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FIRST RECORDS OF POLYCHAETOUS ANNELIDS FROM CENOTE AEROLITO (SINKHOLE AND ANCHIALINE CAVE) IN COZUMEL ISLAND, MEXICO

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Abstract: In this study, polychaetous annelids are recorded for the first time in Mexican cenotes and anchialine caves. These organisms were collected in the Cenote Aerolito (Cozumel Island, on the Caribbean coast of Quintana Roo) during three sampling events from February 2006 to April 2008, among algae, roots of mangroves, and in karst sediments. A total of 1518 specimens belonging to five families (Paraonidae, Capitellidae, Nereididae, Dorvilleidae, and Syllidae), ten genera, and eleven species were collected. In the cave system, two specimens of the amphinomid *Hermodice carunculata* were found. This cenote and its biota are now in danger of disappearing because of a marina construction project in its western shore.

Introduction

Polychaetes constitute the largest class of the phylum Annelida, with about 12,000 species described to date in more than 80 recognized families (Rouse and Pleijel, 2006). They are ubiquitous in marine habitats from intertidal to abyssal depths, where they are often the most diverse or dominant group. However, they are also found in some freshwater habitats and in karst systems like cenotes (or sinkholes) and even in the associated caves. Cave records are scarce, but the most important can be found in Augener, 1932; Remy, 1937; Hartmann-Schröder, 1977 and 1986; Sket and Iliffe, 1980; Culver and Sket, 2000; Wilson and Humphreys, 2001; and Martínez-García et al., 2009.

In 2002, Schmitter-Soto et al. made an exhaustive list of organisms collected in Yucatán cenotes, from bacteria and protozoa to algae and small invertebrates, such as copepods, amphipods, and isopods, but these authors did not report polychaetes; larger animals, such as fishes, amphibians, iguanas or crocodiles are better known in these habitats. Previously, Suárez-Morales and Rivera-Arriaga (1998) mentioned that no published references exist about free living nematodes, annelids, or mollusks in the Yucatán cenotes. Mejía-Ortíz et al. (2007b) studied some of the cenotes' macrofauna of Cozumel Island and mentioned the presence of worms in the cave system of Cenote Aerolito, but they did not specify if they were indeed polychaetes. In this study, we focused solely on the polychaetous annelids in this cenote and its cave system.

Cenotes are sinkholes found almost everywhere in the Yucatán Peninsula, which comprises the Mexican states of Yucatán, Campeche, and Quintana Roo, as well as northern Belize and the Guatemalan department of El Petén. They are a product of the geological characteristics of that region: in the whole peninsula, no rivers are found because its calcareous landscape is characterized, among other factors, by its high permeability. Thus, the abundant rainfall (average 1300 mm per year) sinks down to the phreatic level, where a complex web of subterranean rivers, mostly unknown, are formed and flow towards the sea at different levels (Schmitter-Soto et al., 2002). In places where the underground flow has produced caves, occasionally their ceiling collapses, uncovering the subterranean waters, and a cenote is born (Aguilar, 2003).

Cozumel Island is formed from reef sediments with an average thickness of 100 m or more from the Oligocene to the Quaternary; in these limestone beds, a karst aquifer is present and 18 cenotes are known (Wurl and Giese, 2005).

Site Description

With dimensions of 52 km by 14 km and a surface area of about 650 km^2, Cozumel is the largest island in Mexico. It is located in the northeastern region of the Yucatán Peninsula, in the northern Mexican Caribbean, about 18 km from the mainland (Pacheco and Vega, 2008). Its soil is mainly karstic, composed of limestone (Wurl and Giese, 2005), with four kinds of cenotes represented: those with surface connection narrower than the diameter of the water body (*cenotes cántaro*), those with vertical walls (*cenotes cilíndricos*), those degraded to shallow water basins (*cenotes aguadas*), and those with horizontal entrances to dry sections (*grutas*). The island's freshwater supply comes mainly from the cenotes and associated subterranean water systems (Mejía-Ortíz et al., 2007b). It has approximately 70,000 inhabitants and is totally devoted to tourism, which nowadays is expanding at a rate of more than 100% per year (Solís-Weiss et al., 2007).

