Pandalid shrimps (Crustacea: Decapoda: Caridea: Pandalidae) collected during the TALUD XIV cruise in the Gulf of California, Mexico, and rediscovery of Plesionika carinirostris Hendrickx, 1989

Michel E. HENDRICKX
Laboratorio de Invertebrados Bentónicos, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de Mexico, P.O. Box 811, Mazatlán, Sinaloa 82000, México.
E mail: michel@ola.icmyl.unam.mx

Abstract: Five species of Pandalidae were collected during sampling operations aboard the R/V “El Puma” in the northern part of the central Gulf of California, Mexico. Plesionika carinirostris Hendrickx, 1989, a rare species known exclusively from the type locality in the Gulf of California and from southern California, was rediscovered and proved to be abundant and distributed in a much wider area than previously thought. In addition, new distributions limits are provided for the four other species: Heterocarpus vicarius Faxon, 1893, Pantomus affinis Chace, 1937, Plesionika trispinus Squire & Barrágan, 1976, and P. sanctae catalinae Wicksten, 1983. With an estimated biomass of 123 kg. ha⁻¹, this is the largest capture of H. vicarius ever reported for Pacific Mexico. Samples obtained during this cruise also allow for the largest sample of P. carinirostris (total, 158 specimens), and the second largest sample of P. trispinus (total, 67 specimens) ever reported for Pacific Mexico.


Keywords: Pandalidae ● Distribution ● Abundance ● Gulf of California ● Mexico
Introduction

Pandalid shrimps are particularly important in fishery activities worldwide and many species provide considerable income to fisherman due to their high market value (Holthuis, 1980; Balsiger, 1981; Otto & Jamieson, 2003). Thirteen species of Pandalidae have been reported for the Mexican Pacific, none of which is subject to fishery activity to date (Hendrickx & Wicksten, 1989; Hendrickx, 1993a; Hendrickx & Estrada-Navarrete, 1996). From a fishery point of view, the genus Heterocarpus A. Milne-Edwards, 1881 (29 species worldwide; De Grave & Fransen, 2011) is undoubtedly the most important in the eastern Pacific where four species occur: H. affinis Faxon, 1893 and H. vicarius Faxon, 1893, from the Gulf of California, Mexico, to Peru; H. hostilis Faxon, 1893, from Panama to Peru; and H. reedi Bahamonde, 1957, from Peru and Chile. All species of Heterocarpus were or are still supporting fisheries in Costa Rica, Panama, Peru and Chile, or have been identified as potential resources (Kameya et al., 1997; Hendrickx & Wicksten, 1989; Hendrickx, 1995; Wicksten & Hendrickx, 2003; Wehrtmann & Nielsen-Muñoz, 2009). Only one species of Pantomus A. Milne-Edwards, 1888, P. affinis Faxon, 1893, is reported for the eastern Pacific, including Mexico. It ranges from California to Peru (Wicksten & Hendrickx, 2003), while the only other species of the genus is distributed in the Atlantic. The monotypic genus Stylopandalus Coutière, 1905 is also found off Pacific Mexico where the unique species, Stylopandalus richardi (Coutière, 1905), occurs off Baja California west coast. (Hendrickx & Estrada-Navarrete, 1996). Similarly, species of Plesionika Spence Bate, 1888, are typically tropical and subtropical and comprises 187 species worldwide, making it the more specious genus in the Pandalidae (De Grave & Fransen, 2011). In the eastern tropical Pacific, the genus Plesionika is represented by five species: P. beebei Chace, 1937, a pelagic species, ranges from Mexico to Peru; P. carinirostris Hendrickx, 1990, the largest species known for the area, has a benthic habitat and is known from the type locality, in the central Gulf of California, and from southern California; P. mexicana Chace, 1937, is probably exclusively benthic, and ranges from California to Peru; P. sanctaeccatalinae Wicksten, 1983, another pelagic species, has been collected close to the northern and southern boundaries of the eastern tropical Pacific (i.e., Baja California and northern Peru), and only once in the Gulf of California; P. trispinus Squires & Barragán, 1976, a benthic species, is also known from southern California to Peru (Hendrickx & Wicksten, 1989; Hendrickx & Estrada-Navarrete, 1996; Wicksten & Hendrickx, 2003).

