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Rapid Communication

First detection of the alien snowflake coral *Carijoa riisei* (Duchassaing and Michelotti, 1860) (Cnidaria: Alcyonacea) in the port of Manzanillo in the Mexican Pacific

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Abstract

One colony of the snowflake coral *Carijoa riisei* (Alcyonacea: Clavulariidae) was found in June 2016, and three more in January 2017, during dives in the port of Manzanillo, Colima, Mexico (Tropical Eastern Pacific). This species was considered as native to the tropical Western Atlantic and invasive in the Pacific, but recent studies suggest that it is native to the Indo-West Pacific. Colonies were found and collected from artificial substrates in the port. A total of 29 species of invertebrates of five different phyla were associated with the colonies of *C. riisei*. Moreover, the octocoral was found as an epibiont on the architect crab *Pelia tumida*. Our observations suggest that the invasion of *C. riisei* in Manzanillo is in an early stage and that on-going monitoring and implementation of an eradication plan is necessary before its distribution is increased.

Key words: invasive species, Tropical Eastern Pacific, distribution, octocoral, Mexico

Introduction

The snowflake coral or branched pipe coral, *Carijoa riisei* (Duchassaing and Michelotti, 1860) (Alcyonacea: Clavulariidae), is an octocoral widely distributed in tropical and subtropical waters around the world. This soft coral settles on a broad variety of habitats, often found associated with fouling communities, coral reefs, mangroves, outside harbors on shipwrecks, or in sheltered crevices in turbid waters rich with organic matter (Sánchez 1994). This species has been mainly recorded in shallow waters, but it can be found at depths of up to 95 m (Bayer 1959; Castro et al. 2010). It is a non-photosynthetic coral that feeds on zooplankton and organic particles, which requires moderate amounts of water flow by wave surge, tidal currents, or long-shore currents (Carlton and Eldredge 2009; Lira et al. 2009; Barbosa et al. 2014; Friedlander et al. 2014). *Carijoa riisei* competes with other organisms for food and space, mainly with other soft corals (e.g. black corals) and by displacing native species (Kahng and Grigg 2005).

The snowflake coral was considered for many years as native to the Western Atlantic, although a recent molecular study indicates that it is native to the Indo-West Pacific (Concepción et al. 2010). This coral is almost a circum-tropical species, and is one of the most invasive nonindigenous marine invertebrates in the Hawaiian Islands (Kahng et al. 2008). It has been recorded from Florida, USA, to Santa Catarina including the islands of St. Paul Rocks (Brazil) (Edwards and Lubbock 1983); in the eastern Atlantic off the island of São Tomé, Democratic Republic of São Tomé and Príncipe (Concepción et al. 2010), and on oil platforms off Gabon in the west coast of Central Africa (Friedlander et al. 2014). Reports in the Indian Ocean include the Andaman Islands (Dhivya et al. 2012), the Gulf of Mannar (Padmakumar et al. 2011), and the Gulf of Kutch (Yogesh-Kumar et al. 2014). The Indo-Pacific reports include Chuuk, Palau, the Philippines, Indonesia, Australia, Singapore, Shanghai, Sumatra, Manila, and New Britain (Raghunathan et al. 2013). Finally, recent evidence indicate that *C. riisei* has spread widely in

