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Coral Borers of the Eastern Pacific: *Aspidosiphon* (*A.*) *elegans* (Sipuncula: Aspidosiphonidae) and *Pomatogebia rugosa* (Crustacea: Upogebiidae)[1]

ANA C. FONSECA E. AND JORGE CORTÉS[2]

ABSTRACT: This is the first report of the sipunculan *Aspidosiphon* (*Aspidosiphon*) *elegans* (Chamisso & Eysenhardt, 1821) in the tropical eastern Pacific. With this species the number of coral borers rises to 18 for this region. The upogebiidid crustacean *Pomatogebia rugosa* (Lockington, 1878) was reported previously (as *Upogebia rugosa*) from coral colonies in the Gulf of California, México, and from coral reefs of Golfo Dulce, Costa Rica; the latter represented a southward range extension of approximately 3500 km. Subsequently, *P. rugosa* was recorded from branches of *Pocillopora* corals in Colombia, extending the range farther southward. In our study, both species were extracted from colonies of the massive coral *Porites lobata* Dana from Golfo Dulce, southern Pacific coast of Costa Rica. *Aspidosiphon* (*A.*) *elegans* ranged in length from 1 to 20 mm and was present in a density as high as 300 individuals per 1000 cm^3. *Pomatogebia rugosa* was present in 14% of the colonies examined and was responsible for $0.6 \pm 0.35\%$ of the $CaCO_3$ removed at one site in Golfo Dulce; at another site it was present in 33% of the colonies and was responsible for $2.5 \pm 2.22\%$ of the $CaCO_3$ removed. *P. rugosa* was found living in pairs inside live coral colonies of *Porites lobata*, in branched tunnels about 2.5 mm in diameter and lined with mud. Bioerosion caused by these two species of borers in the eastern Pacific is minimal compared with that caused by sea urchins and boring bivalves.

SIXTEEN CORAL-BORER SPECIES from three different phyla (Mollusca, Crustacea, and Porifera) have been reported from the eastern Pacific (Table 1). However, many sponges and polychaeta, and other organisms extracted from coral colonies, are still unidentified. In some eastern Pacific coral reefs (e.g., Panamá, the Galápagos, and Cocos Island), external bioeroders (mainly sea urchins) are more important than borers (Glynn et al. 1979, Glynn 1988, Eakin 1992, Guzmán and Cortés 1992, Reaka-Kudla et al. 1996). In other localities such as Golfo Dulce and Caño Island in Costa Rica, internal bioerosion, caused primarily by *Lithophaga* spp., is more important (Scott et al. 1988, Guzmán and Cortés 1989, Cortés 1991, 1992). Borers are responsible for internal bioerosion ranging from 8.3 to 9.5 kg/m^2 per yr (Glynn 1988, Eakin 1992, 1996), but this rate is probably not constant over time and may vary between reefs in the same area, as demonstrated in other regions (Hutchings 1986).

In this paper we report for the first time the presence of the sipunculan subgenus *Aspidosiphon* (*Aspidosiphon*) in the eastern Pacific. This increases the number of known coral-borer species for this region to 18. We also confirm the southward range extension of the crustacean *Pomatogebia rugosa* (Lockington, 1878) in the eastern Pacific.

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[2] CIMAR and Museo de Zoología, Escuela de Biología, Universidad de Costa Rica, San Pedro, Costa Rica.

TABLE 1

DISTRIBUTION OF EASTERN PACIFIC BORERS

EASTERN PACIFIC CORAL BORERS	MAINLAND				ISLANDS				
	MAR DE CORTEZ	MÉXICO	PANAMÁ	COSTA RICA	CLIPPERTON	COCOS	CAÑO	GALÁPAGOS	GORGONA
Phylum Porifera									
Class Demospongeae									
Family Clionidae									
Cliona ensifera				3					
Cliona viridis			9				9	9	
Cliona lampa			9				9	9	
Cliona vermifera			9				5	9	
Cliothosa hanckoki			9				9	9	
Thoosa mollis			9				5	9	
Aka sp.			9				9	9	
Anthosigmella sp.			9				9	9	
Phylum Mollusca									
Class Pelecypoda									
Family Mytilidae									
Lithophaga (*M.*) *aristata*			9	12		7	8	1	2
Lithophaga (*D.*) *plumula*			9	12	1		9	10a	2
Lithophaga (*L.*) *attenuata*			9			7	9	9	
Leiosolenus laevigata			9		1		5	10a	2
Family Gastrochaenidae									
Gastrochaena rugulosa		10b		3				6, 10a	
Gastrochaena ovata					1			1	2
Phylum Crustacea									
Class Malacostraca									
Family Upogebiidae									
Pomatogebia rugosa	11			12					
Pomatogebia cocosia						11			
Phylum Sipuncula									
Class Sipunculidea									
Family Sipunculidae									
Antillesoma antillarum				4					
Aspidosiphon elegans				12					

NOTE: Reference code: 1, Bernard (1983); 2, Cantera and Contreras (1988); 3, Cortés (1991, 1992); 4, Cutler et al. (1992); 5, Guzmán (1986, 1988); 6, Keen (1971); 7, Montoya (1983); 8, Scott and Risk (1988); 9, Scott et al. (1988); 10, Skoglund (1991); 10a, Bernard (1983), Finet (1985) (cited in Skoglund [1991]), Kleemann (1980); 10b, Poorman and Poorman (1988) (cited in Skoglund [1991]); 11, Williams (1986); 12, this study.

