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Heteropod molluscs (Carinariidae and Pterotracheidae) of the Gulf of Mexico and the western Caribbean Sea

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Resumen. Se analizó la distribución, composición y abundancia de los moluscos heterópodos Carinariidae y Pterotracheidae, a partir del análisis de 160 muestras de zooplancton recolectadas durante cuatro cruceros oceanográficos, realizados en aguas neríticas y oceánicas del sur y sureste del golfo de México y en el mar Caribe de México. Se identificaron cuatro especies, la más abundante fue *Firoloida desmaresti*, seguida por *Pterotrachea hippocampus*, *Cardiapoda placenta* y *P. coronata*. Estos hallazgos representan más de la mitad de las especies reconocidas en todo el golfo de México y el mar Caribe. No se registraron diferencias de composición o abundancia entre los datos de primavera y verano en la regiones nerítica y oceánica del Golfo de México. Los valores de densidad encontrados son relativamente mayores a los datos obtenidos en otras regiones. El hallazgo de *Pterotrachea coronata* en el mar Caribe mexicano representa un nuevo registro geográfico para la fauna de heterópodos de la zona occidental del mar Caribe. Se presenta una clave dicotómica para la identificación de las especies registradas en este estudio. Este es el primer estudio de la fauna oceánica de heterópodos del Atlántico mexicano.

Palabras clave: heterópodos, mar Caribe, zooplancton, marino

Abstract. The distribution, composition, and abundance of carinariid and pterotracheid heteropod molluscs was analyzed from 160 zooplankton samples collected during four cruises carried out in oceanic and neritic areas of the Mexican Caribbean Sea and the southern Gulf of Mexico. Four species were identified, *Firoloida desmaresti* being the most abundant, followed by *Pterotrachea hippocampus*, *Cardiapoda placenta*, and *P. coronata*. These records represent over half the number of species known in the entire Gulf of Mexico and the Caribbean Sea. No differences of abundance or species composition were recorded when spring and summer data were compared in neritic and oceanic waters of the Gulf of Mexico. The overall density of heteropods in the surveyed area is relatively higher than in other regions. The finding of *Pterotrachea coronata* in the Mexican Caribbean Sea represents a new geographic record for the heteropod fauna of

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the western Caribbean Sea. A dichotomic key for the identification of the species recorded in this survey is presented herein. This is the first survey of the Mexican Atlantic oceanic heteropod fauna.

Key words: heteropods, zooplankton, Caribbean Sea, marine.

Introduction

Heteropod molluscs are holoplanktic marine organisms that are distributed mainly in tropical and subtropical regions (Tesch 1949). They include three families: the microscopic Atlantidae, with an external calcareous shell, the Carinariidae, with a reduced shell, and the Pterotracheidae, without a shell (van der Spoel 1976, 1996). Most species of heteropod molluscs dwell in the upper layers of the sea, but some might be collected down to 400-500 m deep (Lalli & Gilmer 1989; van der Spoel 1996). Most heteropods are active predators consuming a wide variety of zooplankters (Lalli & Gilmer 1989). These pelagic gastropods are scarce in the zooplankton samples, and this is particularly true for the gelatinous Carinariidae and Pterotracheidae, which are infrequently captured by plankton nets.

Despite their ecological relevance and their peculiar beauty, only a few studies have been published on their abundance and distribution in the Northwestern Atlantic. These studies include those of Michel & Michel (1991) in the Straits of Florida, Taylor & Berner (1970) in the northern Gulf of Mexico, and González & Princz (1979) in the Venezuelan Caribbean. Michel & Foyo (1976) recorded 8 species of the 3 families in the Caribbean. In the Mexican Caribbean Sea, there is only one previous work, by Gasca (1992) who recorded representatives of the Atlantidae only (*Atlanta lesueuri, Protatlanta souleyeti*) in the Bahía de la Ascensión. The families Carinariidae and Pterotracheidae have not been investigated in the western Caribbean Sea or in the southern Gulf of Mexico.

The composition, distribution, and abundance of the carinariid and pterotracheid heteropod molluscs are analyzed herein based on 160 epipelagic zooplankton samples collected during four oceanographic cruises carried out in the southern Gulf of México, the Yucatan Shelf, and the western Caribbean Sea.

