



## Deep-water Holothuroidea (Echinodermata) collected during the TALUD cruises off the Pacific coast of Mexico, with the description of two new species

### Holothuroidea (Echinodermata) de mar profundo recolectadas durante las campañas TALUD frente a la costa del Pacífico mexicano, con la descripción de dos especies nuevas

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**Abstract.** Research cruises aboard the R/V “El Puma” were organized to collect deep-water benthic and pelagic specimens off the Pacific coast of Mexico. Seventy four specimens of Holothuroidea were collected off the Pacific coast of Mexico in depths of 377-2 200 m. The collection includes representatives of 5 of the 6 orders of Holothuroidea, 3 Dendrochirotida, 2 Dactylochirotida, 2 Aspidochirotida, 4 Elasipodida and 2 Molpadiida. Apodida were not represented. Of the 13 species recognized, 11 were identified to species level and 2, belonging to the genera *Ypsilocucumis* Panning, 1949, and *Mitsukuriella* Heding and Panning, 1954, are new to science. Five species represent new geographic or depth records. A list of Mexican localities previously and newly reported for each species are plotted on distribution maps. Environmental data, i.e., depth, temperature, and dissolved oxygen measured at the bottom level during the survey are provided. When compared with other areas of the world, the reduced number of specimens collected during this survey could be linked to the limiting effect of the Pacific Mexico Oxygen Minimum Zone. An updated checklist of species of Holothuroidea recorded below 350 m depth along the Pacific coast of Mexico is also provided totaling 31 species: 13 of these occur in the California Current area, 20 in the Gulf of California, and 15 (16) along the SW coast of Mexico.

Key words: Holothuroidea, deep-water community, continental slope, East Pacific, Mexico, new species.

**Resumen.** Una serie de campañas oceanográficas fue organizada a bordo del B/O “El Puma”, frente a las costas del Pacífico mexicano con el propósito de recolectar ejemplares de la fauna bentónica y pelágica de aguas profundas. La recolección incluyó representantes de 5 de los 6 órdenes de Holothuroidea, i.e., 3 Dendrochirotida, 2 Dactylochirotida, 2 Aspidochirotida, 4 Elasipodida y 2 Molpadiida. Los Apodida no están representados. De las 13 especies capturadas por debajo de los 350 m de profundidad (377-2 200 m), 11 fueron identificadas hasta especie y 2 pertenecientes a los géneros *Ypsilocucumis* Panning, 1949, y *Mitsukuriella* Heding y Panning, 1954, son nuevas para la ciencia. El material examinado comprende 74 ejemplares. Las localidades previas y nuevas registradas para cada especie recolectada están compiladas para el Pacífico mexicano en mapas de distribución. Se proporciona información acerca de las condiciones de captura de cada especie (temperatura y oxígeno disuelto). Comparativamente con otras áreas del mundo, el número reducido de organismos recolectados durante el estudio podría estar relacionado con la presencia de una zona del mínimo de oxígeno a lo largo del Pacífico mexicano. Se anexa una lista actualizada de las especies de Holothuroidea registradas en profundidades mayores a 350 m frente a la costa del Pacífico mexicano. En total, 31 especies están registradas: 13 en el área de la corriente de California, 20 en el golfo de California y 15 (16) a lo largo de la costa SO de México.

Palabras clave: Holothuroidea, comunidad de aguas profundas, talud continental, nuevas especies, Pacífico este, México.

#### Introduction

Deep-sea macroinvertebrate communities are characterized by high diversity values (Hessler and Sanders, 1967; Sanders and Hessler, 1969; Grassle, 1989;

Smith et al., 1998). In areas where the oxygen-minimum zone (OMZ) intercepts the continental slope, anoxic and severely hypoxic benthic fringes are species-poor, but in even deeper water the hypoxic zone is species-rich. In the OMZ, depth and dissolved oxygen concentration are the most important factors affecting deep water community composition (Rosenberg et al., 1983; Levin and Gage, 1998; Rogers, 2000; Hendrickx, 2001; Levin et al., 2001;

McClain, 2004; Méndez, 2006; Zamorano et al., 2006) and species size (Rex and Etter, 1998; McClain and Rex, 2001; Olabarria and Thurston, 2003, 2004).

Study of Mexican echinoderms in the East Pacific started with the contributions of A.E. Verrill, who studied material collected along the west coast of America, including specimens from the area of La Paz (Verrill, 1868), Cabo San Lucas and the Gulf of California (Verrill, 1870, 1871b). He also reviewed large collections obtained during surveys covering much larger geographic areas (e.g., Verrill, 1867, 1871a), and described several new taxa. The Holothuroidea collected by the "Albatross" (west coast of America, from Peru to California, including Mexico) were studied by Ludwig (1893, 1894) and H.L. Clark (1913, 1920, 1923). Ludwig's monograph (1894) is by far the most important contribution for deep-water Holothuroidea in the region, with a total of 21 species described that occur below 350 m depth. Several other contributions complement the study of deep-water Holothuroidea in the central eastern Pacific, with the description of 14 species: Müller (1850) described 1 new species, Mitsukuri (1912) 1, H.L. Clark (1913, 1920, 1923) 5, Deichmann (1938a) 1, Cherbonnier (1941) 1, Belyaev (1971) 2, Hansen (1975) 2, and Pawson (1983) 1. Other contributions, essentially by Deichmann (1937, 1938a, 1938b, 1938c), increased the number of deep-water species known to the region.

Several papers, principally based on literature, present compilation lists of holothurians from the central eastern Pacific (see Table 2). Parker (1964) listed material collected in the Gulf of California and in several other sites along the west coast of Mexico, including 12 species of deep-water Holothuroidea. Bergen (1980) listed material collected in Southern California that includes 5 deep-water species. Maluf (1988) compiled thoroughly all the information on Central eastern Pacific echinoderms (list of species, depth distribution, geographical range). According to Maluf (1988), there were 55 species of Holothuroidea occurring below 350 m depth. Two deep-water species cited in the literature and of dubious status were also cited by Maluf (1988: 167) in an annex but were not included in her general analysis: *Achlyonice ecalcareia* Thél, 1879 (off Baja California, 1598 m) and *Bathyploetes hancocki* Domantay, 1961 (Southern California and Gulf of California). Another species, *Penagione leander* Pawson and Foell, 1986, an abyssal benthopelagic sea cucumber, was omitted by Maluf (1988) and therefore increases the list of species known from the Central eastern Pacific to 56. Of these 56 species, 5 were originally described from other regions of the world and later reported for the Central eastern Pacific: *Synallactes ishikawai* Mitsukuri, 1912 (now a junior synonym of *S. sagamiensis* Augustin, 1908), from Japan; *Leptosynapta albicans* (Selenka, 1867), from

the North Atlantic; *Rynkatorpa duodactyla* (H.L. Clark, 1907) (as *Protankyra duodactyla*), from the NW Pacific; *Ceraplectana trachyderma* H.L. Clark, 1907, from the NW Pacific; and *Molpadia musculus* Risso, 1826, from the Mediterranean.

Maluf (1991) proposed a checklist of echinoderms reported from the Galapagos Islands, including 38 Holothuroidea, 16 with records below 350 m depth. Lambert (1996) presented a recapitulation table with distribution, habitat and morphological data for all 8 species of *Psolidium* known from the eastern Pacific. Of these 8 species, only 2 (*P. panamense* Ludwig, 1894, and *P. gracile* Ludwig, 1894) occur deeper than 350 m (at 2 323 m, both at the same and unique known locality, in the Gulf of Panama), and both were cited by Maluf (1988). Solís-Marín et al. (1997) presented a compilation of species of echinoderms known from the Bay of La Paz. Mostly based on literature records, the list includes 27 Holothuroidea with 3 species occurring below 500 m. Further north, a large series of exploratory surveys were performed off the coast of California and Oregon, USA. Echinoderms, particularly Holothuroidea, were often identified to species level. A review of the information available was presented by Nybakken et al. (1998), who also reported on 13 species of Holothuroidea collected or observed by either a beam trawl or a camera sled off central California, many of which were previously reported for Mexico.

Additional information related to deep-water Holothuroidea from off the Galapagos was provided by Pawson and Ahearn (2001). More recently, Maluf and Brusca (2005) have reported 57 species of Holothuroidea for the Gulf of California, most from shallow water, and only 9 deep-water (>350 m depth) species are included in their list. Solís-Marín et al. (2005) published a compilation of echinoderm species from the Gulf of California. This list, based exclusively on records verified in the Dra. María Elena Caso Muñoz (Universidad Autónoma de México, México City) and in the Smithsonian Institution (Washington D.C.) echinoderms collections, includes 45 species of Holothuroidea from all kinds of habitats. Subsequently, Honey-Escandón et al. (2008) presented a list of species for the Mexican Pacific (i.e., excluding the Gulf), based on the same collections, with 46 species of Holothuroidea, and Solís-Marín et al. (2009) summarized our present knowledge of the Gulf of California Holothuroidea in a monograph that includes 55 species.

Many contributions to our knowledge of Mexican echinoderms were authored by M. E. Caso. Because she worked exclusively on intertidal and shallow-water holothurians (see among others Caso 1964, 1966, 1968), her contributions will rarely be cited in this study.

## Materials and methods

Holothuroidea were collected between 377 and 2 200 m depth on the continental slope along the Pacific coast of Mexico using an Agassiz dredge (ca 2.7 m width) and a benthic sledge (2.35 m width, 0.95 m high) equipped with a collecting net of ca 5.5 cm (2 1/4") stretched mesh aperture and an internal net with a ca 2.0 cm (3/4") stretched mesh aperture. A total of 13 cruises were organized in the Gulf of California and along SW Mexico, south of Banderas Bay, from 1989 to 2008. Specimens of Holothuroidea were collected during 9 cruises: TALUD III, September 1991; TALUD VI, March 2001; TALUD VII, June 2001; TALUD VIII, April 2005; TALUD IX, November 2005; TALUD X, February 2007; TALUD XI, June 2007; TALUD XII, March-April 2008; and TALUD XIII, January 2009. Positional coordinates for each station were plotted using a GPS navigation system. Depth was measured with an EdoWestern, analog recorder (TALUD III-VIII) or a digital recorder (TALUD IX-XIII). Epibenthic water temperature was measured with a Seabird CTD, and dissolved oxygen content was measured by the Winkler method (all cruises) and with a probe attached to the CTD (TALUD VIII-XIII). Holothuroidea were fixed on board with a 4% formaldehyde sea water solution, washed with tap water and preserved in 70% ethanol. In the systematic section below, a restricted synonymy including the prime synonym, references to new combination or reviews, and references for the Pacific coast of Mexico are included for each species, together with comments and additional data related to their distribution and ecology. The material examined herein is deposited in the Regional Collection of Invertebrates (EMU), ICML, UNAM, Mazatlán, Sinaloa, Mexico, in the collection of Holothuroidea at the Royal Belgian Institute of Natural Sciences (IG/HOL/RBINS), Brussels, Belgium, and in the Colección Nacional de Equinodermos "Dra. María Elena Caso" (ICML-UNAM), in México D.F., Mexico. Material examined also include 2 lots received on loan from the Scripps Institution of Oceanography, University of California San Diego (SIO, UCSD), La Jolla, USA, and a series of ossicle preparations from the Zoology Museum of Hamburg (ZMH), Hamburg, Germany. Other abbreviations used are: L, total length; St., sampling station; id., identifier; coll., collector. Based primarily on Maluf (1988) contribution, a list of all species with at least 1 record within Mexican waters of the Pacific Ocean was established (Table 1). In most cases the records used by Maluf were checked in the original literature. Literature records posterior to 1988 or based on the material collected during the TALUD cruises were incorporated in this list. The sources of these records are indicated in table 1.

## Results

*Generality and abiotic factors.* During the TALUD cruises, a total of 135 localities were sampled with benthic sledges and Holothuroidea were captured in 25 of these. No specimens of Holothuroidea were caught during the TALUD I, II, IV and V cruises. A total of 13 species represented by 74 specimens were collected. Eleven were identified to species level, 2 of these recognized as new species. The collection includes representatives of 5 of the 6 orders of Holothuroidea, i.e., 3 Dendrochirotida, 2 Dactylochirotida, 2 Aspidochirotida, 4 Elaspodida and 2 Molpadiida. Apodida were not represented. In 23 stations only 1 species was collected. A maximum of 3 species were found in a single station and 2 in another. All species considered, the material obtained in this survey was caught in a depth range of 377 to 2 200 m, and in epibenthic temperature and dissolved oxygen ranges of 2.0 to 10.52 °C and <0.05 to 2.14 ml O<sub>2</sub>/l, respectively (Table 1).

## Descriptions

Class Holothuroidea de Blainville, 1834  
 Order Dendrochirotida Grube, 1840  
 Family Cucumariidae Ludwig, 1894  
 Genus *Abyssoicum* Heding, 1942  
*Abyssoicum albatrossi* (Cherbonnier, 1941)  
 Figs. 1 A-F, 2

*Cucumaria albatrossi* Cherbonnier, 1941: 93-103, fig. 2, fig. 3 a-h, i, k-m.

*Abyssoicum albatrossi*; Cherbonnier, 1947: 462; Panning, 1949: 454; Madsen, 1955: 165, 167; Carney and Carey, 1976: 69; Maluf, 1988: 92, 155; Nybakken et al., 1998: 1778.

*Cucumaria abyssorum*; Ludwig, 1894: 122, pl. XIII, figs. 1-5; Ludwig and Heding, 1935: 179, textfig. 42.

*Stauromicum abyssorum*; Hansen, 1988: 302, Fig. 1; Solís-Marín et al., 2009: 84, pl. 17A-E.

Non: *Cucumaria abyssorum* Théel, 1886: 66.

*Material examined.* One specimen (L = 66 mm), TALUD XIII, St. 37 (EMU-8630).

