Revista Mexicana de Biodiversidad

Revista Mexicana de Biodiversidad 94 (2023): e944975

Taxonomy and systematics

Biodiversity and new records of benthic amphipods (Crustacea: Peracarida: Amphipoda) from coral reef protected natural areas in the Mexican Caribbean Sea

Biodiversidad y registros nuevos de los anfípodos bentónicos (Crustacea: Peracarida: Amphipoda) en áreas naturales protegidas de arrecifes de coral en el mar Caribe mexicano

Ignacio Winfield*, Manuel Ortiz, Sergio Cházaro-Olvera

Universidad Nacional Autónoma de México, Facultad de Estudios Superiores Iztacala, Laboratorio de Crustáceos, Avenida de los Barrios Núm. 1, Los Reyes Iztacala, 54090 Tlalnepantla, Estado de México, Mexico

*Corresponding author: ignacioc@unam.mx (I. Winfield)

Received: 13 February 2022; accepted: 13 January 2023

Abstract

The Mexican Caribbean Sea is the longest section of the Mesoamerican Caribbean Sea, with 16 protected marine areas. During 2015 and 2016, 2 sampling campaigns in the Puerto Morelos Coral Reef National Park and the Sian Ka'an Biosphere Reserve, Quintana Roo, Mexico, were carried out to determine the biodiversity of benthic amphipods. In addition, the previously documented amphipod data were included to summarize the first checklist of such amphipods along the Mexican Caribbean Sea. The present study found 35 families, 70 genera, and 121 species, of which 41 species had not been previously reported in the Mexican Caribbean Sea, and 5 species represented new records of amphipods from the Caribbean Sea. According to the information summarized in this amphipod's inventory, both the coral reefs Puerto Morelos and Sian Ka'an, located in the north and central Mexican Caribbean Sea, represented the protected natural areas with the largest amounts of benthic amphipod species thus far.

Keywords: Checklist; Invertebrates; Quintana Roo; Malacostraca; Taxonomy

Resumen

El Caribe mexicano es la sección más extensa del mar Caribe mesoamericano con 16 áreas marinas protegidas. Durante 2015 y 2016, fueron realizadas 2 campañas de muestreo en el Parque Nacional Arrecife Puerto Morelos y la Reserva de la Biosfera Arrecife de Sian Ka'an, para determinar la biodiversidad de los anfípodos bentónicos. Además, las especies documentados previamente en éstos fueron incluidos para completar el primer listado de especies a lo largo del Caribe mexicano. El presente estudio incluye 35 familias, 70 géneros y 121 especies, dentro de las cuales, 41

ISSN versión electrónica: 2007-8706; Universidad Nacional Autónoma de México, Instituto de Biología. https://doi.org/10.22201/ib.20078706e.2023.94.4975

no habían sido registradas en esta área y 5 correspondieron a registros nuevos de anfípodos. A la fecha y de acuerdo con la información sintetizada en este listado de especies, tanto el área natural arrecife Puerto Morelos y el arrecife de Sian Ka'an, localizados en la zonas norte y central del mar Caribe mexicano, son las 2 áreas naturales protegidas con la mayor cantidad de especies de anfípodos bentónicos.

Palabras clave: Listado; Invertebrados; Quintana Roo; Malacostraca; Taxonomía

Introduction

The Mesoamerican Caribbean Reef System (MCRS) is regarded as the second-largest reef system after Australia's Great Barrier Reef and is one of 200 global priority ecoregions worldwide (Contreras-Silva et al., 2020). This huge ecosystem extends almost 1,600 km along the coastline of Mexico, Belize, Guatemala, and Honduras in the northwest sector of the Caribbean Sea and is comprised mainly of coral reefs along with mangroves, seagrass beds, and lagoon-inlet systems. The longest sector of this system is known as the Mexican Caribbean Sea (MEXCS), which is not only defined as a hotspot of endemic species, where numerous species can inhabit for feeding, nesting, and protection, but also has been impacted by coastal development, tourism, fishing (Perera-Valderrama et al., 2020), pollution, and invasive sargasso (Rodríguez-Martínez et al., 2020). Therefore, during the last 4 decades, the coastline ecosystems have been damaged by intensive urban and touristic expansion that has modified the structure, composition, and abundance of both benthic and pelagic communities.

As a result of natural ecological connectivity, knowledge of biodiversity in the MEXCS is required to design conservation, protection, and multidisciplinary management programs from those marine protected areas. So far, numerous organisms belonging to macroalgae, seagrass, mangroves, invertebrates, and chordates have been analyzed, either through species richness or abundance-distribution in this region (Ardisson et al., 2011; Contreras-Silva et al., 2020; Rioja-Nieto et al., 2019). In the case of peracarid crustaceans, which includes isopods, amphipods, tanaids, and 6 other orders, the taxonomic and ecological information is fragmentary throughout the MEXCS.

The order Amphipoda is comprised of almost 10,200 nominal species grouped in 6 suborders (Lowry & Myers, 2017; Horton et al., 2021). These peracarid crustaceans are associated with hard and soft bottoms, inhabiting areas from the coastline to the abyssal plain. Because of their abundance and wide-ranging geographic distribution, such benthic amphipods are involved in the trophic dynamics of marine communities as grazers, filter feeders, predators, scavengers, and prey (LeCroy et al., 2009). In coral reef ecosystems, amphipods are associated with sediments, coral rubble, seagrass beds, macroalgae mats, and sessile invertebrates such as corals, sponges, bryozoans, echinoderms, and tunicates, among others (Thomas, 1993a).

Due to their ecological importance, numerical abundance, and sensitivity to a variety of toxins and pollutants, amphipod crustaceans are recognized as bioindicators in a broad variety of ecosystems, particularly in the tropics (Thomas, 1993b). Nevertheless, their incorporation into bioassessment programs on coral reefs and coastlines depends on taxonomic studies and inventories being completed (Monroy-Velazquez et al., 2017).

During 2015 and 2016, 2 benthic sampling campaigns in the Coral Reef Puerto Morelos National Park (APM) and the Coral Reef Sian Ka'an Biosphere Reserve (SKAR), Quintana Roo, Mexico, were carried out to determine the biodiversity of benthic amphipods inhabiting several ecosystems and hard-soft bottoms. Also, the previously documented data on these peracarids from Contoy Island to the Xcalak Coral Reef were included in this paper. Therefore, the present study constitutes the first checklist of benthic amphipods along the MEXCS, including new records of benthic amphipod species in the Caribbean Sea, and provides a baseline of the existing marine amphipod biodiversity.