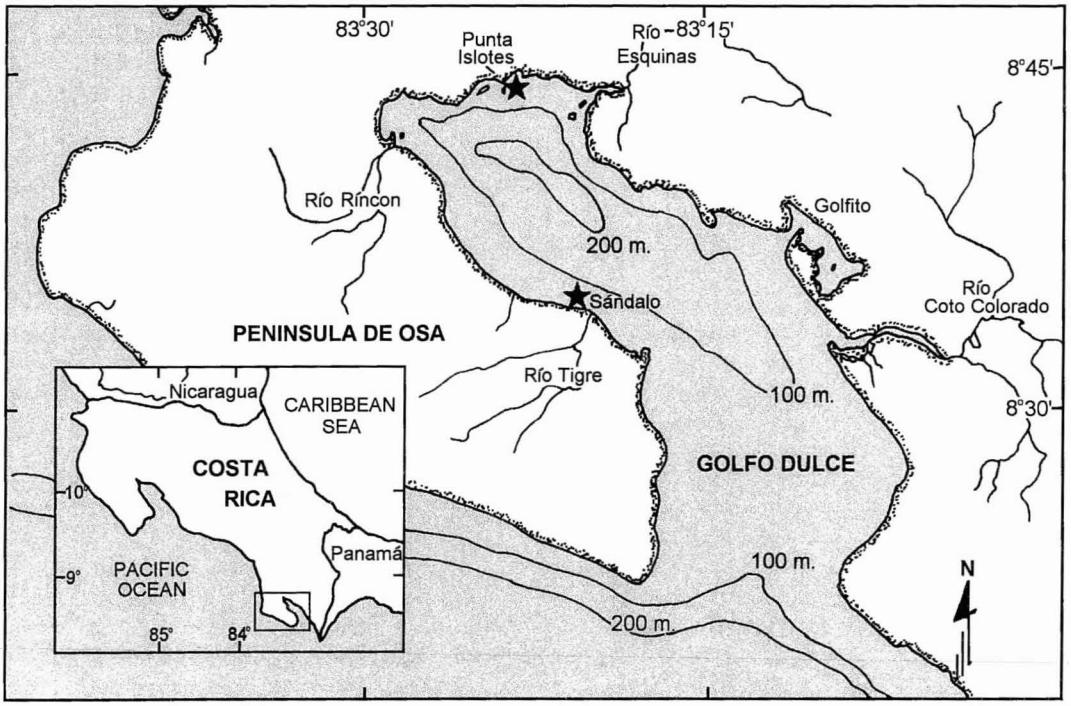

FIGURE 1. Map of Costa Rica with indication of sampling sites (stars) in Golfo Dulce.

MATERIALS AND METHODS

Fifty-five live colonies of *Porites lobata* Dana, 1846 were collected at Punta Islotes (8° 43′ 41.2″ N, 83° 23′ 8.4″ W), Golfo Dulce, southern Pacific coast of Costa Rica (Figure 1), between 1987 and 1989.

The colonies were cut into slabs with a rock saw, and the central slab was x-rayed. The percentage area removed by the different borers was determined with a planimeter from prints (following the method of Hein and Risk [1975]). The percentage of colonies infested was determined by the presence or absence of *Pomatogebia rugosa* excavations in the coral slab.

Six coral fragments (approximately 1000 cm^3 each) of *Porites lobata* were collected at Sándalo (8° 34′ 35″ N, 83° 20′ 15″ W), southern shore of Golfo Dulce, in January 1993. Each coral fragment was rinsed with freshwater and decalcified following Brock and Brock (1977). The remaining fauna was sorted from the organic matrix, fixed in 5% formalin in seawater, identified, counted, and stored in 70% alcohol. The volume of each block was determined by covering it with adherible plastic wrap and then submerging in water; the displaced water was measured. Density of *Aspidosiphon elegans* was calculated for 1000 cm^3.

RESULTS

Aspidosiphon (*Aspidosiphon*) *elegans* (Chamisso & Eysenhardt, 1821)

(Sipuncula: Aspidosiphoniformes: Aspidosiphonidae)

PREVIOUS RANGE: The subgenus *Aspidosiphon* (*Aspidosiphon*) is widespread and common in the Indian and western Pacific Oceans, from south-central Japan to northern Australia and from Hawai'i to the Red Sea. In the Caribbean it is present from northern Brazil to the Florida Keys and Ber-

muda. *Aspidosiphon* (*Aspidosiphon*) spp. live in dead coral and soft rocks in shallow waters (Cutler 1994).

