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SHORT COMMUNICATION

Crustaceans in *Phragmatopoma* sp. (Polychaeta: Sabellariidae) intertidal reefs, Pacific, Costa Rica

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ABSTRACT. **Introduction:** Annelid polychaete worms of the family Sabellariidae build reefs by cementing together sand grains. These reefs increase local habitat heterogeneity and species diversity. The reefs are used as a refuge by invertebrates, and crustaceans are frequent. **Objective:** To list the species of crustaceans found in *Phragmatopoma* sp. reefs on two localities of the North Pacific coast of Costa Rica and at the port of Puntarenas, Gulf of Nicoya estuary. **Methods:** We dislodged fragments of reef colonies qualitatively at low tide with a chisel, stored them in plastic bags and later disaggregated the fragments by hand. We identified the crustaceans whenever possible and deposited them in the collection at the University of Costa Rica (MZUCR). **Results**: We identified 30 species: 26 species of macro-crustaceans in samples from the North coast, eight of them *Petrolisthes* (Porcellanidae). From the Puntarenas samples we identified five species (27 macro-crustaceans and 3 isopods). A few micro-crustaceans (Amphipoda, Isopoda) were also present but not identified. **Conclusions:** The number of crustacean species found in *Phragmatopoma* sp. reefs is relatively high but comparisons with other studies are difficult. Porcellanid crabs are common on these reefs. The low diversity of Puntarenas reefs remains unexplained.

Keywords: ecosystem engineers, Santa Elena Bay, Ostional, estuary, Decapoda, crabs.

RESUMEN. "Crustáceos en arrecifes intermareales de *Phragmatopoma* sp. (Polychaeta: Sabellariidae), Pacífico, Costa Rica" **Introducción:** Los gusanos anélidos poliquetos de la familia Sabellariidae construyen arrecifes mediante la cementación de granos de arena. Estos arrecifes aumentan la heterogeneidad del hábitat local y la diversidad de especies. Además, son refugio de numerosos invertebrados, y son frecuentes los crustáceos. **Objetivo:** Enumerar las especies de crustáceos en arrecifes de *Phragmatopoma* sp. en dos sitios del Pacífico Norte de Costa Rica y en el puerto de Puntarenas, estuario del Golfo de Nicoya**. Métodos:** Desprendimos cualitativamente trozos de colonias de arrecifes durante la marea baja con un cincel; los almacenamos en bolsas de plástico y separamos los trozos manualmente. En lo posible, identificamos los crustáceos, y los depositamos en la Universidad de Costa Rica (MZUCR). **Resultados:** Identificamos 30 especies: 26 especies de macro-crustáceos de la costa norte, ocho de ellas *Petrolisthes* (Porcellanidae). A partir de las muestras de Puntarenas, identificamos cinco especies (27 macro-crustáceos y 3 isópodos). También hallamos algunos micro-crustáceos (Amphipoda, Isopoda), pero no pudimos identificarlos. **Conclusiones:** El número de especies de crustáceos en los arrecifes de *Phragmatopoma* sp. es relativamente alto, pero las comparaciones con otros estudios son difíciles. Los cangrejos porcelánidos son comunes en estos arrecifes. La baja diversidad de los arrecifes de Puntarenas necesita explicación.

Palabras clave: ingenieros ecosistémicos, Santa Elena Bay, Ostional, estuario, Decápoda, cangrejos.

The annelid polychaete worms of the family Sabellariidae build reefs by cementing together sand grains with a biocement produced by the worms themselves (Fournier et al., 2010). These reefs serve as a refuge for a diverse fauna and as such the worms act as ecosystem engineers increasing habitat heterogeneity and species diversity (Bruschetti, 2019). Fauchald (1977), reported the presence of seven species of sabellariid worms for the Pacific coast of Panama including *Phragmatopoma attenuata* Hartman, 1944*. P. attenuata*, was reported from several locations on the Pacific coast of Costa Rica, such as the Gulf of Nicoya estuary (Dean, 2009; Sibaja-Cordero & Vargas-Zamora, 2006) and further North at Culebra Bay by Sibaja-Cordero & García-Méndez (2014). *Phragmatopoma* sp. was reported from Culebra Bay and Junquillal Bay by Sibaja-Cordero et al., (2014). *P. villalobosi* has been described from the North Pacific of Costa Rica by Chávez-López (2020).