Materials and methods

The MEXCS is located in the northwest Caribbean Sea, along the coastline of the Quintana Roo State, Mexico, spreading from Contoy Island on the northern side to Xcalak Coral Reef to the south (Fig. 1). It includes 16 protected marine areas (PMAs), which have been characterized as flora and fauna protection areas, national parks, biosphere reserves, and one sanctuary (Rioja-Nieto et al., 2019). According to Contreras-Silva et al. (2020), this Mexican sector of the Caribbean Sea is divided into 5 main regions, Northern, Center, Southern, Cozumel, and Banco Chinchorro. The PMA belongs to the Northern region, with a total area of 9,067 ha, 21 km in length,

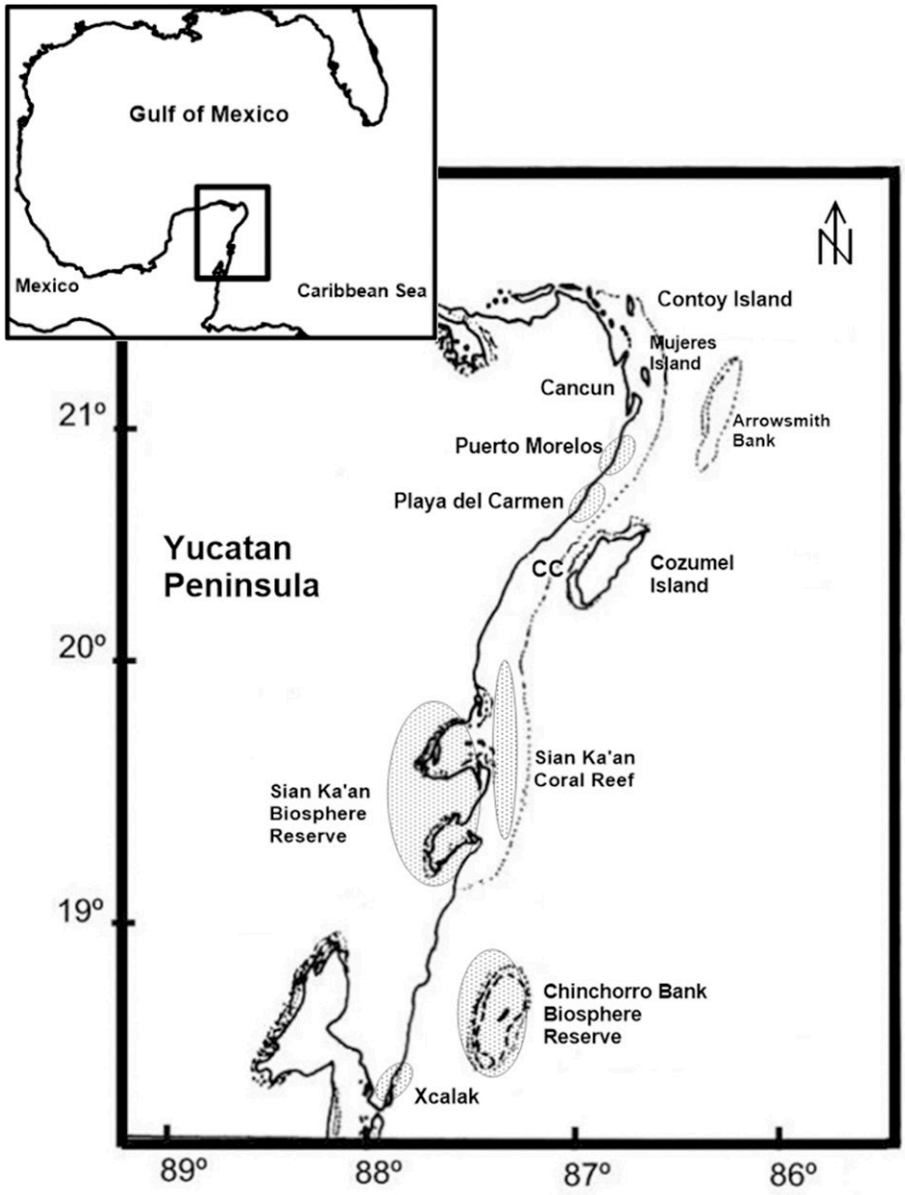

Figure 1. Map showing the Protect Marine Areas throughout the Mexican Caribbean Sea (shadow ellipses); CC, Cozumel Channel.

and 4.5 km seaward in addition to several well-preserved reef sites and extensive areas of seagrass beds (Monroy-Velázquez et al., 2017; Perera-Valderrama et al., 2020). Moreover, the Center region comprises both the Sian Ka'an Biosphere Reserve and the SKAR, which has a total marine area of 33,566 ha, 110 km length, and a maximum coral growth depth of 25 m.

The information that the present study compiled on benthic amphipods arises essentially from the analysis of samples collected from macroalgae mats, seagrass beds, sponges, cnidarians, coral rubble, soft bottom, and wood debris from the APM and the SKAR during July 2015 and June 2016 (DGOPA.01024.110213.0236 and PPF/DGOPA-051/15 permits granted) as part of the "Macrocrustáceos asociados a los arrecifes de coral" project, which was supported by the Universidad Nacional Autónoma de México-DGAPA-PAPIIT. Such substrates were removed from 14 sample sites in both coral reefs by SCUBA diving between 0.5 and 25 m depth. The crustaceans associated with these substrates were separated, put into plastic bags, and preserved with 70% ethanol. Amphipods were divided from each crustacean sample and

transported to the Facultad de Estudios Superiores Iztacala (FESI-UNAM). These specimens were examined and dissected using a stereoscopic microscope Motic SMZ-168 and optical microscope Leica DM750, both with camera lucida, at the Laboratorio de Crustáceos.

The taxonomic analysis was essentially based on Barnard and Karaman (1991), LeCroy (2000, 2002, 2004, 2007), Lowry and Stoddart (1997), Ortiz et al. (2014), and Thomas and Klebba (2007). The classification system of Lowry and Myers (2017) was adopted for this study. The specimens collected were deposited in the Colección Nacional de Crustáceos (CNCR), Instituto de Biología, (UNAM-México).

For the whole amphipod assemblage identified from both the APM and SKAR, specific amphipod richness and the total and relative abundances of each species were quantified, either for family, substrate, or site; additional information for each novel species recognized as a new record with geographic extension in the MEXCS, such as material examined, date, spatial distribution, depth, and substrate type, were provided. Also, new records of amphipods from the Caribbean Sea were documented to elucidate information regarding novel species, material examined, geo-referenced coordinates, the main morphological features, and previous geographic distribution where each species had been documented.

Finally, in addition to the amphipod species collected from the AMP and SKAR, we present previous amphipod records to summarize the benthic amphipods checklist which we compiled using published references from the MEXCS and verified according to the comprehensive taxonomic list for the ecoregions of the Caribbean Sea published by Ortiz et al. (2007) and Martin et al. (2013). Every suborder, family, genus, and species are presented in an alphabetical rather than phyletic order, and the references where every species was reported along the MEXCS are included in the checklist.

Results

The present study documented a total of 120 nominate species grouped into 70 genera and 34 families, belonging to Amphilochidea (14 families), Colomastigidea (1 family), and Senticaudata (19 families) suborders. The most diversified amphipod families in this large sector of the Caribbean Sea were (in decreasing order): Maeridae, Aoridae, Leucothoidae, Ampeliscidae, Ampithoidae, Amphilochidae, Melitidae, Lysianassidae, and Pontogeneiidae. Also, and as a result of the 2 oceanographic campaigns carried out in APM and SKAR, Quintana Roo, not only 82 benthic amphipod species were identified, out of which 41 species had not been previously recognized along the MEXCS, but also 5 species represented new amphipod records from the Caribbean Sea.

New records of amphipods from the Caribbean Sea

Shoemakerella lowryi Gable & Lazo-Wasem, 1990. Material examined: APM; 20°50’28.57” N, 86°52’25.45” W; 12 m depth; 6-VI-2015; 8 specimens, M. Lozano-Aburto and I. Winfield, colls.; I. Winfield and M. Ortiz det., CNCR36044. This species can be recognized by the dorsal process on the peduncle of uropod 3, the proportion between basis and ischium of gnathopod 2, and the shape of basis of pereopod 7. Also, *S. lowryi* differs from *S. cubensis* in the relative lengths of propodus of peraeopod 7 (length 9.5 x width vs. length 5-6 x width in *S. cubensis*). This shallow species had been only documented in Bermuda (Gable & Lazo-Wasem, 1990; WoRMS, 2021), the occurrence of this species in APM associated with coral rubble, represents the first new record from the Caribbean Sea.