Cenote Aerolito, one of the 18 cenotes known in Cozumel Island, is located close to the western coast of Cozumel, at 240 m from shore (20°28′00″ N and 86°58′45″ W). It is approximately 68 m long, 25 m wide, and 8 m deep. It is connected to the sea through an underwater cave system (Mejía-Ortíz et al., 2007a). At its northwestern end,

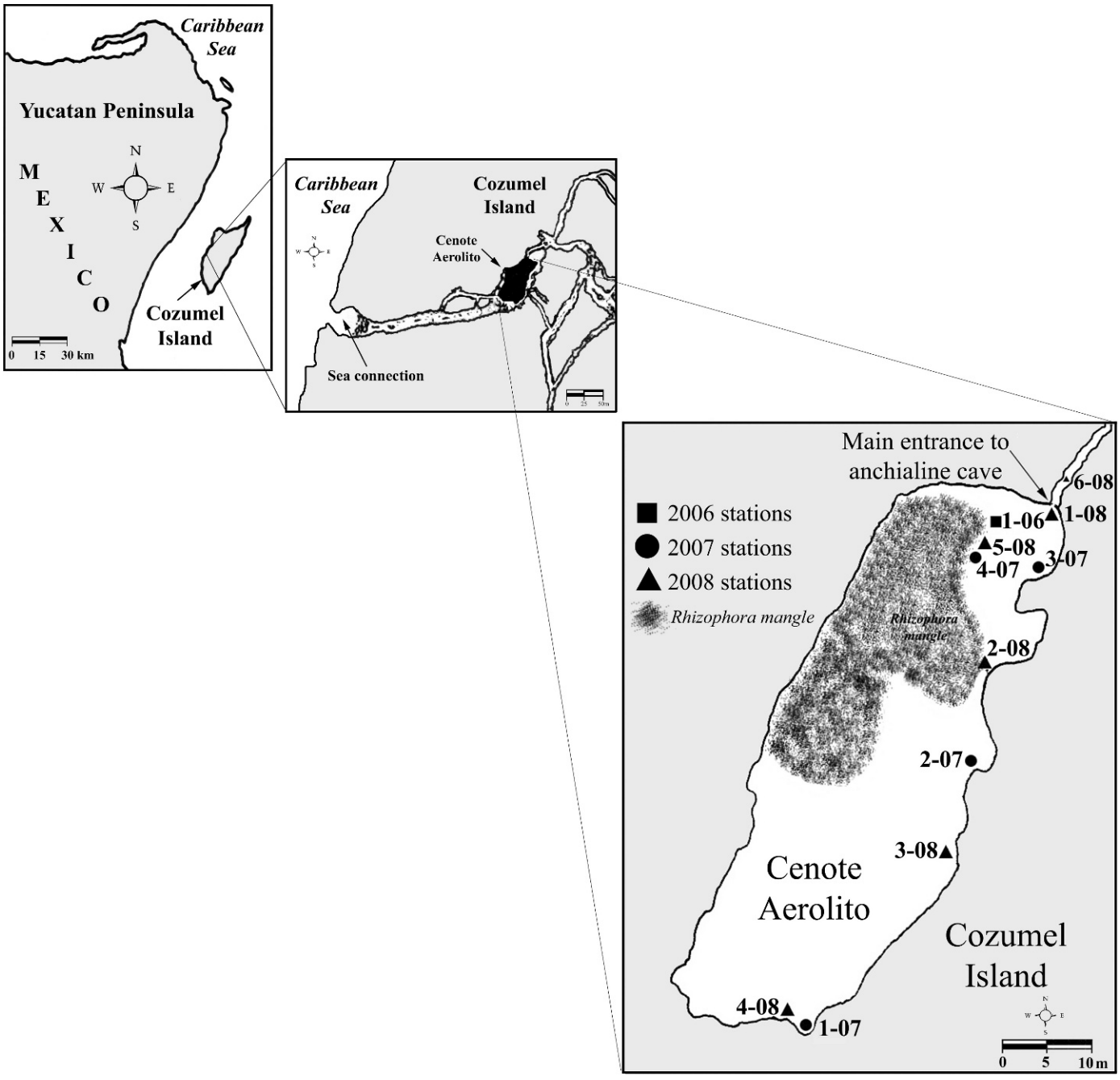

Figure 1. Study Area. Cenote Aerolito on Cozumel Island.

a relict of mangrove vegetation is present (*Rhizophora mangle* Linnaeus, 1753) (Fig. 1), and large aggregations of algae are found all around its edges.

Methods

Samples were collected by hand in February 2006 as part of the project Echinoderms from Cozumel Anchialine Caves. Each sample consisted of 200 ml of algae or karst sediment taken among mangrove roots in an area close to the main cave entrance of the Cenote Aerolito (station 1-06). In June 2007, as part of the project Benthic Fauna of the Mexican Caribbean Shores, further sampling was carried out at four stations (1-07, 2-07, 3-07, and 4-07); approximately 1000 ml of algae were collected, as well as karst sediment along the eastern edge of the cenote. A third sampling occurred in April 2008 at five stations (1-08, 2-08, 3-08, 4-08, and 5-08), and an additional station (6-08) was sampled using scuba diving in its cave system (Fig. 1, Table 1). Physical and chemical parameters were measured during each visit with a Hydrolab Data Sonde (HDS3) multiparameter probe.

