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New records of marine planktonic invertebrates from the Caribbean coast of Costa Rica

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Abstract: The coral reef at Cahuita National Park in the Caribbean coast of Costa Rica represents very diverse marine ecosystem. Most of this diversity knowledge has been the result of benthic surveys, while very little is known from pelagic studies. A zooplankton survey sampling was conducted monthly from September 2010 to August 2011, finding new records of marine invertebrates: 32 for the Caribbean coast of Costa Rica, seven for Costa Rican water and 16 for the Caribbean coast of Central America. These reports include the hoplitomella larva of the sponge *Thoosa* sp., larval stages of three lophophorates, seven families, five genera and six species of polychaetes, a juvenile of the lancet *Branchiostoma* (Phylum Chordata, Subphylum Cephalochordata) and four pelagic chordates. Analyzing the zooplankton of Cahuita, is an essential approach to studying not only the diversity, but also enhances the possibility of better understanding the ecological goods and services that the coral reef can provide. Rev. Biol. Trop. 66(Suppl. 1): S66-S82. Epub 2018 April 01.

Key words: Cahuita, coral reef, marine invertebrate larva, polychaetes, zooplankton.

Coral reefs are the most diverse marine ecosystems, with an estimate of as many as 9 million species worldwide (Plaisance, Caley, Brainard, & Knowlton, 2011; Fisher et al., 2015). The Caribbean region is not the exception, with over 12 000 species in all marine realms (Miloslavich et al., 2010). Most of the reported diversity lies on the benthic fauna, like so many marine habitats (Angel, 1993). But a significant portion is also on the pelagic realm, which harbors a vast diversity of fish and zooplankton (Suárez-Morales & Rivera, 1998). Coral reef zooplankton includes holoplanktonic (e.g. microcrustaceans, appendicularians, chaetognats), meroplanktonic (e.g. marine invertebrate larvae and ichthyoplankton) or epibenthic forms (e.g. microcrustaceans) (Emery, 1968; Glynn, 1973). The species records for these components of zooplankton are being understood in combination with DNA barcoding and phylogeographic studies to better assessed the dynamics of the planktonic communities (Bucklin et al., 2010).

In the Caribbean coast of Costa Rica, most of the coral reef studies have focused on benthic fauna and reef fishes (Cortés & Jiménez, 2003; Fonseca & Gamboa, 2003). These studies had emphasized the fringing reef at Cahuita National Park as having relatively low diversity, due to siltation and anthropogenic impacts on the coral reef (Cortés & Risk, 1985; Cortés, Jiménez, Fonseca, & Alvarado, 2010). Morales-Ramírez & Murillo (1996) suggested that this degradation also affects the meroplankton, presumably reducing the spawning events, feeding or swimming behavior of

larvae. Meroplanktonic forms are of interest, because they could contribute to the benthic diversity, connectivity and dispersal of coral reef organisms (Heidelberg, Sebens, & Purcell, 2004). Here, we present new records of marine invertebrates represented by meroplankic and holoplanktonic organisms, collected from the coral reef of Cahuita National Park, Caribbean coast of Costa Rica. We present these new records across a variety of invertebrate clades, to highlight the diversity of groups that have been underrepresented or unnoticed by performing benthic surveys.

MATERIAL AND METHODS

From September 2010 to August 2011, two 5 min horizontal tows were done at six stations in Cahuita's coral reef (either between 6:00-10:00 or 12:00-17:00) (Fig. 1, Table 1). Once a month, two samples of zooplankton were collected using a WP net 0.47 m in diameter and a 200 µm mesh, attached with a calibrated flow meter and a buoy to maintain the net at approximately 1 m depth. Samples were fixed with a 4 % v/v formaldehyde in seawater, and transferred to 70 % ethanol for preservation.

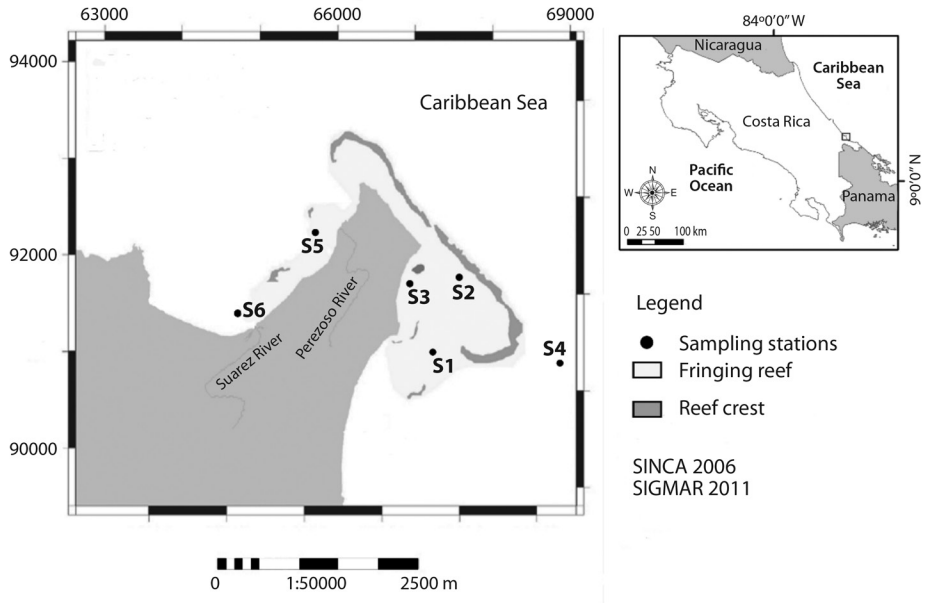

Fig. 1. Location of the stations sampled between September 2010 and August 2011 at Cahuita National Park, Limón, Costa Rica (modified from Fonseca, Salas, & Cortés, 2006).