Other Pacific Mexico species of Pandalidae belong to the genera Pandalus Leach, 1814 (three species in the California Current area) and Pandalopsis Spencer Bate, 1888 (one species, Pandalopsis ampla Spence Bate, 1888, ranging from Washington, USA, to at least El Salvador) (Hendrickx, 1993a; Wicksten & Hendrickx, 2003; Flores et al., 2004).

Recent exploratory surveys in the eastern Pacific have revealed that species like H. vicarius, H. affinis, and P. trispinus are occasionally very abundant. These pandalid species have sustained local fisheries for a certain period of time or are considered a strong potential to replace more shallow resources that are rapidly being depleted (see Kameya et al., 1997; Hendrickx, 2003; Wehrtmann & Nielsen-Muñoz, 2009).

The TALUD project, initiated in 1989, is primarily aimed at studying the deep-water fauna and environmental conditions below the oxygen minimum zone (OMZ) occurring off the Pacific coast of Mexico (see Hendrickx & Serrano, 2010; Serrano & Hendrickx, 2011). The TALUD XIV cruise was specifically designed to try to define more accurately the boundaries of the OMZ in the barrier islands area (Tiburon, Angel de la Guardia and San Lorenzo Islands), where upper and mid-slope hypoxic and anoxic conditions are vanishing due to peculiar water circulation patterns and the presence of shallower bottoms (see Hendrickx et al., 2011). During the TALUD XIV cruise in the northern part of the central Gulf of California, Mexico, a large series of pandalid shrimps belonging to five species was collected between 208 and 907 m depth. This material is reported herein and brings some new light on the presence of deep-water pandalid shrimps in an otherwise poorly known area of the Gulf of California where no fishery activities have been developed to date.

Material and Methods

The material reported in this study was obtained while sampling with the R/V “El Puma”, Universidad Nacional Autónoma de México, in the northern section of the central Gulf of California, roughly between 28°10’ and 29°10’N. A total of 30 stations were visited, with depth ranging from 148 and 1346 m. The selection of sampling stations of lesser depth than in previous TALUD cruises (see Hendrickx, 2012) was justified by the fact that one of the objective of the TALUD XIV cruise was to define the upper and lower boundaries of the OMZ in the area. Most specimens were collected with a 2.35 m wide by 0.95 m high, standard benthic sledge, and a 1.80 m wide by 0.95 m high modified Agassiz dredge, both equipped with an outer collecting net of about 5.5 cm (2 1/4”) stretch mesh and an inner net of about 2.0 cm (3/4”) stretch mesh. Trawling lasted 30 minutes at an average speed of 1.75 knots. In two stations, a 0.9 m x 0.9 m midwater net equipped with a 1 mm mesh aperture net was used to collect micronecton.
Sampling depths were estimated with a digital SIMRAD echo sounder. Epibenthic temperature and oxygen concentration were measured ca 10 m above bottom level with a Seabird CTD-O2 probe. Oxygen concentrations were also double-checked with the Winkler method using water samples collected in closing bottles near bottom.

The specimens examined are deposited in the invertebrate collection at the Mazatlán Marine Station, UNAM, in Mazatlán, Mexico (EMU), with their respective catalogue number. Abbreviations used are: CL, carapace length; TL, total length; ovig., ovigerous; juv., juveniles. The classification used follows De Grave & Fransen (2011). Synonymies includes all references known to the author.