Body cylindrical, 66 mm long, 25 mm across, slightly tapering at both extremities. Mouth and anus terminal. Tentacles fully retracted. Colour in alcohol grayish to black. Body wall gritty to the touch, parchment like, 0.7 mm thick. Tube feet only in the ambulacral zone aligned in 2 rows. Ossicles of the body wall as cross-shaped

**Table 1.** Sampling stations of the TALUD cruises where specimens of Holothuroidea were collected and list of species per station. Position, depth, and epibenthic water temperature and dissolved oxygen concentration are indicated for each station. Precision of data may vary according to the method used during the survey

<i>Cruise</i>	<i>Station</i>	<i>Species</i>	<i>Position</i>	<i>Date</i>	<i>Depth</i> (m)	<i>Temp.</i> °C	<i>Oxygen</i> ml/l
TALUD III	St. 14B	<i>Molpadia musculus</i>	24°39'12"N, 108°37'54"W	8-Sep-1991	1 188-1 208	ND	0.4
TALUD VI	St. 25	<i>Molpadia intermedia</i>	24°51'41"N, 108°57'53"W	16-Mar-2001	830-850	ca 5.0	0.22
TALUD VI	St. 26	<i>Ypsilocucumis californiae</i>	24°56'17"N, 109°6'39"W	16-Mar-2001	1 190-1 270	3.7	1.4
TALUD VIII	St. 3	<i>Pannychia moseleyi</i>	24°32'36"N, 109°30'30"W	16-Apr-2005	1 100	3.0	0.39
TALUD VIII	St. 11	<i>Ypsilocucumis californiae</i> <i>Synallactes alexandri</i> <i>Pannychia moseleyi</i>	24°54'24"N, 110°25'30"W	17-Apr-2005	920	5	0.2
TALUD VIII	St. 16	<i>Ypsilocucumis californiae</i> <i>Synallactes virgulasolida</i>	25°24'48"N, 110°34'48"W	18-Apr-2005	1 030	5	0.2
TALUD VIII	St. 20	<i>Dendrochirotida</i> sp. und.	25°56'54"N, 110°45'0"W	19-Apr-2005	1 150	4	0.30
TALUD VIII	St. 22	<i>Elasipodida</i> sp. und.	26°03'42"N, 110°21'18"W	19-Apr-2005	2 200	2.0	1.27
TALUD IX	St. 10	<i>Pannychia moseleyi</i>	24°56'24"N, 110°16'42"W	12-Nov-2005	969-1 225	3.6	0.11
TALUD IX	St. 16	<i>Molpadia musculus</i>	25°23'48"N, 110°36'42"W	13-Nov-2005	997-1 021	4.6	0.15
TALUD IX	St. 17	<i>Psolidium gracile</i>	25°20'48"N, 110°46'30"W	13-Nov-2005	826-836	5.75	<0.05
TALUD X	St. 3	<i>Ypsilocucumis californiae</i> <i>Psolidium gracile</i>	28°16'40"N, 112°35'10"W	9-Feb-2007	377-379	10.52	1.05
TALUD X	St. 9	<i>Mitsukuriella unusordo</i>	27°52'51"N, 112°15'53"W	10-Feb-2007	1 205-1 215	3.77	0.32
TALUD XI	St.1	<i>Psolidium gracile</i>	16°52'N, 100°20'W	7-Jun-2007	740-790	5.9	<0.05
TALUD XII	St. 5	<i>Ypsilothuria bitentaculata</i>	16°58'17"N, 100°55'12"W	28-Mar-2008	1 925-1 977	2.6	1.43
TALUD XII	St. 8	<i>Elasipodida</i> sp. und.	17°04'09"N, 101°39'16"W	29-Mar-2008	1 880-1 940	2.35	1.99
TALUD XII	St. 9	<i>Laetmogone scotoeides</i>	17°10'15"N, 101°37'23W	28-Mar-2008	1 392-1 420	3.28	1.01
TALUD XII	St. 10	<i>Laetmogone scotoeides</i>	17°11'18"N, 101°28'30W	29-Mar-2008	1 180-1 299	3.73	0.68
TALUD XII	St. 15	<i>Benthodytes</i> cf. <i>sanguinolenta</i>	17°25'33"N, 102°07'20"W	30-Mar-2008	2 015-2 080	2.16	2.14
TALUD XII	St. 25	<i>Pannychia moseleyi</i>	18°26'45"N, 104°16'10"W	1-Apr-2008	1 858-1 879	2.45	1.38
TALUD XII	St. 27	<i>Psolus</i> aff. <i>squamatus</i>	18°40'28"N, 104°35'51"W	2-Apr-2008	1 040-1 095	4.26	0.26
TALUD XII	St. 28	<i>Psolus</i> aff. <i>squamatus</i>	18°50'19"N, 104°34'14W	2-Apr-2008	1 101-1 106	4.25	0.36
TALUD XII	St. 29	<i>Pannychia moseleyi</i>	19°19'37"N, 105°26'20"W	2-Apr-2008	1 609-1 643	2.82	1.38
TALUD XIII	St. B	<i>Elasipodida</i> sp. und.	26°17'04"N, 110°27'53"W	13-Jan-2009	1 295-1 330	3.62	0.87
TALUD XIII	St. 37	<i>Abyssoecumis albatrossi</i>	25°59'30"N, 110°19'21"W	15-Jan-2009	2 056-2 195	2.56	1.68

**Table 2.** Species (total 31) of deep-water (> 350 m depth) Holothuroidea occurring off the coast of Mexico (northernmost limit set at 32°28'16"N; southernmost limit set at 14°32'27"N), including the California Current area (CC), the Gulf of California (GC), the area of southwestern Mexico, south of Banderas Bay (SWM), and the offshore islands (OI). Data used in the table were taken from the following sources: PA, Parker (1964); MA, Maluf (1988); SO1, Solis-Marín et al. (1997); SO2, Solis-Marín et al. (2005); SO3, Solis-Marín et al. (2009); MB, Maluf and Brusca (2005); HE Honey-Escandón et al. (2008); PS, present study. Boldface: species collected during the TALUD cruises. (?) Dubious record. The unidentifiable specimens collected during the TALUD cruises are not included in this list (see text for further comments). For convenience species are listed following Maluf's (1988) sequence

<i>Species</i>	CC	GC	SWM	OI
<i>Psolidium gracile</i> Ludwig, 1894		<b>PS</b>	<b>PS</b>	
<i>Psolus cf. squamatus</i> (O.F. Müller, 1776)	PA <b>PS</b>	MA	<b>PS</b>	
<i>Abyssocucumis abyssorum</i> (Théel, 1886) (1)	PA MA HE	MA MB SO1	PA MA HE	
<i>Abyssocucumis albatrossi</i> (Cherbonnier, 1941) (2)		<b>PS</b> SO3		
<i>Mitsukuriella unusordo</i> sp. nov.		<b>PS</b>		
<i>Ypsilocucumis californiae</i> sp. nov.		<b>PS</b>		
<i>Ypsilothuria bitentaculata</i> (Ludwig, 1893) (3)	PA MA	MA MB	MA <b>PS</b>	
<i>Paelopatides confundens</i> Théel, 1886		MA MB		
<i>Pseudostichopus mollis</i> Théel, 1886		PA MA MB	PA MA	
<i>Bathyplotes</i> sp.	MA	PA		
<i>Synallactes sagamiensis</i> Augustin, 1908 (4)			PA MA	
<i>Synallactes alexandri</i> Ludwig, 1894		<b>PS</b>		
<i>Synallactes virgulasolida</i> Massin and Hendrickx, 2010		<b>PS</b>		
<i>Oneirophanta mutabilis mutabilis</i> Théel, 1979	PA		PA MA	
<i>Laetmogone scotoeides</i> (H.L. Clark, 1913)	MA		<b>PS</b>	
<i>Laetmogone wyvillethomsoni</i> Théel, 1879	MA			
<i>Pannychia moseleyi</i> Théel, 1882	MA	MA MB SO1 SO2 SO3 <b>PS</b>	MA <b>PS</b>	
<i>Psychronaetes hanseni</i> Pawson, 1983				MA (Clarion)
<i>Benthodytes sanguinolenta</i> Théel, 1882 (5)	PA MA HE		<b>PS</b>	
<i>Psychropotes longicauda</i> Théel, 1882 (6)	PA MA		PA MA	
<i>Peniagone intermedia</i> Ludwig, 1894			MA(?)	
<i>Peniagone papillata</i> Hansen, 1975			MA	
<i>Peniagone</i> sp.		PA		
<i>Scotoplanes clarki</i> Hansen, 1975		SO3		
<i>Scotoplanes globosa</i> (Théel, 1879)	MA			
<i>Leptosynapta albicans</i> (Selenka, 1867)				MA (Socorro)
<i>Molpadia granulata</i> (Ludwig, 1894) (7)		PA MA MB		

**Table 2.** Continues

<i>Species</i>	<i>CC</i>	<i>GC</i>	<i>SWM</i>	<i>OI</i>
<i>Molpadia intermedia</i> (Ludwig, 1894)	MA HE	MA MB SO1 SO3 PS		
<i>Molpadia musculus</i> Risso, 1826	MA HE	PA MA SO1 SO3 MB PS	PA MA	
<i>Heldingia californica</i> (Ludwig, 1894) (8)		MA SO1 SO3		
<i>Paracaudina chilensis</i> (J. Müller, 1850)		MA SO2	MA	

(1) Also cited in the genus *Staurocucumis*.

(2) See text for further details.

(3) Previously in the genus *Sphaerothuria*.

(4) Cited as *S. ishikawai* f. ind.

(5) Not cited by Maluf and Brusca (2005).

(6) Cited by Parker (1964) as *P. dubiosa* Ludwig, 1894, and *P. raripes* Ludwig, 1894, both junior synonyms of *P. longicauda*.

(7) Cited by Parker (1964) as *M. granulosa*.

(8) Also cited in the genus *Caudina*.

ossicles, 270-330 µm long, very spiny, with or without perforation at the extremities of the arms (Fig. 1A). Most of these cross-shaped ossicles have 4 arms, a few have 3 or 5 arms. In the tube feet same kind of ossicles (Fig. 1B, C), somewhat larger (up to 450 µm), the most common with 2 long and 2 short arms (Fig. 1B). Extremities of these arms multi-perforated (Fig. 1C). In the tentacles 2 kinds of rods: very thin, with strong spines on 1 side (Fig. 1D), or with a central apophysis, 180-250 µm long, and large straight to V-shaped rods, smooth or spiny, up to 600 µm long, with a central apophysis (Fig. 1E-F),

## Remarks

The present specimen fits particularly well with the detailed description of *Abyssocucumis albatrossi* given by Cherbonnier (1941). The spiny arms of the cross-shaped ossicles are characteristic of the species whereas smooth arms are characteristic of *Abyssocucumis abyssorum* Théel, 1886. Ludwig (1894: pl. XIII, figs. 1-5) illustrated an *A. albatrossi*, but named his material *abyssorum*. Hansen (1988), who considered *albatrossi* a synonym of *abyssorum*, moved *abyssorum* to the genus *Staurocucumis*. Hansen considered that the cross-shaped ossicles are characteristic of the juveniles and disappear in adults to be replaced by perforated plates. However, the 60 mm long specimen here examined is an adult with a well developed gonad. Ludwig (1894) observed also only cross-shaped

ossicles in large specimens (up to 90 mm long) and no perforated plates. Another argument to sustain the opinion of Hansen (1988) is the fact that among the dendrochirotes (particularly in the genus *Staurocucumis*) the ossicles become more spiny with increasing body size (Massin, 1994). Indeed, in the paper of Cherbonnier (1941) the *A. abyssorum* (smooth ossicle arms) are small specimens, <30 mm long, whereas the *A. albatrossi* (spiny ossicle arms) are large specimens, 60 mm long. *Abyssocucumis abyssorum* could thus be the juveniles of *A. albatrossi*. However, this does not fit with the presence of a well developed gonad in both species, whatever the body size (Théel, 1886; Ludwig, 1894; Cherbonnier, 1941). Moreover, small and large specimens of *A. abyssorum* present smooth ossicle arms (Théel, 1886; Ludwig, 1894; Heding, 1942). Spiny or smooth ossicle arms seem to not be related to body size. Consequently, we consider that *A. albatrossi* and *A. abyssorum* are well separated species, both belonging to the genus *Abyssocucumis* as defined by Heding (1942).

The *Staurocucumis abyssorum* illustrated by Solís-Marín et al. (2009: 84, pl. 17, Fig. B) is, according to us, a specimen of *Abyssocucumis albatrossi* because of the very spiny arms of the cross-shaped ossicles.

*Distribution.* Records in Mexico. Known from the type locality ("Albatross" St. 3414, 10°14'N, 96°28'W) located about 500 km off the coast of Chiapas, SW Mexico; 4 085 m (2 232 fm) (Fig. 2). According to Cherbonnier (1941), the 2 specimens he examined had been collected at the "Albatross" St. 3414, located off SW Mexico (above). He also stated, however, that *A. albatrossi* is found in the Gulf

of Panama (1°05'N, 29°40'N) and in the Gulf of California (27°34'N, 110°53'40"W), at 1 466-3 615 m depth, but it seems he did not actually examine material from these 2 localities. According to Maluf (1988), *A. albatrossi* is known only from off Peru (ca 6°S) and from a (doubtful) locality off California (ca 32°N), in depths of 1 585-5 690 m. In addition to the original description by Cherbonnier (1941), Maluf (1988) only cited the reference of Madsen (1955) as sources for the geographic and bathymetric ranges of *A. albatrossi*, and the data provided by her are exactly the same as those provided by Madsen. Although much more detailed than the information provided by Madsen, the compilation presented by Maluf (1988) does not include the Chiapas (type locality) record, which is rather surprising. We were not able, however, to trace the records for California, the Gulf of California and Peru cited by Cherbonnier (1941) and Maluf (1988). *Abyssococumis albatrossi* has been reported from Oregon, NE Pacific, in a depth range of ca 2 700-4 000 m, and appears to dominate the holothurian community below 3 000m (Carney and Carey, 1976; not cited by Maluf). It was also recently reported by Nybakken et al. (1998) during a survey off central California, but this Californian record could obviously not be used as a source of information by earlier authors. The geographic range of *A. albatrossi* is provisionally set as off Oregon, USA, to off the coast of Chiapas, Mexico, including the central Gulf of California, Mexico (Fig. 2).

Family Psolidae R. Perrier, 1902

Genus *Psolus* Oken, 1815

*Psolus* aff. *squamatus* (O.F. Müller, 1776)

Fig. 2

*Holothuria squamata* O.F. Müller, 1776: 232.

*Cuvieria squamata*; Koren, 1845: 211, pls. 2, 3.

*Psolus squamatus*; Lütken, 1857:14, 69, 81, 104; Ludwig, 1900: 158 (list of citations); Vaney, 1906a: 27, pl. 2, figs. 16a-c, 17a-c; Mitsukuri, 1912: 225, pl. 7, figs. 61, 62, textfig. 42 (list of citations); Ohshima, 1915: 280; Ekman, 1923: 1-56 (passim), figs. 12-14, 20-24, 26-27, 29-30, 36-37; Bergen, 1980: 275; Imaoka, 1980: 361, figs. 1-9; Maluf, 1988: 88, 152 (in part, probably not the record of *P. squamatus segregatus* Perrier, 1905); Lambert, 1997: 51, figs. 21, 22; Maluf and Brusca, 2005: 343.

*Psolus pauper* Ludwig, 1894: 139.

*Psolus valvatus* Östergren, 1904: 659.

**Material examined.** Two specimens (L = 68 mm, EMU-8609; L = 64 mm, IG 31487/HOL 1511 RBINS/HOL/738992), TALUD XII, St. 27. One specimen (L = 45 mm), TALUD XII, St. 28 (EMU-8610).

**Additional material examined.** Three specimens (L = 10, 16, 27 mm), SW of Punta Banda (31°38'18"N, 116°51'24"W), Baja California, 12/February/1960, 183-458 m (coll. R. Parker: id. E. Deichmann) (SIO, UCSD, SOB1-31-6333). Ossicle preparations from a specimen of *Psolus squamatus segregatus*, Patagonia (ZMH, E 4170).

Body elongate to nearly rounded. Dorsal surface covered by large overlapping scales; ventral surface thick with a double row of tube feet along the margin. Midventral radius without tube feet or with a few at the front and at the rear. Mouth and anus dorsal, each at the top of a cone covered by irregular, elongated plates. No clearly defined oral or anal valves. Dorsal scales multilayered, 0.6 to 8.0 mm across, covered or not with rounded or ovoid granules. When present, granules are 150-250 µm across, whatever the size of the specimen. In the ventral sole small perforated plates with 2-9 large holes in the smallest specimen and 3-5 in the large specimens. Largest plates with a few knobs. Size of the plates from 150 to 250 µm across in small specimens to 130-165 µm across in large specimens. Ossicles of tentacles smooth, perforated plates, rounded, triangular or elongated, slightly curved, 100-500 µm long. In the tube feet elongated perforated plates, 160-320 µm long; end plate in 1 piece, 240-450 µm across.