TABLE 1
Geographical coordinates of the stations sampled at Cahuita National Park, Limon, Costa Rica

Station	Range of bottom depth (m)	Coordinates
1	4-6	9°44'09.85" N - 82°48'23.96" W
2	2-3.5	9°44'31.25" N - 82°48'13.52" W
3	1.5-2	9°44'30.45" N - 82°48'30.88" W
4	10-15	9°44'03.30" N - 82°47'29.43" W
5	5-7.5	9°44'43.00" N - 82°49'18.69" W
6	4-6	9°44'16.30" N - 82°49'40.53" W

Subsamples of 2 ml were sorted and quantified until reaching a minimum of 400 zooplankters. Specimens were separated by group; unknown meroplanktonic and holoplanktonic specimens were sorted from the sample for taxonomic analysis. Here we report the new records for the Caribbean coast of Costa Rica. Annelids were deposited in the Museo de Zoología, Universidad de Costa Rica (MZ-UCR).

RESULTS

We report in this study the occurrence of the larval forms of 13 invertebrate taxa, including an hoplitomella larvae of the boring sponge *Thoosa*, "lophophorates" larval stages: an actinotroch of phoronids, ciphonaute of bryozoans and lobate of brachiopods. We also report seven families (six as larval stages and the remaining as adults or epitokes), five genera and six species of polychaetes as new records for the Caribbean coast of Costa Rica. Of those polychaete families found, only adult stages of Amphinomidae, Sabellidae, Spionidae and Syllidae were reported previously for this location (Dean 2009, 2012, 2017) (Table 2). Unidentified larvae of echinoids and ophiurids, as well as unidentified larvae of mollusks

TABLE 2
New records of marine invertebrate fauna from the coral reef of Cahuita National Park. NR: new record; X: previously recorded; CR: Costa Rican waters; CarCR: Caribbean of Costa Rica; CarCA: Caribbean coast of Central America.

Taxa	Record status			Life stage
	CarCR	CR	CarCA	
Phylum Porifera				
Class Demospongiae				
Family Thoosidae	NR	X	X	
Thoosa sp.	NR	X	X	Hoplitomella larva
Phylum Brachiopoda				
Class Lingulata	NR	X	NR	
Family Lingulidae	NR	X	NR	
?*Lingula* sp.	NR	NR	NR	Larvae
Phylum Bryozoa				
Class Gymnolaemata	X	X	X	Cyphonautes larvae
Phylum Phoronida				
?*Phoronis* sp.	NR	NR	X	Actinotroch larva
Phylum Annelida				
Class Polychaeta				
Family Alciopidae	NR	X	NR	
Alciopina parasitica	NR	X	NR	Adult
Family Amphinomidae	X	X	X	
Hipponoe gaudichaudi	NR	NR	NR	Larva
Family Magelonidae	NR	X	X	
Magelona sp.	NR	X	X	Metatrochophore larvae
Family Maldanidae	X	X	X	Larvae
Family Paraonidae	NR	X	X	
Aricidea (*Acmira*) *simplex*	NR	NR	X	Adult
Family Pectinariidae	NR	X	NR	Larvae
Family Phyllodocidae	NR	X	X	
?*Sige* sp.	NR	X	X	Metatrochophore larvae
Family Sabellidae	X	X	X	
Parasabella jamaicensis	X	X	X	Juvenile
Family Spionidae	X	X	X	Metatrochophore larvae
Family Syllidae	X	X	X	

TABLE 2 (Continued)

Taxa	Record status			Life stage
Subfamily Autolytinae	NR	X	X	Adult epitoke, male polybranchius
Subfamily Eusyllinae	X	X	X	
Odontosyllis sp.	X	X	X	Larva
Subfamily Exogoninae	X	X	X	
Exogone breviantennata	NR	X	NR	Adult
Subfamily Syllinae	X	X	X	
Syllis cf. *armillaris*	NR	NR	X	Adult
Trypanosyllis parvidentata	NR	NR	X	Adult
Family Terebellidae	NR	X	X	Larva
Family Trichobranchidae	NR	X	X	Larva
Phylum Chordata				
Subphylum Cephalochordata	NR	X	NR	
Family Branchiostomidae	NR	X	NR	
Branchiostoma sp.	NR	X	NR	Juvenile
Subphylum Tunicata				
Class Larvacea				
Family Fritillaridae	NR	X	NR	
Fritillaria formica	NR	X	NR	Adult
Fritillaria haplostoma	NR	X	NR	Adult
Family Oikopleuridae	NR	X	X	
Oikropleura longicauda	NR	X	NR	Adult
Class Thaliacea				
Family Doliolidae	NR	X	X	
Doliolum nationalis	NR	NR	NR	Ozooids blastozooids

were found year-round. Finally, in addition to meroplanktonic forms, we found a juvenile of the lancet *Branchiostoma*, and new holoplanktonic records represented by four members of Tunicata: three appendicularians and one salp. Altogether, we present 32 new reports for the Caribbean coast of Costa Rica, seven for Costa Rican waters and 16 for the Caribbean coast of Central America. Spatiotemporally mean abundance in for these groups at Cahuita NP is reported in Table 3.

SYSTEMATICS

Phylum Porifera Grant, 1836
Class Demospongiae Sollas, 1885
Order Astrophorida Sollas, 1887
Familiy Thoosidae Cockerell, 1925
Thoosa Hancock, 1849
Thoosa sp.

Locality: Puerto Vargas, Outer crest (Station (St.) 4): Nov 2010; Perezoso River (St.5): Dec 2010; Shallow patch (St.3): Dec 2010; Deep patch (St.2): Dec 2010, Jun 2011.