Results

Heterocarpus A. Milne-Edwards, 1881

Heterocarpus vicarius Faxon, 1893

Material examined

TALUD XIV. St. 1 (28°15′38″N-111°58′33″W), 32 males (CL 25.1-29.4 mm) and 16 females (CL 25.8-31.2 mm), 7/April/2011, 208-212 m, benthic dredge (EMU-9473). Same station, two males (CL 25.8 and 26.1 mm) and one female (CL 26.6 mm) (EMU-9481). St. 2 (28°14′31″N-112°08′27″W), 167 males (CL 17.0-26.2 mm) (EMU-9474), 115 females (CL 14.1-27.9 mm), and 33 juveniles (CL about 8.0-about 12.1 mm) (EMU-9475), and 76 ovig. females (CL 22.2-29.0 mm) (EMU-9476), 7/April/2011, benthic sledge, 512-525 m. Same station, 36 juveniles (EMU-9482). St. 4 (28°11′27″N-112°32′06″W), 17 males (CL 20.9-26.5 mm), 7 females (CL 18.1-27.7 mm), and three ovig. females (CL 24.1-27.9 mm), 7/April/2011, benthic sledge, 512-525 m. Same station, 36 juveniles (EMU-9482). St. 4 (28°11′27″N-112°32′06″W), 17 males (CL 20.9-26.5 mm), 7 females (CL 18.1-27.7 mm), and three ovig. females (CL 24.1-27.9 mm), 7/April/2011, benthic sledge, 512-525 m. Same station, 36 juveniles (EMU-9482). St. 4 (28°11′27″N-112°32′06″W), 17 males (CL 20.9-26.5 mm), 7 females (CL 18.1-27.7 mm), and three ovig. females (CL 24.1-27.9 mm), 7/April/2011, benthic sledge, 512-525 m. Same station, 36 juveniles (EMU-9482). St. 4 (28°11′27″N-112°32′06″W), 17 males (CL 20.9-26.5 mm), 7 females (CL 18.1-27.7 mm), and three ovig. females (CL 24.1-27.9 mm), 7/April/2011, benthic sledge, 512-525 m. Same station, 36 juveniles (EMU-9482). St. 4 (28°11′27″N-112°32′06″W), 17 males (CL 20.9-26.5 mm), 7 females (CL 18.1-27.7 mm), and three ovig. females (CL 24.1-27.9 mm), 7/April/2011, benthic sledge, 512-525 m. Same station, 36 juveniles (EMU-9482). St. 4 (28°11′27″N-112°32′06″W), 17 males (CL 20.9-26.5 mm), 7 females (CL 18.1-27.7 mm), and three ovig. females (CL 24.1-27.9 mm), 7/April/2011, benthic sledge, 512-525 m. Same station, 36 juveniles (EMU-9482). St. 4 (28°11′27″N-112°32′06″W), 17 males (CL 20.9-26.5 mm), 7 females (CL 18.1-27.7 mm), and three ovig. females (CL 24.1-27.9 mm), 7/April/2011, benthic sledge, 512-525 m. Same station, 36 juveniles (EMU-9482). St. 4 (28°11′27″N-112°32′06″W), 17 males (CL 20.9-26.5 mm), 7 females (CL 18.1-27.7 mm), and three ovig. females (CL 24.1-27.9 mm), 7/April/2011, benthic sledge, 512-525 m. Same station, 36 juveniles (EMU-9482). St. 4 (28°11′27″N-112°32′06″W), 17 males (CL 20.9-26.5 mm), 7 females (CL 18.1-27.7 mm), and three ovig. females (CL 24.1-27.9 mm), 7/April/2011, benthic sledge, 512-525 m. Same station, 36 juveniles (EMU-9482). St. 4 (28°11′27″N-112°32′06″W), 17 males (CL 20.9-26.5 mm), 7 females (CL 18.1-27.7 mm), and three ovig. females (CL 24.1-27.9 mm), 7/April/2011, benthic sledge, 512-525 m. Same station, 36 juveniles (EMU-9482).
while the largest catch (St. 33 with an estimated total of 8,864 individual) was caught in severe hypoxic conditions (0.24 ml O₂.l⁻¹). Bottom temperature associated with the capture of *H. vicarius* varied from 6.84 to 11.67°C.