## Remarks

Vaney (1906a), Ekman (1923), and Deichmann (1941) considered *P. squamatus segregatus* as a valid species. The characters separating *P. squamatus* from *P. squamatus segregatus* are: ossicles of the ventral sole (large perforated plates, 150-300 µm across, with large holes vs. small massive perforated plates, 75-110 µm across, with small holes, respectively) and the size of the dorsal granules (150-250 µm across vs. 330-470 µm across, respectively) (Ekman, 1923: Fig. 33). The specimens examined fit particularly well with *P. squamatus* as far as the body size and the general aspect of dorsal and ventral ossicles are concerned. H.L. Clark (1913), studying material from California, came to the same conclusion. However, H.L. Clark (1913), Mortensen (1927), Madsen (in Maluf, 1988), and Madsen and Hansen (1994) considered that the *P. squamatus* from Norway and the East Pacific are not conspecific. Contrary to the specimens from the Gulf of California, those from Japan show an increase in the number of holes of the ventral perforated plates with increasing body size (Imaoka, 1980). The small specimen from Japan (L = 41 mm) is very close to the small specimen (L = 45 mm) from SW Mexico examined herein (EMU-

8610), particularly in the ossicles of the tentacles and the tube feet. The species is also reported to be present in the Pacific waters from Japan (Imaoka, 1980) to Patagonia (Pawson, 1969), through Canada (Lambert, 1997). For the specimens from Patagonia, R. Perrier (1905) erected the variety *segregatus*. Ekman (1923) and Deichmann (1941) consider that this variety extends from Patagonia to the Bering Sea. According to Ekman (1923) and Imaoka (1980), *P. squamatus* is a highly variable species. Moreover, most of the citations in the literature are restricted to a name without description and/or illustrations. In these circumstances, it is very difficult to establish the limit of its distribution. Parker (1964: 165) reported a capture of *Psolus squamatus* var. *segregatus* from the west coast of Mexico (ca 183-458 m depth, SW of Ensenada, off Banda Point; 31° 38'20"N, 116° 51'24"W), in the California Current area. The material was presumably identified by E. Deichmann. The same lot was later deposited at Scripps Institution of Oceanography and included by Luke (1982: 56) in his catalogue of echinoderms as *Psolus squamatus*. Three of the 117 specimens contained in this lot were examined during this study. Unfortunately, this material corresponded to juveniles that had been previously kept dry and ossicles could not be properly examined, thus making a positive identification impossible.

We are convinced that *P. squamatus* and *P. squamatus segregatus* are distinct species. Considering the very wide distribution range of *P. squamatus* s.l., they could even represent more than 2 species. *Psolus squamatus segregatus* seems to be restricted to the Pacific coast of South America. We believe that this taxonomical problem will not be solved until material preserved for DNA analysis from Japan, Canada, Central and South America, and the North Atlantic is available. Such a study is obviously beyond the scope of the present paper.

**Distribution.** Records in Mexico. Type locality of *Psolus pauper*, "Albatross" St. 3424 (21°15'N, 106° 23'W), off Tres Marias Islands, SW Gulf of California; 1 237 m (676 fm), 3.3°C (Ludwig, 1894). H.L. Clark (1923: 161) reported on a single specimen (L = 55 mm) of *Psolus squamatus*, collected off California, "Albatross" St. 5695 (33°33'N, 120°17'W), in 977 m depth (534 fm). Probably restricted to the East Pacific, north of Central America to the Bering Sea. Present records extend the Mexican distribution of this species to SW Mexico (18°40'28"N) (Fig. 2).

*Psolidium* Ludwig, 1887

***Psolidium gracile*** Ludwig, 1894

Figs. 2, 3A-G, 4A-F, pl. 1A-D

*Psolidium gracile* Ludwig, 1893: 184 (nomen nudum).

*Psolidium gracile* Ludwig, 1894: 132, pl. XIII, figs. 17-19; Maluf, 1988: 88, 152; Lambert, 1996: table; Nybakken et al., 1998: 1760.

**Material examined.** Six specimens (L = 13-17 mm, EMU-8611; L = 16 and 17 mm, IG 31487/HOL 1512 RBINS/HOL/738988), TALUD IX, St. 17. Seventeen specimens (L = 12-18 mm), TALUD XI, St. 1 (EMU-8612). Three specimens (L = 15-17 mm), TALUD X, St. 3 (EMU-8624).

Small species 13-18 mm long, 6-11 mm wide and 5 mm height (pl. 1 A-C). Ventral sole more or less 70% of body length, packed with ossicles visible to naked eyes. One row of 30-35 tube feet on each side of the ventral sole (pl. 1D). Along the mid-ventral radius 1 row of a 10 of tube feet located mainly at the rear and at the front, more widely spaced out at mid-body. Dorsal tube feet very small, easily overlooked. Dorsally, very large, rounded scales up to 1 200 µm across (pl. 1C-D); 16-20 scales between mouth and anus. No valves closing mouth and anus. Dorsal scales 180-1 200 µm across, small ones 180-350 µm across and made of 1 layer (Fig. 3B), large ones half or ¾ of their surface with 1 layer and the remaining surface with 2 layers. Calcareous ring simple, without posterior processes; radial and interradial plates of the same width but radial plates nearly twice the height of the interradial (Fig. 3A). Ventral sole packed with rounded, perforated plates (3-15 holes), 125-290 µm across (Fig. 3C), surface of plates smooth, edge slightly knobbed or with blunt spines (Fig. 3C). In large specimens, ventral plates larger, more elongate, up to 450 µm long, perforated by 4-19 holes (Fig. 3D). In the ventrolateral tube feet, curved rods 120-250 µm long (Fig. 3F), perforated plates (250-360 µm long) (Fig. 3G), and a small end-plate (170-220 µm across) (Fig. 3E). Tentacles with spiny curved rods, 200-400 µm long, perforated at the extremities by 1-9 small holes (Fig. 4A); also a few perforated plates, 330-350 µm long with large holes (Fig. 4B-C). In the gonads, spiny rods, 150-300 µm long (Fig. 4D-F); spines often ending in 2-3 spinules.

## Remarks

According to Maluf (1988) there are 6 species of *Psolidium* along the Central eastern Pacific coast. Two deep-water (*P. panamense* Ludwig, 1894, and *P. gracile*) and 4 shallow-water species (*Psolidium dorsipes* Ludwig, 1886; *P. ekmani* Deichmann, 1941; *P. eubullatum* Deichmann, 1941; and *P. planum* Deichmann, 1941). The specimens here observed fit particularly well with *Psolidium gracile*. Only the number of tube feet in the mid-ventral radius and the size of the dorsal scales are different

from the holotype. Unfortunately, the material reported by Nybakken et al. (1998) from off central California was not illustrated or described, and the species is known only from the description of the holotype. The differences observed in the TALUD specimens could be ascribed to species variability.

*Distribution.* No previous records in Mexico. Known from the type locality, "Albatross" St. 3392 (7°05'30" N, 79°40'W), Cabo Mala, Gulf of Panama, 2 323 m (1 270 fm) (Lambert, 1996), and off central California, between 2 300 and 3 075 m depth (Nybakken et al., 1998). The material collected during the TALUD survey was obtained in much shallower water (377-920 m) and represents the first record for the Pacific coast of Mexico (off north of Acapulco and off southern Baja California) (Fig. 2).

Dendrochirotida sp. und.

*Material examined.* One specimen (not measured), TALUD VIII, St. 20 (EMU-8625).

### Remarks

The specimen is damaged and completely eviscerated, calcareous ring included. The presence of 5 longitudinal muscle bands and of retractor muscles of the pharynx indicate that it belongs with the Dendrochirotida. Unfortunately, the absence of ossicles in the tissues does not allow for further identification.

Order Dactylochirotida Pawson and Fell, 1965  
Family Vaneyellidae Pawson and Fell, 1965  
Genus *Mitsukuriella* Heding and Panning, 1954  
*Mitsukuriella unusordo* sp. nov.  
Figs 5A-F, 6, 7, pl. 1E-G

*Material examined.* Holotype (L = 13.4 mm), TALUD X, St. 9 (EMU-8629).

Small specimen 13 mm long, cylindrical, tapering at both ends (pl. 1E-F), 4 mm across at the rear, 2 mm across at the front and 4 mm across at the end. Mouth and anus terminal. Mouth surrounded by 15 digitiform tentacles (pl. 1G), 5 large and 10 very small, a pair of small tentacles between 2 large tentacles. Anus surrounded by 5 anal papillae. Tube feet on 1 row in each radius (pl. 1E), more crowded and longer at mid-body (pl. 1F). Dorsally, 15 tube feet on radii, and 25-30 per radius ventrally. Color in alcohol yellow-grayish. Body wall gritty to the touch, very thin, packed with large perforated plates visible to the naked eye. Calcareous ring without posterior processes;

gonad present as a few undivided tubules.

In the body wall large, elongated, perforated plates, 375-850  $\mu\text{m}$  long (Fig. 5A-B), smaller plates smooth (Fig. 5A), larger plates partly knobbed (Fig. 5B).

Ossicles of the tube feet small perforated plates with 2-4 holes, 90-125  $\mu\text{m}$  long (Fig. 5C-D). A few larger plates, 160  $\mu\text{m}$  long, with up to 8 holes and partly knobbed (Fig. 5D). At the apex of the tube feet a small perforated end-plate (Fig. 5E) surrounded by V-shaped ossicles 100-190  $\mu\text{m}$  long, with a central apophysis (Fig. 5F). Ossicles of the tentacles spiny curved rods, 130-200  $\mu\text{m}$  long (Fig. 6), with 1 hole at each extremity, spines large, blunt.

*Etymology.* From the Latin "unus", "one", and "ordo", "row", in reference to the single row of tube feet in each radius.

### Remarks

The presence of 15 digitate tentacles and of a calcareous ring without posterior processes are characteristic of the family Vaneyellidae as defined by Pawson and Fell (1965) and of the genus *Mitsukuriella*. According to Heding and Panning (1954) 2 species are known in this genus: *M. squamulosa* (Mitsukuri, 1912) from Japan, and *M. inflexa* (Koehler and Vaney, 1908) from India. *Mitsukuriella unusordo* sp. nov. is easily separated from *M. squamulosa* by the presence of knobs on the large perforated plates, and from *M. inflexa* by the presence of a single row of tube feet in each radius and by the shape of the large plates (elongated vs. rounded, respectively).

*Distribution.* Known only from the type locality (Fig. 7), *Mitsukuriella unusordo* sp. nov. has been collected deeper (1 205-1 215 m) than the 2 other species of the genus: 250 m depth for *M. squamulosa* and 170 m for *M. inflexa*.

Family Ypsilothuriidae Heding, 1942  
Genus *Ypsilocucumis* Panning, 1949  
*Ypsilocucumis californiae* sp. nov.  
Figs 7, 8A-F, pl. 1H

*Material examined.* Eight specimens from the Gulf of California. Holotype, TALUD VI, St. 26 (L = 15 mm) (EMU-8613). Paratypes. Two specimens (L = 12 and 15 mm), TALUD VIII, St. 11 (EMU-8614), 3 specimens (L = 13, 14 and 21 mm), TALUD VIII, St. 16 (ICML-UNAM 5.177.0), and 2 specimens (L = 13 and 17 mm), TALUD X, St. 3 (IG 31487/HOL 1514 RBINS/HOL/738995).

Specimens spherical, with 2 dorsal tubes (1 oral and 1 anal) contracted and well separated from each other (pl. 1H). Length of specimens (tubes not included) from

13 to 21 mm. Distance between mouth and anus from 7 to 12 mm. Body wall bristle, thin, translucent and gritty to the touch, packed with large scales (visible to naked eye) with spires protruding outside. Tube feet very small, difficult to observe, apparently only present along the radius. Calcareous ring brittle, very thin, with radial and interradial plates of the same size and without posterior process (Fig. 8A); anterior process of radial plates with a deep groove for the insertion of the retractor muscles of the introvert.

All specimens contracted, with the introvert inside. After dissection 2 very long (at least 2 mm long when contracted) digitiform tentacles observed. Other tentacles minute, not counted. Retractor muscles of introvert very thin, attached to the body wall at mid-body length. Gonad present, reduced to a few, short, divided tubules, some containing very large oocytes.

Body wall with large scales, developing from small, single layered perforated plates, 200-700  $\mu\text{m}$  across, without pillar (Fig. 8B), to 2-layered perforated scales (edge of the scale very often single layered) with an eccentric spire (Fig. 8C). Scales are 700 to 1 000  $\mu\text{m}$  across, their spire, made of the fusion of several spiny pillars, 350-400  $\mu\text{m}$  high (Fig. 8D). In the long digitiform tentacles curved rods, 150-370  $\mu\text{m}$  long, with lateral blunt spines and enlarged perforated extremities (Fig. 8E), most rods very thin ( $\pm 10$   $\mu\text{m}$  across), a few thicker (20-25  $\mu\text{m}$  across) (Fig. 8 F).

## Remarks

The specimens at hand fit well with the diagnosis of the family Ypsilothuriidae. The presence of multilayered scales, the eccentric position of the spire of the scales, and the retractile oral and anal cones clearly indicate that the new species belongs to the genus *Ypsilocucumis* (see Panning, 1949) which included 3 species: *Ypsilocucumis asperrima* Théel, 1886, *Y. turricata* (Vaney, 1906), and *Y. scotiae* (Vaney, 1906). The latter 2 species, erected by Vaney (1906b), have since been moved by O'Loughlin (2002) and O'Loughlin et al. (2009) to the genera *Paracucumis* Mortensen, 1925 and *Crucella* Gutt, 1990, respectively. *Ypsilocucumis californiae* sp. nov. differs from *Y. asperrima* in the size of the scales (700-1 000  $\mu\text{m}$  vs.  $>2$  000  $\mu\text{m}$ , respectively), in the number of layers of the scales (maximum 2 vs. several, respectively) and in its zoogeographic distribution (Pacific coast of North America vs. Caribbean Sea, respectively). According to Théel (1886) and Deichmann (1930, 1954) small specimens of *Y. asperrima* (length of body, oral

and anal cones not included,  $<15$  mm) have many single-layered scales. *Ypsilocucumis californiae* sp. nov. presents the same characteristics. The rods of the tentacles are identical to those of *Ypsilothuria bitentaculata attenuata* E. Perrier, 1886 (see Massin 1996: Fig. 2A).

*Etymology.* The species is a noun in the genitive, referring to the geographic area (Gulf of "California") of collection. *Distribution.* Central and southern Gulf of California, Mexico (Fig. 7).

## *Ypsilothuria bitentaculata* (Ludwig, 1893)

Fig. 7

*Sphaeroturina bitentaculata* Ludwig, 1893: 184; 1894: 141, pl. XII, figs. 16-17, pl. XIV, figs. 5-14; H.L. Clark, 1913: 229; Ohshima, 1915: 266; Ludwig and Heding, 1935: 76, textfigs. 55-57 (list of citations and synonymy); Parker, 1964: 165; Hansen, 1975: 216; Luke, 1982: 56.

*Ypsilothuria bitentaculata*; R. Perrier, 1902: 517; Koehler and Vaney, 1905: 87; Panning, 1949: 455; Madsen, 1955: 167; Caso, 1961: 371; Thandar, 1984: 226, Fig. 39a-k (list of citations and synonymy); Maluf, 1988: 95, 156; Nybakken et al. 1998: 1759, 1778; Maluf, 1991: 358; Lane et al., 2000: 491; Maluf and Brusca, 2005: 342; Tilot, 2006: 59; Sastry, 2007: 254.

*Material examined.* One specimen (L = 12 mm), TALUD XII, St. 5 (EMU-8615).

## Remarks

*Ypsilothuria bitentaculata* is considered a cosmopolitan species, collected in the East and West Pacific Ocean, Indian Ocean, North Atlantic Ocean and Mediterranean Sea. Two varieties have been recognized by Heding (1942): *Y. b. attenuata* E. Perrier, 1886 and *Y. b. virginensis* Heding, 1942. The latter is only known from the North Atlantic Ocean, whereas the former is cosmopolitan. Due to the complexity in separating the varieties or subspecies of *Y. bitentaculata* and the lack of reliable information related to their distribution, we have considered the Mexican material as belonging to *Sphaeroturina bitentaculata* sensu Ludwig (1893, 1894).

*Distribution.* Records in Mexico. "Albatross" St. 3424 (21°15'N, 106°23'W), 1 237 m (676 fm) (Ludwig, 1894). "Albatross" St. 5675, SW of San Cristobal Bay (27°07'08"N 114°33'10"W), Baja California, 520 m (284 fm) (Parker, 1963). Off Salina Cruz (14°28'30"N, 93°09'30"W), 3 539-3 610 m (Parker, 1964; Luke, 1982).

Off Tres Marias Islands (probably “Albatross” St. 3424) (Maluf and Brusca, 2005). Syntypes were collected at different stations of the “Albatross”, roughly between 00°54'N and 21°15'N (Ludwig, 1894). From central California (Nybakken et al. 1998), where it is the most abundant species, San Cristobal Bay, Baja California, Mexico, to San Francisco Cape, Equator; Indo-West Pacific (Maluf and Brusca, 2005). Widely distributed along the Pacific coast of Mexico (Fig. 7).