There are no reports on the associated fauna of *Phragmatopoma* spp. reefs from Costa Rica except the recent description of several species of tardigrades from worm tubes of *P. attenuata* (Bartels et al., 2021). Thus, the objective of this report is to list the species of crustaceans found in sabellariid reef samples from the Pacific coast of Costa Rica.

At low tide (Tidal range: 3m) we dislodged fragments of worm colonies (Fig. 1A) with a chisel, stored them in plastic bags and later disaggregated the material by hand. We collected occasionally from 2012 to 2021 on the North coast of Costa Rica at two relatively pristine sites: Ostional Beach-Ostional Wildlife Refuge (9.993420° N - 85.701841° W) and Junquillal Bay-Santa Elena Gulf (10.965081° N - 85.696202° W), Table 1. Additional samples, collected on July 20, 2023, came from worm reefs found on rock groins at the tip of the port city of Puntarenas in the mid upper Gulf of Nicoya estuary (9.976638° N - 84.851288° W). This site receives pollutants from the city, river discharges, tourist and fishing boat operations (Sibaja-Cordero & Gómez-Ramírez, 2022). We sorted the samples under a stereoscope and placed the crustaceans in 70% ethanol for further identification and storage. We deposited a reference collection at the Museum of Zoology of the University of Costa Rica (MZUCR).

As mentioned by Chávez-López (2020) the separation of *P. attenuata* from *P. villalobosi* is based on the length of the filaments of the median plume and we are uncertain of the presence of this feature in the worms collected. We refer to the worm reefs sampled in this study as build by *Phragmatopoma* sp. (Fig. 1B) until further taxonomic work allows a clear identification of the species involved. Voucher specimens of *Phragmatopom*a spp. are deposited at the Museum of Zoology, University of Costa Rica, Polychaete collection (MZUCR-2506-01, MZUCR-2501-01, MZUCR-2505-01). For the identification of the crustaceans, Rathbun (1930), Haig (1960), Brusca (1980), Brusca & Iverson (1985), Kim & Abele (1988), Anker et al., (2009), and Salgado-Barragan & Hendrickx (2010) were consulted. We included photographs of selected species in Fig. 1 C-L.

A total of 26 species of macro-crustaceans belonging to Anomura (16 species), Brachyura (5), Caridea (4), and Stomatopoda (1), were found in samples from the North coast. The family Porcellanidae was represented by 12 species (Table 1). Eight species belonged to the genus *Petrolisthes*, but *Neopisosoma* spp. were more abundant. Micro-crustaceans were also present, including unidentified amphipods (MZUCR 3089-01). Two isopods: *Aphantolana costaricensis* (Brusca & Iverson, 1985) (MZUCR 3609-07) and *Cirolana browni* Van Name, 1936 (MZUCR 3369-10) were identified but several were not (MZUCR 3089-02, 04, 05; 3369-08, 09, 10).

Samples from the Puntarenas worm reefs yielded 183 individuals and five identified species: *Neopisosoma mexicanum* (MZUCR 3803-01, Fig.1C) was the most abundant (127 ind., 69%, 35 ovigerous females, Fig.1I), followed by *Pachygrapsus transversus* (42 ind., 23%, Fig.1F, MZUCR 3803-02); *Alpheus javieri* (6 ind., 3%, Fig.1E, MZUCR 3803-03); *Acantholobulus* sp. (5 ind., 2,6%, Fig.1H, MZUCR 3803-04), and the isopod *Ligia baudiniana* (3 ind., 1,6%, MZUCR 3803-05). Thus, the reef samples collected in this study yielded a total of 30 identified species including decapods, the stomatopod *Neogonodactylus festae* (Fig.1D) and three isopods.

TABLE 1

List of species of macro-crustaceans found in *Phragmatopoma* sp worm reefs, North Pacific coast of Costa Rica.