**Remarks**

The larger specimen examined is a female 104.4 mm TL, close to the larger individual on record to date (TL up to 115 mm; Méndez, 1981). Although *H. vicarius* is undoubtedly a benthic species in its adult phase, records by Chace (1937) in the water column correspond to young specimens captures about 500 m above bottom (see Hendrickx & Wicksten, 1989). 

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**Figure 1.** Position of sampling stations visited during the TALUD XIV cruise (open circles) and where specimens of Pandalidae were collected (solid circles). **A.** *Heterocarpus vicarius* Faxon, 1893. **B.** *Pantomus affinis* Chace, 1937, and *Plesionika sanctaecatalinae* Wicksten, 1983. **C.** *Plesionika carinirostris* Hendrickx, 1990. **D.** *Plesionika trispinus* Squires & Barragán, 1976.


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*Pantomus* A. Milne-Edwards, 1888

*Pantomus affinis* Chace, 1937


*Pantomus sp.* Méndez, 1981: 103, figs. 308, 308a-b-c.
Material examined

TALUD XIV. St. 4 (28°11’27”N-112°32’06”W), one ovig. female (CL 7.3 mm), 7/April/2011, 435-451 m, benthic sledge (EMU 9470).

Distribution

California, USA; from Bahía Santa Inés (26°56’30”N-111°48’30”W; west coast) and Bahía Santa María (25°46’12”N-109°35’06”W; east coast), Gulf of California, Mexico, to Islas Lobos de Fuera, Peru (Hendrickx & Wicksten, 1989; Montagne & Cadien, 2001). Material from TALUD XIV extends the northernmost distribution limit within the Gulf of California by 1°15’ of latitude (Fig. 1 B).

Ecology

*Pantomus affinis* has been recorded from 35 to 744 m throughout its distribution range (Hendrickx, 1995), but the deepest records are from off Peru (Hendrickx & Wicksten, 1989). Previous records in the Gulf of California are from 35 to 120 m, in the southern and central Gulf (Hendrickx & Wicksten, 1989), but the material collected at St. 4 indicates that this species occurs in much deeper water (435-451 m) in the northern Gulf of California. Information provided by Hendrickx & Wicksten (1989) indicated that *P. affinis* occurs in a wide range of oxygen concentrations (0.90-1.47 ml O₂.l⁻¹) and intermediate temperatures (13.2-15.0°C). The unique specimen captured during the TALUD XIV cruise was found in 0.21 ml O₂.l⁻¹ and 8.3°C (Table 1).

*Plesionika* Spence Bate, 1888

*Plesionika carinirostris* Hendrickx, 1990

(Fig. 2 A)


Material examined

TALUD XIV. St. 4 (28°11’27”N-112°32’06”W), three ovig. females (CL 15.1-20.0 mm), 7/April/2011, 435-451 m, benthic sledge (EMU 9460). Same station, three males (CL 13.3 and 16.8 mm), 3 females (CL 13.8-15.8 mm), two ovig. females (CL 19.0 mm), and four unmeasured, damaged specimens, including two ovig. females (EMU-9465). St. 8 (28°17’06”N-112°33’39”W), 2 males (CL 16.3 and 17.1 mm), one female (CL 17.8 mm), and one ovig. female (CL 19.8 mm), 8/April/2011, 520-557 m, Agassiz dredge (EMU-9458). Same station, 72 males (CL 13.6-19.3 mm) (EMU-9471), 38 females (CL 12.5-19.9 mm), and 22 ovig. females (CL 14.6-19.9 mm) (EMU-9472). St. 14 (28°35’32”N-112°27’53”W), one ovig. female (CL 21.5 mm), 8/April/2011, 305-316 m, benthic dredge (EMU-9463). St. 20 (28°46’29”N-112°45’40”W), one male (CL 18.8 mm), 9/April/2011, 410-414 m, benthic sledge (EMU-9459). St. 27 (29°08’53”N-113°25’28”W), two males (CL 19.5 and 20.3 mm), 10/April/2011, 860-907 m, benthic sledge (EMU-9462). St. 29 (28°36’25”N-112°58’29”W), 1 ovig. female (CL 12.0 mm), 11/April/2011, 627-643 m, benthic sledge (EMU-9464). St. 30 (28°32’57”N-112°59’26”W), 2 ovig. females (CL 19.9 mm; damaged specimen CL about 20.0 mm), 11/April/2011, 270-309 m, benthic sledge (EMU-9466).
**Distribution**