Table 1. Sampling stations at Cenote Aerolito.

Sample No.	Latitude (N)	Longitude (W)	Depth (m)	Salinity (ppt)	Water Temp. (°C)	pH	Substrate
1-06[a]	20° 27′ 58.64″	86° 58′ 41.43″	0.5	18.1	25.08	7.25	algae and sediment
1-07[b]	20° 27′ 56.76″	86° 58′ 42.21″	0.3	15.1	27.02	7.30	algae and sediment
2-07[b]	20° 27′ 57.74″	86° 58′ 41.55″	0.5	15.8	27.08	7.42	algae
3-07[b]	20° 27′ 58.48″	86° 58′ 41.27″	0.5	15.8	27.04	7.37	algae
4-07[b]	20° 27′ 58.54″	86° 58′ 41.54″	0.5	15.8	26.89	4.44	algae
1-08[c]	20° 27′ 58.70″	86° 58′ 41.20″	1.0	19.68	24.67	7.35	algae
2-08[c]	20° 27′ 58.11″	86° 58′ 41.49″	0.3	20.33	24.61	7.34	algae and sediment
3-08[c]	20° 27′ 57.40″	86° 58′ 41.70″	1.0	20.41	24.88	7.40	algae
4-08[c]	20° 27′ 56.80″	86° 58′ 42.30″	0.5	20.30	25.07	7.45	algae and sediment
5-08[c]	20° 27′ 58.55″	86° 58′ 41.51″	0.3	19.68	24.67	7.37	algae
6-08[c]	Anchialine cave		8.0	34.71	26.03	7.74	sediment

[a] Collected February 15, 2006.
[b] Collected July 5, 2007.
[c] Collected April 19, 2008.

All the biological material was fixed in 7% formalin in the field, later rinsed with water, sieved through a 0.5 mm sieve, preserved in 70% alcohol, and identified to species level. The taxonomic arrangement follows Rouse and Fauchald (1997). In the faunal list, the syllids listed as sp. 1 are incomplete specimens, so their identification could only be carried out to the genus level. The dorvilleids identified as *Ophryotrocha* sp. A could not be referred to a known species and are now under study as potentially new to science. All the specimens are deposited in the National Polychaete Collection of the Laboratorio de Ecología y Biodiversidad de Invertebrados Marinos, Instituto de Ciencias del Mar y Limnología, UNAM (CPICML-UNAM, DFE.IN.061.0598).

The sediment was classified following Folk's (1974) method for size classes, while mineralogical and organic composition was done with the method of Gaudette et al. (1974).

Results

A total of 1518 specimens belonging to five families (Paraonidae, Capitellidae, Nereididae, Dorvilleidae, and Syllidae), ten genera, and eleven species are reported for Cenote Aerolito, while in its cave system two specimens of *Hermodice carunculata* were found. All the polychaete species collected during this study represent first records for the location in which they were found.

Species Account

Capitellidae Grube, 1862

Capitella cf. *capitata* (Fabricius, 1780) species complex

Material examined. Cenote Aerolito, Cozumel Island, Quintana Roo, February 15, 2006 (25 specimens), July 5, 2007 (66 specimens), April 19, 2008 (21 specimens) in soft bottoms associated with mangrove roots, algae, and karst sediments (CPICML-UNAM-PO-17-015).

Description. Largest specimen complete with 36 chaetigers, 11-mm long and 0.9-mm wide including parapodia, smaller specimen complete with 12 chaetigers, 5-mm long and 0.5-mm wide including parapodia. Prostomium broad and triangular; eyes absent. Body elongate, thoracic region broadest, partially inflated, with narrow segments; thoracic chaetigers with reduced podial lobes and capillary chaetae in both rami from chaetigers 1–6; chaetiger 7 with capillaries or mixed fascicles of capillary and hooded hooks; parapodia of chaetigers 8–9 with only hooks and, in most of the specimens, with enlarged opposing notopodial genital spines. Abdominal region narrower and segments longer with tori of hooded hooks. Pygidium without appendixes.

Habitat. In intertidal and subtidal mud and sand, especially in organically enriched sediments (Blake, 2000), dead coral (Ochoa-Rivera et al., 2000).

Distribution remarks. The species *C. capitata* has been considered cosmopolitan but is composed by several sibling species found to be genetically distinct, but morphologically similar (Grassle and Grassle, 1976; Grassle, 1980). Following the recent publication by Blake (2009) on this subject, we believe, as he does, that the true *C. capitata* will ultimately be confined to arctic and sub-arctic environments and that all other records of the species will ultimately be recognized as different species, some of them new to science. His important study of the taxonomic problems surrounding the so-called *C. capitata* complex will result in further studies of these species, so that, in this case, the species previously reported from Cozumel Island by Ochoa-Rivera et al. (2000) as *C. capitata* will probably have to be corrected, and that record, as well as the present one from Cenote Aerolito, will have to be re-evaluated.