Order Elaspodida Théel, 1882

Family Laetmogonidae Ekman, 1926

Genus *Pannychia* Théel, 1882

*Pannychia moseleyi* Théel, 1882

Fig. 9

*Pannychia moseleyi* Théel, 1882: 3, 88, pl. XVII, figs. 1-2, pl. XXXII, figs. 1-13; Hansen, 1975: 72, fig. 26 (synonyms and citations); Maluf, 1988: 101, 161 (synonyms and citations); Solís-Marín et al., 1997: 256; Nybakken et al., 1998: 1778; Pawson and Ahearn, 2001: 42; Solís-Marín et al., 2005: 132; Tilot, 2006: 42, 43, fig. 75, 60; Anonymous, 2004: 4, 1 pl.; Pawson, 2009: 398; Solís-Marín et al., 2009: 144, pl. 47, figs. A-H.

*Material examined.* Two specimens (L = 180 mm, EMU-8632; L = 182 mm, IG 31487/HOL 1509 RBINS/HOL/738972), TALUD VIII, St. 3. One specimen (L = 11 mm), TALUD VIII, St. 11 (EMU-8617). One specimen (L = 85 mm), TALUD IX, St. 10 (EMU-8616). Four specimens (L = 41-89 mm; EMU-8631; L = 79 mm, IG 31487/HOL 1516 RBINS/HOL/739010) and 3 specimens (L = 40 and 80 mm, EMU-8619; L = 61 mm, IG 31487/HOL 1510 RBINS/HOL/738978), TALUD XII, St. 25. One specimen (L = 104 mm), TALUD XII, St. 29 (EMU-8618).

The 12 specimens examined are 40-182 mm long and 6-34 mm across. The body wall contains a few characteristic wheels, 120-235 µm across, with 11-15 spokes.

## Remarks

As noticed by Hansen (1975), the number and size of wheels are highly variable and not related to the size of the specimens. The observed wheels are similar to the ones described and figured by Hansen (1975) from a Challenger's specimen from the Gulf of Panama.

*Distribution.* Records in Mexico. “Albatross” St. 3431 (23°59'N, 108°40'W), 1 748 m (955 fm); St. 3432 (24°22'30"N, 109°03'20"W), 2 600 m (1 421 fm); St. 3436 (27°34'N, 110°53'40"W), 1 656 m (905 fm); 2.9-3.9°C

(Ludwig, 1894). “Albatross” St. 5676, off San Juanico (25°31'15"N, 113°29'30"), 1 165 m (647 fm); St. 5685, SW of Ballenas Bay (25°42'45"N, 113°38'30"), 1 180 m (645 fm); 3.8°C (39°F) (H.L. Clark, 1913). “Albatross” St. 3418 (16°33'N, 99°52'30"W), 1 208 m (660 fm); St. 3425 (21°19'N, 106°24'W) 1 245 m (680 fm); St. 3435 (26°48'N, 110°45'20"W) 1 572 m (859 fm); St. 3436 (27°34'N, 110°53'40"W), 1 656 m (905 fm); 2.9-3.2°C (Ludwig, 1894; as *Laetmophasma fecundum*) (Fig. 9). The record of Luke (1982: 58), at 32°24'42"N-117°27'45"W, is at the southern limit of the Mexican-USA border (1 204-1 226 m, San Diego Trough). Solís-Marín et al. (1997) cited this species off Isla Espíritu Santo (ca 24°30'N, 110°17'W), Baja California, Mexico, and Solís-Marín et al. (2005) include 2 records for the Gulf of California, both corresponding to material collected by the “Albatross” (Solís-Marín, pers. comm.). Two additional records are provided by Solís-Marín et al. (2009) for the Gulf of California (25°43'50"N, 109°53'59"W) and the California Current area (28°03'N, 111°10'W) (Fig. 9). Syntypes are from “Challenger” Sts. 164 and 169, 34°8'S, 152°E, and 37°34'S, 179°22'E, E of New Zealand, in depths of 1 281-1 739 m (700-950 fm); 2.2-4.2°C (Théel, 1882). Widely distributed throughout the East Pacific, *Pannychia moseleyi* has been reported from off Central California (Nybakken et al. 1998) and San Diego (Luke, 1982) to ca 6°S, off northern Peru, with many intermediate localities (Maluf, 1988: 101). It also occurs off Hawaii and in the SW Pacific, and features a very wide Indo-Pacific distribution (Hansen, 1975; Maluf, 1988; Thandar, 2008). It ranges from 212 to 2 599 m depth, and the TALUD material was collected within that depth range (920-1 879 m). Information based on deep-water trawls and photographs taken in the Gulf of California and off the coast of California (Solís-Marín et al., 1997; Anonymous, 2004; Nybakken, 2010) and off California-Oregon-Washington (Keller et al., 2007) indicates that *P. moseleyi* is an abundant species in these areas. According to Tilot (2006: fig. 75) this species is present (photographic evidence) in the Clipperton-Clarion fractures zone.

Genus *Laetmogone* Théel, 1879

*Laetmogone scotoeides* (H.L. Clark, 1913)

Figs 9, 10, A-E

*Laetmenoceus scotoeides* H.L. Clark, 1913:231.

*Laetmogone scotoeides* Hansen, 1975: 61, Fig. 23; Maluf, 1988: 100, 160; Thandar, 1998: 87.

*Material examined.* One specimen (L = 90), TALUD XII, St 9 (EMU-820). One specimen (L = 150 mm), TALUD XII, St. 10 (EMU-8634).

*Additional material examined.* One specimen (L= 86 mm)

of *Laetmogone wyvillethomsoni*, Cruise MV69-VI-9-W, Patton Escarpment, off Baja California, Mexico (31°11'N, 119°36'W), 18/December/1969, 3600-3676 m depth (SIO-E 8) (coll. C. Hubbs, S. Luke).

The 90 mm long specimen is in poor condition and does not allow for an anatomical description. The 150 mm long specimen is dark violet. On each side of the ventral sole, a single row of approximately 20 very large tube feet. Mouth ventral, surrounded by 15 tentacles; anus terminal. In the body wall numerous wheels. Small wheels 55-130 µm in diameter with 13 spokes and 4 central rays. Large wheels 120-280 µm in diameter with 8-12 spokes and 5 central rays (fig 10 A). No clear-cut distinction between large and small wheels. Tube feet with spiny rods (190-420 µm long) (Fig. 10D), wheels, and an end-plate. Wheels similar to those of the body wall, small wheels 30-100 µm in diameter (Fig. 10B), large wheels 120-290 µm in diameter (Fig. 10C). The end-plate is composed of several spiny, irregularly ramified rods (fig 10E).

## Remarks

According to Hansen (1975), the number of tentacles (15), the size of the large wheels (up to 300 µm) with 5 central rays are typical of *Laetmogone scotoeides*. The size of the large wheels is particularly striking: 50% to 100% larger than in any other *Laetmogone* species. (Hansen, 1975; Thandar, 1998). The specimen in poor condition (L = 150 mm) was first identified as a *L. wyvillethomsoni*. However, examination of the wheel diameter of a specimen of *L. wyvillethomsoni* collected off northern Baja California and obtained on loan (see additional material examined) shows that this poorly preserved specimen also belongs to *L. scotoeides*.

*Distribution.* Record in Mexico. Type locality, "Albatross" St. 5685, SW of Ballenas Bay (25°42'45"N, 113°38'30"W), west coast of Baja California, 1 180 m (645 fm) (H.L. Clark, 1913). Now from off Petatlán, Guerrero (17°11'18"N, 101°28'30"W), SW Mexico (Fig. 9). According to Maluf (1988) *L. scotoeides* had been reported only from the type locality. The record for the Bay of La Paz (east coast of the southern Baja California Peninsula), Mexico, in Solís-Marín et al. (1997: 255) is an error (Solís-Marín, pers. comm.). It is not cited by Solís-Marín et al. (2005) and Honey-Escandón et al. (2008) for Pacific Mexico and we therefore conclude that no additional record is available for this species. Present records off SW Mexico occur in a depth range of 1 180-1 420 m, very similar to the type locality (1 173 m) and are new for the Pacific coast of Mexico. It confirms the restricted distribution of *L. scotoeides* which

seems to be endemic of Pacific Mexico. This is in contrast with the other *Laetmogone* species which generally have a wide distribution (Hansen, 1975).

Family Psychropotidae Théel, 1882

Genus *Benthodytes* Théel, 1882

*Benthodytes cf. sanguinolenta* Théel, 1882

Fig. 9

*Benthodytes sanguinolenta* Théel, 1882: 3-4, 104, pl. XXIII, pl. XL, figs. 4-5, pl. XLII, fig. 6; Ludwig, 1894: 53, pl. I, figs. 1-8; H.L. Clark, 1913: 233; 1920: 142; 1923: 162; Hansen, 1975: 94, pls. III-VI, pl. IX, figs. 6-7, pl. XII, figs. 4-5, fig. 116 (list of citations); Parker, 1964: 165; Luke, 1982: 58; Maluf, 1988: 101, 161; Nybakken et al. 1998: 1778; Maluf, 1991: 360; Honey-Escandón et al., 2008: 58.

*Material examined.* One specimen (L = 120 mm), Talud XII, St 15 (EMU-8627).

Specimen flattened, with mouth ventral and anus dorsal. Skin slightly damaged. Unpaired dorsal appendage absent. Circum-oral papillae present. Mid-ventral tube feet present, well developed. Color in alcohol grey-white, with patches of purple. Tentacles purple. No ossicle in body wall and tube feet.

## Remarks

According to Hansen (1975) the general aspect of the specimen examined herein fits well with the genus *Benthodytes*. Because of the absence of ossicles and the size and position of the ventral tube feet (see Ludwig, 1894: pl. I, fig. 1), the specimen examined is most probably *B. sanguinolenta* but some doubt remains, and it was labeled *B. cf. sanguinolenta*.

*Distribution.* Records in Mexico. "Albatross" St. 3415 (14°46'N, 98°40'W), 3 383 m (1 879 fm); 2.2°C (Ludwig, 1894). Off San Tomas Point, SW of Magdalena Bay, and off Rosario Bay; 1 969-3 221 m (1 076-1 760 fm); 2.83-3.30°C (37.1-38.1°F) (H.L. Clark, 1913). "Albatross" station 4732 (16°32'30"N, 119°59'W); 3 682 m (2 012 fm); 1.5°C (34.8°F) (H.L. Clark, 1920). Undetermined stations of the "Albatross", off Baja California, in depths exceeding 1 000 fm (H.L. Clark, 1923). W of Punta Banda (31°18'N, 117°36'W), Patton Escarpment (30°52'N, 116°53'W), and basin off Magdalena Bay (23°59'30"N, 113°11'54"W), Baja California, Mexico; 1 975-3 518 m depth (Parker, 1964; Luke, 1982). Off western Baja California (29°40'12"N, 117°06'36"W); 2 708-2 763 m (Parker, 1964). Environmental data of the material cited by Parker (1964): 2.0-2.5°C and 1.3-2.8 ml O<sub>2</sub>/l. Honey-Escandón et

al. (2008) reported this species for the California Current area, in 2 localities off Baja California (W of San José Point, 31°23'45"N, 118°31'30"W; SW of San Carlos Point, 29°29'N, 116°18'W) (Solís-Marín, pers. comm.) (Fig. 9). Syntypes are from off Chile (34°7'S, 73°56'W, and 38°7'S, 94°4'W), in depths of 2 745-4 072 m (1 500-2 225 fm); 1.3-1.4°C (Théel, 1882). Throughout almost the entire Indo-Pacific, from 768 to 7 250 m depth, mostly in depths >2 000 m (Hansen, 1975). Central California and the Channel Islands, California, USA, to Chile (Maluf, 1988; Nybakken et al., 1998).

#### Unidentified Elasipodida

*Material examined.* One specimen (L = 95 mm), TALUD VIII, St. 22 (EMU-8626). One specimen (L = 115 mm), TALUD XII, St. 8. (EMU-8623). One specimen (L = 152 mm), TALUD XIII, St. B (EMU-8628).

#### Remarks

The 3 specimens examined look like *Elasipodida* because of their general shape and color pattern (dark violet). The body wall of each specimen, however, is damaged making it very difficult to ascertain the number and position of the tube feet and the presence/absence of a brim. Moreover, ossicles are completely lacking.

Order Aspidochirotida Grube, 1840  
 Family Synallactidae Ludwig, 1894  
 Genus *Synallactes* Ludwig, 1893  
*Synallactes alexandri* Ludwig, 1893  
 Figs. 11A-H, 12

*Synallactes alexandri* Ludwig, 1893: 178; Hansen, 1975: 215; Maluf, 1988: 99, 160; Maluf, 1991: 360; Solís-Marín 2003: 249, figs. 194-200.

*Scotodeima alexandri*; Ludwig, 1894: 21, pl. IX, figs. 10-19.

*Bathyplores hancocki*; Domantay, 1953:136 (nomen nudum); 1961: 333 (nomen nudum).

*Bathyplores macullochae*; Domantay, 1953: 136 (nomen nudum); 1961: 333 (nomen nudum).

*Bathyplores hancocki* Domantay, 1961: 334.

*Bathyplores macullochae* Domantay, 1961: 335.

*Material examined.* Six specimens (L = 46-97 mm, EMU-8633; L = 81 mm, IG 31487/HOL 1515 RBINS/HOL/739007), TALUD VIII, St. 11.

Six specimens examined, 46-97 mm long and 4-12 mm

across. Disposition of mouth, anus, ventral tube feet and dorsal papillae as described by Ludwig (1894), with the rows of dorsal papillae less visible than in the type material. 18-20 small peltate tentacles. No ossicles in the ventral body wall; a few, gathered in heaps, in the dorsal body wall. In the dorsal body wall and dorsal papillae only cross-shaped ossicles with 3-4 arms and 1 central pillar (Fig. 11A-B); each arm forked or perforated at the extremity. Cross-shaped ossicles 80-100 µm across in the body wall (Fig. 11A), and 100-115 µm across in the dorsal papillae (Fig. 11B). In the tube feet very numerous, spiny, slightly curved rods, 300-700 µm long (Fig. 11C), a 1 piece end-plate, 550-650 µm across, and cross-shaped ossicles similar to those in the body wall (Fig. 11D), some transformed in table with 4-5 large perforations (Fig. 11E). Central pillar of cross-shaped ossicles ending in a few spines, its height never exceeding cross diameter. Tentacles with numerous spiny rods, straight to strongly curved, 40-700 µm long (Fig. 11F-H), longer rods (Fig. 11H) located at the base of the tentacles.

#### Remarks

The specimens examined are much smaller than in the types series (46-97 mm vs. 145-175 mm) but the ossicles are very similar. According to Maluf (1988) 4 species of *Synallactes* have been reported in the Central eastern Pacific, all from water deeper than 350 m, between SW Mexico and northern Peru. The only previous record of the genus for Pacific Mexico is for *Synallactes ishikawai* f. ind. (= *S. sagamiensis* Augustin, 1908), reported from the Gulf of Tehuantepec, SW Mexico, by Parker (1964). Whether this identification (presumably by E. Deichmann) was correct or not is impossible to determine. Haney (2004) reports *S. alexandri* from off California, but a close examination of the illustrations included in this contribution indicates that her material most probably belongs to a new species recently described: *Synallactes virgulosolida* Massin and Hendrickx, 2010. Nybakken et al. (1998) reported *S. aenigma* from central California, with no illustrations, but this species is clearly distinct from *S. alexandri*.