NEW RANGE: We collected specimens of *A.* (*A.*) *elegans* at Sándalo and Islotes (Figure 1), which represents an addition to the sipunculan fauna, at the subgeneric level, for the eastern Pacific. These and other lithocryptobionts were extracted from dead coral colonies of *Porites lobata*. At Sándalo and Islotes, 92% and 83% of the colonies, respectively, were infested ($n = 12$). Sipunculans were 1 to 20 mm in length and were present at a density of 300 individuals per 1000 cm^3. The species was identified by Edward Cutler and Harlan K. Dean and voucher specimens were deposited in the sipunculan collections of the Museo de Zoología, Escuela de Biología, Universidad de Costa Rica (UCR 42), and at the Museum of Comparative Zoology (MCZ), Harvard University.

COMMENTS: The phylum Sipuncula (peanut worms) includes 17 genera and 147 species. *Aspidosiphon* (*Aspidosiphon*) is the most common and widespread tropical subgenus (Cutler 1994). Cutler et al. (1992) identified nine species in seven genera from Costa Rica and reported that *A.* (*Paraspidosiphon*) *parvulus* was found inside coral colonies from Cahuita, a Caribbean reef. With our report the Costa Rican sipunculan fauna is raised to 10 species.

Pomatogebia rugosa (Lockington, 1878)

(Crustacea: Thalassinoidea: Upogebiidae)

RANGE: This species was recorded as *Upogebia rugosa* from Bahía Agua Verde, Puerto Escondido, in the Mar de Cortez, México (25° 31′ N, 110° 02′ W), in 1940 during the Velero III expedition. It lives inside coral colonies (Williams 1986). Cortés (1991, 1992) reported the presence of *U. rugosa* in coral reefs of Golfo Dulce, Costa Rica (Figure 1). He found low numbers of colonies infested (14% of the total analyzed, $n = 25$) and low $CaCO_3$ removal ($0.6 \pm 0.35\%$) at Sándalo; and higher values, infestation of 33% of the colonies ($n = 30$), and $CaCO_3$ removal of $2.5 \pm 2.22\%$ at Punta Islotes. Cortés' report represented a southward range extension of approximately 3500 km. Later, Lemaitre and Ramos (1992) recorded *P. rugosa* from branches of *Pocillopora* corals in Colombia, again extending the range southward. In the study reported here we found the species at Sándalo, southern shore of Golfo Dulce (Figure 1), in 60% of colonies ($n = 5$) of the massive coral *Porites lobata* at 6 m depth. We found no infestation in colonies collected at 3 m depth ($n = 7$) at Sándalo nor in any of the samples collected from Islotes, northern shore of Golfo Dulce (Figure 1). It was found living in pairs inside live coral colonies of *Porites lobata*, in branched tunnels about 2.5 mm in diameter that are lined with mud. Specimens were identified by Austin Williams and deposited in the crustacean collection of the Museo de Zoología, Escuela de Biología, Universidad de Costa Rica (UCR 1770).

COMMENTS: Williams and Ngoc-Ho (1990) proposed the new genus *Pomatogebia* for three species of thalassinidean shrimps previously placed in *Upogebia*: *P. rugosa* and *P. cocosia* from the eastern Pacific and *P. operculata* from the western Atlantic. These species are specialized for burrowing into massive stony corals. They differ from related shrimps in the region in their carapace, appendages, and in the caudal section of the abdomen, which is shaped like an operculum and blocks the entrance to the burrow system from the inside. The operculum surface mimics that of the coral (Williams and Ngoc-Ho 1990).

DISCUSSION

The Galápagos Islands, Caño Island, and Panamá are the sites in the eastern Pacific with the most identified borer species, especially bivalves and sponges (Table 1). Of the 18 species reported, three species (*Lithophaga aristata*, *L. plumula*, and *L. attenuata*) are reported from most of the eastern Pacific. Four species are endemic to the eastern Pacific (*Lithophaga attenuata*, *Gastrochaena rugulosa*, *Pomatogebia rugosa*, *P. cocosia*).

All the sponges are also present in the Indo-Pacific and Mediterranean Sea (Scott et al. 1988). *Lithophaga aristata* has a cosmopolitan distribution (Keen 1971), and *Leiosolenus laevigata* is distributed across the whole Indo-Pacific (Kleemann 1980). Sipunculans are also widely distributed (Cutler 1994).

In this paper we report the presence of the sipunculan *Aspidosiphon (Aspidosiphon) elegans* for the first time and confirm the distribution of the crustacean *Pomatogebia rugosa* in the eastern Pacific. Their role in bioerosion is minor compared with that of sea urchins and boring bivalves in this region. With this report, the list of internal bioeroders of the eastern Pacific increases to 18 species (Table 1). As more studies are carried out in this region, the number of bioeroders will probably increase.

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