Capitella aciculatus (Hartman, 1959)

Material examined. Cenote Aerolito, Cozumel Island, Quintana Roo, April 19, 2008 (2 specimens) in karst sediments (CPICML-UNAM-PO-17-034).

Description. Both specimens incomplete, males, largest with 20 chaetigers, 11-mm long and 1-mm wide including parapodia, smaller specimen with 17 chaetigers, 9-mm long and 1.2-mm wide including parapodia. Body elongate, thoracic region barrel-shaped, partially inflated, with narrow segments, abdominal region narrower, segments longer. Prostomium broadly triangular; eyes absent. Thorax with 9 chaetigers, the first and second are unique in bearing heavy acicular spines, 2 or 3 in a fascicle, they are known to occur in both notopodia and neuropodia in the males, 3–7 with capillary chaetae. On chaetigers 8–9 (sometimes 6–8), enlarged opposing notopodial genital spines are present. Abdominal segments with tori of hooded hooks in slightly elevated ridges located closer to the posterior end of the segment; single series of few uncini numbering 5 to 10 in a row. Hooded hooks with long shafts and distally end in recurved fangs surmounted by five smaller teeth in two rows.

Habitat. Subtidal mud (Tagatz et al., 1982)

Distribution. Atlantic Ocean in Florida (Hartman, 1959), Costa Rica (Dean, 2004). This species is newly recorded for Mexican waters.

Heteromastus filiformis (Claparède, 1864)

Material examined. Cenote Aerolito, Cozumel Island, Quintana Roo, April 19, 2008 (2 specimens) in karst sediment (CPICML-UNAM-PO-17-029).

Description. Both specimens incomplete, largest with 30 chaetigers, 7.5-mm long and 0.25-mm wide including parapodia, smaller specimen with 20 chaetigers, 4.1-mm long and 0.25-mm wide including parapodia. Prostomium thin and conical; eyes absent. Eversible proboscis inflated, with papillae, peristomium a single achaetous ring. Thorax with 12 segments, first achaetous. Chaetigers 1–5 with capillary chaetae, chaetigers 6–11 with hooded hooks. Thoracic-abdominal junction indistinct, but anterior abdominal segments larger in cross-section, especially dorsally. Posterior chaetigers campanulate, trapezoid in section, widest ventrally. Parapodial dorsal branchiae (located posteriorly) and pygidium could not be observed.

Habitat. Intertidal muds, anaerobic and estuarine habitats (Blake, 2000). Muddy sands and sands (Dean, 2004).

Distribution. Mediterranean Sea (Hutchings and Rainer, 1981) Atlantic and Pacific Oceans, Australia (Blake, 2000), Southern California (Cadien and Lovell, 2008).

Paraonidae Cerruti, 1909

Paradoneis lyra (Southern, 1914)

Material examined. Cenote Aerolito, Cozumel Island, Quintana Roo, February 15, 2006 (154 specimens) in soft bottoms associated with mangrove roots (CPICML-UNAM-PO-02-004).

Description. Largest specimen complete with 105 chaetigers, 18.5-mm long and 0.2-mm wide; smaller specimen complete with 51 chaetigers, 6.8-mm long and 0.2-mm wide. Body elongate, prostomium short, bluntly conical, fused to achaetigerous peristomium. Antennae and subdermal eyes absent. Prebranchial chaetigers from 1–3, branchiae from segments 4 to 12 to14, long, slender and blunt, first few pairs generally shorter. Notochaetae lyrate, slender, from chaetigers 2–3 with two unequal tines with inner row of spines, acicular neurochaetae absent. Pygidium rounded, anal cirri short.

Habitat. Sandy muds, sands, gravels (Mackie, 1991).

Distribution. Northeastern Atlantic (Mackie, 1991), Indo-Pacific, Mediterranean, Panama (Aguado and López, 2003), Southern California (Cadien and Lovell, 2008).

Amphinomidae Lamarck, 1818

Hermodice carunculata (Pallas, 1766)

Material examined. Anchialine cave of the Cenote Aerolito, Cozumel Island, Quintana Roo, April 19, 2008 (2 specimens) (CPICML-UNAM-PO-49-008).