Solís-Marín (2003) re-examined material and descriptions of *Synallactes* worldwide and retained 22 valid species. He synonymized both *Bathyplores hancocki* and *B. macullochae* with *Synallactes alexandri*, thus extending the distribution of the latter to southern California. The record of *B. hancocki* for the Gulf of California, cited by Domantay (1961), however, is in error. All specimens examined by this author (9 specimens from 5 stations) and presently in the echinoderms collection at the Los

Angeles County Museum of Natural History (except the holotype from off San Clemente Island, California, which is apparently missing), were collected off Santa Catalina Islands, California (G. Hendler, pers. comm.). The material examined herein, however, extends the distribution of *S. alexandri* to the Gulf of California.

**Distribution.** The species is new to Mexico. The syntypes are from "Albatross" Sts. 3354, off Mariato Point, Panama (07°45'N, 80°50'W), and 3406, off the Galapagos Islands (00°16'S, 90°21'30"W) (Ludwig, 1894). Off Santa Barbara, California, in depths of 278-550 m (152-300 fm) (Domantay, 1961, as *B. hancocki* and *B. maccullochae*; Solís-Marín, 2003). In depths of 585-1 018 m (Hansen, 1975; Maluf, 1988; Maluf, 1991). Present record extends the distribution range of *S. alexandri* within the southwestern Gulf of California (Fig. 12) and fills the distribution gap between Panama and California.

***Synallactes virgulasolida*** Massin and Hendrickx, 2010  
*Synallactes virgulasolida* Massin and Hendrickx, 2010: 600, figs. 1-3.

**Material examined.** Three specimens (L = 50-85 mm), TALUD VIII, St. 16 (EMU-8608; IG.31487-HOL 1506; ICML-UNAM 5.171.0).

#### Remarks

This species has been recently described in a separate paper (Massin and Hendrickx, 2010).

**Distribution.** Known only from the SW Gulf of California (Fig. 12), Mexico, at 1 030 m depth.

Order Molpadiida Haeckel, 1896  
Family Molpadiidae J. Müller, 1850  
Genus *Molpadia* Risso, 1826  
***Molpadia intermedia*** (Ludwig, 1894)  
Figs 13, 14

*Trochostoma intermedium* Ludwig, 1893: 185 (nomen nudum).

*Trochostoma intermedium* Ludwig, 1894: 161, pl. XVI, figs. 7-21.

*Molpadia intermedia*; H.L. Clark, 1907: 162, pl. 12, figs. 5-15; 1913: 228; Deichmann, 1937: 174; Caso, 1961: 375; Maluf, 1988: 105, 163; Nybakken et al. 1998: 1778; Maluf and Brusca, 2005: 343; Solís-Marín et al., 2005: 132; Tilot, 2006: 62; Honey-Escandón et al., 2008: 58; Solís-Marín et al., 2009: 148, pl. 49.

*Haplodactyla intermedia*; Heding, 1931: 280.

**Material examined.** One specimen (L = 92 mm), TALUD VI, St. 25 (EMU-8621).

Body very similar to *M. musculus*, with a short tail ( $\pm 10\%$  of body length). No ossicles in body wall but numerous phosphatic deposits. Ossicles of the tail tables only, no fusiform rods. Most of the tables are very irregular and broken. The disc is 130-210  $\mu\text{m}$  across, perforated by 3-5 large holes (Fig. 13). Spire made of 2-3 pillars, 100-120  $\mu\text{m}$  high, fused at the top.

#### Remarks

*Molpadia intermedia* is said to have a long tail (20-25% of total body length; Ludwig, 1894; H.L. Clark, 1907; Solís-Marín et al., 2009). The tail of the observed specimen is very short (10% of body length), making it close to *M. musculus*. The absence of fusiform rods and the presence of irregular tables in the tail, however, are characteristic of *M. intermedia* (see Ludwig, 1894: pl. XVI, figs. 16-19). *Molpadia intermedia* is the most common species of the genus along the Central eastern Pacific coast (H.L. Clark, 1907; Deichmann, 1937) and it is therefore surprising that only 1 specimen was collected during the TALUD survey. **Distribution.** Records in Mexico. "Albatross" Sts. 2838 (28°12'N, 115°09'W), 79 m depth, and 3431 (23°59'N, 108°40'W), 1 791 m depth (H.L. Clark, 1907); "Albatross" Sts. 5676 (off San Juanico; 25°31'15"N, 113°29'30"W), 5683 (off Cabo San Lucas; 22°46'45"N, 109°50'15"W), 5688 (off Cedros Island; 27°38'5"N 115°17'40"W), 5689 and 5690 (off Ballenas and Rosario Bay; 29°23'00N 116°14'W and 29°29'N 116°18'W), Baja California, in depths of 961-2 015 m (525-1 101 fm); 3.30-4.38°C (38.1-39.9°F) (H.L. Clark, 1913). East of Cedros Island (St 126-DA, Templeton Crocker), Baja California (Deichmann, 1937). Solís-Marín et al. (2005) reported 2 records for the Gulf of California and Honey-Escandón et al. (2008) 2 records for the California Current area. These records are probably the same as those cited by Solís-Marín et al. (2009; 5 records in total), and were included in this compilation (28°12'00" N, 115°09'09" W; 24°15'18" N, 108°24'06" W; 24°53'12" N, 108°59'24" W; 24°56'24" N, 109°05'36" W; 24°51'41" N, 108°57'52" W) (Fig. 14). From Alaska to Cabo Mala, Panama; West Pacific (Maluf and Brusca, 2005); in depths of 55-2 014 m (Maluf, 1988).

***Molpadia musculus*** Risso, 1826  
Fig. 14

*Molpadia musculus* Risso, 1826: 293; H.L. Clark, 1907: 35, 158, 165, pl. XI; 1913: 228; 1923: 161; Caso 1961:

375; Pawson, 1977: 100, figs. 3a-d, map 1 (synonymy and list of citations); Luke, 1982: 59; Maluf, 1988: 105, 163; Nybakken et al., 1998: 1778; Maluf and Brusca, 2005: 343; Solís et al., 2005: 132; Honey-Escandón et al., 2008: 58; Solís-Marín et al., 2009: 150, pl. 50.

*Molpadia musculus* forma *violacea*; Parker 1964: 165.

*Molpadia musculus* forma *spinosa*; Parker, 1964: 165.

**Material examined.** Four specimens (L = 17 and 47 mm, EMU-4203; L = 52 and 58 mm, IG 31487/HOL 1513 RBINS/HOL/738993), TALUD III, St. 14B. One specimen (L = 98 mm), TALUD IX, St. 16 (EMU-8622).

No ossicles in the body wall, but only numerous phosphatic deposits. In the tail fusiform rods only. The smaller the specimen, the more numerous the ossicles.

## Remarks

Rods in the tail show the same diversity as the one reported and illustrated by Pawson (1977: fig. 2a-f) for *M. musculus* from off southern Chile and South Shetland Island. *Molpadia musculus* is considered a cosmopolitan and highly variable species, described repeatedly under different names or varieties (see Maluf, 1988). A detailed review of species of *Molpadia* occurring in the southern oceans is available in Pawson (1977), including the redescription of *M. musculus*. Records for *Molpadia musculus* forma *musculus* and for *Molpadia musculus* forma *spinosa* by Parker (1964: 165) are for southern California and northern Guatemala, respectively, in both cases close to the border limit with Mexico.

**Distribution.** Records in Mexico. "Albatross" Sts. 3418, 3429 (16°33'N, 99°52'30"W; 22°30'30"N, 107°01'W), 1 188-1 654 m (H.L. Clark, 1907). SW of Magdalena Bay ("Albatross" St. 5684; 23°23'30"N, 112°30'W) and off Santo Tomas Point ("Albatross" St. 5692, 31°23'45"N, 118°31'30"W), 1 969-3 170 m (1 076-1 760 fm); 2.83 (37.1°F) (H.L. Clark, 1913, 1923). "Albatross" St. 3434 (25°29'30"N, 109°48'W), 2 906 m (1 588 fm) (Ludwig, 1894; as *Trochostoma violaceum*). "Albatross" St. 3436 (27°34'N, 110°53'40"W), 1 656 m (905 fm); 2.9° C (Ludwig, 1894; as *Ankyroderma spinosum*). Off Salina Cruz (15°38'N, 95°18'30"W), Gulf of Tehuantepec, and NW of San Juanico Island (22°11'12"N, 107°46'06"W), Gulf of California, in depths of 1 006-3 001 m; 2.0-8.0°C and 0.1-2.0 ml O<sub>2</sub>/l (Parker, 1964). Solís-Marín et al. (2005) reported 1 record for the Gulf of California, off Mazatlán (22°30'30"N, 107°01'W), and Honey-Escandón et al. (2008) 1 record over the Lusitania Bank (23°23'30"N, 112°00'30"W), off Baja California Sur, in the California

Current area (Solís-Marín pers. comm.). Solís-Marín et al. (2009) reported an additional lot in the holdings of the Smithsonian Institution, from off Mazatlán (23°12'N, 106°25'W) (Fig. 14). The type locality is the Gulf of Nice, Mediterranean Sea. Widely distributed in the East Pacific, it is known from Monterey, California, to southern Chile. A cosmopolitan species also recorded worldwide except north of the Arctic Circle (Pawson, 1977; Maluf, 1988; Borrero-Peréz et al., 2005).

The depth range provided by Maluf (1988) for this species (4 to 5 205 m depth) is astonishing. A search in the literature indicates that the sample presumably collected at only 4 m depth most certainly corresponds to a record by Parker (1964) at a locality situated in the Bay of La Paz (St. 4, depth 4-7 m, water temperature 22°C), sampled in 1959. The extremely high water temperature and the subtidal character of the sampling site indicate that this record is uncertain. Perhaps this sample had been confused with the preceding sample (St. 3, visited 2 days earlier, same area, 2 710 m depth) and erroneously labeled. Depth records for Pacific Mexico are from 830 to 3 170 m. According to Pawson (1977), however, *M. musculus* has been collected from 35 to 5 205 m, still a remarkably wide bathymetric range.

## Discussion

It should be emphasized that in most surveys either survey methods, sampling effort, or depth range are distinct, thus rendering formal comparison difficult. Depth range, for example, is very important for the distribution of the Elasipodida, particularly for the families Psychropotidae and Elpidiidae (Hansen, 1975; Gebruk, 1990). Most of the species belonging to those families live deeper than 2 000 m. Consequently, Elasipodida collected at a depth range of 350-2 200 m (present study) or 400-2 900 m (Gage et al., 1985) represent 31% and 27 % of the species diversity, respectively. If the sampled depth is 2 000-4 000 (Sibuet, 1977) or 350-4 000 (Ludwig, 1894) the Elasipodida species diversity can reach up to 37% and 45%, respectively.

As a result of the compilation of the data available in the literature, and including the 13 species collected during the TALUD cruises, 31 deep-water species (29 identified at species level and 2 at genus level) have at least 1 record from off the Pacific coast of Mexico: 13 in the California Current area (CC, south of the USA border), 20 in the Gulf of California (GC), and 14 (15 if the doubtful record of *Peniagone intermedia* is considered) along southwestern Mexico (SWM, south of Banderas Bay to the Guatemala border). Two species have been collected off Mexican oceanic islands (see Table 2). It should be noted, however, that the Gulf of California southern limit

used in table 2 is a line extending from San Lucas Cape (ca 22°53'N, 109°58'W) to Corrientes Cape (20°24'44"N, 105°43'38"W), on the southern edge of Banderas Bay (see Hendrickx et al., 2005). Consequently, the record of *Molpadia granulata* off Mazatlán (ca 23°13'N, 106°27'W), a locality sometimes considered as being outside the Gulf limits, allows us to include it in the Gulf of California species list. Parker (1964) included 17 species living deeper than 350 m in this data base: *Peniagone* sp. could correspond to any of the 3 species reported for deep water in the Central eastern Pacific (see Maluf, 1988). *Psychropotes dubiosa* and *P. raripes* are now considered junior synonyms of *P. longicauda*, and Parker's information is therefore considered as valid record for the later species in the California Current and along SW Mexico. The record for *S. sagamiensis* should be taken with care due to the difficulty to properly identify species in this genus. In this survey we collected 3 species cited by Parker (i.e., *B. sanguinolenta*, *Y. bitentaculata*, and *M. musculus*). Seven of the 23 "Mexican" species reported by Maluf (1988) were collected during this survey (see Table 2). *Peniagone leander* was described after Maluf (1988) had completed her search but has not been found off Mexico. The contribution by Solís-Marín et al. (1997) refers to 3 records of deep-water species off SW Baja California (*Laetmogone scotoeides*, *Pannychia moseleyi* and *Paracaudina chilensis*) (see Table 2). The record of *L. scotoeides*, however, is in error (F. Solís-Marín, pers. comm.). Within the Gulf of California, Maluf and Brusca (2005) have reported 57 species of Holothuroidea, most from shallow water. Eight deep-water (>350 m depth) species are included in their list, all previously included in Maluf's 1988 list of species (see Table 2).

Compilations by Solís-Marín et al. (2005) and Honey-Escandón et al. (2008) include, when combined, 55 species of Holothuroidea for Pacific Mexico. Unfortunately, depth ranges were not indicated in these lists, but review of bathymetric records available in literature indicates that 6 of these species are from water deeper than 350 m (see Table 2), all also previously reported by Maluf (1988) for the Gulf of California. In their synopsis of the Gulf of California Holothuroidea, Solís-Marín et al. (2009) include 11 species with bathymetric range reaching depths greater than 350 m. We believe, however, that the following 5 records are either doubtful [i.e., *Cucumaria crax* Deichmann, 1941; *Pseudocnus californicus* (Semper, 1868); *Holothuria leucospilota* (Brands, 1835); *Parastichopus californicus* (Stimpson, 1857)] or need to be verified (i.e., *Chiridota aponocrita* H.L. Clark, 1920, which depth information was taken from another species) (see Appendix I). *Holothuria leucospilota*, for example, a very common species throughout the Indo-Pacific Ocean,

is known as an intertidal species with a maximal depth record of 10 m (Samyn and Massin, 2003). The 695 m cited by Solís-Marín et al. (2009) seems unlikely. We have considered as valid only the record for *Abyssocucumis albatrossi* (cited as *Stereocucumis abyssorum*; however, presence of spiny arms on the ossicles indicates the material belongs to *A. albatrossi*), *Pannychia moseleyi*, *Molpadia intermedia*, and *M. musculus*, all 4 species collected during this survey, and for *Scotoplanes clarki* and *Heldingia californica* (see Table 2), not collected during the TALUD cruises. Finally, a new deep water species of *Synallactes* was recently described from the Gulf of California (Massin and Hendrickx, 2010) and has also been included in the list of Mexican species (Table 2).

The capture of 1 large specimen of *Abyssocucumis albatrossi* in the central Gulf of California confirms the presence of a second species of the genus in Mexican waters and is the first confirmed record for the Gulf. The rediscovery of *Psolidium gracile*, reported only once from off California since its original description, based on material from off Panama, allows us to report it from off SW Mexico and within the Gulf of California. *Laetmogone scotoeides* was previously known only from the type locality, SE of Ballenas Bay, in the California Current area, and is now cited for SW Mexico. The large series of specimens of *Pannychia moseleyi* collected during this survey confirms the abundance and high occurrence of this species along western Mexico. *Synallactes alexandri* is recorded for the first time in Mexican waters.