Species name			MZUCR crustacean collection catalogue
Alpheidae sp. 1		C - A	3050-06
Alpheus sp.		C - A	3089-03, 3716-02
Alpheus javieri	Anker et al., 2009	C - A	3551-08
Alpheus hyeyoungae	Kim & Abele, 1988	C - A	3551-07
Calcinus obscurus	Stimpson, 1859	A - D	3639-01
Clibanarius albidigitus	Nobili, 1901	A - D	3639-02
Coenobita compressus	H. Milne-Edwards, 1836	A - C	3639-12
Eriphia squamata	(Stimpson, 1860)	B - E	3667-03, 3369-05, 3639-03, 3050-02
Eucinetops panamensis	Rathbun, 1923	B - I	3639-09, 3639-02
Megalobrachium pacificum	Gore & Abele, 1974	A - P	3551-05, 3639-10, 3050-05
Neogonodactylus festae	(Nobili, 1901)	S - G1	3551-10
Neopisosoma bicapillatum	Haig, 1960	A - P	3050-01
Neopisosoma mexicanum	(Streets, 1871)	A - P	3369-01, 3551-04, 3667-02, 3802-01, 3639-05, 3326-01, 3050-04
Pachycheles calculosus	Haig, 1960	A - P	3639-06
Pachycheles chacei	Haig, 1956	A - P	3551-02
Pachygrapsus transversus	(Gibbes, 1850)	B - G2	3369-03, 3551-09, 3639-04, 3802-02
Petrolisthes agassizii	Faxon, 1893	A - P	3639-11
Petrolisthes artifrons	Haig, 1960	A - P	3050-03, 3326-02, 3369-06, 3667-01
Petrolisthes haigae	Chace, 1962	A - P	3716-01
Petrolisthes holotricus	Nobili, 1901	A - P	3716-03, 3050-09
Petrolisthes nobilii	Haig, 1960	A - P	3551-03
Petrolisthes lewisi	(Glassell, 1936)	A- P	3669-04
Petrolisthes platymerus	Haig, 1960	A - P	3050-08
Petrolisthes tonsorius	Haig, 1960	A - P	3551-06
Williamstimpsonia stimpsoni	(A. Milne-Edwards, 1879)	B - X	3050-07, 3639-08
Xanthodius sternberghii	Stimpson, 1864	B - X	3639-07

Ostional Beach, Guanacaste, stations: 3050, 3089, 3326, 3639, 3369, 3551, 3667. Junquillal Bay, Ostional Wildlife Refuge, Santa Elena Gulf, stations: 3505, 3716. (A: Anomura, B: Brachyura, C: Caridea, S: Stomatopoda). (A: Alpheidae, C: Coenobitidae, D: Diogenidae, E: Eriphiidae, G1: Gonodactylidae, G2: Grapsidae, I: Inachidae, P: Porcellanidae, X: Xanthidae)

A two-year quantitative survey of crustaceans from *Phragmatopoma lapidosa* reefs on the coast of Florida found 51 species and pointed out the dominance of porcellanid, xanthid and grapsid crabs such as *P. transversus* (Gore et al., 1978). Moran (1984) found that in El Salvador two porcellanids (*N. mexicanum* and *Petrolisthes artifrons*), *P. transversus,* and the xanthid *Eriphia squamata* (Fig.1K) were the more abundant species in sabellariid reefs. *P. lapidosa* reefs from Brazil yielded five species of porcellanids (Micheletti-Flores & Negreiros-Fransozo, 1999). In Panama reef colonies of *Idanthyrsus cretus* had a diverse fauna of 27 species of crustaceans (Barrios et al., 2009), while the fauna associated to *P. moerchi* reefs in Chile included only five species (Sepúlveda et al., 2003). In Venezuela, *Phragmatopoma* sp. reefs provided habitat for 27 species of decapods among 1 527 individuals of which 928 (60%) were porcellanids (Velásquez et al., 2017). *P. caudata* reefs in Brazil yielded 3 390 individuals and 39 species of macro-crustaceans were found of which the most abundant was the porcellanid *Pachycheles greeleyi* with 351 (10%) individuals (Lane-Medeiros et al., 2021).

The diversity of crustaceans found in sabellariid worm reef studies is highly variable and is influenced by the species of worm, sampling effort, and qualitative *vs* quantitative collection methods thus comparisons are difficult. The number of crustacean species found in

Phragmatopoma sp. reefs from pristine sites on the North coast of Costa Rica appears relatively high when compared to other studies cited above. The relative lower diversity of Puntarenas reefs deserves further study to evaluate the roles of pollution and estuarine conditions. As found in other studies, porcellanid crabs seem to prefer these habitats. The grapsid *P. transversus* is a frequent inhabitant of worm reefs at both sides of the American continent.