Description. Specimens complete with 45 to 48 chaetigers, 45- to 65-mm long and 8-to 10-mm wide including parapodia. Body elongate, intensely red in color, the largest specimen with intersegmental transverse black lines from chaetigers 5–6. Prostomium covered by an elaborate caruncle covering the first 3 chaetigers and formed by two series of 7 or 8 transverse folds; two pairs of eyes and 3 antennae. Double dendritic branchiae present along whole body. Parapodia with abundant notochaetae and neurochaetae. Notochaetae very long capillaries and harpoon chaetae (stout pointed chaetae with recurved barbs near the tip) of smaller size; three types of acicular neurochaetae: subdistally flat, distally denticulate (3 to 5 teeth), subdistally with a tooth and denticulate until the apex, with up to 15 small teeth. Notopodial cirri biarticulated and larger than neuropodial cirri. Last segment encircling the anus.

Habitat. Associated to sessile organisms in rocky substrate (Salazar-Vallejo, 1996–1997); in dead coral (Ochoa-Rivera et al., 2000).

Distribution. Transatlantic and Mediterranean in tropical and subtropical waters (Salazar-Vallejo, 1996–1997); in the Mexican Caribbean previously reported from Cozumel Island by Ochoa-Rivera et al. (2000).

Dorvilleidae Chamberlin, 1919

Ophryotrocha sp. A.

Material examined. Cenote Aerolito, Cozumel Island, Quintana Roo, February 15, 2006 (10 specimens), July 5, 2007 (758 specimens), April 19, 2008 (227 specimens) in soft bottoms associated with mangrove roots, algae, and karst sediments (CPICML-UNAM-PO-53-012).

Description. Most of the specimens complete with 12 to 15 chaetigers, 0.5- to 0.8-mm long and 0.4- to 0.5-mm wide including parapodia. Body short, cylindrical, compressed dorsoventrally, tapering towards pygidium. Prostomium bluntly triangular with two lateral antennae and ciliary aggregations both in the frontal region and at the top. Peristomium with two apodous rings. Parapodia unirramous, with ventral retractile lobe and simple chaetae.

Supra-acicular fascicle with 2 to 3 simple chaetae, infra-acicular fascicle with 4 to 5 heterogomph falcigers and one inferior-most simple Chaeta. Both types of chaetae finely serrated subdistally, tapering to small distal tooth. Pygidium with one pair of minute ovate pygidial cirri. Jaw apparatus with elongate distally bifid mandibles with serrated cutting edge. Maxillary apparatus of P or K type; P type present in smallest specimens and K type in larger specimens. K-forceps distally falcate. D1–D7 denticles attached by ligament to forceps. With blue methyl dye a reduced ciliary distribution on each segment and pygidium is evident

Remarks. The maxillary apparatus known as P-type may have falcate or bidentate forceps and the number of free denticles ranging from five to seven pairs, while the maxillary apparatus known as K-type may have two unidentate, two bidentate, or one unidentate and one bidentate prong and the number of free denticles ranges from six to eight pairs; there may be one, two or three different kinds of denticles in one jaw apparatus. The remarkable feature here is that in these organisms, both types are found, depending on the size of the specimens, raising the question of the importance of this character to differentiate between species in this genus.

Other species of *Ophryotrocha* are opportunistic (Desbruyères et al., 2006) and therefore found in many different habitats, which could explain why this species is so abundant here. Its status as a new species is presently under study.

Nereididae Johnston, 1865

Stenoninereis martini Wesenberg-Lund, 1959

Material examined. Cenote Aerolito, Cozumel Island, Quintana Roo, February 15, 2006 (14 specimens), July 5, 2007 (203 specimens), April 19, 2008 (9 specimens) in soft bottoms associated with mangrove roots.

Comparative material examined. San Julián, Laguna de Términos, Campeche, México 1 March 1984 (18 specimens) (CPICML-UNAM-PO-39-039).

Description. Largest specimen complete with 33 chaetigers, 10.5-mm long and 1.5-mm wide including parapodia, smaller specimen complete with 21 chaetigers, 2.5-mm long and 0.6-mm wide. Prostomium pentagonal, slightly notched frontally. Two pairs of eyes. Frontal antennae cirriform and not longer than distal palps. Palps marginal, globular, biarticulate with elongate conical palpostyles. Peristomium slender with four pairs of tentacular cirri, anterior dorsal pair reaching posterior to chaetiger 6. Pharynx with paired jaws armed with 10 to 12 teeth, no paragnaths or papillae. First two parapodia subbiramous with notopodia reduced to small notoacicula; following parapodia biramous; anterior ones with long dorsal cirri consisting of elongate basal cirrophore and short pyriform cirrostyle, becoming longer towards end of the body. Notopodia trilobate, superior lobe short and digitiform, decreasing in size in posterior chaetigers; inferior lobes subulate, with small presetal lobe at base of upper lobe. Neuropodia with bluntly conical acicular lobe in anterior region, becoming more elongate in middle chaetigers and shorter, more pointed in posterior region. Supra-acicular notochaetae sesquigomph spinigers, infra-acicular notochaetae homogomph spinigers; both with slender appendix, serrated on the inner edge. Supracicular neurochaetae heterogomph and sesquigomph spinigers; one heterogomph spiniger with a strongly serrated short blade on at least three quarters of its length on its inner margin; heterogomph falcigers with spinulose distally hooked long blade. Pygidium with a pair of lateral flattened, wide lobes, and a pair of long anal cirri.