## Ecology

For most species studied herein, depth and epibenthic water temperature are similar to the data available in the literature (e.g., Ludwig, 1894; H.L. Clark, 1913, 1920; Parker, 1964). Information on epibenthic dissolved oxygen concentration at sampling sites is rarely available for deep-water species. In this study, focused on the fauna living at the edge and below the minimum oxygen zone off the Pacific coast of Mexico, we were able to measure close-to-bottom oxygen concentration associated with the capture of Holothuroidea (Table 1). These data indicate adaptation to mild hypoxic conditions for *Laetmogone scotoeides* (0.68-1.01 ml O<sub>2</sub>/l) and to more severe hypoxic condition for *Psolus squamatus* (0.26-0.36 ml O<sub>2</sub>/l), *Molpadia musculus* (0.15-0.40 ml O<sub>2</sub>/l), and both species of *Synallactes* (0.20 ml O<sub>2</sub>/l). It is to be noted, however, that *Molpadia musculus* has been reported by Parker (1964) in dissolved oxygen concentration of 1.80-2.00 ml O<sub>2</sub>/l in localities just north and south of Mexico. *Mitsukurietta unusordo* sp. nov. was also collected in low oxygen concentration (0.32 ml O<sub>2</sub>/l) but additional information is needed to confirm its affinity

to a hypoxic environment. Some species were collected in a wide range of dissolved oxygen values (*Psolidium gracile*, <0.05-1.05 ml O<sub>2</sub>/l; *Ypsilocucumis californiae* sp. nov., 0.20-1.40 ml O<sub>2</sub>/l; *Pannychia moseleyi*, 0.11-1.38 ml O<sub>2</sub>/l) corresponding to a wide bathymetric range, thus indicating the possibility for these species to extend their vertical distribution from the edge of the anoxic zone into deeper water. Moreover, the number of *P. gracile* collected in 2 stations (i.e., 6 specimens in St. 17, TALUD IX, and 17 in St. 1, TALUD XI) indicates that this species can be abundant in this habitat. *Benthodytes sanguinolenta*, a species occurring mostly below 2 000 m depth, was collected at a similar depth, in relatively well oxygenated waters (i.e., 1.61 ml O<sub>2</sub>/l) during this survey, and its known range of tolerance to oxygen concentration is 1.30-2.80 ml O<sub>2</sub>/l (Parker, 1964). The unique locality where *Ypsilothuria bitentaculata* and *Abyssocucumis albatrossi* were found features similar environmental conditions (1 925-1 977 m, 1.43 ml O<sub>2</sub>/l for the former; 2 056-2 195 m, 1.68 ml O<sub>2</sub>/l for the latter). Off western Mexico, oxygen concentrations increase to values superior to 1.50 ml O<sub>2</sub>/l below 2 000 m, and this might indicate that *B. sanguinolenta*, *Y. bitentaculata*, and *Abyssocucumis albatrossi* are not able to tolerate the low oxygen concentrations found in shallower water (i.e., between 700 and 1 300 m where oxygen values range from almost zero to ca 1.00 ml O<sub>2</sub>/l) (Table 1) (see Hendrickx, 2001; Hendrickx and Serrano, 2010). Off Oregon, these species were collected below 2 000 m, also much deeper than the oxygen minimum zone occurring in that area (Carney and Carey, 1976). The possibility for several species of deep-water holothurians to survive in severe or extreme hypoxic conditions represents a decisive advantage with regards to competition for food or potential predators. On the other hand, as noted by Alton (1972) and Carney and Carey (1976) off Oregon, the presence of a minimum oxygen zone might serve as a physiological barrier to both upward and downward extension of range for many species, a similar pattern to the one described for shrimp (Dendrobranchiata and Caridea) along the west coast of Mexico (Hendrickx and Serrano, 2010). Still, it is interesting to note that the 2 stations where more than 1 species of Holothuroidea were found during this survey experienced severe hypoxia (see Table 1).

#### Distribution and biodiversity

Comparison with neighbouring areas. There are few recent data available to compare the material collected during the TALUD survey with the rest of the Central eastern Pacific. Bluhm (1994) reported on holothurians collected in manganese module sites off northern Peru (ca 90°W) and in the central Pacific, but none of his species

(most identified to genus) matches with the TALUD material. Bluhm and Gebruk (1999) reported 20 holothurian species observed by means of a remote control camera in the Peru Basin, roughly between 3 800 and 4 200 m depth. Many species were identified to genus level, and only 1 species, *Benthodytes sanguinolenta*, coincides with our study. Pawson and Ahearn (2001) studied a small series of holothurians collected off the Galapagos Islands and reported the presence of 7 species, 3 probably undescribed and only 1 (*Pannychia moseleyi*) common with our study.

On the other hand, there has been a large series of surveys of the megafauna on the continental slope and abyssal plains off the west coast of the USA, using both conventional trawls and camera sled. A comparative analysis of the composition of the Holothuroidea fauna collected in this area is provided by Nybakken et al. (1998). According to this review, the highest species richness was reported by Carney and Carey (1976) off Oregon, who reported 28 species below the continental shelf zone (>300 m to the 4 000 m depth range). Six of these species were found during the TALUD project, including 2 species (i.e., *A. albatrossi* and *B. sanguinolenta*) reported by these authors only in water much deeper (>2 700 m) than in our study. Carney and Carey (1982) collected 22 species of Holothuroidea between 2 162 and 3 961 m on Cascadia Basin and Tufts Abyssal Plain, off Oregon, including 5 species (*A. albatrossi*, *B. sanguinolenta*, *P. moseleyi*, *M. musculus*, and *Y. bitentaculata*) found during the TALUD project in much shallower waters. Of the 13 species collected by Nybakken et al. (1998) off central California, 6 were found during the TALUD cruises. Quite remarkably, these 6 species are the same as those common between the "1976" Oregon and the TALUD surveys. A more recent survey along the coast of California, Oregon and Washington, detected the presence of 8 deep-water species ranging to 721-1 285 m depth, including *Molpadia intermedia*, *Pannychia moseleyi*, and *Psolus squamatus*, all 3 considered among the moderately-frequent species (Keller et al., 2007). According to Lambert (2007), there are 45 species of sea cucumbers reported for British Columbia, 34 occurring below 200 m. His list includes *Pannychia moseleyi*, *Ypsilothuria bitentaculata*, *Psolus squamatus*, and *Molpadia intermedia*, but the former 2 are only found above 200 m off British Columbia. Including the material collected during the TALUD survey, the deep-water (>350 m) Holothuroidea fauna occurring off the Pacific coast of Mexico comprises of 31 species, a number quite similar to those numbers reported for Oregon (28 in >300 m) and British Columbia (34 in >200 m), but apparently higher than those reported for California.

Comparison with remote areas. If we compare deep-water species richness from the Philippines (Cherbonnier and Féral, 1981) and the Rockall Trough (U.K.) (Gage et

al., 1985) with Pacific Mexico (all 3 with similar sampling depth: 379-1 125, 400-2 900, and 350-2 200, respectively), the Philippines and the U.K. areas appear much richer. The number of species per number of samples is 1.20 for the Philippines, 0.97 for U.K. and only 0.09 for Mexico. This difference, of an order of magnitude of 10, could be linked to the limiting effect of the Pacific Mexico OMZ, which is not present in the 2 other areas. Rockall Trough and the Mexican Pacific differ also drastically by their holothurian species composition. Of the 34 and 31 species collected respectively only 2 are shared, i.e. *Psychropotes longicauda* and *Ypsilothuria bitentaculata*.

Even considering the strong limitations of this study (i.e., reduced number of days at sea and samples, sampling depth, extension of the study area), the TALUD exploratory survey initiated in 1989, with major collecting efforts in 2000-2001 and 2005-2008, represents one of the most important event for the knowledge of deep-water Holothuroidea of western Mexico since the "Albatross" collected material between Guatemala and the southern Gulf of California, in 1891-92. There have been very few recent studies of deep-water Holothuroidea (and other Echinodermata) in the East Pacific. Yet, every single study has fully demonstrated that even limited sampling effort on the bathyal seafloor can bring very interesting results, particularly considering the impact of the Minimum Oxygen Zone on the composition and distribution of the deep-water benthic communities in the East Pacific.

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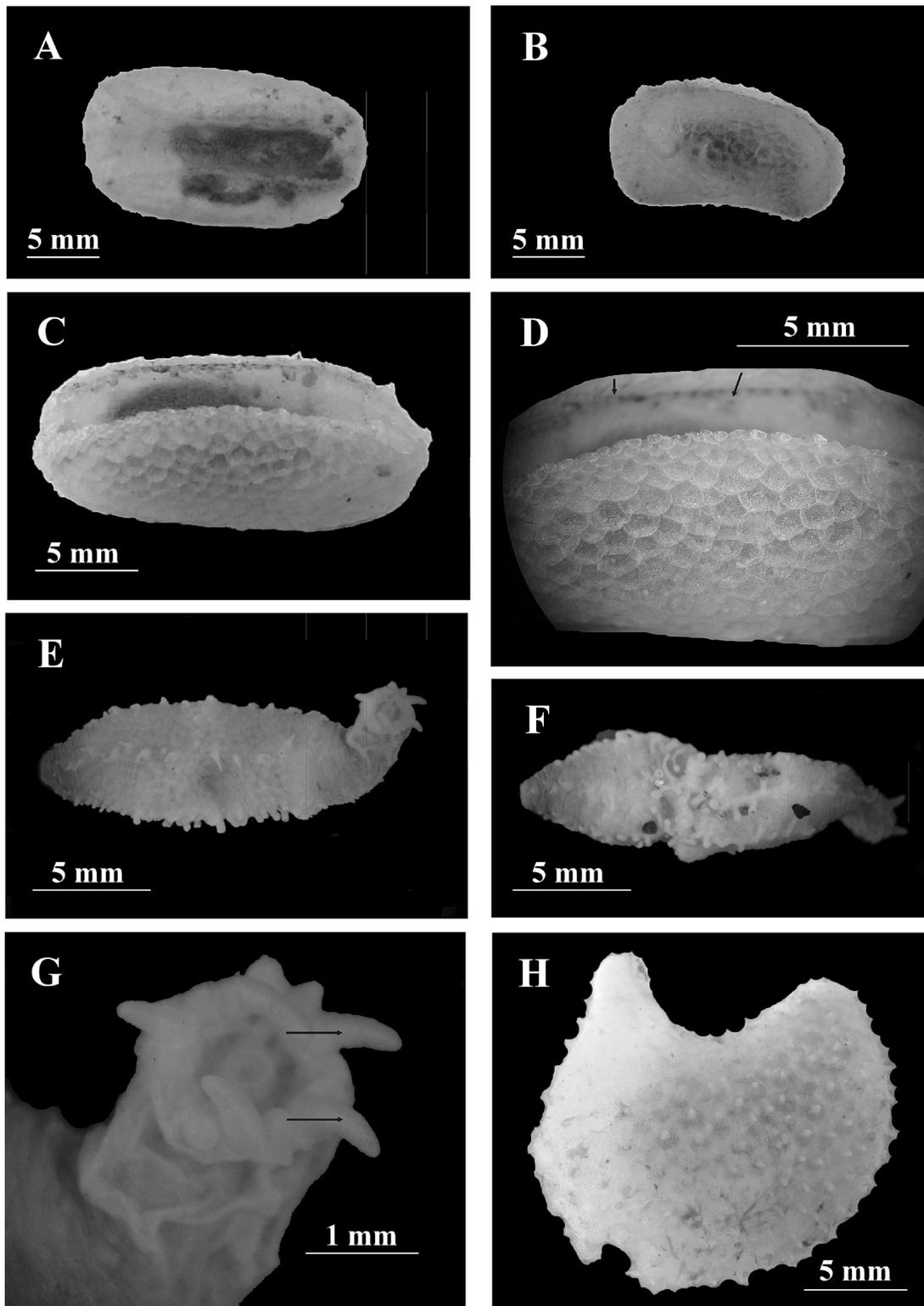
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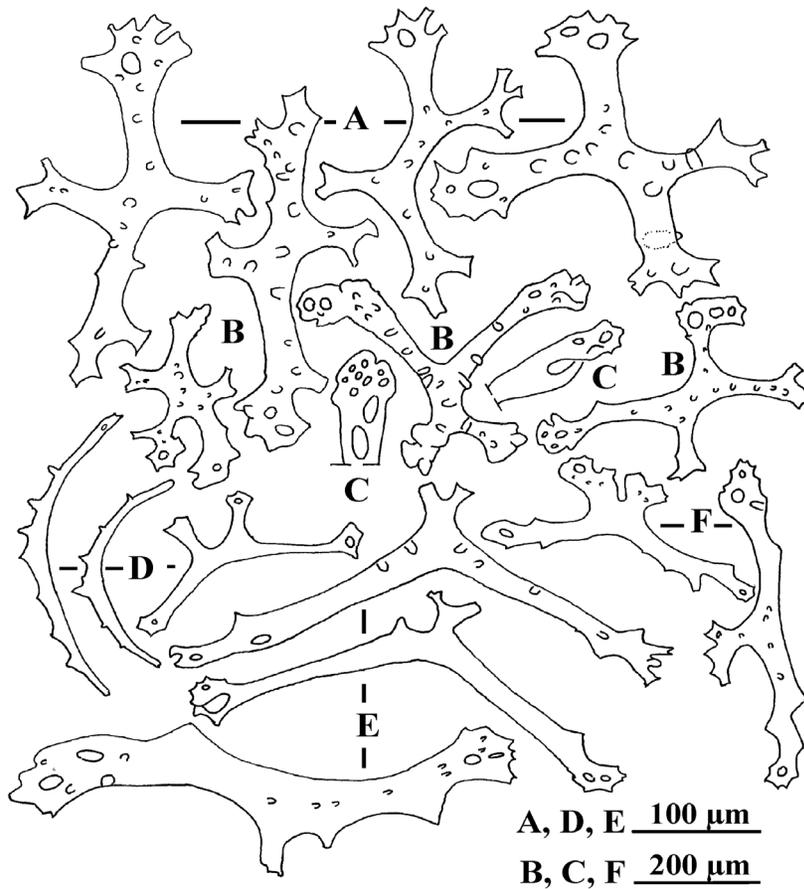
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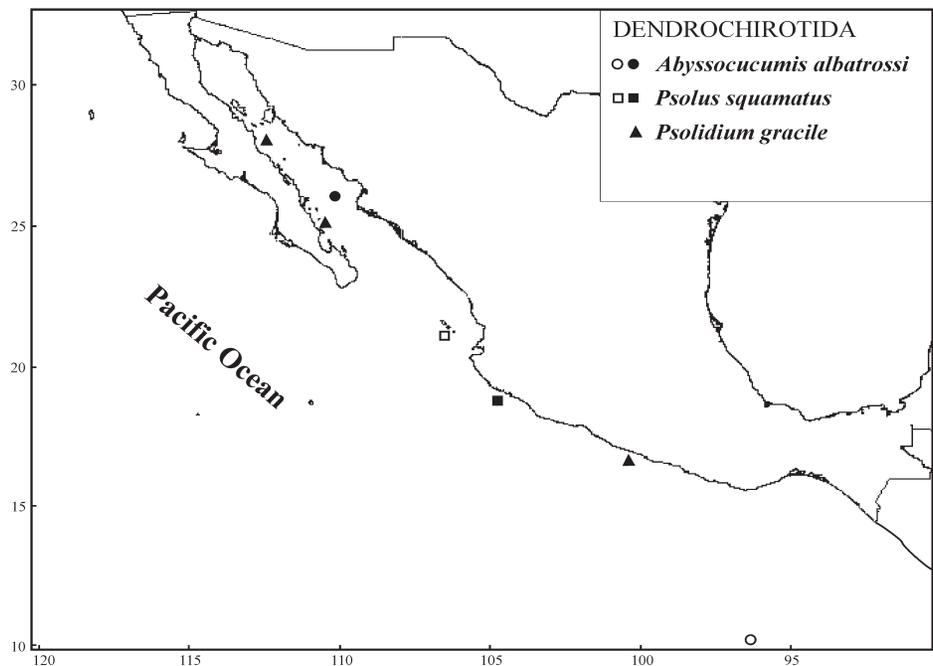
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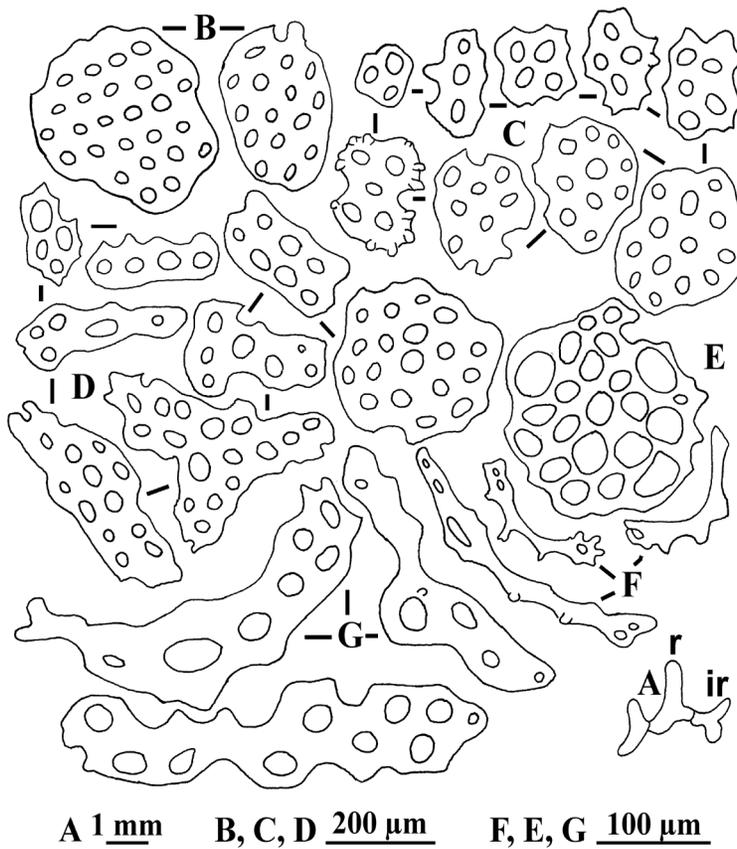
**Plate 1.** A-D. *Psolidium gracile* Ludwig, 1894. A: ventral view. B: lateral view. C: lateroventral view. D: detail of lateroventral side (arrows indicate a ventrolateral row of tube feet). E-G. *Mitsukuriella unusordo* sp. nov. (holotype). E: dorsal view. F: ventral view. G: tentacle crow (arrows indicate long tentacles). H: *Ypsilocucumis californiae* sp. nov. (holotype) lateral view.