Remarks: Larval specimens have strongyles-like plates, characteristic of the hoplitomella larvae of the astrophoridean sponge *Thoosa* (Maldonado & Berquist, 2002; Bautista-Guerrero, Carballo, & Maldonado, 2010). These larva lack cilia and have the characteristic spicules discostrongyles, and radiating styles. *Thoosa* sponges are viviparous, and use the radiating styles to get free from the parental tissue to the water column, where the styles get a buoyancy function (Bautista-Guerrero et al., 2010).

Thoosa species have been found boring the corals *Montastraea annularis* (Ellis & Solander, 1786) and *Montastraea cavernosa* (Linnaeus, 1767) in Belize (Highsmith, Lueptow, & Schonberg, 1983), as well as in Cuba (Miloslavich et al., 2010; Table S3). Cortés, Van der Hal, & Van Soest (2009) reported an unidentified species of an adult Thoosa from Punta Morales on the Pacific coast of Costa Rica.

TABLE 3
Mean abundance (± standard error) ind./m^3 of new records of zooplankton from Cahuita National Park, Limón; from September 2010 to August 2011

Taxa*	Month												Station					
	Set.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	1	2	3	4	5	6
Hop	0 ± 0	0 ± 0	1 ± 1	8 ± 4	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1	0 ± 0	0 ± 0	0 ± 0	2 ± 1	1 ± 1	1 ± 1	2 ± 1	0 ± 0
Brac	5 ± 5	4 ± 2	0 ± 0	9 ± 4	0 ± 0	0 ± 0	3 ± 2	3 ± 2	4 ± 4	0 ± 0	0 ± 0	1 ± 1	2 ± 1	7 ± 3	1 ± 1	0 ± 0	4 ± 3	2 ± 1
Bryo	63 ± 50	13 ± 6	85 ± 25	11 ± 5	443 ± 110	0 ± 0	2 ± 1	11 ± 7	354 ± 125	418 ± 113	75 ± 34	83 ± 37	141 ± 60	130 ± 48	48 ± 21	205 ± 74	56 ± 31	200 ± 68
Phor	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2 ± 1	1 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.2 ± 0	1 ± 1	0 ± 0	0 ± 0	0 ± 0
Apar	0 ± 0	1 ± 1	4 ± 4	0 ± 0	11 ± 4	1 ± 0	0 ± 0	2 ± 2	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1	2 ± 2	1 ± 0	2 ± 2	0 ± 0	3 ± 2
Hgau	9 ± 5	23 ± 10	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	6 ± 4	2 ± 2	4 ± 3	1 ± 1	2 ± 2
Mag	1 ± 1	0 ± 0	18 ± 17	5 ± 3	0 ± 0	2 ± 1	5 ± 2	2 ± 2	0 ± 0	1 ± 1	7 ± 4	3 ± 3	3 ± 2	12 ± 9	1 ± 1	2 ± 2	2 ± 1	3 ± 2
Mald	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1	0 ± 0	0.3 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Nereid	0 ± 0	1 ± 1	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.4 ± 0	0 ± 0
Pect	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.3 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Phyl	0 ± 0	0 ± 0	0 ± 0	4 ± 5	1 ± 1	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1	0 ± 0	0 ± 0	2 ± 2	1 ± 1	0 ± 0	0 ± 0	0.4 ± 0	0 ± 0
Spio	50 ± 22	61 ± 24	73 ± 34	41 ± 12	2 ± 2	19 ± 5	40 ± 11	35 ± 16	81 ± 32	35 ± 8	37 ± 16	9 ± 4	59 ± 17	41 ± 17	40 ± 9	41 ± 14	39 ± 13	21 ± 7
Syll	6 ± 5	0 ± 0	2 ± 2	3 ± 2	0 ± 0	0 ± 0	1 ± 1	0 ± 0	7 ± 7	2 ± 2	0 ± 0	1 ± 1	1 ± 0	0.3 ± 0	1 ± 1	3 ± 3	4 ± 9	2 ± 5
Tereb	0.4 ± 0	6 ± 4	0 ± 0	0 ± 0	3 ± 3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1	2 ± 1	4 ± 2	0 ± 0	0.4 ± 0	0 ± 0	0 ± 0
Trich	0 ± 0	0 ± 0	0 ± 0	3 ± 2	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1
Fritil	162 ± 62	0 ± 0	0 ± 0	0 ± 0	0.3 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	41 ± 32	10 ± 7	20 ± 15	9 ± 8	3 ± 2
Oiko	510 ± 110	538 ± 176	7274 ± 2239	1362 ± 653	62 ± 25	118 ± 48	172 ± 45	322 ± 114	4476 ± 1506	926 ± 154	465 ± 107	456 ± 90	3423 ± 1293	1164 ± 522	1076 ± 761	1654 ± 557	544 ± 186	479 ± 109
Dolio	0.4 ± 0	0 ± 0	66 ± 35	3 ± 2	0 ± 0	0 ± 0	0 ± 0	1 ± 1	1738 ± 696	82 ± 29	21 ± 10	3 ± 2	34 ± 17	35 ± 18	8 ± 4	522 ± 371	255 ± 175	105 ± 70
Amp	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2 ± 2	0 ± 0	0 ± 0	0 ± 0	0 ± 0	4 ± 3	0 ± 0	0 ± 0	1 ± 1	2 ± 1	0 ± 0	0 ± 0	0 ± 0	0 ± 0

***Taxa:** Hop: Hoplitomella larvae of sponge *Thoosa*; Brac: brachiopod larvae; Bryo: bryozoan larvae; Phor: ?*Phoronis* sp. larva; Apar: *Alciopina parasitica*; Hgau: *Hipponoe* Amphinomidae; Magel: *Magelona* sp.; Mald: Maldanidae; Nerei: *Ceratonereis* sp.; Pectin: Pectinariidae; Phyll: Phyllodocidae; Spio: Spionidae; Syll; Syllidae; Tereb: Terebellidae; Trich: Trichobranchidae; Fritil: *Fritillaria*; Oiko: *Oikopleura*; Amp: *Branchiostoma* sp.; Dolio: *Doliolum nationalis.*

Phylum Brachiopoda Duméril, 1806
Class Lingulata Goryanskij & Popov, 1985
Lingulata indet.