Stenothoe minuta Holmes, 1905. Material examined: SKAR; 20°04’09.30” N, 87°28’09.30” W; 13 m depth; 19-VI-2016; 2 specimens, M. Lozano-Aburto and I. Winfield, colls., I. Winfield and M. Ortiz det., CNCR36050. This stenothoid species is identified by outer ramus of uropod 2 shorter than inner ramus, gnathopod 1 propodus posterior margin straight and shorter than palmar margin, gnathopod 2 palmar angle weakly angled-unrounded, without spinose lobe, peraeopod 7 basis broad with posterior margin convex, uropod 3 peduncle longer than article 1 of ramus. This shallow species had been only documented in several shoreline ecosystems along the Gulf of Mexico, from northeast Florida to the southwest of the Gulf of Mexico (LeCroy et al., 2009). The presence of *S. minuta* in macroalgae mats in SKAR is the second new record from the Caribbean Sea.

Bemlos tigrinus (A.A. Myers, 1979). Material examined: APM; 20°52’06.9” N, 86°50’51.6” W; 10 m depth; 6-VI-2015; 5 specimens, M. Lozano-Aburto and I. Winfield, colls., I. Winfield and M. Ortiz det., CNCR36068. This species can be distinguished by peraeon segments 2-4 with mid-ventral sternal process, third the largest, pigmentation pattern on body composed of dorsal dark bands combined along the body, gnathopod 2 merus and carpus setose on anterior margin, peraeopods 5-6 basis with margin short simple setae. This shallow species had been recorded from West Florida Bay, NW Gulf of Mexico (LeCroy et al., 2009), a consequence of such species, which was collected from APM in *T. testudinum*, is a new record for the Caribbean Sea.

Protohyale (*Protohyale*) *frequens* Bousfield & Hendrycks, 2002. Material examined: APM; 20°52’23.43”

N, 86°51'9.95" W; 10 m depth; 9-VI-2015; 140 specimens, M. Lozano-Aburto and I. Winfield, colls., I. Winfield and M. Ortiz det., CNCR36082; SKAR; 20°00′40.07″ N, 87°28′07.41″ W; 3 m depth; 18-VI-2016; 5 specimens, M. Lozano-Aburto and I. Winfield, colls., I. Winfield and M. Ortiz det., CNCR36083. This species can be distinguished by the antenna 2 flagellum long, gnathopod 1 propodus elongate and subrectangular, gnathopod 2 propodus with anterior margin lacking robust setae, uropod 1 peduncular distolateral spine short, uropod 3 ramus slightly shorter than peduncle. This shallow species had only been recorded from coastline habitats, NE Gulf of Mexico (LeCroy, 2000), therefore, the finding of this species in APM, and SKAR, in wood debris, wood dock, and macroalgae mats, represents a new record from the Caribbean Sea.

Melita elongata Sheridan, 1980. Material examined: SKAR; 20°00'40.07" N, 87°28'07.41" W; 4 m depth; 18-VI-2016; 2 specimens, M. Lozano-Aburto and I. Winfield, colls., I. Winfield and M. Ortiz det., CNCR36104. This species can be distinguished by gnathopod 1 parachelate, gnathopod 2 oval, female with anterior lobe of coxa 6 with a large hook backward, telson without robust dorsal setae. According to LeCroy et al. (2009), it is distributed along the coastline of the Gulf of Mexico, from W Florida to Términos Lagoon. This species was found in coral rubble and soft bottoms in SKAR, consequently, it is a new record from the Caribbean Sea.

Benthic amphipods from coral reefs APM and SKAR

All amphipod species collected from both coral reefs' protected areas were organized into 2 suborders, 27 families, 44 genera, and 82 nominal species. Particularly, APM included 58 species with 2,469 specimens, and 53 species with 1,319 organisms in SKAR, out of which 27 amphipod species were distributed in both protected areas, also Maeridae, Aoridae, and Leucothoidae were the most specious families (Table 1). On the other hand, 80% of the total abundance were accumulated for Chevaliidae (19%), Maeridae (16%), Ampithoidae (15%), Leucothoidae (14%), Pontogeneiidae (9%), and Ischyroceridae (8%) from APM, and Maeridae (33%), Ampithoidae (17%), Chevalidae (14%), Photidae (12%), and Aoridae (9%), in SKAR (Table 1).

The dominant species of benthic amphipod in AMP, which represented almost 75% of abundance, were *Chevalia mexicana*, *Leucothoe saron*, *Ampithoe longimana*, *A. marcuzzii*, *Ericthonius brasiliensis*, *Nasageneia yucatanensis*, *Elasmopus balkomanus*, *E. pocillimanus*, and *Protohyale frequens*; whereas in SKAR, *Quadrimaera miranda*, *Q. quadrimana*, *C. mexicana*, *Latigammaropsis atlantica*, *Elasmopus rapax*, *A. longimana*, *Leucothoe barana*, *L. kensleyi*, *L. ashleyae*, *L. garifunae*, *Concarnes concavus*, *and Hourstonius laguna*, which accumulated 80% of such relative abundance.

The abundance and biodiversity of the whole amphipod assemblage in AMP were predominantly associated with macroalgae mats and coral rubble, each one with 41%, reducing in sponges (13%), octocoral (12%), seagrass beds (3%), and soft bottoms (> 1%). In contrast, the substrate prevalence in SAKR included the macroalgae mats with 75%, and 25% was distributed among coral rubble, octocoral, soft bottoms, seagrass beds, and sponges.

Table 1

Families, species, and total abundance of each benthic amphipods. AMP, coral reef Puerto Morelos; SKAR, coral reef Sian Ka'an. Suborders and voucher numbers (CNCR) were included.

Suborder/Family	Species	CNCR	APM	SKAR
Amphilochidea				
Ampeliscidae	*Ampelisca bicarinata* Goeke & Heard, 1983	36010	4	
	Ampelisca burkei J.L. Barnard & Thomas, 1989	36011 36012	12	3
	Ampelisca schellenbergi Shoemaker, 1933	36013		4
Amphilochidae	*Apolochus casahoya* (Mckinney, 1978)	36014	2	
	Apolochus delacaya (Mckinney, 1978)	36015	4	
	Apolochus pillaii (Barnard & Thomas, 1983)	36016	6	
	Gitana dominica Thomas and Barnard, 1990	36017 36018	2	3
	Hourstonius laguna (McKinney, 1978)	36019 36020	3	4