Habitat. Soft bottoms associated with mangrove roots (de León-González and Solís-Weiss, 1997).

Distribution. Laguna de Términos, Campeche, Mexico (de León-González and Solís-Weiss, 1997), greater Caribbean region, San Martín Island, Sarasota Florida, western Gulf of Mexico (Texas), Cuba, North Carolina (Wesenberg-Lund, 1958; Pettibone, 1971; Hartman-Schröeder, 1977).

Syllidae Grube, 1850

Erinaceusyllis centroamericana (Hartmann-Schröder, 1959)

Material examined. Cenote Aerolito, Cozumel Island, Quintana Roo, February 15, 2006 (1 specimen), July 5, 2007 (4 specimens), April 19, 2008 (1 specimen) (CPICML-UNAM-POH-076).

Description. One specimen complete with 21 chaetigers, 1.5-mm long and 0.2-mm wide including parapodia. Body small, covered with small, scattered papillae. Prostomium oval with 4 small eyes in rectangular arrangement and 2 anterior eyespots; antennae pyriform, median and lateral antennae similar in size. Palps short, fused along their length. Peristomium long, tentacular cirri similar to antennae. Dorsal cirri similar to antennae, with bulbous bases and short tips, absent on chaetiger 2. Ventral cirri digitiform. Compound chaetae heterogomph, similar throughout body; blades slender, elongate, unidentate, distally slightly hooked, provided with proportionally long marginal spines on bases of longer blades; parapodia each with one long bladed compound chaeta and 6 falcigers. From chaetiger 1, simple unidentate chaetae with short marginal spines dorsally. Simple chaetae ventrally. Aciculae acuminate, one per parapodium throughout the body. Pharynx extending from chaetigers 1 to 3 or even 4; pharyngeal tooth small and enlarged on anterior margin. Proventricle barrel-shaped, extending from chaetigers 3–6; with about 13 to 16 rows of transverse muscle bands. Pygidium small, with two anal cirri.

Habitat. In sand, algae and mangroves (San Martín, 2005).

Distribution. Circumtropical: El Salvador, Galápagos Islands, Caribbean Sea, Hawaii, Samoa, Angola, Mozambique, Tanzania, Australia (San Martín, 2005). New record for Mexican Caribbean.

Salvatoria sp. 1

Material examined. Cenote Aerolito, Cozumel Island, Quintana Roo, July 5, 2007 (4 specimens), in soft bottoms associated with mangrove roots, algae, and karst sediments (CPICML-UNAM-PO-37-077).

Description. All specimens incomplete, largest with 21 chaetigers, 1.8-mm long and 0.25-mm wide including parapodia. Body small. Prostomium with 3 antennae, 4 eyes and, usually, without 2 eyespots. Palps well developed, joined along their length by a dorsal membrane. Two pairs of tentacular cirri. Antennae tentacular, dorsal cirri long and slender, slightly bulbous at their base and with an elongate, acute tip; dorsal cirri present on all segments. Ventral cirri digitiform, shorter than parapodial lobes. Compound chaetae heterogomph with small indistinct subdistal tooth; dorsal simple chaetae bidentate, with short subdistal marginal spines, ventral simple chaetae not observed. Acicula distally rounded, one per parapodium throughout the body. Pharynx extending through chaetigers 1–3, surrounded by a crown of 12 soft pharyngeal papillae and a small tooth on anterior margin; proventricle of the same length through chaetigers 4–6, with about 19 rows of transverse muscle bands. Pygidium unknown.

Exogone (Paraexogone) sp. 1.

Material examined. Cenote Aerolito, Cozumel Island, Quintana Roo, July 5, 2007 (1 specimen), in soft bottoms associated with mangrove roots and algae (CPICML-UNAM-PO-37-077).

Description. Specimen incomplete with 15 chaetigers, 0.5-mm long and 0.2-mm wide. Body small and slender. Prostomium without antennae, four eyes with 2 eyespots. Palps slender, well developed, completely fused to each other. Tentacular cirri fragmented. Dorsal cirri small, ovoid, present on all segments. Compound chaetae falcigers, incomplete and no spinigers visible, dorsal bifid simple chaetae present from first chaetiger. Acicula distally truncate. Pharynx sinuous, extending through chaetigers 1 and 2, pharyngeal tooth small on anterior margin. Proventricle through chaetigers 2–4, with about 22 rows of transverse muscle bands. Pygidium unknown.