Locality: all stations, year-round.

Remarks: Specimens having two larval shells and 13 cirri were similar to the larvae of *Lingula* sp. (Pennington & Stricker, 2002). This genus has been reported for the Caribbean of Colombia Caribbean (Ávila-de Tábares et al., 2007). Emig (2009a) mentions that only *Liothyrella moseleyi* (Davidson, 1878) member of the Class Rhynchonellata has been found offshore of Martinique, which makes the specimen of this study the first record of lingulate brachiopods for the Caribbean coast of Central America.

Phylum Bryozoa Ehrenberg, 1831
Class Gymnolaemata Allman, 1856
Gymnolaemata indet.

Locality: all stations, year-round.

Remarks: Cyphonautes larvae belonging to the gymnolaemate bryozoans were found in all the stations in most of the months sampled. These larvae have a lateral compressed triangular body bearing an apical sense organ with few cilia and a ciliated corona on the opposite side (Temkin & Zimmer, 2002). Ávila-de Tábares et al. (2007) also reported cyphonautes larvae for the Colombian Caribbean.

Phylum Phoronida Haetschek, 1888
Phoronis Wright, 1856
?*Phoronis* sp.
(Figure 2)

Locality: Puerto Vargas, Shallow patch (St.3): Mar 2011; Deep patch (St.2): Apr 2011.

Remarks: The actinotroch larva from Cahuita has distinct pre-oral lobe, larval tentacles and the stomach diverticulum matching the larva of *Phoronis* sp. described by Ávila-de Tábares, Martínez-Ramírez, & Franco-Herrera (2007) for the Caribbean coast of Colombia. Emig (2009b) confirmed the presence of three species of *Phoronis* from the Caribbean coast of Panama: *Phoronis hippocrepia* Whrigth, 1856, *Phoronis muelleri* Selys-Longchamps, 1903

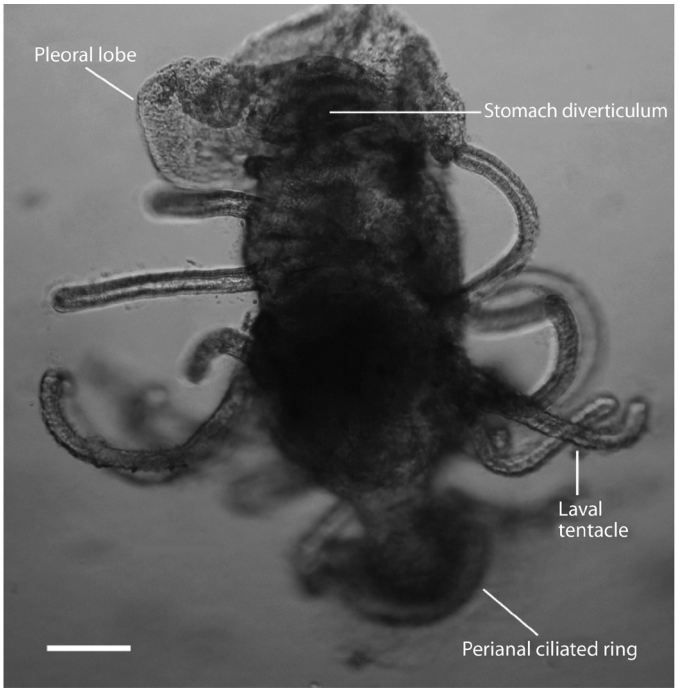

Fig. 2. Actinotroch larva of ?*Phoronis* sp. found at Cahuita's coral reef. Scale bar: 100 μm.

and *Phoronis psammophila* Cori, 1889. Specimens from Cahuita match with the description of *Actinotrocha sabatieri* (Roule, 1896) larvae of *P. psammophila*. These specimens are the second report of phoronids for Costa Rican waters after the finding of the adult *Phoronopsis albomaculata* Gilchrist, 1907 in Isla del Coco, Pacific of Costa Rica (Dean, Sibaja-Cordero, & Cortés, 2010).

Phylum Annelida Lamarck, 1809
Class Polychaeta Grube, 1850
Family Alciopidae Ehlers, 1864
Alciopina Clapèrede & Panceri, 1867
Alciopina parasitica Clapèrede & Panceri, 1867

Locality: Puerto Vargas, Deep patch (St.2): Nov 2010. Outer crest (St.4): Nov 2010 (MZ-UCR 291-01).

Remarks: The specimens have folliaceous parapodia cirri, with acicular simple, capillary chaetae. Chetigerous lobes absent (Støp-Bowitz, 1996; Fernández-Álamo, 2009). This holoplanktonic species is distributed in the Atlantic Ocean, and Indo- Pacific region (Fernández-Álamo, 2009). In the Caribbean Sea, the first record was for the Yucatan Peninsula (Jiménez-Cueto & Suárez-Morales, 2008). Later, Díaz, Radha, Liñero-Arana, & Marín (2009) reported this species in Venezuela, but this study is the first report for the Caribbean of Central America.

Family Amphinomidae Savigny
in Lamarck, 1818
Hipponoe Audouin & Milne Edwards, 1830
Hipponoe gaudichaudi Audouin &
Milne Edwards, 1830

Locality: all stations: Sep and Nov 2010; except for Puerto Vargas, Inner Crest (St.1) (MZ-UCR 297-01).