Table 1. Continued

Suborder/Family	Species	CNCR	APM	SKAR
	Hourstonius tortugae (Shoemaker, 1942)	36021	29	
Bateidae	*Batea campi* (Ortiz, 1991)	36022	12	
	Batea carinata (Shoemaker, 1926)	36023 36024	4	2
	Batea catharinensis Muller, 1865	36025	15	
Cyproideidae	*Hoplopheonoides obesa* Shoemaker, 1956	36026	3	
Leucothoidae	*Anamixis cavatura* Thomas, 1997	36027		2
	Anamixis hanseni Sttebing, 1897	36028		2
	Leucothoe ashleyae Thomas & klebba, 2006	36029 36030	59	5
	Leucothoe barana Thomas & Klebba, 2007	36031 36032	30	17
	Leucothoe garifunae Thomas & Klebba, 2007	36033 36034	8	3
	Leucothoe kensleyi Thomas & Klebba, 2005	36035 36036	4	6
	Leucothoe laurensi Thomas & Ortiz, 1995	36037		3
	Leucothoe saron Thomas & Klebba, 2007	36038	244	
	Leucothoe spinicarpa (Abildgaard, 1789)	36039		15
	Leucothoe ubouhu Thomas & Klebba, 2007	36040		2
Liljeborgiidae	*Liljeborgia bousfieldi* McKinney, 1979	36041	3	
Lysianassidae	*Concarnes concavus* Shoemaker, 1933	36042		10
	Lysianopsis alba (Holmes, 1905)	36043		2
	Shoemakerella lowryi Gable & Lazo-Wasem, 1990	36044	8	
	Tantena zlatarskii Ortiz, Lalana & Varela, 2007	36045		2
Oedicerotidae	*Westwoodilla longimana* Shoemaker, 1934	36046		2
Phoxocephalidae	*Eobrolgus spinosus* (Holmes, 1905)	36047	3	
	Metharpinia floridana (Shoemaker, 1933)	36048	5	
Stenothoidae	*Stenothoe gallensis* Walker, 1904	36049	3	
	Stenothoe minuta Holmes, 1905	36050		2
	Stenothoe valida Dana, 1852	36051		2
Synopiidae	*Synopia ultramarina* Dana, 1853	36052		2
Senticaudata				
Ampithoidae	*Ampithoe longimana* Smith, 1873	36053 36054	225	122
	Ampithoe marcuzzii Ruffo, 1954	36055	125	
	Ampithoe ramondi Audouin, 1826	36056 36057	17	3
	Ampithoe valida Smith, 1873	36058	10	
	Pseudamphithoides bacescui Ortiz, 1976	36059		102
Aoridae	*Bemlos dentischium* (A.A. Myers, 1977)	36060		18

Table 1. Continued

Suborder/Family	Species	CNCR	APM	SKAR
	Bemlos inermis Myers, 1979	36061 36062	2	6
	Bemlos kunkelae (A.A. Myers, 1977)	36120		4
	Bemlos longicornis (A.A. Myers, 1989)	36063	18	
	Bemlos mackinneyi (A.A. Myers, 1978)	36064		2
	Bemlos spinicarpus (Pearse, 1912)	36065 36066	11	6
	Bemlos tigrinus (A.A. Myers, 1979)	36067	5	
	Bemlos unicornis (Bynum & Fox, 1977)	36068 36069	11	4
	Globosolembos smithi (Holmes, 1905)	36070		4
	Lembos unifasciatus Myers, 1977	36071 36072	14	63
	Plesiolembos rectangulatus (A.A. Myers, 1977)	36073 36074	4	6
Chevaliidae	*Chevalia carpenteri* Barnard & Thomas, 1987	36075		2
	Chevalia mexicana Pearse, 1913	36076 36077	477	188
Hadziidae	*Dulzura schoenerae* (Fox, 1973)	36078	3	
Hyalidae	*Apohyale media* (Dana, 1853)	36079		5
	Parhyale hawaiensis (Dana, 1853)	36080		4
	Protohyale (Protohyale) frequens Bousfield & Hendrycks, 2002	36081 36082	140	5
Ischyroceridae	*Ericthonius brasiliensis* (Dana, 1853)	36083 36084	204	53
	Ericthonius rubricornis (Stimpson, 1853)	36085	2	
Maeridae	*Ceradocus (Denticeradocus) sheardi* Shoemaker, 1948	36086	3	
	Ceradocus shoemakeri Fox, 1973	36087		2
	Elasmopus balkomanus Tomas & Barnard, 1988	36088 36089	170	4
	Elasmopus levis (S.I. Smith in Verrill, 1873)	36090 36091	13	4
	Elasmopus pocillimanus (Spence Bate, 1862)	36092	146	
	Elasmopus rapax Costa, 1853	36093 36094	7	7
	Elasmopus thomasi Ortiz & Lalana, 1994	36095	3	
	Quadrimaera inaequipes (A. Costa in Hope, 1851)	36096	3	
	Quadrimaera miranda (Ruffo, Krapp-Schickel & Gable, 2000)	36097 36098	14	196
	Quadrimaera pacifica (Schellenberg, 1983)	36099	10	
	Quadrimaera quadrimana (Dana, 1852)	36100 36101	17	226

Table 1. Continued

Suborder/Family	Species	CNCR	APM	SKAR
	Spathiopus looensis Thomas & Barnard, 1985	36102	3	
Melitidae	*Melita elongata* Sheridan, 1980	36103		2
Neomegamphopidae	*Neomegamphopus hiatus* Barnard & Thomas, 1987	36104	3	
Nuuanuidae	*Nuuanu muelleri* Ortiz, 1976	36105 36106	2	4
Phliantidae	*Pariphinotus seclusus* (Shoemaker, 1933)	36107	73	
Photidae	*Gammaropsis chelifera* (Chevreux, 1901)	36108 36109	4	30
	Latigammaropsis atlantica (Stebbing, 1888)	36110 36111	72	161
Podoceridae	*Podocerus kleidus* Thomas & Barnard, 1992	36112 36113	2	7
Pontogeneiidae	*Nasageneia bacescui* Ortiz & Lalana, 1994	36114 36115	10	4
	Nasageneia yucatanensis Ledoyer, 1986	36116 36117	195	10
	Tethygeneia longleyi (Shoemaker, 1933)	36118	10	
Talitridae	*Chelorchestia forceps* Smith & Heard, 2001	36119		2

New records and geographical extension along the MEXCS

1. *Ampelisca burkei* Barnard & Thomas, 1989. Material examined: APM; 15 m depth; 6-VI-2015; 12 specimens; SKAR; 8 m depth; 16-VI-2016; 3 specimens. This shallow species inhabits macroalgae mats in APM and SKAR associated with coral rubble.

2. *Apolochus delacaya* (Mckinney, 1978). Material examined: APM; 9 m depth; 4-VI-2015; 4 specimens. This shallow species occurs in the APM in coral rubble and macroalgae mats.

3. *Apolochus pillaii* (Barnard & Thomas, 1983). Material examined: APM; 15 m depth; 7-VI-2015; 6 specimens. This shallow species occurs in the APM in coral rubble and macroalgae mats.

4. *Hourstonius laguna* (McKinney, 1978). Material examined: APM; 8 m depth; 5-VI-2015; 3 specimens; SKAR; 12 m depth; 16-VI-2016; 4 specimens. This shallow species occurs associated with macroalgae mats and coral rubble.

5. *Batea campi* (Ortiz, 1991). Material examined: APM; 8 m depth; 6-VI-2015; 12 specimens. This shallow species is recorded from APM in coral rubble and macroalgae mats.

6. *Batea catharinensis* Muller, 1865. Material examined: APM; 12 m depth; 4-VI-2015; 15 specimens. This shallow species occurs in the APM associated with coral rubble.

7. *Hoplopheonoides obesa* Shoemaker, 1956. Material examined: APM; 12 m depth; 4-VI-2015; 3 specimens. This shallow species is restricted to APM associated with coral rubble.