Syllis prolifera Krohn, 1852

Material examined. Cenote Aerolito, Cozumel Island, Quintana Roo, July 5, 2007 (15 specimens), in algae and karst sediments (CPICML-UNAM-PO-37-007).

Description. Largest specimen complete with 48 chaetigers, 9-mm long and 0.25-mm wide. Body thick. Prostomium oval with 4 small eyes in trapezoidal arrangement; median antennae longer than prostomium and palps together, with about 24 articles; lateral antennae with about 29 or 30 articles. Palps triangular, robust, larger than prostomium. Dorsal tentacular cirri long, with about 37 to 45 articles; ventral tentacular cirri with about 33 to 38 articles. Dorsal cirri long and slender, with about 45 to 52 articles. Ventral cirri digitiform. Compound chaetae falcigers, strongly bidentate with teeth of similar size. Aciculae rounded with hollow tips; their number changes depending on body region, four in anterior and median region and only one in posterior region; dorsal bifid simple chaetae present from chaetiger 18 and ventral simple chaetae only present in posterior chaetigers. Pharynx extending through chaetigers 1–7; pharyngeal tooth small on middle dorsal position. Proventricle through chaetigers 7–10, with about 25 rows of transverse muscle bands. Pygidium small, with two anal cirri with 28 to 30 articles.

Habitat. On *Rhizophora mangle* roots, coralline rocks (San Martín, 1992). Abundant in algae, sandy and hard substrate (San Martín, 2003).

Distribution. A cosmopolitan species in tropical and temperate seas (San Martín, 2003). The closest record to the study area is Cuba (San Martín, 1992).

Syllis maryae San Martín, 1992

Material examined. Cenote Aerolito, Cozumel Island, Quintana Roo, April 19, 2008 (1 specimen) (CPICML-UNAM-POH-37-045).

Description. Specimen complete with 61 chaetigers, 8.5-mm long and 0.5-mm wide. Body thick. Prostomium oval with 4 small eyes in trapezoidal arrangement; median antennae longer than prostomium and palps together, with about 25 articles; lateral antennae, with about 12 to 14 articles. Palps triangular, similar in length to prostomium. Dorsal tentacular cirri long, with about 13 to15 articles; ventral tentacular cirri with 10 to 12 articles. Dorsal cirri slender, alternating long (23 to 26 articles) and short (10 to 16 articles). Ventral cirri digitiform. Dorsal glands on segments 14–16. Compound chaetae including 1 or 2 bidentate pseudospinigers with teeth of similar size and about 6 bidentate falcigers with proximal tooth shorter than distal one, and with short spines on cutting margin with dorsoventral gradation. Aciculae distally truncate, forming a right angle, their number changing along the body, two in anterior and median region and only one in posterior region. Pharynx extending through chaetigers 1–7; pharyngeal tooth small on anterior margin. Proventricle through chaetigers 7–10, with about 29 rows of transverse muscle bands. Pygidium small, with two anal cirri with 16 to 18 articles.

Habitat. Shells (San Martín, 1992), dead coral (Granados-Barba et al., 2003).

Distribution. North Carolina, Cuba (San Martín, 1992), Gulf of Mexico (Granados-Barba et al., 2003).

Seasonal Species Occurrence

In this study, the family Dorvilleidae is dominant, with 995 specimens or 65.5% of the polychaetes collected, although it is represented by only one species, *Ophryotrocha* sp. A. Some differences in seasonal distribution were noted. In July 2007 and April 2008, *Paradoneis lyra* was absent, while in February 2006 it was by far the most abundant species (75% of the total). *Syllis prolifera* was present only in July 2007, *Capitella aciculatus* and

Heteromastus filiformis where present only in April 2008, and the specimens of *Salvatoria* sp.1 and *Exogone* sp.1 were present only in July 2007. In all samples and at almost all stations, except in the cave system, (February 2006, July 2007, and April 2008) the *Capitella capitata* species complex and *Ophryotrocha* sp. A, were present (Table 2). The differences observed in species composition and distribution are recorded here as part of this first study on the polychaete fauna of Mexican cenotes, but cannot be fully interpreted at this point until more sampling is carried out. Nevertheless, this study documents both the fact that polychaetes are present and diversified in this habitat, and that seasonal changes or species replacements might take place. It is interesting to note that, in the second sampling period, epitokes were collected from the families Nereididae and Syllidae, while none were present in the first and third sampling periods.

Bottom-water salinity and temperature were different in each sampling period. In February 2006, the salinity was 18.1 ppt with a temperature of 25 °C, in July 2007 the salinity was between 15 and 15.8 ppt and temperature 26.89 to 27.08 °C whereas in April 2008 the salinity was between 19.68 and 20.33 ppt and temperature 24.61 to 24.88 °C. In the cave system, the salinity was 34.71 ppt and temperature 26.03 °C. The sediment in the cave consists of sand of biogenic origin (very fine coral debris).