Remarks: This species is recognized by the absence of a caruncle (fleshy outgrowth of the nuchal organs in the prostomium) and neurochaetae with simple hooks (Yáñez-Rivera, 2009). Frequently found in floating logs or within the valves of the barnacles of the genus *Lepas* (Núñez, Riera, & Brito, 2010). That is the reason why Moore (1903) considered it a pelagic species.

Family Magelonidae
Cunningham & Ramage, 1888
Magelona Müller, 1858
Magelona sp.

Locality: all stations, year-round except Oct 2010, Jan and May 2011 (MZ-UCR 291-01).

Remarks: This larva presents long, coiled and flexible prototrochal tentacles (Plate & Husemann, 1994). It has acharacteristic flat, shovel-shaped prostomium and dentate hooded hooks (Hernández-Alcántara & Solís-Weiss, 2009).

Seven species have been reported for the Caribbean (Salazar-Vallejo, 1996). *Magelona pettiboneae* Jones, 1963 and *Magelona riojai* Jones, 1963 reported from Belize, are the nearest species to Costa Rica (Dean, 2009).

Family Maldanidae Malmgren, 1867
Maldanidae indet.

Locality: Puerto Vargas, Deep patch (St.2): Aug 2011 (MZ-UCR 299-01).

Remarks: This family has a truncate anterior end, with a head consisting of keel between two nuchal slits (Salazar-Vallejo & Díaz-Díaz, 2009). 18 genera and 24 species are reported for the Caribbean (Salazar-Vallejo, 1996). Adults of *Clymenella* sp. and *Isocirrus longiceps* (Moore, 1923) have been found in the Gulf of Nicoya, Pacific coast of Costa Rica (Dean, 2009).

Family Paraonidae Cerruti, 1909
Aricidea Webster, 1879
Aricidea (*Acmira*) *simplex* Day, 1963
(Figure 3A)

Locality: Puerto Vargas, Shallow patch (St.3): Oct 2010 (MZ-UCR 285-01).

Remarks: Adult with a median antenna in the prostomium, without eyes. Branchiae starts

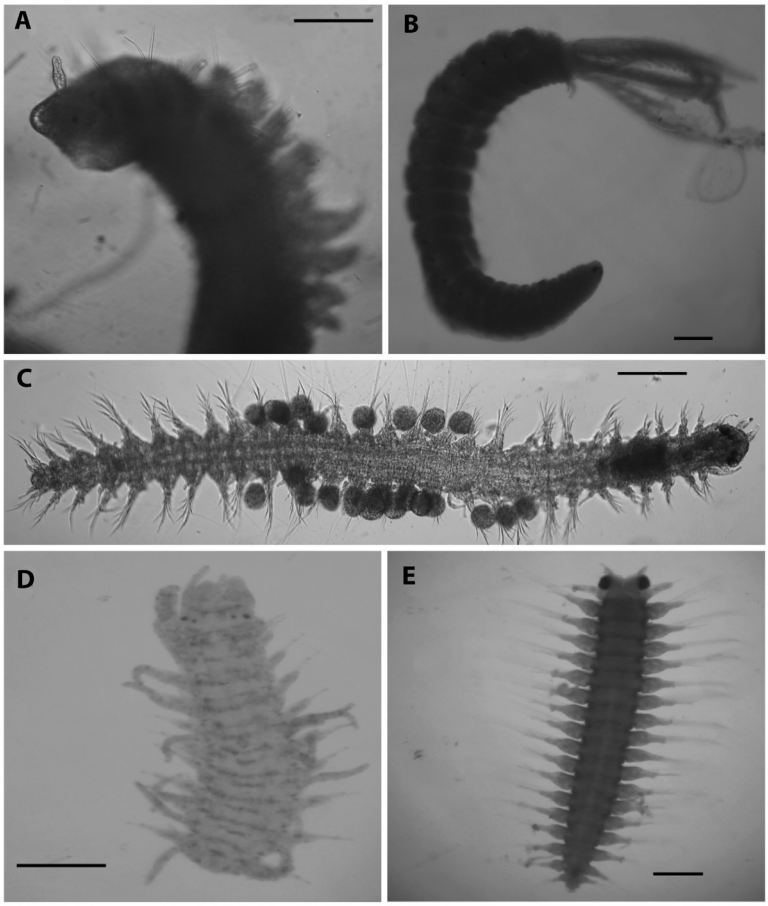

Fig. 3. Diversity of polychaetes found in zooplankton tows at Cahuita's coral reef; **A:** *Aricidea* (*Acmira*) *simplex* Day, 1963; **B:** *Parasabella jamaicensis* Augener, 1924; **C:** *Exogone* (*Exogone*) *breviantennata* Eisig, 1870; **D:** *Syllis* cf. *armillaris* Müller, 1776; **E:** *Trypanosyllis parvidentata* Perkins, 1981. Scale bars: (A, C-E), 100 µm; (B) 500 µm.

at the 4th setiger. Winged capillary chaetae on the anterior, and without wings on the posterior. Neurochaetae with wide hooks, curved spiniform (Solís-Weiss, 1996). This species had been recorded for deep benthic waters from Venezuela (Bone & Chollett, 2005).

Family Pectinariidae Quatrefages, 1866
Pectinariidae indet.

Locality: Puerto Vargas, Inner crest (St.1): Jan 2011 (MZ-UCR 292-01).

Remarks: Specimens with tusk-shape tubes, open in both sides (Londoño-Mesa, 2009a). This characteristic is present also in the nectochaete (Plate & Husemann, 1994). Six species in two genera are reported for the Greater Caribbean (Londoño-Mesa, 2009a).