Off California; off Isla San Lorenzo (28°46'N-112°54'W; type locality), Gulf of California (Montagne & Cadien, 2001; Wicksten & Hendrickx, 2003). The material collected during the TALUD XIV survey increases the known distribution range of *P. carinirostris* to 28°11'27”N to the south and to Canal de Ballenas to the northwest (Fig. 1C).

**Ecology**

The type locality material (one male; 360-380 m depth) and the unique specimen reported by Montagne & Cadien (2001) (145 m depth) gave the idea that *P. carinirostris* was a rare species. However, the relatively frequent (seven samples) and abundant material reported herein (158 specimens) indicates that it is an important component of the northern Gulf deep-water community. It also allows to modify the depth range within the Gulf of California which is now set at 270-907 m. The TALUD XIV material was associated to the following epibenthic environmental conditions: temperature, 6.8-12.7°C; dissolved oxygen concentration, 0.18-1.45 ml O₂.l⁻¹ (Table 1).

**Remarks**

As noted by Montagne & Cadien (2001), Hendrickx (1995) mistakenly referred to the holotype as a female, while the original description (Hendrickx, 1990) refers to a “male” holotype. Maximum body size (TL) reported to date: male, 105.9 and female 103.3 mm.

**Plesionika sanctaecatalinae** Wicksten, 1983


**Material examined**

St. 19 (28°37’37”N-112°41’05”W), 1 male (CL 14.3 mm) and one female (CL 9.5 mm), 9/April/2011, 560-580 m, benthic sledge (EMU-9469A). St. 26 (29°02’11”N-113°17’12”W), one female (CL 12.2 mm), 10/April/2011, 1150-1165 m, benthic sledge (EMU-9469B) period.

**Distribution**

A pelagic species, *P. sanctaecatalinae* is known from off Santa Barbara, California to Chile (20°46’S) (Retamal, 1993; Wicksten, 2002). It has been reported in three Mexican localities off Baja California, in the California Current area (Hendrickx & Wicksten, 1989), and there is an additional capture for the southern Gulf of California (26°23’30”N-111°23’18’W; Hendrickx & Estrada-Navarrete, 1996). The records of the TALUD XIV cruise are the second and third for the Gulf of California (Fig. 1B) and extend the northernmost distribution limit of *P. sanctaecatalinae* within the Gulf by 2°40’ of latitude.

**Ecology**

No precise depth data are available for the specimens captured during the TALUD XIV cruise, hence no environmental data can be associated with the capture of this species.

**Remarks**

The presence of *P. sanctaecatalinae* in two samples obtained with a benthic dredge is accidental and the specimens were certainly collected in midwater when the net was hauled to the surface. Discrete samples cited by Wicksten (1989) taken

<table>
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<th>Stations</th>
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<th>Temp. range (°C)</th>
<th>Dissol. O₂ range (ml.l⁻¹)</th>
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<td>6.84-11.67</td>
<td>0.15-0.54</td>
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<td>6.8-12.7</td>
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<td><em>Plesionika trispinus</em></td>
<td>208-316</td>
<td>11.52-11.70</td>
<td>0.94-1.54</td>
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at different depths with a midwater trawl indicate that *P. sanctaeclalinae* occurs at least between 1000 and 3,500 m. Material from St. 19 demonstrate that it also occurs in water shallower that 560-580 m.