Discussion

Since this is the first study about polychaetes in cenotes in Mexico, all records are new for Cenote Aerolito itself and its cave system, but so far only the dominant species *Ophryotrocha* sp. A is potentially new to science.

The polychaete species already recorded for the Cozumel area include *Hermodice carunculata* and the so-called complex of species under the name *Capitella capitata*, both recorded from dead coral (Ochoa-Rivera et al., 2000). In this case, the presence of this species complex could be attributed to the abundance of organic matter (mangrove roots, algae) in which the species complex is known to thrive.

At the regional scale, *Stenoninereis martini* is known from Florida, down to the Gulf of Mexico (Términos lagoon) and the greater Caribbean (de León-González and Solís-Weiss, 1997), and the capitellids *Capitella aciculatus* and *Heteromastus filiformis* have also been recorded previously for the greater Caribbean. Although some species of Exogoninae of the Caribbean have been reported by Ruíz-Ramírez and Salazar-Vallejo (2000), the species *Erinaceusyllis centroamericana* is a new record for the Mexican Caribbean. This species had been previously recorded from the West Indies (San Martín, 2005). *Syllis prolifera* is considered cosmopolitan but, like *Syllis maryae*, the closest records to the study area are from Cuba and the Gulf of Mexico (San Martín 1992; 2003).

Conclusions

This first study on polychaetous annelids in Mexican cenotes revealed a relatively diversified (10 genera and 11 species) and interesting polychaete fauna in the best-known and most popular cenote on Cozumel Island. We believe that the underwater connection to the sea, in addition to the nearby mangrove habitat, create propitious conditions for Polychaeta, and many other species can be expected in these unique habitats.

Even though there are important differences between the cenote habitat and a truly marine one, no morphological differences could be observed in any of the species recorded, with the possible exception of the *Ophriotrocha* sp. 1.

Although the best-represented macrofaunal invertebrate animal group in caves and also cenotes is macrofaunal crustaceans (Schmitter-Soto et al., 2002; Mejía-Ortíz et al., 2007b), more recent studies are revealing new taxa. Mejía-Ortíz et al. (2007a) and Solís-Marín and Laguarda-Figueras (2008), for example, found species of all the echinoderm classes except the Crinoidea for the system of caves connected to Cenote Aerolito.

In addition, this study constitutes a baseline study that will be especially important because the cenote is on the verge of being severely transformed by the construction of a marina at its western end, which will include the destruction of the cave in creating a direct connection between the marina area of the cenote to the sea. This will certainly affect the local fauna as we know it now, not only because of the change in salinity, which will become like the surrounding sea, but because of the construction itself and subsequent maritime traffic. All this impact will change the environmental conditions and not only the polychaete composition but also the other fauna groups already recorded.

There is concern in the scientific community, because legislation concerning the cenotes in Mexico is not yet well defined. They are not differentiated from other freshwater bodies, so they cannot be properly protected. The Mexican government agency CONAGUA (Comisión Nacional del Agua) has only begun in 2009 to work on a legal framework to promote the sustainable use and conservation of these unique water bodies.

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Table 2. Abundance of polychaetes collected in Cenote Aerolito and its anchialine cave in 2006–2008.

Taxa	Stations											Total Specimens
	1-06	1-07	2-07	3-07	4-07	1-08	2-08	3-08	4-08	5-08	6-08	
Family Capitellidae Grube, 1862												
Capitella capitata (Fabricius, 1780) *sensu lato*	25	9	16		41	3	2	2	6	8		112
Capitella aciculatus (Hartman, 1959)									2			2
Heteromastus filiformis (Claparède, 1864)							2					2
Family Paraonidae Cerruti, 1909												
Paradoneis lyra (Southern, 1914)	154											154
Family Amphinomidae Lamarck, 1818												
Hermodice carunculata (Pallas, 1766)											2	2
Family Dorvilleidae Chamberlin, 1919												
Ophryotroca sp. A	10	144	34	239	341	84	8	10	4	121		995
Family Nereididae Johnston, 1845												
Stenoninereis martini Wesenberg-Lund, 1959	14		91		112	1		8				226
Family Syllidae Grube, 1850												
Subfamily Exogoninae Langerhans, 1879												
Erinaceusyllis centroamericana (Hartmann-Schröder, 1959)	1	2	1		1					1		6
Salvatoria sp.1			3		1							4
Exogone sp.1					1							1
Subfamily Syllinae Grube, 1850												
Syllis prolifera Krohn, 1852		1	13	1								15
Syllis maryae San Martín, 1992										1		1

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