Family Phyllodocidae Örsted, 1843
Sige Malmgren, 1865
?*Sige* sp.

Locality: Puerto Vargas, Inner crest (St.1): Dec 2010; Perezoso River: Jan 2011 MZ-UCR 298-01).

Remarks: The specimens are in the metatrochophore stage with segment 1 fused to segment 2 and showing flat ventral tentacular cirri. Only *Sige belizensis* Eibye-Jacobsen,

1992 for Belize, *Sige parvicirrus* (Perkins, 1984) for Florida, and *Sige macroceros orientalis* Imajima and Hartman, 1964 have been reported for the Greater Caribbean (Salazar-Vallejo, 1996; Perkins, 1998; Dean, 2012).

Family Sabellidae Latreille, 1825
Parasabella Bush, 1905
Parasabella jamaicensis Augener, 1924
(Figure 3B)

Locality: Puerto Vargas, Shallow patch (St.3): Nov 2010 (MZ-UCR 286-01).

Remarks: Thoracic uncini with avicular appearance. Abdomen with a row of neuropodial chaetae, thoracic notochaetae broadly hooded. Radioles without ocelli (Tovar-Hernández & Salazar-Vallejo, 2006). Fewer radioles and abdominal chaetigers on Cahuita's specimen indicate that it is a juvenile, in comparison with the adult found by Dean (2017).

Family Spionidae Grube, 1850
Spionidae spp. indet.

Locality: all stations, year-round.

Remarks: Trochophores and metatrochophores are frequently found in zooplankton surveys, because a planktotrophic or lecithotrophic larvae are present in most of the reproductive strategies of Spionidae (Wilson, 1991). Most of the nectochaetes have two pair of short or long palps and two or three pair of eyes (Plate & Husemann 1994). *Scolelepis* (*Scolelepis*) *squamata* (O. F. Müller, 1806) was recorded for Cahuita, and it is the only spionid for the Caribbean coast of Costa Rica (Dean, 2009), in overall of 25 genera and 56 species recorded for the Greater Caribbean (Delgado-Blas, 2009).

Family Syllidae Grube, 1850
Subfamily Autolytinae Langerhans, 1879
Autolytinnae indet.

Locality: Puerto Vargas, Inner crest (St.1): Feb 2011; Suarez River (St. 6): Feb 2011 (MZ-UCR 293-01).

Remarks: Palps not so well developed. Head appendages not articulated. Ventral cirri absent (Góngora-Garza, 2009). Autolytoids are rare in the plankton, most in the form of stolons. The collected specimen belongs to a male stolon or "polybostrichus", with a bifid antennae on the front of the head and three posterior horns (Franke, 1999). Allen (1957) found both male and female stolons at La Parguera, Puerto Rico. There are three genera and 11 spp. of this subfamily in the Greater Caribbean (Góngora-Garza, 2009).

Subfamily Eusyllinae Malaquin, 1893
Odontosyllis Claparède, 1863
Odontosyllis sp.

Locality: Puerto Vargas, Shallow patch (St.3): Mar 2011 (MZ-UCR 296-01).

Remarks: Eversible pharynx, armed without a complete trepan or a median dorsal tooth. Eight species are recorded for the Greater Caribbean (Góngora-Garza, 2009; Dean, 2012). *Odontosyllis luminosa* San Martín, 1990 and *Odontosyllis twincayensis* Russell, 1989 from Belize, are the closest to the Caribbean coast of Costa Rica (Dean, 2009).

Subfamily Exogoninae Langerhans, 1879
Exogone Örsted, 1845
Exogone (*Exogone*) *breviantennata*
Hartmann-Schröeder, 1959
(*sensu* Zottoli and Long, 2000)
(Figure 3C)

Locality: Perezoso River (St.5): Nov 2010 (MZ-UCR 288-02).

Remarks: The specimen is an epigamic female incubating eggs, and presents a digitiform antenna and rounded acicula (Ruíz-Ramírez & Salazar-Vallejo, 2001). The species has been previously reported as an adult for Cuba, Florida and Venezuela (San Martín, 1991; San Martín & Bone, 2001); in Costa Rica from the Gulf of Nicoya and Isla del Coco (Dean, 2009; Dean, Sibaja-Cordero, & Cortés, 2012).

Subfamily Syllinae Rioja, 1925
Syllis Lamarck, 1818
Syllis cf. *armillaris* (O. F. Müller, 1776)
(Figure 3D)

Locality: Suárez River (St.6): Dec 2010 (MZ-UCR 289-01).

Remarks: Median antenna with nine articles, lateral antenna with 13 articles and dorsal cirri at the mid-body with 10 articles. With an acuminate aciculae, matching Góngora-Garza (2009) and Liñero-Arana & Díaz-Díaz (2011). Found as commensal of hermit crabs in the Mediterranean Sea (López, Britayev, Martin, & San Martín, 2001).

Trypanosyllis Claparède, 1864
Trypanosyllis parvidentata Perkins, 1981
(Figure 3E)

Locality: Puerto Vargas, Shallow patch (St.3): Nov 2010, Jan 2011; Inner crest (St.1) and Deep patch (St.2): Jan 2011 (MZ-UCR 290-01).

Remarks: With a trepan consisting of 10 small teeth, and one single-median large tooth (Góngora-Garza, 2009). It has been found in Mexico (Granados-Barba, Solíz-Weiss, Tovar-Hernández, & Ochoa-Rivera, 2003) and Venezuela (Liñero-Arana & Díaz-Díaz, 2011)

Family Terebellidae Malmgren, 1867
Terebellidae indet.