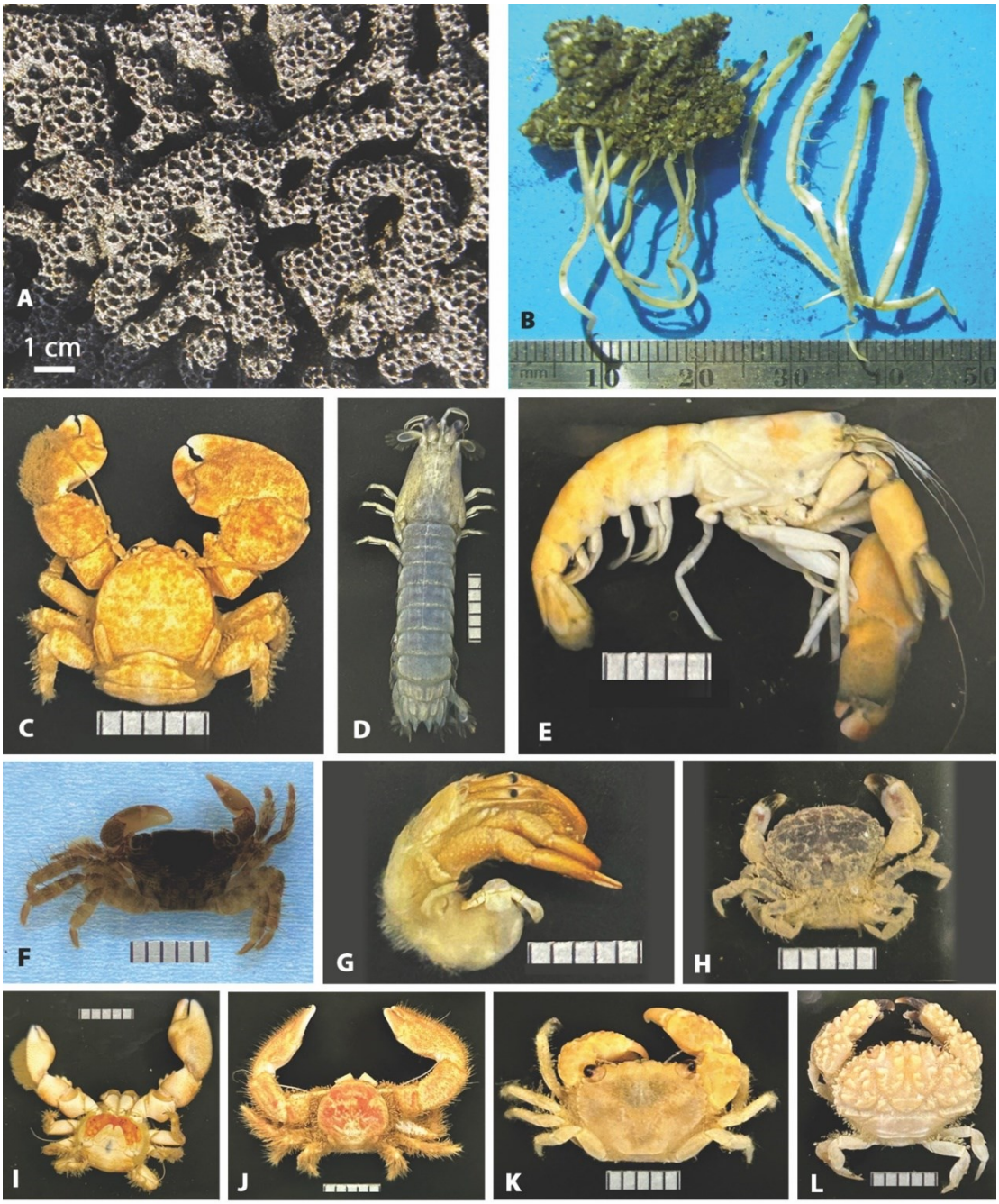

Fig. 1. A. Cluster of sand tubes of *Phragmatopoma* sp. **B**. A group of whole worms. **C.** *Neopisosoma mexicanum.* **D.** *Neogonodactylus festae.* **E**. *Alpheus javieri*. **F**. *Pachygrapsus transversus.* **G**. *Clibanarius albidigitus.* **H.** *Acantholobulus* sp. **I.** *N.mexicanum,* with eggs. **J.** *Megalobrachium pacificum.* **K.** *Eriphia squamata.* **L.** *Williamstimpsonia stimpsoni.* **B-L**. Scale in mm.

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ETHICAL, CONFLICT OF INTEREST AND FINANCIAL STATEMENTS

The authors declare that they have complied with all ethical and legal requirements, both during the study and in the production of the manuscript; that there are no conflicts of interest of any kind, and agree with the final edited version. A signed document has been filed in the journal archives. The contribution of each author was: J.V. Original idea, writing and editing, sample collection. R.V.C. Sample collection, crustacean identification, museum collection curator, writing. J.S.C., sample collection, polychaete identification, museum collection curator, writing.

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