Methods

A total of 160 zooplankton samples were collected during four oceanographic cruises: CIRCAM II, PYZO 194, CARIBE IV, and ARCOMM I. The CIRCAM II cruise, in the southern portion of the Gulf of México, was performed on board the R/V "Justo Sierra", between July 12-23, 1991 (Fig. 1A). Sampling was made by oblique hauls (0-50 m) of a standard plankton net (0.33 mm mesh size and mouth diameter 0.45 m) at 53 stations. The

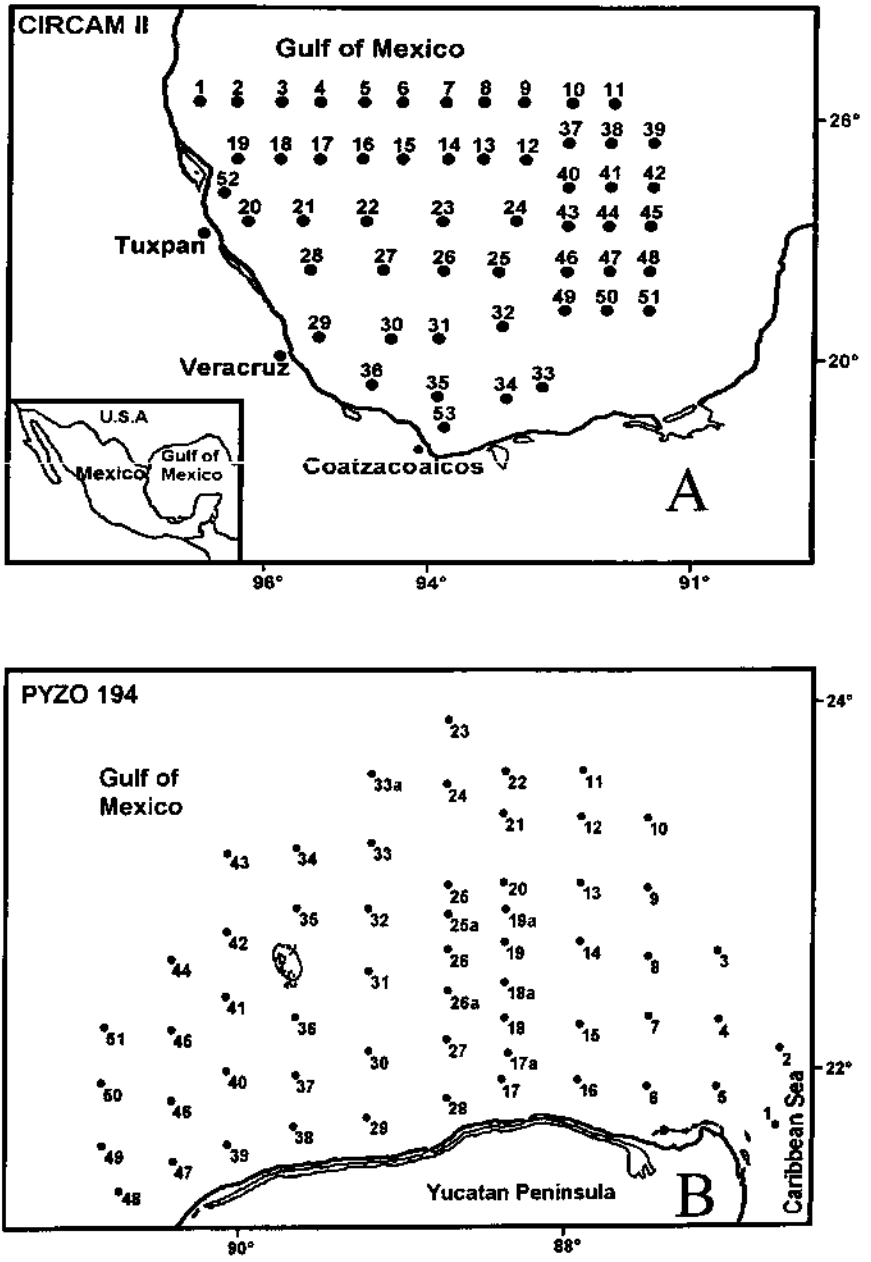

Fig. 1. Surveyed area and location of sampling sites during the oceanographic cruises A) CIRCAM II, and B) PYZO 194 in the southern Gulf of Mexico.

