as a new combination), following a recent redefinition of this genus (Clark 2008), without further comments on the slit formula (Schwabe & Sellanes 2010). This discrepancy in slit number and the assignment of "*balaenophila*" (with 1–2 slits on intermediate valves) to *Tripoplax* (with 2–4 slits on intermediate valves) cannot be solved without a more thorough review of both *Lepidozona* and *Tripoplax*. *Tripoplax* species are generally found in higher latitudes in the northern Pacific (Clark 2008), which is the case of the material examined herein (27°08′11″N). The presence of *T. balaenophila* in deep water from off both western Mexico (northern hemisphere) and Chile (southern hemisphere), however, is an interesting issue that needs to be addressed within a general biogeographically context of the distribution of the genera *Tripoplax* (southeastern and northern Pacific) and *Lepidozona* (with a worldwide distribution) in the eastern Pacific (Clark 2008; Schwabe & Sellanes 2010).

Conclusions

Tripoplax cf. *balaenophila* is a member of the deep-sea mollusks fauna associated with the lower boundary of the OMZ occurring off western Mexico, an habitat characterized by severe hypoxic conditions and colonized by well-adapted species that are generally abundant (Zamorano et al. 2006; Papiol & Hendrickx 2015). Specimens from Chile were collected in shallower depth compared to the Mexican material, but the OMZ off Chile is also much shallower than in the Mexican Pacific (Helly & Levin 2004). The presence of *T. balaenophila* off western Mexico would considerably extend its geographic range (by ca 8280 km to the north). The disjunct distribution of the genera *Tripoplax* in the eastern Pacific is also an interesting biogeographical issue. Assignment of species to *Tripoplax* or *Lepidozona* is still a conflictive issue, in part due to lack of abundant material that would allow for more detailed studies. The existing discrepancy in slit number and the assignment of "*balaenophila*" to *Tripoplax* cannot be solved without a more

thorough review of both genera. Further exploration of the deep-sea in the eastern Pacific might also bring additional specimens that would fill the gap in the distribution range of the deep-water Polyplacophora.

Methods

Specimens were collected during the TALUD XV cruise, off the west coast of the Baja California Peninsula (July 29 to August 6, 2012) aboard the R/V "El Puma", of the Universidad Nacional Autónoma de México (UNAM). Positional coordinates for each sampling station were obtained using a GPS navigation system. Depth was measured with a digital recorder. Epibenthic temperature and oxygen concentration were measured ca 10 m above bottom level with a Seabird CTD-O_2 probe. Oxygen concentrations were also double-checked with the Winkler method using water samples collected in closing bottles near bottom. The specimens were captured with a standard benthic sledge (2.35 m width, 0.9 m high) equipped with a modified shrimp net (ca 5.5 cm stretched mesh size) with a ca 2.0 cm (3/4″) internal lining net. The material collected during this survey is deposited in the Regional Collection of Marine Invertebrates (EMU), at UNAM in Mazatlán, Mexico. To confirm the identification, the radula was extracted following recent literature (Geiger et al. 2007) and photographed with a Scan Electronic Microscope (SEM). Dorsal girdle scales (also photographed with the SEM) and disarticulated valves were also examined. Entire specimens and the photographs were compared to the original description (Schwabe & Sellanes 2004). Photographs were sent to Boris Sirenko (Russian Academy of Sciences, Moscow) and to Enrico Schwabe (Bavarian State Collection of Zoology, Munich) for comparison with the type material. Ethics, consent and permissions have been followed in the manuscript. Collection of specimens was covered by permit FAUT-0053 of the National Institute of Ecology, Mexico.

Abbreviations

St.: station; TL: total length.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

NYSM carried out the revision of the specimens, elaborate the manuscript draft and processed the illustrations. MEH is responsible of the TALUD cruises, participate in the organization and final version of the manuscript. All authors read and approved the final manuscript.

Authors' information

NYSM is a postgraduate student at UNAM and this contribution is part of her master thesis. MEH is a senior scientist at UNAM and head scientist of the TALUD project.

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