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ORIGINAL ARTICLE

New records of the shrimp *Periclimenes crinoidalis* Chace, 1969 (Decapoda: Palaemonidae) and its crinoid host *Nemaster grandis* A.H. Clark, 1909 (Echinodermata: Crinoidea) in the Caribbean Sea

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ABSTRACT

During exploratory trips conducted between August and December 2016, six shrimps, found in association with the crinoid *Nemaster grandis* A.H. Clark, 1909, were collected in Chichiriviche de la Costa, Vargas State (Venezuela). A photographic record of the crinoids and the shrimps was conducted *in situ*. Shrimps were preserved in ethyl alcohol 90% and carried to the Laboratorio de Carcinología de la Universidad de Oriente, Núcleo Nueva Esparta. Once in the laboratory, the shrimps were taxonomically described and sexed. Shrimps were identified as *Periclimenes crinoidalis* Chace, 1969, constituting the first record of this species in Venezuelan waters. These findings also expand the known distribution range for the crinoid *N. grandis* in Venezuela, where the species exhibits two morphotypes, one of them not previously described. Additionally, a table with the species of decapods found associated with echinoderms in Venezuela is provided.

KEYWORDS

Caridea, association, biodiversity, echinoderm, Venezuela.

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Introduction

Many crustaceans are often found in association with members of their own, or of another phyla more often than perhaps any other major group of marine invertebrates (Ross, 1983). In the Caribbean, some of these associations are shortly documented in inventories of Crustacea (Rathbun, 1900; Holthuis, 1951; Chace, 1972). Associations between shrimps and echinoderms have been studied by Chace (1969), Críales (1984), Bruce (1986), and Berggren and Svane (1989), among others.

Periclimenes Costa, 1844 is one of the genera with the greatest number of species within the palaemonids. The genus is composed by more than 100 species, both free-living species and obligated symbionts of sessile or slow-moving benthonic invertebrates (Bruce, 2007; De Grave and Anker, 2009; De Grave and Fransen, 2011; WoRMS, 2018). More than 20 species of the genus have been reported in the Caribbean Sea, some of them in association with sponges, anemones or echinoderms (Chace, 1956; Chace, 1972; Críales, 1984; De Grave and Anker, 2009).

Little is known about associations between species of the genus *Periclimenes* and crinoids in the Caribbean. Only four species have been described associated with crinoids in western Atlantic [*Periclimenes crinoidalis* Chace, 1969, associated with *Nemaster grandis* A.H. Clark, 1909; *P. meyeri* Chace, 1969, associated with *Nemaster* sp.; *P. bowmani* Chace, 1972 associated with *Davidaster rubiginosus* (Pourtalès, 1869) or *Tropiometra carinata* (Lamarck, 1816); and *P. rincewindi*, De Grave, 2014 associated with *Analcidometra armata* (Pourtalès, 1869)]. The only reference to any of these species in Venezuela is made by Rodríguez (1980), who suspected the presence of *P. crinoidalis* and *P. meyeri* in Venezuelan waters due to the proximity of the type locality of both species (Curaçao); however, neither has been found in our waters to date.

Nine genus and nine species of crinoids are known to be present in Venezuelan waters: *Crinometra brevipinna* (Pourtalès, 1868), *Tropiometra carinata* (Lamarck, 1816), *Antedon duebenii* Böhlsche, 1866, *Davidaster rubiginosus* (Pourtalès, 1869), *Neocomatella pulchella* (Pourtalès, 1878), *Stylometra spinifera* (Carpenter, 1881), *Neocrinus decorus* (Thomson, 1864), *Democrinus brevis* (A.H. Clark, 1909) and *Nemaster grandis* A.H. Clark, 1909 (see Zoppi, 1967; Tommasi, 1971; Meyer *et al.*, 1978; Gómez-Maduro and Hernández-Ávila, 2011). *Nemaster grandis* is distributed along the Caribbean coast of Central and South America (Meyer *et al.*, 1978); the only records from Venezuela were documented by Tommasi (1971) and Meyer *et al.* (1978) in waters off the country (no further details) and Los Roques Archipelago, respectively.

The present article documents the first confirmed record of *P. crinoidalis* in Venezuelan waters, expanding its known distribution range in the Caribbean, as well as an additional record of the crinoid *N. grandis* in Venezuela.

Materials and Methods

During exploratory sampling conducted in waters off Chichiriviche de la Costa, Vargas State (Venezuela) between August and December 2016, six specimens of shrimps associated with crinoids were detected and collected. Photographs of the shrimps and the crinoids were taken *in situ* and were used to identify the echinoderms and to examine variations in coloration patterns of both species. Shrimps were preserved in ethyl alcohol 90% and carried to the Laboratorio de Carcinología de la Universidad de Oriente, Núcleo Nueva Esparta, for further analysis and taxonomic identification. Once in the laboratory, the specimens were sexed and measures of the carapace length (CL), from the dorsal proximal border to the base of the first spine of the rostrum, were taken.