PYZO 194 cruise took place over the Yucatan Shelf, on board the R/V "Aldebarán" from April 20 through 27, 1994; 57 stations were visited (Fig. 1B) and samples were obtained with a 0.33 mm mesh size standard net, by means of oblique hauls (0-100 m). The CARIBE IV cruise was carried out on board a surveillance ship of the Mexican Secretaría de Marina, between August 6 and 9, 1991; 22 stations were visited (Fig. 2A), samples were obtained in the surface layer (0-5 m) using a squared-mouth (0.45 m per side) plankton net (0.33 mm mesh size). The ARCOMM I cruise included 28 sampling sites distributed in the Mexican Caribbean, and was conducted by the Instituto de Ciencias del Mar y Limnología of the UNAM from August 9 to 20, 1986 on board the R/V "Justo Sierra" (Fig. 2B); a Bongo net (0.33 mm mesh, mouth diameter 0.6 m) was used in this survey and sampling was made by oblique hauls (0-200 m). We analyzed the entire, original zooplankton samples of the CIRCAM II, PYZO 194, and CARIBE IV cruises. We had access only to 25% aliquots of the ARCOMM I samples. A flowmeter was used in all cases in order to estimate the amount of water filtered by the nets. Density was standarized to org./1000 m^3.

Zooplankton samples were fixed and preserved in a 4% formalin solution buffered with sodium borate. Identification of carinariid and pterotracheid heteropods was performed with the aid of the keys, descriptions and illustrations published by Van der Spoel (1972, 1976, 1996). Beforehand, we considered that records of *Pterotrachea minuta* are not valid (Seapy 2000). A total of 30 specimens of Heteropoda were collected and identified in the different oceanographic cruises. Representative specimens were deposited in the Zooplankton Collection of El Colegio de la Frontera Sur (ECO-CHZ), in Chetumal, Mexico.

Results

Four species of heteropod molluscs belonging to the families Carinariidae (*Cardiapoda placenta* (Lesson 1830)) and Pterotracheidae (*Pterotrachea hippocampus* Philippi 1836, *Pterotrachea coronata* Niebur 1775, and *Firoloida desmaresti* Lesueur 1817) were identified. In Table 1 we present the collection data and the catalog number of the specimens deposited in the zooplankton collection held at ECOSUR in Chetumal. Two specimens of *Pterotrachea hippocampus* were recorded in the southern Gulf of Mexico during night samplings (CIRCAM II cruise, sta. 15, 31). Its density was 17 org./1000 m^3 at each of these sites. Body lengths were 35 and 39.3 mm. A single specimen of *Pterotrachea coronata* was recorded in the Caribbean area, during daytime, from the ARCOMM I cruise (sta. 17), with a density of 5 org./1000 m^3. The specimen was not measured because it was badly damaged.

Firoloida desmaresti was the only relatively abundant species captured (Table 1). During the CARIBE IV cruise it was recorded at two sampling sites (sta. 7 and 15), with densities of 41 and 36 org./1000 m^3; respectively. During the PYZO 194 cruise, it occurred at 4 stations (sta. 12, 23, 25a, 27); this species showed a mean density of 22 org./1000 m^3, ranging from 18 to 53 org./1000 m^3. It was even more frequent, thus