8. *Anamixis hanseni* Sttebing, 1897. Material examined: SKAR; 12 m depth; 17-VI-2016; 2 specimens. This shallow species occurs from macroalgae mats in SKAR.

9. *Leucothoe ashleyae* Thomas & Klebba, 2006. Material examined: APM; 15 m depth; 6-VI-2015; 59 specimens; SKAR; 8 m depth; 15-VI-2016; 5 specimens. This shallow species inhabits both APM and SKAR in macroalgae mats.

10. *Leucothoe barana* Thomas & Klebba, 2007. Material examined: APM; 20°50’28.57” N, 86°52’25.45” W; 12 m depth; 6-VI-2015; 30 specimens; SKAR; 12 m depth; 18-VI-2016; 17 specimens. This shallow species is found in APM and SKAR associated with coral rubble, macroalgae mats, and *T. testudinum*.

11. *Leucothoe garifunae* Thomas & Klebba, 2007. Material examined: APM; 10 m depth; 6-VI-2015; 8 specimens; SKAR; 11 m depth; 17-VI-2016; 3 specimens. This shallow species is found from both APM and SKAR associated with wooden piles and macroalgae mats.

12. *Leucothoe kensleyi* Thomas & Klebba, 2005. Material examined: APM; 10 m depth; 6-VI-2015; 4 specimens; SKAR; 9 m depth; 16-VI-2016; 6 specimens. This shallow species is found from both APM and SKAR associated with *T. testudinum*.

13. *Leucothoe saron* Thomas & Klebba, 2007. Material examined: APM; 8 m depth; 6-VI-2015; 244 specimens. This shallow species is found in APM in sponges *Callyspongia aculeata*, Ircinia *strobilina*, and coral rubble.

14. *Leucothoe ubouhu* Thomas & Klebba, 2007. Material examined: SKAR; 13 m depth; 17-VI-2016; 2 specimens. This shallow species is restricted to SKAR in macroalgae mats.

15. *Tantena zlatarskii* Ortiz, Lalana & Varela, 2007. Material examined: SKAR; 10 m depth; 18-VI-2016; 2 specimens. This shallow species is restricted to SKAR in soft bottoms.

16. *Westwoodilla longimana* Shoemaker, 1934. Material examined: SKAR; 11 m depth; 18-VI-2016; 2 specimens. This shallow species is restricted to SKAR in macroalgae mats.

17. *Eobrolgus spinosus* (Holmes, 1905). Material examined: APM; 10 m depth; 8-VI-2015; 3 specimens. This shallow species is restricted to APM associated with coral rubble and seagrass beds.

18. *Stenothoe gallensis* Walker, 1904. Material examined: APM; 7 m depth; 6-VI-2015; 3 specimens. This shallow species is restricted to APM associated with macroalgae mats.

19. *Stenothoe valida* Dana, 1852. Material examined: SKAR; 15 m depth; 18-VI-2016; 2 specimens. This shallow species is documented from SKAR associated with macroalgae mats.

20. *Ampithoe marcuzzii* Ruffo, 1954. Material examined: APM; 11 m depth; 7-VI-2015; 125 specimens. This shallow species is found in APM in coral rubble and sponge *Ircinia felix*.

21. *Ampithoe valida* Smith, 1873. Material examined: APM; 12 m depth; 8-VI-2015; 10 specimens. This shallow species is recorded from APM in coral rubble.

22. *Pseudamphithoides bacescui* Ortiz, 1976. Material examined: SKAR; 16 m depth; 16-VI-2016; 102 specimens. This shallow species is recorded from SKAR in macroalgae mats.

23. *Bemlos dentischium* (A.A. Myers, 1977). Material examined: SKAR; 9 m depth; 17-VI-2016; 18 specimens. This shallow species is found in SKAR associated with coral rubble and macroalgae.

24. *Bemlos inermis* Myers, 1979. Material examined: APM; 8 m depth; 5-VI-2015; 2 specimens; SKAR; 10 m depth; 17-VI-2016; 6 specimens. This shallow species is found in APM, and SKAR inhabits coral rubble, macroalgae mats, and *T. testudinum*.

25. *Bemlos kunkelae* (A.A. Myers, 1977). Material examined: SKAR; 12 m depth; 17-VI-2016; 4 specimens. This shallow species is recorded from SKAR associated with coral rubble, and macroalgae mats.

26. *Bemlos longicornis* (A.A. Myers, 1989). Material examined; APM; 12 m depth; 8-VI-2015; 18 specimens. This shallow species is found in APM inhabits in *T. testudinum*.

27. *Bemlos mackinneyi* (A.A. Myers, 1978). Material examined: SKAR; 12 m depth; 18-VI-2016; 2 specimens. This shallow species occurs in SKAR inhabits macroalgae mats.

28. *Plesiolembos rectangulatus* (A.A. Myers, 1977). Material examined: APM; 19 m depth; 8-VI-2015; 4 specimens; SKAR; 7 m depth; 16-VI-2016; 6 specimens. This shallow species had been collected in APM and SKAR associated with macroalgae mats and coral rubble.

29. *Dulzura schoenerae* (Fox, 1973). Material examined: APM; 15 m depth; 9-VI-2015; 3 specimens. So far, this shallow species is only recorded from APM associated with coral rubble.

30. *Apohyale media* (Dana, 1853). Material examined: SKAR; 4 m depth; 18-VI-2016; 5 specimens. This shallow species is found in SKAR inhabits macroalgae mats.

31. *Parhyale hawaiensis* (Dana, 1853). Material examined: SKAR; 3 m depth; 18-VI-2016; 4 specimens. This shallow species is found in SKAR in macroalgae mats.

32. *Elasmopus pocillimanus* (Spence Bate, 1862). Material examined: APM; 10 m depth; 7- VI-2015; 146 specimens. So far, this shallow species is recorded in APM in macroalgae mats.

33. *Elasmopus thomasi* Ortiz & Lalana, 1994. Material examined: APM; 15 m depth; 8-VI-2015; 3 specimens. So far, this shallow species is found in APM associated with coral rubble.

34. *Quadrimaera pacifica* (Schellenberg, 1983). Material examined: APM; 10 m depth; 8-VI-2015; 10 specimens. So far, this shallow species is recorded from APM associated with *T. testudinum*.

35. *Neomegamphopus hiatus* Barnard & Thomas, 1987. Material examined: APM; 19 m depth; 9-VI-2015; 3 specimens. So far, this shallow species is recorded in APM associated with macroalgae mats.

36. *Gammaropsis chelifera* (Chevreux, 1901). Material examined: APM; 7 m depth; 6-VI-2015; 4 specimens; SKAR; 5 m depth; 18-VI-2016; 5 specimens. It is found in APM, and SKAR associated with coral rubble, macroalgae mats, and soft bottoms.

37. *Podocerus kleidus* Thomas & Barnard, 1992. Material examined: APM; 14 m depth; 9-VI-2015; 2 specimens; SKAR; 10 m depth; 18-VI-2016; 7 specimens. This shallow species is found in APM, and SKAR associated with macroalgae mats, and seagrass beds.

38. *Nasageneia bacescui* Ortiz & Lalana, 1994. Material examined: APM; 9 m depth; 9-VI-2015; 10 specimens; SKAR; 4 m depth; 18-VI-2016; 4 specimens. This shallow species is reported in APM, and SKAR inhabits in macroalgae mats and coral rubble.