Locality: Puerto Vargas, Inner crest (St.1): Oct 2010, Jan and Aug 2011; Deep patch (St.2): Sep and Oct 2010 and Jan 2011; Outer crest (St.4): Aug 2011 (MZ-UCR 295-01).

Remarks: With one or more stout anterior tentacles (Cumrine, 2001). Thoracic and abdominal uncini with short shaft (Harris, de León-González, & Salazar-Vallejo, 2009). Nineteen genera and 33 species have been reported for the region (Londoño-Mesa, 2009b).

Family Trichobranchidae Malmgren, 1866
Trichobranchidae indet.

Locality: Suáres River (St.6): Dec 2010 (MZ-UCR 291-02).

Remarks: Thoracid uncini with long shaft, abdominal unicni with short shaft (Harris et al. 2009). Two genera and five species have been reported for the Caribbean region (Solís-Weiss, Londoño-Mesa, & Hernández-Alcántara, 2009). Rouse & Pleijel (2001) and Garrafoni & Lana (2008) consider Trichobranchidae as a subfamily of Terebellidae.

Phylum Chordata Haeckel, 1874
Subphylum Cephalochordata Owen, 1846
Class Leptocardii
Family Branchiostomidae
Branchiostoma Bonaparte, 1941
Branchiostoma sp.

Locality: Puerto Vargas, Deep patch (St.2): Jan 2011, Jun 2011; Outer crest (St.4): Jan 2011; Inner crest (St.1): Jun 2011.

Remarks: The presence of a gonad on each lateral site of the body confirms that the specimens belong to *Branchiostoma* (Poss & Boschung, 1996). However, the lack of well-defined myotomes or segments of the dorsal storage chamber, reflects their juvenile stage, which inhibits the clarification to a species level.

Subphylum Tunicata Lamarck, 1816
Class Appendicularia
Order Copelata
Family Fritillariidae Lohman, 1915
Fritillaria Fol, 1872
Fritillaria formica Fol, 1872

Locality: all stations: Set 2010.

Remarks: Strongly bend trunk. Length up to 2 mm. With two lateral lobes and one median lobe on the mouth (Esnal, 1999). At

Chinchorro Bay, Caribbean of Mexico, is the second most abundant species of appendicularians after *Oikopleura* (*Coecaria*) *longicauda* (Vogth, 1864) (Castellanos-Osorio 2003). This is the first record of the family for the Caribbean coast of Central America.

Fritillaria haplostoma Fol, 1872

Locality: all stations: Set 2010.

Remarks: Slightly bend trunk, not as strong or long as *Fritillaria formica*. No lobes on the mouth (Esnal, 1999). On the southern Gulf of Mexico, it can represent up to 49 % of appendicularian abundance (Flores-Coto, San Vicente-Añorve, & Sánchez-Ramírez, 2010).

Family Oikopleuridae Lohman, 1915
Oikopleura Mertens, 1830
Oikopleura (*Coecaria*) *longicauda*
(Vogth, 1864)

Locality: all stations, year-round.

Remarks: Specimens presented a compact trunk and muscular tail. Postcardial caecum joins the genital wall of the esophagus (Esnal, 1999). The most abundant appendicularian in the Caribbean (Castellanos, Suárez-Morales, & Morales-Ramírez, 2009). As well as the *Fritillaria* species, they are found throughout the Greater Caribbean and the South Atlantic (Esnal, 1999), but this is the first report for the Caribbean of Central America, after the genus *Oikopleura* was reported in the San Blas Archipielago in Panama (D'Croz, Robertson, & Martínez, 1999).

Class Thaliacea Nielsen, 1995
Order Doliolida
Family Doliolidae
Doliolum Quoy & Gaimard, 1834
Doliolum nationalis Borgert, 1893

Locality: all stations; September and November 2010, from April to August 2011.

Remarks: With a barrel form, Thaliacea is characterized by an alternation of asexual (oozooids) and sexual (blastozooids) generations (Esnal, 1996). Oozooids have nine muscular bands and blastozooids have eight, in the doliolids (Esnal & Daponte, 1999). In Cahuita, both generations of *Doliolum nationalis* were found. Specimens have a gill-septum that extended from the muscular band II to the muscular band V and VI (Bone, 1998).

Esnal & Daponte (1999) mentioned a neritic distribution for the salp *D. nationalis*. Specimens of *Doliolum* have been found in coral reefs of Barbados (Lewis & Fish 1969; Moore & Sander, 1976), Venezuela (Casanova, Zoppi de Roa, & Montiel, 2007), offshore of Jamaica (Moore & Sander 1976, 1979). *Doliolum nationalis* have been reported for Port Royal Cays in Jamaica (Webber, Roff, Chisholm, & Clarke, 1996). This is the first record of this species for Central American waters, after specimens of *Doliolum* sp. was reported in Isla del Coco, Pacific of Costa Rica (Morales-Ramírez, 2008).

DISCUSSION

The Caribbean coast of Costa Rica does not have as many species as other countries in the Caribbean and Western Atlantic (Cortés & Wehrtmann, 2005). However, it is considered the most diverse country of the region, in terms of the numbers of species related to the coastline length (Wehrtmann, Cortés, & Echeverría-Sáenz, 2009).

An example of this diversity is shown here with new records of a variety of developmental stages of important biogenic architects of the coral reef (Cocito, Ferdeghini, & Sgorbini, 2001), such as sponges, polychaetes and "lophophorates". In addition, unidentified larvae of echinoderms and mollusks were a large year-around component of Cahuita's zooplankton (Morales-Ramírez & Murillo, 1996). Apart from the meroplantonick forms, 13 new records of copepods (Morales-Ramírez, Suárez-Morales, Corrales-Ugalde, & Esquivel-Garrote, 2014), and the description of two new species of monstrilloid copepods: *Monstrillopsis cahuitae* Suárez-Morales & Carrillo, 2013 and *Cymbasoma alvaroi* Suárez-Morales

& Carrillo, 2013, were previously reported (Suárez-Morales, Carrillo-Baltodano, & Morales-Ramírez, 2013). Moreover, although highly abundant, only two records at the specific level of pelagic chordates were reported for the Caribbean of Costa Rica (Castellanos et al., 2009) until the present study. Reported here are four species of tunicates and one species of cephalochordates, which is likely an underestimate of their diversity and more species could be found in oceanic waters of the region.