**Plesionika trispinus** Squires & Barrágan, 1976

Fig. 2 B


**Material examined**

St. 1 (28°15'38"N-111°58'33"W), 15 males (CL 8.8-12.5 mm) and 38 females (CL 6.9-14.2 mm), 7/April/2011, 208-212 m, benthic sledge (EMU-9461). St. 12 (28°15'19"N-112°57'03"W), 15 males (CL 8.8-12.5 mm) and 38 females (CL 6.9-14.2 mm), 7/April/2011, 208-212 m, benthic sledge (EMU-9461). St. 13 (28°15'38"N-111°58'33"W), 15 males (CL 8.8-12.5 mm) and 38 females (CL 6.9-14.2 mm), 7/April/2011, 208-212 m, benthic sledge (EMU-9461). St. 14 (28°36'14"N-112°28'03"W), one male (CL 6.3 mm), 8/April/2011, 305-316 m, benthic sledge (EMU-9461). St. 15 (28°36'14"N-112°28'03"W), one male (CL 6.3 mm), 8/April/2011, 305-316 m, benthic sledge (EMU-9461). St. 16 (28°36'14"N-112°28'03"W), one male (CL 6.3 mm), 8/April/2011, 305-316 m, benthic sledge (EMU-9461). St. 17 (28°36'14"N-112°28'03"W), one male (CL 6.3 mm), 8/April/2011, 305-316 m, benthic sledge (EMU-9461). St. 18 (28°36'14"N-112°28'03"W), one male (CL 6.3 mm), 8/April/2011, 305-316 m, benthic sledge (EMU-9461). St. 19 (28°36'14"N-112°28'03"W), one male (CL 6.3 mm), 8/April/2011, 305-316 m, benthic sledge (EMU-9461).

**Distribution**

From Palos Verde, California, Gulf of California, Mexico, and south to Salavery, Peru; Galapagos Islands (Wicksten & Hendrickx, 2003). Previous records in the Gulf of California are from Sinaloa (off Santa María Bay, 24°56'12"N, and El Fuerte River, 25°46'12"N; Hendrickx & Wicksten, 1989). The material collected during the TALUD XIV cruise include specimens from ca 2°50' of latitude further to the north (St. 14: 28°35'32"N-112°27’53"W) (Fig. 1B).

**Ecology**

Throughout its range, *P. trispinus* has been recorded from a depth range of 96 to 500 m, but the Gulf of California material was captured between 96 and 112 m, in the following epibenthic conditions: 0.70-1.47 ml O₂.l⁻¹; 13.1-13.2°C (Hendrickx & Wicksten, 1989). The TALUD XIV material was captured in depths of 208-316 m, with epibenthic oxygen concentrations of 0.94-1.54 ml O₂.l⁻¹ and temperature of 11.52-11.70°C (Table 1).

**Remarks**

Hendrickx & Wicksten (1989) reported a large catch of *P. trispinus* (247 specimens; 198 specimens/ha based on the swept area method) in an otter trawl sample off Santa María Bay, in the SE Gulf of California. The largest catch obtained during the TALUD XIV cruise (St. 1, 53 specimens) correspond to a density of 141 specimens/ha. The largest specimen on record is 82 mm of total length (Hendrickx, 1995).

Hendrickx (1990) noted some superficial resemblance between *P. trispinus* and *P. carinirostris*. However, these two species are easy to separate using the following characters: the posteriormost fixed dorsal tooth on the rostrum of *P. trispinus* is clearly in line with or slightly behind the posterior orbital margin, while in *P. carinirostris* this tooth is located anteriorly to the orbital margin; rostral teeth in *P. trispinus* feature a narrow base, while in *P. carinirostris* these teeth are longer, carinated; there is a cluster of two mobile teeth, posterior to the orbital margin in *P. carinirostris*, while there are three such mobile teeth in *P. trispinus*; number of carpal articles in *P. carinirostris* is 23-28, vs. 14-17 in *P. trispinus*. In addition to these characters, close observation of the cornea of both species in lateral view offers another criteria to separate them rapidly. In *P. trispinus*, a very deep, rounded notch is observed at about mid-height of the eye, and this notch is absent in *P. carinirostris* (Fig. 2).