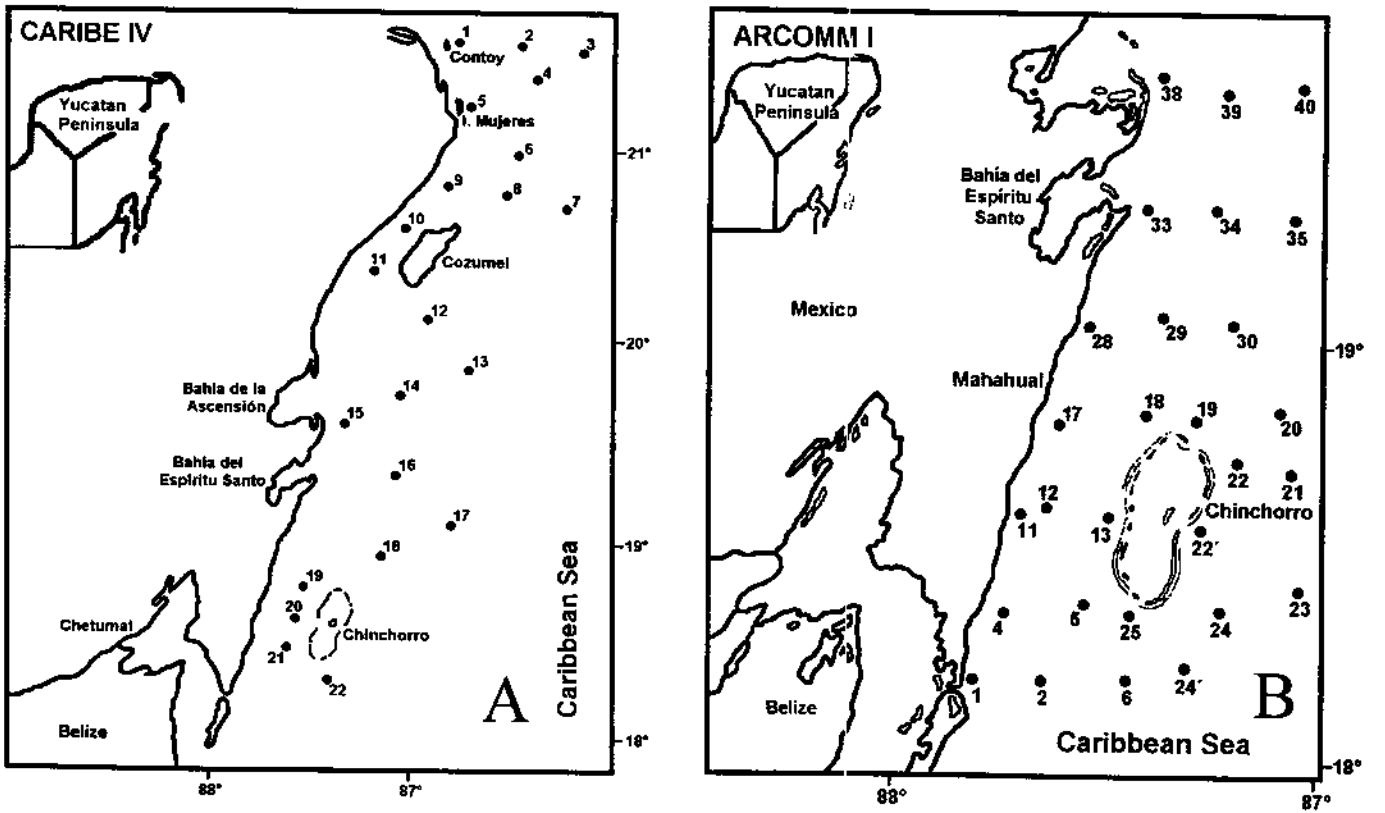

Fig. 2. Surveyed area and location of sampling sites during the oceanographic cruises A) CARIBE IV, and B) ARCOMM I in the western Caribbean Sea.

Table 1. Material examined from the oceanographic cruises in the Gulf of Mexico and Mexican Caribbean Sea

Species	Cruise	Date	No. of org.	Station	Latitude	Longitude	Depth	Catalog number
Pterotrachea hippocampus	CIRCAM II	18-07-91	1	15	21° 45	95° 00′	50 m	
		22-07-91	1	31	19° 35′	94° 30′	50 m	ECO-CH-Z-00501
Firoloida desmaresti	CIRCAM II	12-07-91	1	1	22° 25′	97° 30′	50 m	
		14-07-91	1	7	22° 25′	94° 30′	50 m	
		14-07-91	1	8	22° 25′	94° 00′	50 m	
		21-07-91	1	29	19° 35′	96° 00′	50 m	
		15-07-91	1	37	22° 00′	93° 30′	50 m	
		20-07-91	1	44	21° 00′	92° 30′	50 m	
	PYZO 194	25-04-94	1	12	23° 25.9′	87° 52′	95 m	ECO-CH-Z-00499
		24-04-94	2	23	23° 28′	88° 45′	100 m	
		24-04-94	1	25a	22° 46.4	88° 45.9′	50 m	
		24-04-94	1	27	22° 09′	88° 45′	35 m	
	CARIBE IV	09-08-91	9	7	20° 41′	86° 16′	Surface	
		07-08-91	5	15	19° 35′	87° 21′	Surface	
Cardiapoda placenta	PYZO 194	23-04-94	1	32	23° 15′	89° 11′	75 m	ECO-CH-Z-00502
	ARCOMM I	13-08-86	1	20	18° 49.9′	87° 07′	203 m	
Pterotrachea coronata	ARCOMM I	14-08-86	1	17	18° 48′	87° 38′	210 m	ECO-CH-Z-00500