Considering polychaetes, Miloslavich et al. (2010; Table S5) showed Costa Rica as having the lowest richness on the South-Western Caribbean ecoregion (the other four are: Western Caribbean, Southern Caribbean, Greater Antilles and Eastern Caribbean), the ecoregion with the lowest polychaete richness. This trend was also seen by Dean (2009, 2012, 2017) who argued that this discrepancy is due to the low sampling effort especially along the Caribbean coasts of Nicaragua and Costa Rica.

In the present study, we increase the knowledge concerning polychaete identification, but five specimens where only identified to the family level due to the lack of keys or diagnostic characters for the larval stages. Previously, 75 species across 22 families were reported from the Caribbean of Costa Rican (Dean, 2009, 2012, 2017). *Glycera oxycephala* Ehlers, 1887, however, was reported for Moín, and have not been reported for Cahuita (Böggemann, 2002). The new records found in the present study raises the diversity of polychaetes up to 29 families, 74 genera and 81 species for the Caribbean of Costa Rica. These figures remain an underestimate, and a more careful revision of deposit material and adult surveys will reveal a larger amount of new reports (Bogantes-Aguilar, 2014).

The polychaetes reported here, either to family, generic or specific level have been reported for the Caribbean coasts of Mexico (Salazar-Vallejo, 1996), Belize (Young & Young, 1982), Panama (Fauchald, 1977), Venezuela (Liñero-Arana & Díaz-Díaz, 2011) and other countries of the region (Dean, 2012). This is expected, since the Caribbean region is connected by major currents, from southeast to northwest, in the Greater and Lesser Antilles, and to the opposite direction in the southern Central American coast (Centurioni & Niiler, 2003). This means that many coral reef invertebrates and fishes with a planktonic larva, could be distributed and shared throughout the region (Warner & Goodbody, 2005; Salas, Molina-Ureña, Walter, & Health, 2010), emphasizing the need for more studies of meroplankton and their role in population recruitment in the Caribbean of Central America.

Morales-Ramírez & Murillo (1996) mentioned that Cahuita might have low meroplankton diversity due to the degradation of the coral reef at Cahuita (Cortés et al., 2010). In addition, warmer waters during the 1982-1983 El Niño event (Cortés, Murillo, Guzmán, & Acuña, 1984) could have caused a mismatch between the availability of phytoplankton (González et al., 2000) and the right time for spawning of many sessile invertebrates (Przeslawski, Ahyong, Byrne, Wörheides, & Hutchings, 2008). Nevertheless, with the findings of the current study, including all the larval forms of echinoderms, the three larvae of lophoporates clades, and many polychaetes forms, we showed that Cahuita's coral reef may hold more diversity than previously thought. Even with a great diversity of marine invertebrate larvae, recruitment studies are still lacking to understand the population dynamics of the reef (Alvarado, Cortés, & Salas, 2004).

The present study fills a gap in the knowledge of planktonic communities of the Caribbean coast of Costa Rica (Cortés & Wehrtmann, 2005). Using the same methodology as Morales-Ramírez & Murillo (1996) with the inclusion of two more stations (Carrillo-Baltodano & Morales-Ramírez, 2016) had allowed the evaluation of the zooplankton in terms of abundance, biomass and diversity after 25 years. Many of the reports shown here, were present only at one station in a single month, while other were present year-round. The spatio-temporal dynamics of their presence correlate with abiotic variables during the year sampled (Carrillo-Baltodano &

Morales-Ramírez, 2016). Looking into the zooplankton is an essential approach to studying not only the diversity, but also the trophic, biogeochemical and ecosystemic dynamics of the coral reef. The relevance of species or groups diversity exceeds the value of the taxonomic inventory, because it enhances the possibility of better understanding the ecological goods and services (e.g. tourism, fisheries) that it can provide, leading us to an improvement in its management and conservation (Mumby et al., 2008; Miloslavich et al., 2010).

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RESUMEN

Nuevos reportes de invertebrados planctónicos marinos de la costa Caribe de Costa Rica: El arrecife coralino del Parque Nacional Cahuita en el Caribe de Costa Rica representa un importante y biodiverso ecosistema marino. Sin embargo, la mayoría de la diversidad reportada es el resultado de estudios del bentos, con una minoría de estudios pelágicos. Un muestreo mensual del zooplancton arrecifal fue realizado entre Septiembre 2010 y Agosto 2011. Se encontraron 32 reportes nuevos para el Caribe de Costa Rica, siete para Costa Rica y 16 para el Caribe de Centroamérica. Estos reportes incluyen una larva hoplitomela de la esponja *Thoosa* sp.; estadios larvales de los tres lofoforados; siete familias, cinco géneros y seis especies de poliquetos; un juvenil del anfioxo Branchiostoma (Filo Chordata, Subfilo Cephalochordata); y cuatro cordados pelágicos. Una comprensión del zooplancton es un enfoque esencial para el estudio de la diversidad, y a su vez aumenta la posibilidad de entender mejor los bienes y servicios ecológicos que el arrecife coralino puede proveer.

Palabras clave: arrecife coralino; larvas de invertebrados marinos; Cahuita; poliquetos; zooplancton

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