39. *Nasageneia yucatanensis* Ledoyer, 1986. Material examined: APM; 10 m depth; 8-VI-2015; 195 specimens; SKAR; 15 m depth; 16-VI-2016; 10 specimens. This shallow species is reported in APM, and SKAR inhabits macroalgae mats and coral rubble.

40. *Tethygeneia longleyi* (Shoemaker, 1933). Material examined: APM; 10 m depth; 9-VI-2015; 10 specimens. So far, this shallow species is documented from APM associated with macroalgae mats and soft bottoms.

41. *Chelorchestia forceps* Smith & Heard, 2001. Material examined: SKAR; 3 m depth; 18-VI-2016; 2 specimens. This shallow species is found in SKAR associated with coral rubble.

Discussion

The present study contributes to the first inventory of benthic amphipod species along the MEXCS documented from 1977 to date, including those species collected and analyzed in this work from both the APM and the SKAR, Quintana Roo, in 2015 and 2016. Previously, Paz-Ríos et al. (2021) documented some species richness ranges in benthic amphipods for the Western Caribbean ecoregion.

The MEXCS coastline includes beaches, rocky shores, seagrass beds, coral reefs, mangroves, and karstic bottoms, where the freshwater aquifer and seawater are frequently mixed (Rodríguez-Martínez et al., 2020). Such ecosystems make up a complex semi-continuous coral reef barrier with the key geomorphological features of back-reef, reef-crest, and front-reef (Rioja-Nieto & Álvarez-Filip, 2019). Throughout the MEXCS the benthic amphipods occur in diverse types of substrates, but are predominantly associated with coral rubble (88 species) and macroalgae mats (60 species), decreasing in species richness in seagrass beds and soft bottoms (22 species in each). According to the information summarized in this amphipod inventory, both the APM (38%, 83 species) and the SKAR (24%, 52 species), located in the north and central sectors of the MEXCS, represented the protected natural areas with the largest amounts and percentages of benthic amphipod species, with decreases in peracarids from the north sector to the south sector: Isla Mujeres (3%, 6 species), Isla Cozumel (7%, 17 species), Bahía Ascención (13%, 29 species), Banco Chinchorro (12%, 26 species), and Chetumal-Belice border (3%, 8 species). Besides, 84% of amphipod records belong to shallow water substrates (either soft-hard bottoms or living substrata), and 16% are from deep coral rubble (deeper than 25 m).

Although most coral reef works have documented tens of sponges hosting amphipod species belonging to Colomstigidae, Leucothoidae, Aoridae, and Maeridae, only *Leucothoe spinicarpa*, *Leucothoe saron*, *Ampithoe marcuzzii*, and *Ericthonius brasiliensis* have been recorded in sponges throughout the MEXCS. This fact is a result of the multidisciplinary management strategies proposed by the Protected Natural Areas Agency-Mexico, where the conservation and protection of numerous benthic invertebrates, such as sponges, represents a key component as a refuge for feeding, protection, and reproduction for several invertebrate species. Thus, knowledge of biodiversity and interactions between amphipod-sponges are fragmentary in the MEXCS.

Until now, 13 benthic amphipod species have been reported in most coral reef protected areas belonging to the MEXCS, out of which only *Leucothoe spinicarpa*, *Lysianopsis alba*, *Elasmopus rapax*, and *E. levis* occur throughout the whole MEXCS (Table 2). Recent analyses on biogeographic aspects showed 2 of these species (*E. rapax* and *L. spinicarpa*) are widely distributed across the warm Northwest Atlantic ecoregions (Paz-Ríos et al., 2021). Until the amphipod inventory is completed for the Mexican Caribbean Sea protected areas, we cannot determine if the geographic distribution pattern of such benthic crustaceans is continuous or if it is defined as "patches" in each coral reef protected area. Thomas (1993a) suggested that the ecological features of these amphipod assemblages in each coral reef ecosystem, such as substrate specificity and biological adaptations, should be analyzed by microhabitats rather than a huge macrohabitat, which is a hypothesis to be tested in future research.

Table 2

Checklist of benthic amphipods throughout MEXCS. IM, Isla Mujeres; APM, Arrecife Puerto Morelos; IC, Isla Cozumel; SKA, Arrecife Sian Ka'an; BA, Bahía Ascención; RBC, Reserva Biosfera Chinchorro; Ch-B, Chetumal-Belice; REF, referencia. 1, Monroy-Velázquez et al. (2017); 2, Monroy-Velázquez et al. (2020); 3, Escobar-Briones and Winfield (2003); 4, Oliva-Rivera (2003); 5, Oliva-Rivera (1998); 6, McKinney (1977); 7, Oliva-Rivera and Jiménez-Cueto (1992); 8, Cházaro-Olvera et al. (2021); 9, Oliva-Rivera and Jiménez-Cueto (1992); 10, LeCroy et al. (2009); 11, Wildish and LeCroy (2014).

Taxon	IM	APM	IC	SKA	BA	RBC	Ch-B	REF
Ampeliscidae								
Ampelisca abdita		*						1, 2
Ampelisca agassizi		*						1
Ampelisca bicarinata		*	*					1, 3
Ampelisca burkei		*		*				PS
Ampelisca holmesi			*					3
Ampelisca schellenbergi		*		*				1
Ampelisca vadorum			*					3
Ampelisca verilli			*					3
Amphilochidae								
Apolochus casahoya		*				*	*	4, 5
Apolochus delacaya		*						PS
Apolochus neapolitanus		*		*	*	*		4, 6, 7
Apolochus pillaii		*						PS
Gitana dominica			*	*				3
Hourstonius laguna				*				PS
Hourstonius tortugae		*						1, 2
Atylidae								
Nototropis minikoi	*			*				8
Bateidae								
Batea campi		*						PS
Batea carinata		*		*	*	*		4
Batea catharinensis		*						PS
Batea cuspidata		*						1, 2
Cyproideidae								
Hoplopheonoides obesa		*						PS
Leucothoidae								
Anamixis cavatura		*		*				1, 2
Anamixis hanseni				*				PS
Leucothoe ashleyae		*						PS
Leucothoe barana		*		*				PS
Leucothoe garifunae		*		*				PS
Leucothoe kensleyi		*		*				PS
Leucothoe laurensi		*		*				1
Leucothoe saron		*						PS
Leucothoe spinicarpa	*	*	*		*	*		1, 2, 3, 5, 6, 7

Table 2. Continued

Taxon	IM	APM	IC	SKA	BA	RBC	Ch-B	REF
Leucothoe ubouhu				*				PS
Liljeborgiidae								
Liljeborgia bousfieldi		*			*			1, 5
Lysianassidae								
Concarnes concavus		*	*	*				1, 3
Dissiminassa dissimilis					*			5
Lysianopsis alba		*	*	*	*	*		1, 2, 3, 4, 5, 6, 7
Shoemakerella lowryi		*						PS
Tantena zlatarskii				*				PS
Ochlesidae								
Curidia debrogania		*				*		1, 6
Idunella quintana	*					*		5, 9
Oedicerotidae								
Perioculodes cerasinus		*						1, 2
Westwoodilla longimana				*				PS
Phoxocephalidae								
Eobrolgus spinosus		*						PS
Metharpinia floridana		*						1, 2
Sebidae								
Seba tropica		*					*	1
Stenothoidae								
Stenothoe gallensis		*						PS
Stenothoe minuta				*				PS
Stenothoe valida				*				PS
Synopiidae								
Synopia ultramarina		*		*	*	*		1, 6, 3
Trion triocellatus		*						1
Colomastigidae								
Colomastix janiceae		*						1
Colomastix pusilla					*			5
Ampithoidae								
Ampithoe longimana	*	*		*				8
Ampithoe marcuzzii		*						PS
Ampithoe ramondi		*		*				1, 2
Ampithoe valida		*						PS
Cymadusa filosa					*	*		6, 7, 9
Pseudamphithoides bacescui				*				PS
Pseudampithoides incurvaria		*						1, 2
Aoridae								