occurring in a higher number of sites, during the CIRCAM II cruise, collected at 6 stations (sta. 1, 7, 8, 29, 37, 44); however, it showed lower density values (13-24 org./1000 m^3). This species was absent in the ARCOMM I cruise. In the CARIBE IV material, collected in Caribbean waters, the length of this species (9.1-18.3 mm), was similar to the figure recorded for the specimens from the oceanic Gulf of Mexico (CIRCAM II, 3.6-23.4 mm). However, the Caribbean specimens tended to be smaller than those of the PYZO194 cruise (14.5-49 mm), all collected in neritic waters of the Gulf. This species was collected during both daytime and night samples.

Cardiapoda placenta was recorded at two stations only (ARCOMM I, sta. 20 and PYZO 194, sta. 32), with a low abundance (4 and 13 org./1000 m^3). Body length 7.6 and 11.5 mm, respectively.

Discussion

The families Pterotracheidae and Carinariidae include 13 recognized species in the South Atlantic (Richter & Seapy 1999) and only 8 are know in the Northwestern Atlantic (van der Spoel 1976). Three of the species recorded in the Gulf of Mexico and the Mexican Caribbean Sea during this survey are epipelagic forms and one is mesopelagic (*P. coronata*). All the species recorded herein are known from tropical and subtropical waters of the Atlantic Ocean (Owre 1964; Raymont 1983; van der Spoel 1996; Richter & Seapy, 1999). Furthermore, these four species have been recorded in the northern Gulf of Mexico (Taylor & Berner 1970), in the Florida Straits area (Michel & Michel 1991), and in the Caribbean Sea, including the coasts of Panamá, Venezuela, and Cuba (Michel & Foyo 1976). In the Venezuelan Caribbean, González & Princz (1979) recorded *Cardiapoda placenta* (see Fig. 3).

In the Gulf of Mexico and the Caribbean Sea, only 6 species of carinariid and pterotracheid heteropod molluscs have been recorded: *Pterotrachea hippocampus, P. scutata, P. coronata, Firoloida desmaresti, Cardiapoda placenta,* and *Carinaria lamarcki* (van der Spoel 1996). Our results show that the representativity of the analyzed samples is relatively high, we recorded 4 out of the 6 species known in the region.

Pafort-van Iersel (1983) indicated that some heteropods show a certain degree of seasonality and tend to be more abundant during the summer. We found no seasonal changes of our species composition in the Gulf of Mexico. According to Van de Spoel (1996), it is during the summer when largest specimens tend to occur and they show a higher abundance by the end of the year due to the larger size of their preys. Two out of the present four cruises were performed during the summer time. Our results revealed no increase in the heteropod summer abundance or size when compared with other seasons surveyed. Furthermore, the measurements of the specimens of *F. desmaresti, C. placenta,* and *P. hippocampus* collected during this survey are well within the range published in others works (see Table 2).

The low heteropod overall densities recorded in the Gulf of Mexico (13-57 org./1000 m^3) and the Mexican Caribbean Sea (4-41 org./1000 m^3) are higher than the