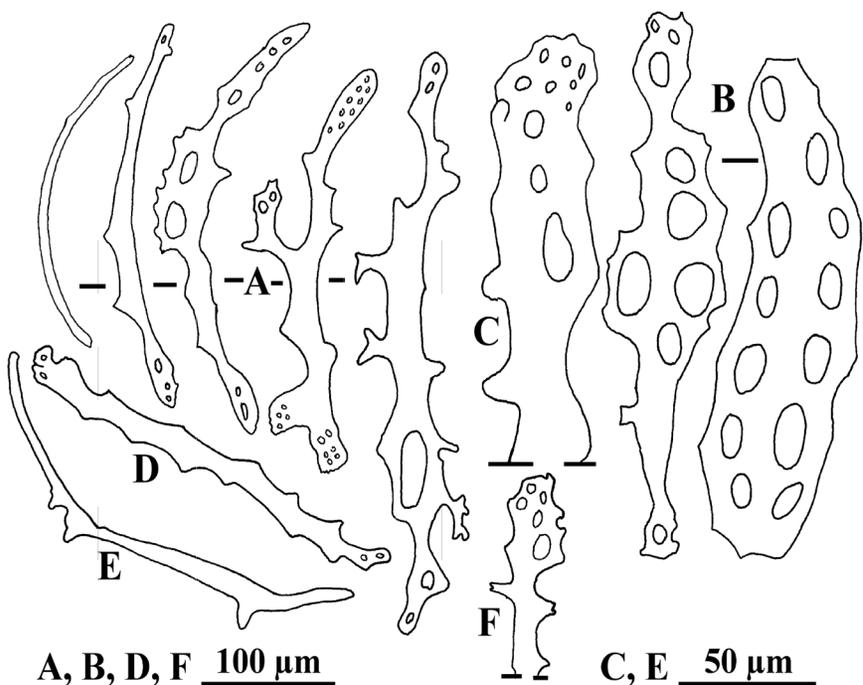
**Figure 1.** *Abyssocucumis albatrossi* (Cherbonnier, 1941). A: cross-shaped ossicles from body wall. B: cross-shaped ossicles from tube feet. C: details of the arm's end of B. D: small, curved rods from tentacles. E, F: large rods of the tentacles.



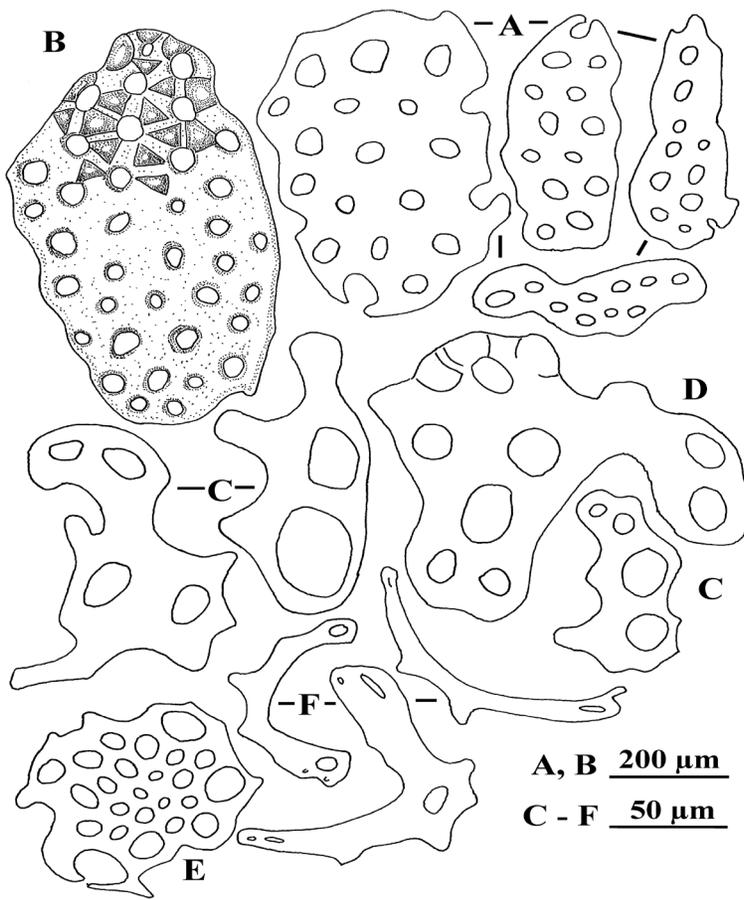
**Figure 2.** Distribution of examined species of Dendrochirotida off the Pacific coast of Mexico, including previous records (open symbols) and localities where material was collected (solid symbols).



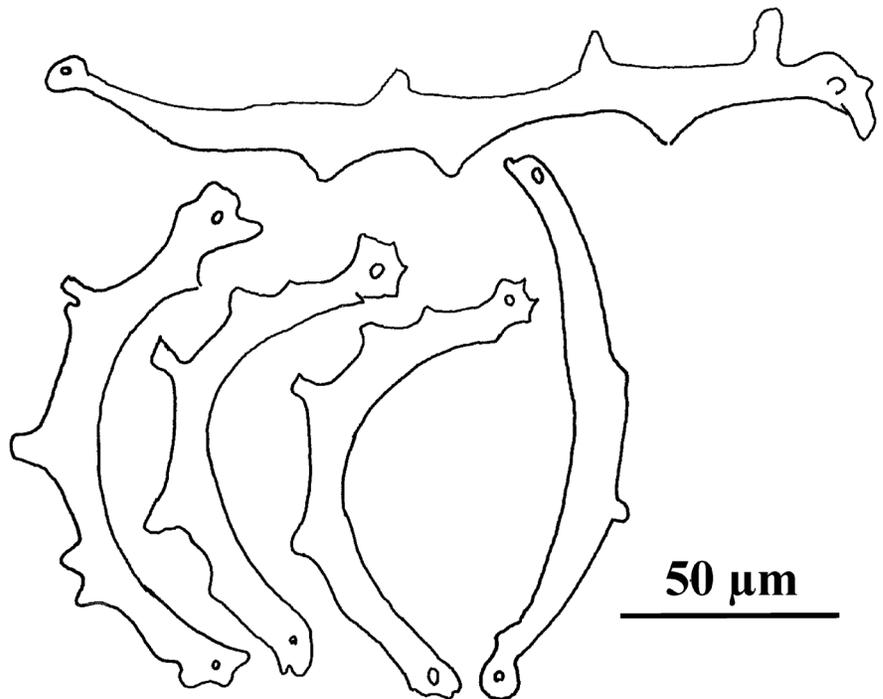
**Figure 3.** *Psolidium gracile* Ludwig, 1894. A: calcareous ring (r: radial piece; ir: interradial piece). B: small dorsal scales. C: perforated plates from ventral sole (L= 16.7 mm). D: perforated plates from ventral sole (L= 18.5 mm). E: end plate of ventral tube feet. F: rods of the ventral tube feet. G: perforated plate of the tube feet.



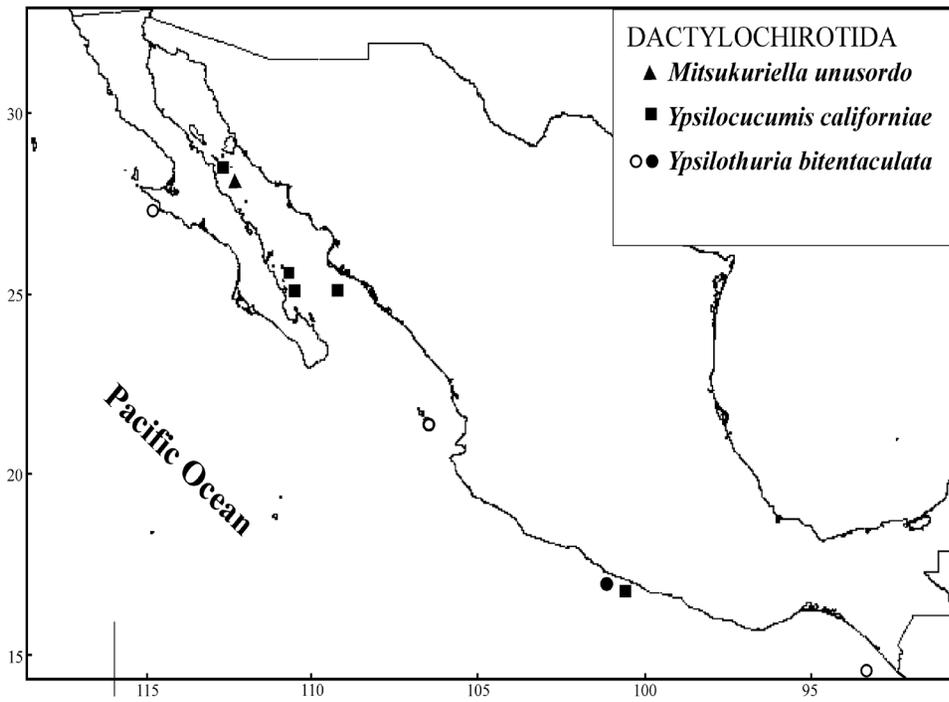
**Figure 4.** *Psolidium gracile* Ludwig, 1894. A: spiny curved rods of the tentacles. B: elongated perforated plates from tentacles. C: details of B extremity. D, E, F: rods of the gonad.



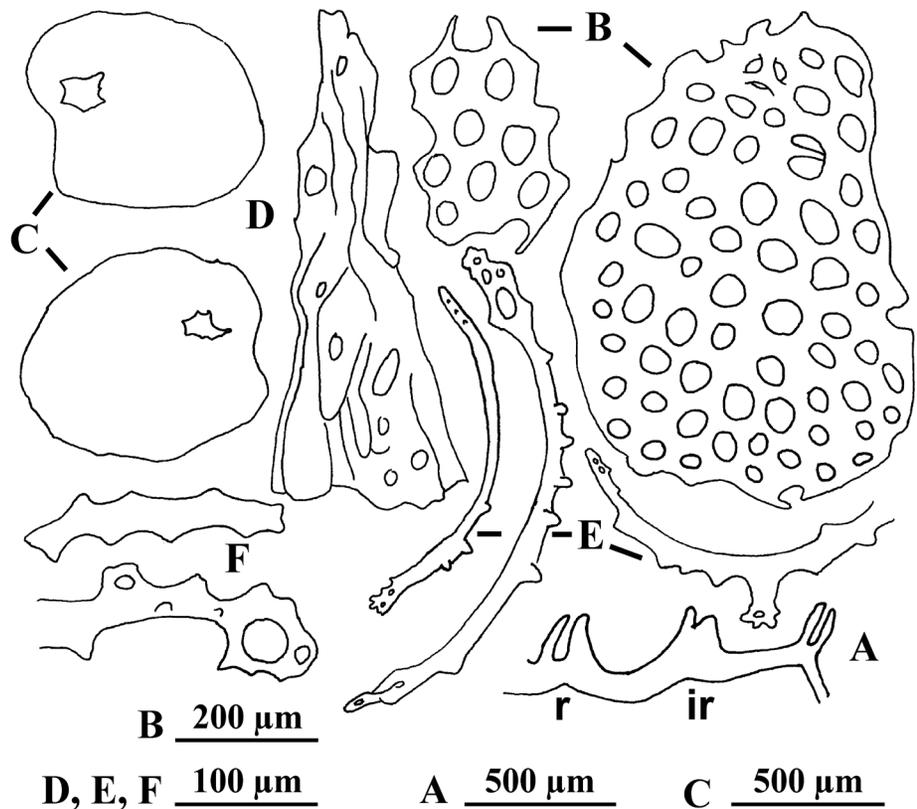
**Figure 5.** *Mitsukuriella unusordo* sp. nov. (holotype) A: smooth body wall scales. B: knobbed body wall scales. C-D: perforated plates of tube feet. E: end-plate of the tube feet. F: V-shaped rods from tube feet.



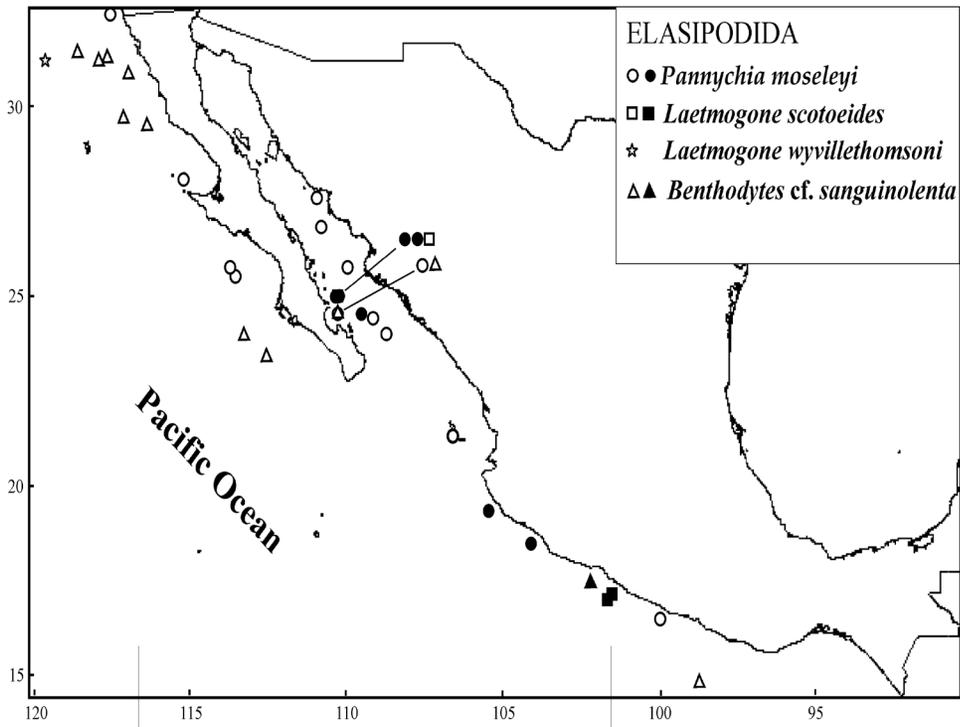
**Figure 6.** *Mitsukuriella unusordo* sp. nov. (holotype) Rods of the tentacles.