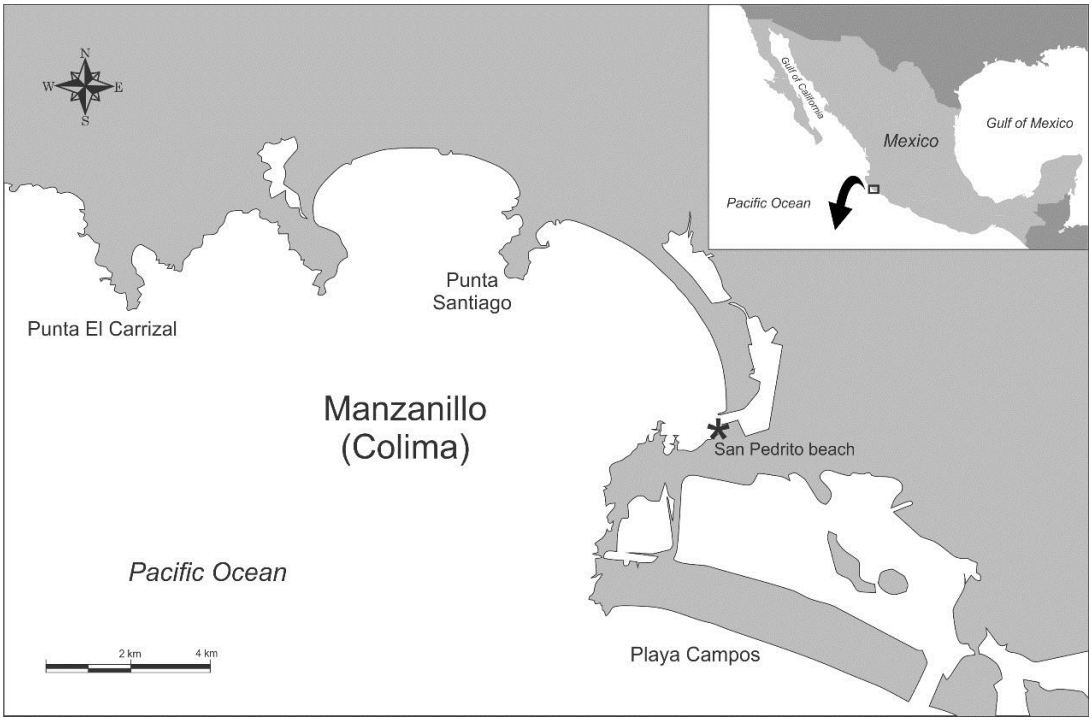

Figure 1. Location of the port of Manzanillo, Mexico and the *Carijoa riisei* collection site (*).

in the southern Eastern Pacific and might have been introduced from the Atlantic into the Colombian Tropical Eastern Pacific, possibly via the Panama Canal (Quintanilla et al. 2017). According to genetic studies, the introduction of this octocoral species to the Hawaiian Islands occurred from the Indo-Pacific, separately from its arrival to the Caribbean (Concepcion et al. 2010). Our work reports the first detection of the invasive snowflake coral *Carijoa riisei* in the Mexican Pacific and its associated invertebrate fauna.

Methods

During a SCUBA dive on 8 June 2016 in a sheltered area of the port of Manzanillo, Colima, Mexico (19º03′33″N; 104º18′16″W) one colony of *Carijoa riisei* was observed (Figure 1). The colony was photographed and collected to confirm the species identification. On 21 January 2017, three other colonies were collected from the same area. Colonies were preserved in alcohol 70% and deposited in the LEMA laboratory (Laboratorio de Ecosistemas Marinos y Acuicultura in Spanish) of the Applied Ecology Department, CUCBA, University of Guadalajara, Mexico. Confirmation of the species was made using the guide of Devictor and Morton (2010) for octocorals of the South Atlantic Bight and the photographic identification guide of Collin et al. (2005) for invertebrates of Panama. Further identification of the species was also carried out by sclerite examination. Sclerites were extracted from the body wall (axis) of the octocoral. The tissue was dissolved in fresh household bleach (10%) and sclerites were washed in distilled water and mounted on a glass microscope slide for observation. Additionally, identification keys and visual guides of invertebrates from the Tropical Eastern Pacific were consulted for associated species.

Results and discussion

The colonies of *Carijoa riisei* (from 14 to 50 cm long) were found attached to submerged breakwater concrete blocks located in San Pedrito beach in the port of Manzanillo at depths between 6 and 8 m (Figure 2A). In general, all colonies were densely branched, with orange coloration, large white polyps, and branching sclerites as thorny rods and spindles (Figure 2B). Artificial substrates where colonies were found were covered with epifauna such as hydroids, sponges, briozoos, and tubeworms. Associated with the colonies of *C. riisei* were invertebrates from a variety of phyla (Table 1); the most