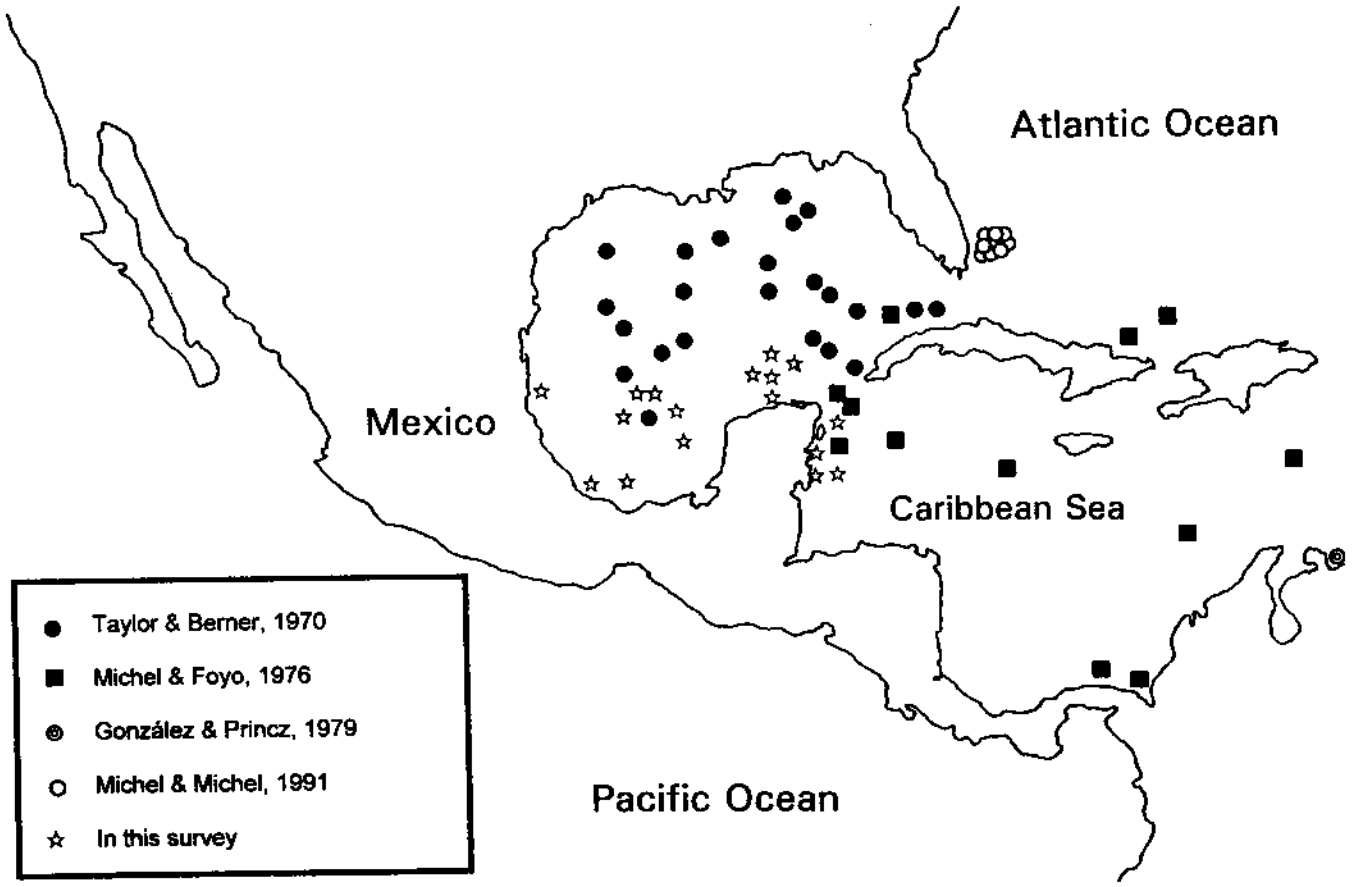

Fig. 3. Distribution of general records of pterotracheid and carinariid heteropod molluscs in the Gulf of Mexico and the Caribbean Sea.

Table. 2. Lengths (mm) of heteropod species recorded in the Gulf of Mexico and Mexican Caribbean Sea compared with records of other authors. Van der Spoel's data are only the maximal sizes.