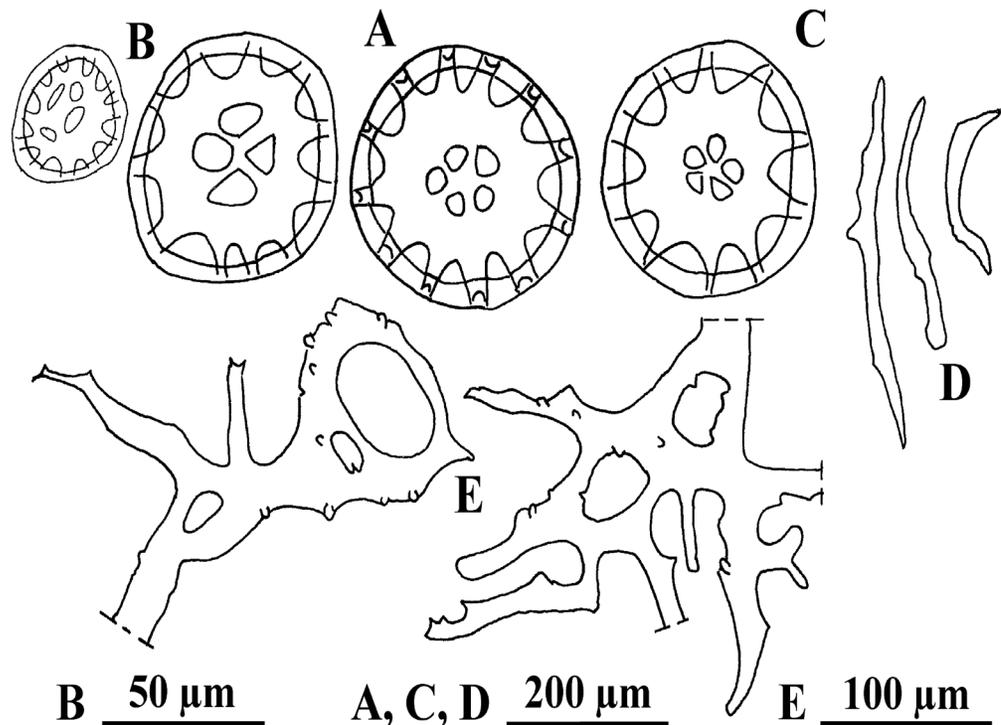
**Figure 7.** Distribution of examined species of Dactylochirotida off the Pacific coast of Mexico, including previous records (open symbols) and localities where material was collected (solid symbols).



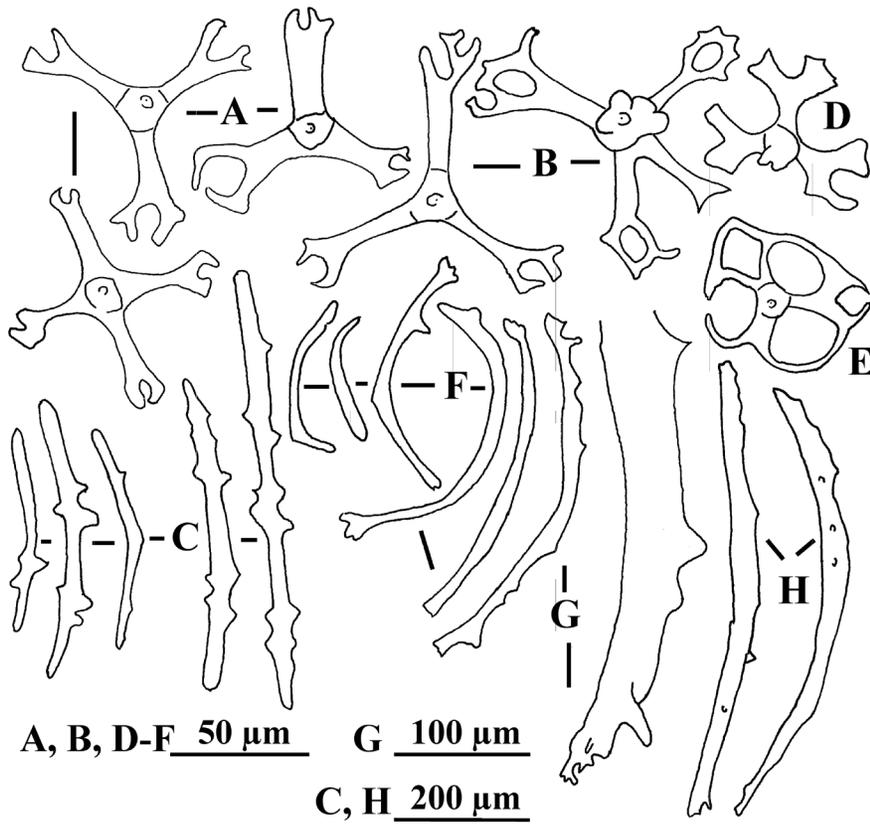
**Figure 8.** *Ypsilocucumis californiae* nov sp. (holotype) A: calcareous ring (r: radial piece; ir: interradial piece); B: small body wall scales; C: large multilayered body wall scales; D: excentric spire of the large body wall scale; E-F: rods of the tentacles.



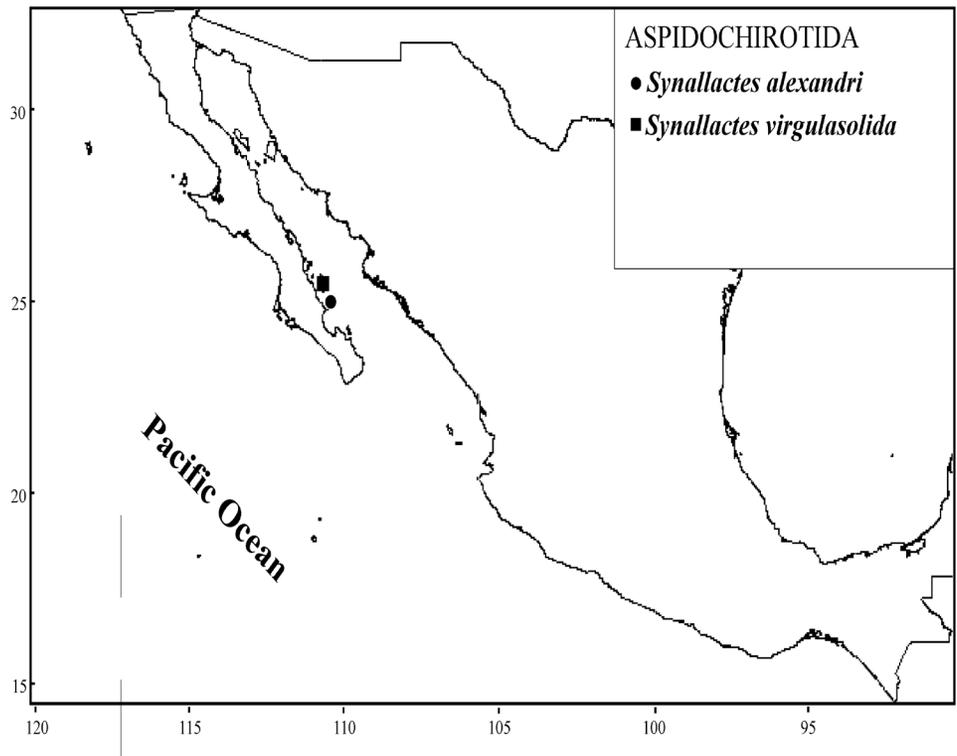
**Figure 9.** Distribution of examined species of Elasiopoda off the Pacific coast of Mexico, including previous records (open symbols) and localities where material was collected (solid symbols).



**Figure 10.** *Laetmogone scotoeides* (H.L. Clark, 1913). A: large wheel of body wall. B: small wheels of the tube feet. C: large wheel of the tube feet. D: rods of the body wall and tube feet. E: irregular, branching rods of the tube feet end-plate.



**Figure 11.** *Synallactes alexandri* Ludwig, 1893. A: cross-shaped ossicles from body wall. B: cross-shaped ossicles from dorsal papillae. C: rods of the tube feet. D: cross-shaped ossicle from tube feet. E: pseudo table of tube feet. F, G, H: rods of the tentacles.



**Figure 12.** Distribution of examined species of Aspidochirotida off the Pacific coast of Mexico, including previous records (open symbols) and localities where material was collected (solid symbols).

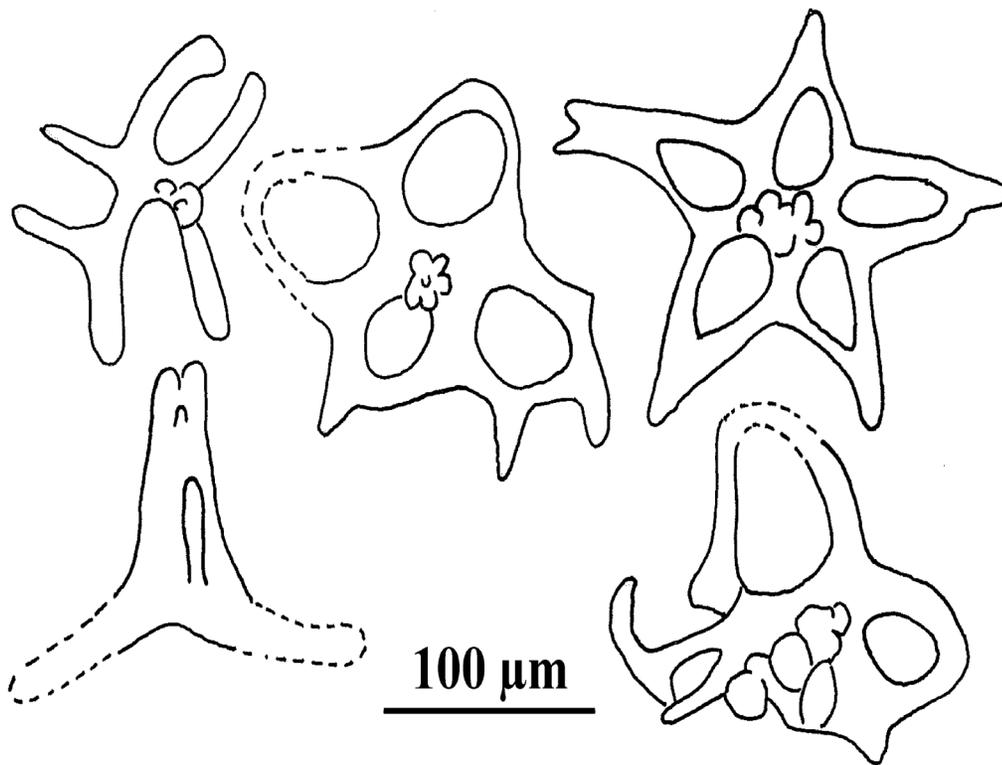


Figure 13. *Molpadia intermedia* (Ludwig, 1894). Tables of the tail.

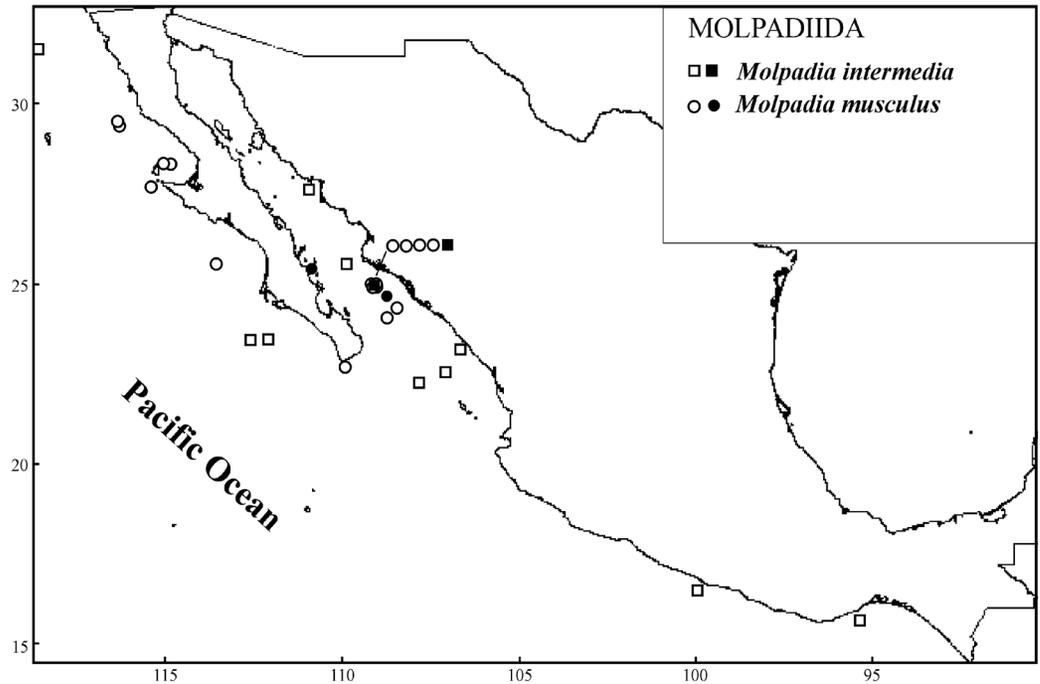


Figure 14. Distribution of examined species of *Molpadiiida* off the Pacific coast of Mexico, including previous records (open symbols) and localities where material was collected (solid symbols).

**Appendix 1.** Remarks concerning doubtful or erroneous depth records in Solís-Marín et al. (2009).

*Cucumaria crax* Deichmann, 1941, is reported by Solís-Marín et al. (2009) in depths of 8-549 m. According to Maluf (1988), this species occurs between 15 and 55 m depth. We could not locate a reference to the 549 m record. When the list of material cited by Solís-Marín et al. (2009; 3 records) is examined, the only option for this record seems to be the one of “Bahía Sta. María”, 24°56.3'N, 108°44.6'W (the 2 others are cited by Maluf, 1988). However, there is no citation of a cruise sampling at that depth in this area and, according to ecological data gathered in that area, bottom at ca 549 m depth is almost anoxic (Hendrickx and Serrano, 2010). In addition, plotting the latitude-longitude data on a map indicates that the “Sta. María” station actually corresponds to a depth of less than 200 m.

*Pseudocnus californicus* (Semper, 1868), in 0-717 m (Solís-Marín et al. 2009). An intertidal to 190m species according to Maluf (1988). We were not able to locate a record at this depth. All records by Solís-Marín et al. (2009) are from intertidal or very shallow water; only 1 is from the same sample as previous species (i.e., *C. crax*; Bahía Sta. María), but the authors provide a distinct maximum depth range (717 m vs. 549 m for *C. crax*).

*Holothuria leucospilota* (Brands, 1835), in 0-695 m (Solís-Marín et al. 2009). An intertidal species according to Maluf (1988). According to Samyn and Massin (2003), deeper record is from 8 m. We found no trace of a 695 m record in the Gulf of California or in the eastern Pacific for this species.

*Parastichopus californicus* (Stimpson, 1857), in 5-5 640 m (Solís-Marín et al. 2009). From the intertidal to 180 m (Maluf, 1988) and to 216 m (Lambert, 1986). There seem to be no such depth in the Gulf of California. The 2 lots cited by Solís-Marín et al. (2009) are from San Benedito and Angel de la Guarda Islands, certainly from much shallow water. Also, the reference to Théel (1886) in the synonymy refers to Théel's “Challenger” contribution but it should be the “Blake” contribution. See “Referencias Bibliográficas” in Solís-Marín et al. (2009).

*Chiridota aponocrita* H.L. Clark, 1920, in 9-4 755 m (Solís-Marín et al. 2009). In the intertidal (Maluf 1988). Actually the data reported by Solís-Marín et al. (2009) correspond to 1 of the 2 Albatross stations where another species, *Protankyra “abyssicola”* (see H.L. Clark, 1920), was collected (top of page 125 in H.L. Clark, 1920). The depth range reported for *Ch. aponocrita* is therefore due to a confusion.