**Discussion**

Five of the eleven species of pandalid shrimps known to occur off the coast of western Mexico were captured during the TALUD XIV survey. *Heterocarpus vicarius* and *P. carinirostris* were both collected in seven of the 30 stations visited during the survey. The third species in abundance, *P. trispinus*, was caught in three samples, while *P. sanctaeclalinae* was found in two samples and *P. affinis* in one sample only. Co-occurrence among the most commonly collected species (*H. vicarius*, *P. carinirostris*, and *P. trispinus*) was low: three times for *H. vicarius* - *P. carinirostris*, and one time each for *H. vicarius* - *P. trispinus* and *P. trispinus* - *P. carinirostris*. Wehrtmann & Echeverria-Sáenz (2007) reported a very high incidence of *P. trispinus* in the *H. vicarius* catches off Costa Rica, where the former species is occasionally extraordinary dominant (up to 91.8% of the catch) and abundant (up to 1,585 kg in a 20-minute haul).

The very high abundance of *H. vicarius* (up to 123 kg, ha⁻¹) observed during the TALUD XIV cruise is not surprising and is comparable to what has been reported off the coast of Costa Rica where Wehrtmann & Echeverria-Sáenz (2007) observed a dominance by weight of *H. vicarius* in the depth range of 250-300 m (maximum sampling depth, 350 m), with maximum catch reaching 135 kg for a 20-minutes haul. The average hauling speed in this
survey was of 2 knots (I. Wehrtmann, pers. com. July 2011) and, assuming a 80% efficiency of the otter trawl used (5.35 m opening; Wehrtmann & Echeverría-Sáenz, 2007), this would correspond roughly to 160 kg.ha⁻¹. Comparatively, preliminary intents to evaluate the density of unexploited, deep-water resources off the coast of Peru (Kameya et al., 1997) indicate that the largest captures of *H. vicarius* in the depth range of 300-500 m (maximum sampling depth, 1,021 m) corresponded to a maximum density of only 0.393 tons.nautical mile⁻² (about 1.2 kg.ha⁻¹). The only previous data available for the Gulf of California is by Hendrickx et al. (1998), who calculated a density of 10.36 kg.ha⁻¹ for a large sample collected off Sinaloa, in the SE Gulf of California.

The second pandalid species in order of abundance, *P. carinirostris* (158 specimens in seven samples), has no previous records of density. Larger specimens are slightly smaller that larger individuals of *H. vicarius* reported to date, and the fact that both species co-occur occasionally might represent an advantage for a potential fishery of this resource.

As stated earlier (supra), the third most abundant species collected during the TALUD XIV cruise, *P. trispinus* (67 specimens in three samples) has proved to be very abundant off the coast of Costa Rica (Wehrtmann & Echeverría-Sáenz, 2007). Much smaller than either *H. vicarius* or *P. carinirostris*, this species has not yet been considered as a target species for fishery. Catches reported for this species in higher (Mexico) and lower (Colombia) latitudes within its distribution range are relatively small. Squires & Barragán (1976) reported a maximum catch of 25 specimens per trawl, in 265-275 m depth, off Colombia. Maximum known density for this species, prior to the abundant captures off Costa Rica, is of 247 specimens (Hendrickx & Wicksten, 1989), corresponding to 198 specimens.ha⁻¹. These values do not match, even remotely, the abundance reported for Costa Rica by Wehrtmann & Echeverría-Sáenz (2007): up to 2,288 kg in one 20-minute haul, corresponding to a hefty 3,558 kg.ha⁻¹.