Table 2. Continued

Taxon	IM	APM	IC	SKA	BA	RBC	Ch-B	REF
Bemlos dentischium				*				PS
Bemlos inermis		*		*				PS
Bemlos kunkelae				*				PS
Bemlos longicornis		*						PS
Bemlos mackinneyi				*				PS
Bemlos spinicarpus		*	*	*		*		1, 5
Bemlos tigrinus		*						PS
Bemlos unicornis		*		*				1
Bemlos waipio					*	*		6, 7
Globosolembos smithi		*		*				1, 2
Grandidierella bonnieroides			*		*	*	*	3, 5, 6, 7
Lembos unifasciatus		*		*				1, 2
Plesiolembos rectangulatus		*		*				PS
Chevaliidae								
Chevalia aviculae		*	*					1, 2, 3
Chevalia carpenteri				*			*	10
Chevalia mexicana		*		*			*	10
Eriopisidae								
Netamelita barnardi		*						1, 2
Gammaridae								
Gammarus mucronatus		*						1
Hadziidae								
Dulzura schoenerae		*						PS
Hyalidae								
Apohyale media				*				PS
Parhyale hawaiensis				*				PS
Protohyale (Protohyale) frequens		*		*				PS
Ischyroceridae								
Ericthonius brasiliensis		*		*	*	*		1, 5, 7, 9
Ericthonius rubricornis		*	*					3
Maeridae								
Anamaera hixoni		*						1
Ceradocus (Denticeradocus) sheardi		*		*	*	*		1, 2, 5, 7
Ceradocus shoemakeri		*		*				1
Dulichiella appendiculata			*			*		3, 5
Dumosus atari							*	10
Elasmopus balkomanus		*		*				1
Elasmopus levis	*	*		*	*	*		1, 2, 5, 6, 7
Elasmopus pocillimanus		*						PS

Table 2. Continued

Taxon	IM	APM	IC	SKA	BA	RBC	Ch-B	REF
Elasmopus rapax	*	*	*	*	*	*		1, 2, 3, 5, 6, 7
Elasmopus thomasi		*						PS
Maera jerrica		*	*			*		1, 3
Quadrimaera inaequipes		*			*			5
Quadrimaera miranda		*		*				1
Quadrimaera pacifica		*						PS
Quadrimaera quadrimana		*		*	*	*		2, 6, 9
Spathiopus looensis		*						1
Megaluropidae								
Gibberosus myersi		*						1
Melitidae								
Dulichiella appendiculata		*	*		*	*		3, 6, 9
Elasmopus fusimanus					*			6
Elasmopus levis					*	*		5
Elasmopus rapax			*		*	*		3, 5
Melita elongata		*						PS
Melita nitida					*	*		5, 9
Neomegamphopidae								
Neomegamphopus hiatus		*						PS
Nuuanuidae								
Nuuanu copillius					*			10
Nuuanu muelleri		*		*				2
Phliantidae								
Pariphinotus seclusus		*			*	*	*	1, 2, 6
Photidae								
Gammaropsis chelifera		*		*				PS
Latigammaropsis atlantica		*		*				1, 2
Podoceridae								
Podocerus kleidus		*		*				PS
Pontogeneiidae								
Nasageneia bacescui		*		*				PS
Nasageneia yucatanensis		*						PS
Pontogeneia barstchi					*	*		5, 6
Tethygeneia longleyi		*						PS
Talitridae								
Chelorchestia forceps				*				PS
Mexorchestia carpenteri					*		*	11
Tethorchestia antillensis					*	*		5
Unciolidae								
Rudilemboides naglei			*	*				3

Acknowledgments

To the PAPIIT program, sponsored by the Dirección General de Asuntos del Personal Académico, Universidad Nacional Autónoma de México, for the financial support. In addition, thanks are due to Comisión Nacional de Acuacultura y Pesca (Conapesca-DGOPA) for the collecting license (DGOPA.01024.110213.0236 and PPF/DGOPA-051/15). Additionally, we would like to thank to M. A. Lozano-Aburto for his support during the sampling and sorting of species.

References

Ardisson, P. L., May-Kú, M. A., Herrera-Dorantes, M. T., & Arellano-Guillermo, A. (2011). El Sistema Arrecifal Mesoamericano, México: consideraciones para su designación como Zona Marítima Especialmente Sensible. *Hidrobiológica*, *21*, 261–280.

Barnard, J. L., & Karaman, G. (1991). The families and genera of marine gammaridean Amphipoda (except marine gammaroids). *Records of the Australian Museum*, *13*, 1–866. https://doi.org/10.3853/j.0812-7387.13.1991.367

Cházaro-Olvera, S., Ortiz, M., Winfield, I., & Viveros-Villaseñor, B. (2021). Parámetros poblacionales de *Nototropis minikoi* y *Ampithoe longimana* (Crustacea: Amphipoda) en dos Islas del Mar Caribe mexicano. *Revista de Biología Marina y Oceanografía*, *56*, 1–12. https://doi.org/10.22370/rbmo.2021.56.1.2794

Contreras-Silva, A. I., Tilstra, A., Migani, V., Thiel, A., Pérez-Cervantes, E., Estrada-Saldívar, N. et al. (2020). A meta-analysis to assess long-term spatiotemporal changes of benthic coral and macroalgae cover in the Mexican Caribbean. *Scientific Reports*, *10*, 8897. https://doi.org/10.1038/s41598-020-65801-8

Escobar-Briones, E., & Winfield, I. (2003). Checklist of benthic Gammaridea and Caprellidea (Crustacea: Peracarida: Amphipoda) from the Gulf of Mexico Continental Shelf and Slope. *Belgian Journal of Zoology*, *113*, 37–44. https://doi.org/10.3989/scimar.2006.70n199

Gable, M. F., & Lazo-Wasem, E. A. (1990). Lysianassidae (Amphipoda: Lysianassoidea) of Bermuda. *Journal of Crustacean Biology*, *10*, 721–734. https://doi.org/10.2307/1548416

Horton, T., Lowry, J., De Broyer, C., Bellan-Santini, D., Coleman, C. O., Corbari, L. et al. (2021). World Amphipoda Database. Available at https://www.marinespecies.org/amphipoda (Accessed on: 2021-10-15).

LeCroy, S. (2000). *An illustrated identification guide to the nearshore marine and estuarine Gammaridean Amphipoda of Florida. Volume 1. Families Gammaridae, Hadziidae, Isaeidae, Melitidae and Oedicerotidae*. Tallahassee: Florida Department of Environmental Protection. USA.

LeCroy, S. (2002). *An illustrated identification guide to the nearshore marine and estuarine Gammaridean Amphipoda of Florida. Volume 2. Families Ampeliscidae, Amphilochidae, Ampithoidae, Aoridae, Argissidae and Haustoriidae*. Tallahassee: Florida Department of Environmental Protection. USA.