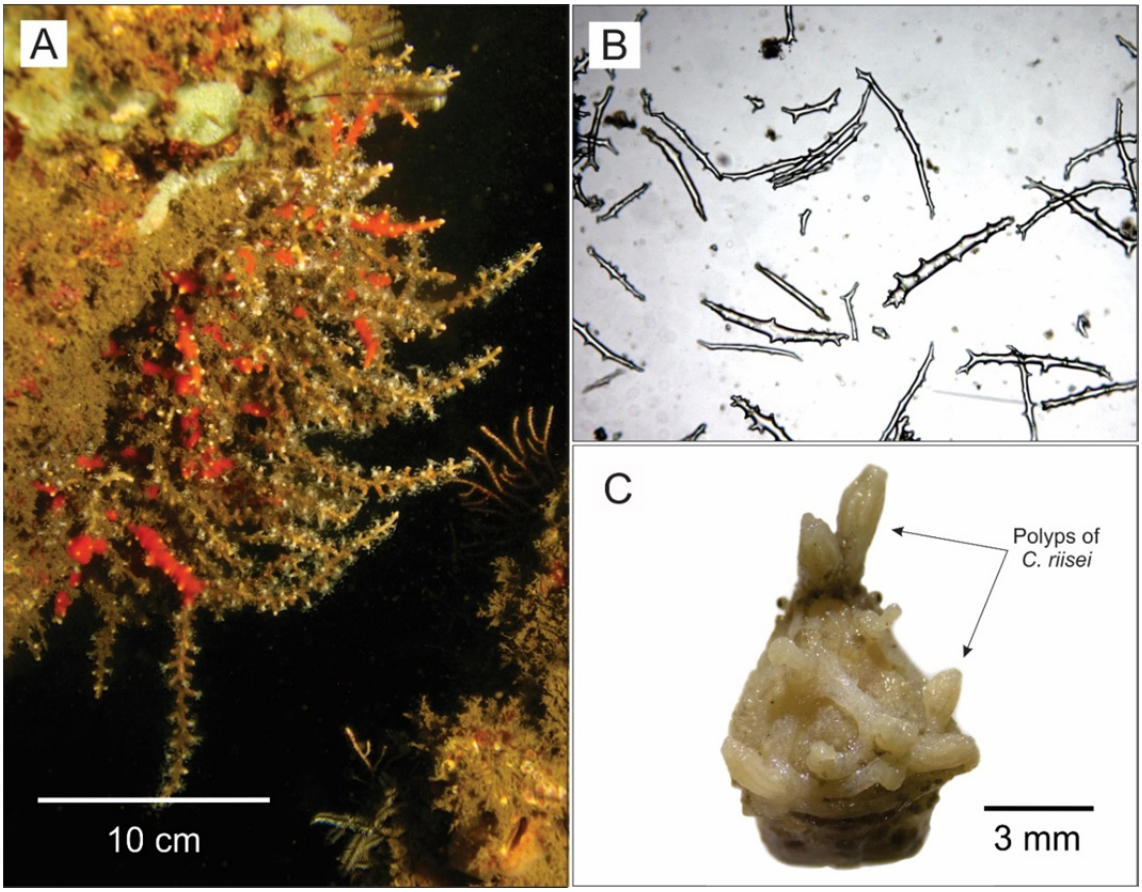

Figure 2. (A) Invasive soft coral *Carijoa riisei* in the port of Manzanillo, (B) sclerites of *C. riisei*, and (C) ovigerous female of *Pelia tumida* with the octocoral as epibiont on the carapace (Photos by C.M. Galván-Villa).

abundant were the polychaete worms *Branchiomma bairdi* (McIntosh, 1885) and the epizoic brittle star *Ophiothela mirabilis* Verrill, 1867, which is also common on pencil urchins and gorgonians (Hickman 1998). Eight species of decapods were found associated with *C. riisei*. Remarkably, nine specimens (six females and three males) of the crab *Pelia tumida* (Lockington, 1877) had the octocoral as an epibiont (Figure 2C). In this case, confirmation of the epibiont species was made by examination of sclerites. Epibiont association between crustaceans and *C. riisei* has been reported before by Bruto-Costa et al. (2014) who found 12 decapod crustaceans associated with this species and found an unusual case of *C. riisei* as an epibiont of the architect crab *Mycrophrys interruptus* Rathbun, 1920. According to these authors, it is likely that these crabs use polyps of *C. riisei* as camouflage and have a commensal relationship in which the crab benefits from the protection of the octocoral (i.e. mimetic protection). Most of the females (83%) of *P. tumida* associated with the octocoral were ovigerous. This observation supports the theory that ovigerous females have a higher epizoic density to obtain more protection during egg incubation and more appropriate conditions for the settlement of epibionts (Jeffries et al. 1992; Bruto-Costa et al. 2014). On the other hand, epibiosis can be beneficial for the octocoral by providing dispersion due to the mobility of the crab (Fernandez-Leborans 2013). Many other organisms such as algae, protozoans, sponges, other cnidarians, ctenophores, brachiopods, annelids, pycnogonids, and chordates have been reported associated with colonies of *C. riisei* (Bayer 1961), thus further studies are necessary to understand these associations.

There are no reports of other cnidarian exotic species in the Central Mexican Pacific; however, many other marine invertebrates have been reported as introduced or invasive species (Tovar-Hernández et al. 2012; Mendoza and Koleff 2014). According to the Global Invasive Species Database (GISD 2017),

Table 1. Invertebrates associated with colonies of *Carijoa riisei* from the port of Manzanillo, Mexico. The total number of individuals is in parenthesis.