In the Gulf of California, *Heterocarpus vicarius* occurs above the upper limit of the OMZ, while the only other species of the genus occurring off the coast of Mexico, *H. affinis* Faxon, 1893, has so far been collected exclusively below the lower limit of the OMZ (Hendrickx, 2004; Hendrickx & Serrano, 2010). Both species, however, show a similar degree of tolerance to hypoxic conditions. During the TALUD XIV survey, the shallow species, *H. vicarius*, was found in epibenthic conditions of 0.15-0.54 ml O₂.l⁻¹ on the upper slope. According to Hendrickx (2001 & 2004), *H. affinis*, found on the mid and lower slope, has a similar tolerance to low oxygen concentrations, from 0.13 to 0.87 ml O₂.l⁻¹. These two species can therefore be considered as mirror species as far as their depth distribution and tolerance to hypoxy are concerned. Kameya et al. (1997: Fig. 21) analysed the relationship between *H. vicarius* density and bottom oxygen concentration, noting that the highest catches were clearly obtained in the range of 0.17 and 0.25 ml O₂.l⁻¹ (values estimated from figure). Unfortunately, the Costa Rica survey of Wehrtmann & Echeverría-Sáenz (2007) does not provide oxygen measurements for comparison purpose.

There are no previous data available regarding the tolerance of *Plesionika carinirostris* to low oxygen content. Data gathered during the TALUD XIV survey (0.18-1.45 ml O₂.l⁻¹) indicated a rather wide range of tolerance for this species, although the bulk of the specimens captured were caught at station 8, with an oxygen concentration of 0.50 ml O₂.l⁻¹. In a similar way, previous data related to potential oxygen deficiency tolerance of *P. trispinus* are lacking altogether. In the TALUD XIV survey, this species shows a mild tolerance to hypoxy and was captured in stations with oxygen concentration close to 1.0 ml.l⁻¹ or higher.

Several species of Pandalidae are fully planktonic, from the first larval stage to the adults. Three of the eleven pandalids recorded in the Mexican Pacific, *Plesionika beebei*, *P. sanctaebeatinae*, and *Stylopandalus richardi*, are considered holoplanktonic (see Hendrickx & Estrada-Navarrete, 1996). The situation is more complicated in the case of *Plesionika trispinus*. Hendrickx & Estrada-Navarrete (1996: 135) demonstrated the presence of this species in the pelagic realm (1000 m above bottom), but most data available, including those related with the enormous amounts of specimens reported in bottom trawl off Costa Rica by Wehrtmann & Echeverría-Sáenz (2007), point at a benthonic habitat. Further information is also needed to confirm if juveniles of *H. vicarius* have a pelagic phase as seems to indicate the data provided by Chace (1937). Discrete sampling in the water column is difficult to obtain for micronecton, including pelagic shrimps. They often feature a vigorous swimming capacity and hence easily escape approaching zooplankton nets. Larger sampling devices like multiple opening-closing Isaac-Kidds midwater trawl are needed (see Roe & Shale, 1979), but these equipments are not available in the area.

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References


Faxon W. 1895. Reports on an exploration off the west coast of Mexico, Central and South America and off the Galapagos Islands by the U.S. Fish Commission steamer “Albatross”, during 1891.. XV: The stalk-eyed Crustacea. Memoirs of the Museum of Comparative Zoology Harvard University, 18: 1-922.


Hendrickx M.E. 1990. The stomatopod and decapod crustaceans collected during the GUAYTEC II Cruise in the Central Gulf of California, Mexico, with the description of a new species of Plesionika Bate (Caridea: Pandalidae). Revista de Biología Tropical, 38: 35-53.


Hendrickx M.E. & Estrada Navarrete F.D. 1989. A checklist of the species of pelagic shrimps (Penaeoidea and Caridea) from the eastern Pacific with notes on their geographic and depth distribution. CalCoFi Reports, 30: 104-121.


(Crustacea: Caridea) del Pacífico mexicano, con una clave para su identificación. *Caldasia*, 16: 71-86.