LeCroy, S. (2004). *An illustrated identification guide to the nearshore marine and estuarine Gammaridean Amphipoda of Florida. Volume 3. Families Bateidae, Biancolinidae, Cheluridae, Colomastigidae, Corophiidae, Cypropoideiae and Dexaminidae*. Tallahassee: Florida Department of Environmental Protection. USA.

LeCroy, S. (2007). *An illustrated identification guide to the nearshore marine and estuarine Gammaridean Amphipoda of Florida. Volume 4, Families Anamixidae, Eusiridae, Hyalellidae, Hyalidae, Iphimedidae, Ischyroceridae, Lysianassidae, Megaluropidae and Melphidippidae*. Tallahassee: Florida Department of Environmental Protection. USA.

LeCroy, S. E., Gasca, R., Winfield, I., Ortiz, M., & Escobar-Briones, E. (2009) Amphipoda (Crustacea) of the Gulf of Mexico. In D. L. Felder, & D. K. Camp (Eds.), *Gulf of Mexico-origins, waters, and biota. Biodiversity*. College Station: Texas A&M University Press.

Lowry, J. K., & Myers, A. A. (2017). A phylogeny and classification of the Amphipoda with the establishment of the new order Ingolfiellida (Crustacea: Peracarida). *Zootaxa*, *4265*, 1–89. https://doi.org/10.11646/zootaxa.4265.1.1

Lowry, J. K., & Stoddart, H. E. (1997). Amphipoda Crustacea IV. Families Aristiidae, Cyphocarididae, Endevouridae, Lysianassidae, Scopelocheiridae, Uristidae. *Memoirs of the Hourglass Cruises*, *10*, 1–148.

Martín, A., Díaz, Y., Miloslavich, P., Escobar-Briones, E., Guerra-García, J. M., Ortiz, M. et al. (2013). Regional diversity of Amphipoda in the Caribbean Sea. *Revista de Biología Tropical*, *61*, 1681–1720.

McKinney, L. D. (1977). *The origin and distribution of shallow water Gammaridean Amphipoda in the Gulf of Mexico and Caribbean Sea with notes on their ecology (Ph.D. Thesis)*. Texas A&M University, Texas, USA.

Monroy-Velázquez, L. V., Rodríguez-Martínez, R. E., & Álvarez, F. (2017). Taxonomic richness and abundance of cryptic peracarid crustaceans in the Puerto Morelos Reef National Park. Mexico. *PeerJ*, *5*, e3411. https://doi.org/10.7717/peerj.3411

Monroy-Velázquez, L. V., Rodríguez-Martínez, R. E, Blanchon, P., & Álvarez, F. (2020). The use of artificial substrate units to improve inventories of cryptic crustacean species on Caribbean coral reefs. *PeerJ*, *8*, e10389. https://doi.org/10.7717/peerj.10389

Oliva-Rivera, J. J. (1998). Anfípodos. In X. Maiza, (Ed.), *Enciclopedia de Quintana Roo, Tomo I, A-B* (pp. 148–169). Gobierno del Estado de Quintana Roo, Chetumal, México.

Oliva-Rivera, J. J. (2003). The Amphipod fauna of Banco Chinchorro, Quintana Roo, Mexico, with ecological notes. *Bulletin of Marine Science*, *73*, 77–89.

Oliva-Rivera, J. J., & Jiménez-Cueto, M. S. (1992). Anfípodos bentónicos (Crustacea: Peracarida) de la Reserva de la

Biosfera de Sian Ka'an, Quintana Roo, México. In D. Navarro, & E. Suárez-Morales (Eds.), *Diversidad biológica en la Reserva de la Biosfera de Sian Ka'an Quintana, Roo, México. Vol. II.* (pp. 170–195). México D.F.: IQRO/Sedesol.

Oliva-Rivera, J. J., & Jiménez-Cueto, M.S. (1997). Composición, distribución y abundancia de los crustáceos peracáridos de la laguna de Yalahau, Quintana Roo. *Avacient*, *23*, 26–31.

Ortiz, M., Martín, A., & Díaz, Y. J. (2007). Lista y referencias de los crustáceos anfípodos (Amphipoda: Gammaridea) del Atlántico occidental tropical. *Revista de Biología Tropical*, *55*, 479–498.

Ortiz, M., Winfield, I., Scheinvar-Gottdiener, E., & Cházaro-Olvera, S. (2014). *Clave ilustrada de los anfípodos del golfo de México y el mar Caribe (Gammaridea y Caprellidea)*. México D.F.: UNAM-FES, Iztacala.

Paz-Ríos, C. E., Pech, D., Carrera-Parra, L. F., & Simoes, N. (2021). Biodiversity and biogeographic affinity of benthic amphipods from the Yucatan Shelf: an analysis across the warm Northwest Atlantic ecoregions. *Systematics and Biodiversity*, *19*, 928–939.

Perera-Valderrama, S., Cerdeira-Estrada, S., Martell-Dubois, R., Rosique-de la Cruz, L., Caballero-Aragón, H., Valdez-Chavarin, J. et al. (2020). A new long-term marine biodiversity monitoring program for the knowledge and management in Marine Protected Areas of the Mexican Caribbean. *Sustainability*, *12*, 7814. https://doi.org/10.3390/su12187814

Rioja-Nieto, R., & Álvarez-Filip, L. (2019). Coral reef systems of the Mexican Caribbean: Status, recent trends, and conservation. *Marine Pollution Bulletin*, *140*, 616–625. https://doi.org/10.1016/j.marpolbul.2018.07.005

Rioja-Nieto, R., Garza-Pérez, R., Álvarez-Filip, L., Mariño-Tapia, I., & Enríquez, C. (2019). The Mexican Caribbean: from Xcalak to Holbox. In S. Charles (Eds.), *World seas: an environmental evaluation* (pp. 637–653). San Diego: Academic Press, USA.

Rodríguez-Martínez, R. E., Roy, P. D., Torrescano-Valle, N., Cabanillas-Terán, N., Carrillo-Domínguez, S., Collado-Vides, L. et al. (2020). Element concentrations in pelagic *Sargassum* along the Mexican Caribbean coast in 2018-2019. *PeerJ*, *8*, e8667. https://doi.org/10.7717/peerj.8667

Thomas, J. D. (1993a). *Identification manual for marine Amphipoda (Gammaridea): I. Common coral reef and rocky bottom amphipods of South Florida*. Tallahassee, Florida: Florida Department of Environmental Protection.

Thomas, J. D. (1993b). Biological monitoring and tropical biodiversity in marine environments: a critique with recommendations, and comments on the use of amphipods as bioindicators. *Journal of Natural History*, *27*, 795–806. https://doi.org/10.1080/00222939300770481

Thomas, J. D., & Klebba, K. (2007). New species and host associations of commensal leucothoid amphipods from coral reefs in Florida and Belize (Crustacea: Amphipoda). *Zootaxa*, *1494*, 1–44. https://doi.org/10.11646/zootaxa.1494.1.1

Wildish, D. J., & LeCroy, S. E. (2014). *Mexorchestia*: a new genus of talitrid amphipod (Crustacea, Amphipoda, Talitridae) from the Gulf of Mexico and Caribbean Sea, with the description of a new species and two new subspecies. *Zootaxa*, *3856*, 555–577. https://doi.org/10.11646/zootaxa.3856.4.5

WoRMS Editorial Board. (2021). *World Register of Marine Species*. At VLIZ, accessed on: 2021-10-25, at: http://www.marinespecies.org