Species	In this survey	Seapy (1990b)	Tesch (1949)	van der Spoel (1976)
Firoloida desmaresti	9.1 - 49	4 - 24	—	to 40
Cardiapoda placenta	7.6 - 11.5	—	—	to 50
Pterotrachea hippocampus	35 - 39.3	14 - 39	20 - 80	to 80

* The specimen of *P. coronata* was not measured because it was badly damaged

density range reported by Pafort-van Iersel (1983) for heteropods of the mid-North Atlantic (0.02-2 org./1000 m^3). In the California Current the heteropod *Carinaria japonica* Okutani 1955 occurred at densities of 1-10 org./1000 m^3 (Seapy 1974) and Seapy (1990a) recorded a maximum density (38 org./1000 m^3) of the atlantiid heteropod *Atlanta lesueuri* from Hawaiian waters. Heteropod densities are never high (Seapy 1974, 1990c; Richter & Seapy 1999), and in the epipelagic zone off Hawaii most are collected within the 0-140 m layer (Seapy 1990b). The low numbers of specimens captured by plankton nets could be related to the visual and swimming capabilities of these molluscs, allowing them to evade the plankton net (Seapy 1990b). Our results in the Gulf of Mexico and the Caribbean Sea seem to support these statements. Low densities are also because all these species are predatory forms, therefore less abundant than other zooplankton groups (Lalli & Gilmer 1989). It is recommended to perform replicate tows in order to estimate more accurately the real number of heteropods in the pelagic environment (Seapy 1990c).

Firoloida desmaresti, the most abundant species in this survey, was also recorded as the most abundant heteropod in the 1-100 m layer in the Caribbean Sea (Michel & Foyo 1976) and in the oceanic waters of the Gulf of Mexico (Taylor & Berner 1970). Conversely, Pafort-van Iersel (1983) reported low numbers of *F. desmaresti* in the North Atlantic and Michel & Michel (1991) did not found it in the Florida Straits area. Local high densities of this species seem to be related to reproductive aggregation (Pafort-van Iersel 1983). The temperature and salinity range in which it was collected (21.6-27.4°C, 36.27-36.64 PSU) in the surveyed area is within the previously reported hydrographic range (8.7- 21°C, 36-37.3 PSU) known for this species (Van der Spoel 1996).

Pterotrachea hippocampus and *P. coronata* are regarded as the second and third most abundant gelatinous heteropods in the northern Gulf of Mexico, respectively (Taylor & Berner 1970). Michel & Michel (1991) collected most individuals within the 50-100 m layer. In the Caribbean Sea, Michel & Foyo (1976) recorded one specimen of *P. coronata* only, in the surface layer. In the surveyed area, this species was found in the neritic zone, which agrees with van der Spoel (1996) who considered it a species with neritic affinities. This is the first record of *P. coronata* in the western Caribbean Sea.

Cardiapoda placenta was recorded by Michel & Foyo (1976) and by González & Princz (1979) in the Caribbean Sea; in both cases only a single specimen was collected. Taylor & Berner (1970) recorded only three specimens in the Gulf of Mexico. Michel & Michel (1991) reported very low densities of this species in the Florida area (1-3 org./10000 m^3). In this survey their densities were also relatively low, they fluctuated between 4 (1 spec.) (ARCOMM I) to 13 org./1000 m^3 (PYZO 194) (1 spec.).

Key for the identification of the species of Carinariidae and Pterotracheidae recorded in the Gulf of Mexico and the Mexican Caribbean Sea

1a. Swimming fin located at approximately midlength between head region and visceral mass. Tail without terminal star-like process, eyes cylindrical or triangular, inserted in a retinal base ..... Pterotracheidae 2

1b. Swimming fin located at the same level or very near the visceral mass. Tail with terminal star-like process, numerous gills, eyes triangular, not inserted in a retinal base..... *Cardiapoda* ..... ***C. placenta***

2a. With tentacles located in the region anterior to the eyes in males only. Tail short and followed either by a filamentous extension in males or a permanent egg string in females ..... ***Firoloida desmaresti***

2b. Without tentacles before the eyes, tail well defined in both males and females, without egg strings or filamentous extensions ..... ***Pterotrachea*** 3

3a. Eyes broadly triangular, as long as the retinal diameter; in juveniles eyes are narrowly triangular. The shape of the visceral nucleus is short and wide (length less than four times width) ..... ***Pterotrachea hippocampus***

3b. Eyes cylindrical, longer than retinal diameter, eye length is about twice the retinal width. The shape of the visceral nucleus is long and narrow (length over four times width) ..... ***Pterotrachea coronata***

An accurate impression of the appearance of these animals and of their structure is best given by live photographs, such as those in Lalli & Gilmer's (1989) book and in Richter & Seapy (1999) paper and also by the fine line drawings in van der Spoel (1976, 1996) papers.

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