Phylum	Class	Order	Family	Species
Platyhelminthes	Turbellaria	Polycladida	Leptoplanidae	Sp. (5)
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Sp. (1)
		Amphinomida	Amphinomidae	Sp. (24)
			Euphrosinidae	Sp. (2)
		Eunicida	Eunicidae	Sp. (1)
		Sabellida	Sabellidae	*Branchiomma bairdi* (McIntosh, 1885) (1363)
Arthropoda	Maxillopoda	Thoracica	–	Sp. (90)
	Malacostraca	Isopoda	Paranthuridae	*Paranthura elegans* Menzies, 1951 (1)
		Amphipoda	Podoceridae	*Podocerus* cf. *fulanus* J.L. Barnard, 1962 (1)
			Neomegamphopidae	*Neomegamphopus* sp. (3)
		Decapoda	Benthesicymidae	*Benthesicymus tanneri* Faxon, 1893 (5)
			Palaemonidae	*Palaemon hiltoni* (Schmitt, 1921) (1)
			Thoridae	*Thor cordelli* Wicksten, 1996 (2)
			Paguridae	*Pagurus lepidus* (Bouvier, 1898) (26)
			Mithracidae	*Ala cornuta* (Stimpson, 1860) (1)
				Teleophrys cristulipes Stimpson, 1860 (1)
			Pisidae	*Pelia pacifica* A. Milne-Edwards, 1875 (2)
				Pelia tumida (Lockington, 1877) (19)
Mollusca	Gastropoda	Caenogastropoda	Turritellidae	*Vermicularia frisbeyae* McLean, 1970 (4)
		Neogastropoda	Columbellidae	*Anachis nigrofusca* Carpenter, 1857 (22)
			Muricidae	*Murexsul jaliscoensis* (Radwin & D'Attilio, 1970 (1)
				Trachypollia lugubris (C. B. Adams, 1852) (2)
			Buccinidae	*Cantharus* sp. (1)
			Drilliidae	*Brephodrillia ella* Pilsbry & Lowe, 1932 (1)
			Pseudomelatomidae	*Crassispira discors* (Sowerby I, 1834) (1)
Echinodermata	Ophiuroidea	Ophiurida	Ophiactidae	*Ophiactis savignyi* (Müller & Troschel, 1842) (8)
				Ophiactis simplex (Le Conte, 1851) (106)
			Ophiothrichidae	*Ophiothela mirabilis* Verrill, 1867 (224)
				Ophiothrix spiculata Le Conte, 1851 (5)

the amethyst gem clam *Gemma gemma* Totten, 1834, native to the Atlantic coast of North America is an established invasive species in the Northeastern Pacific including the Central Mexican Pacific. The Japanese oyster *Crassostrea gigas* (Thunberg, 1793) [now valid as *Magallana gigas* (Thunberg, 1793) see Salvi et al. 2014] was introduced deliberately from Asia, for mariculture purposes, to the Mexican Pacific it is known to compete with native intertidal species, destroying the natural habitat, and causing eutrophication of the water bodies that it invades (Eno et al. 1997). The false mussel *Mytilopsis adamsi* Morrison, 1946 is another invasive alien bivalve accidently introduced from Panama (Ortíz-Arellano and Salgado-Barragán 2012). Polychaetes such as *Hydroides sanctaecrucis* Krøyer in Mörch, 1863 and *Polydora websteri* Hartman in Loosanoff and Engle, 1943; sponges as *Halichondria* (*Halichondria*) *panicea* (Pallas, 1766), *Haliclona turquoisia* (de Laubenfels, 1954), *Haliclona* (*Reniera*) *tubifera* (George and Wilson, 1919), and *Suberites aurantiacus* (Duchassaing and Michelotti, 1864); and tunicates such as *Botrylloides violaceus* Oka, 1927, *Lissoclinum fragile* (Van Name, 1902), and *Styela canopus* (Savigny, 1816) have also been reported as exotic invertebrate species in the Central Mexican Pacific (Tovar-Hernández et al. 2012). One of the major goals in assessing invasions is to determine the origin of these species and their species-associations in new areas in order to establish strategies to protect native species and ecosystems (Mooney and Cleland 2001; Burlakova et al. 2014; Jackson 2015).

The port of Manzanillo is one of the most important in the Mexican Pacific. The main ship routes come from the western Pacific (China, Taiwan, Korea, Hong Kong, Malaysia, Singapore, Indonesia, Japan, and Russia), the northern Pacific (Canada and USA), and one important route from the Southeastern Pacific (Chile, Ecuador, Colombia, and Guatemala) (SCT 2009). The port area has favorable conditions for the growth of *C. riisei*, such as turbid waters, high levels of organic matter, and no natural predators. The introduction of *C. riisei* to Manzanillo, Mexico, is possibly by larvae traveling in the ship's ballast water from the Western Pacific or possibly by routes from the Atlantic through the

Panama Canal. Genetic analyses of *C. riisei* populations from Asia, Hawaii, the Caribbean and the Mexican Pacific are necessary in order to determine the origin of this octocoral.

Since only a few colonies of *C. riisei* have been found in the bay of Manzanillo, we do not consider their presence as a massive invasion yet. However, due to the rapid growth and high dispersal potential of the species, it is important to monitor its possible expansion in the bay, as well as in the nearby coral reef areas such as Carrizales located to the north, and in other areas of the Mexican Pacific.

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