Taxonomy

Echinodermata Brugière, 1791

Crinoidea Miller, 1821

Comatulida A.H. Clark, 1908

Comatulidae Fleming, 1828

***Nemaster* A.H. Clark, 1909**

***Nemaster grandis* A.H. Clark, 1909**

Nemaster grandis A.H. Clark, 1909: 504.— Meyer *et al.*, 1978: 414.— Benavides-Serrato *et al.*, 2011: 58, fig. 2 A.

Diagnosis. Organisms robust; cirrus XXV–XXX, 30–35, approximately 40 mm long, big and strong; 24–31 arms, about 200 mm long; color: translucent purple or black with white spinules, no black line in the middle of the dorsal surface of the arms. Without dark spot in the middle of each segment of the pinnules, the pinnules single-colored or with white tips (A.H. Clark, 1931; Meyer and Macurda, 1976; Benavides-Serrato *et al.*, 2011).

Type locality. Albatross station 2146, off Colon, Canal Zone, Panama.

Geographical distribution. Jamaica; Dominican Republic; Caribbean coast of Central and South America from Honduras to Los Roques Archipelago (Venezuela), including Panama, Colombia, Curaçao and Bonaire (Meyer *et al.*, 1978).

Records for Venezuela. Off Venezuela (Tommasi, 1971), Los Roques (Meyer *et al.*, 1978) and Chichiriviche de la Costa, Vargas State (present study).

Habitat. The organisms were observed in coral reefs with sandy bottoms, between 5–18 m deep.

Remarks: Some specimens of the *Nemaster grandis* (Figs. 2, 4) presented orange, black and white colours, instead of the typical coloration combining dark purple, black and white previously described for the species (Clark, 1931; Meyer and Macurda, 1976; Benavides-Serrato *et al.*, 2011). For that reason, we chose the denomination *Nemaster* cf. *grandis* for the observed coloration; further studies need to be conducted to confirm the specific identity and check whether this is a just another variation never described to date.

Artropoda Von Siebold, 1848

Malacostraca Latreille, 1802

Decapoda Latreille, 1802

Caridea Dana, 1852

Palaemonidae Rafinesque, 1815

***Periclimenes* Costa, 1844**

***Periclimenes crinoidalis* Chace, 1969**

Periclimenes crinoidalis Chace, 1969: 251, Figs. 1, 2 — Chace, 1972: 34.— Críales, 1984: 309.

Description: Rostrum slightly upturned in males and largest females, overreaching half of second antennular segment in males and extending to the distal margin of the third segment in females. Dorsal margin armed with 6–8 spines in males, and 8–10 spines in females, the first proximal spine placed almost at level of the orbital margin; ventral margin of the rostrum armed distally with a small spine (sometimes absent) in males and with 3 spines in the females. Antennal spine strong, slightly smaller than the ventral angle of the orbit; slimmer and shorter than hepatic spine.

Cornea pigmented, fill almost half of the ocular peduncle.

Antennular peduncle with stylocerite sharp and slender, reaching nearly to mid length of basal segment; first segment armed with 2-3 subequal spines in the distolateral margin.

Antennal scale overreaching distal margin of the third antennular segment, three or slightly more than three times longer than wider. Basal segment of the scale with a strong spine near the base.

Third maxilliped with exopod reaching the distal margin of the first segment. The rest of the mandibular appendices were not examined.

First pair of pereiopods reaching the distal margin of the antennal scale; merus about twice as long as the ischium; carpus slightly longer than chela and slightly shorter than merus; fingers of the chela longer than palm, unarmed. Second pereiopods subequal in males, overreaching antennal scale by distal third to entire length of fingers; fingers slender, unarmed, about three-fourths as long as chela and shorter than merus; ischium slightly shorter than merus. Second pairs of pereiopods unequal in shape and size in females, the left bigger than the right. Major cheliped reaching antennal scale with the carpus; fingers of the chela more than half the length of the palm, incurved in horizontal plane, apexes acute and hook-shaped, crossed distally; cutting margins of both fingers with a pair of the small proximal teeth. Minor cheliped exceeds the antennal scale with proximal end of the fingers; fingers longer than palm. Third pair of pereiopods overreaching

antennal scale, dactyls simples, with a small projection in the mid length of the flexor margin. Fourth pair reaching with the dactylus 2/3 of antennal scale. Fifth pair of pereiopods almost reaching the distal end of the antennal scale, dactyls wider than in the third and fourth pair of pereiopods.

Abdomen with all pleura rounded. Third abdominal somite produced posteriorly in a dorsal hump shape projection over base of fourth somite. Fifth somite more than half the length of the sixth.

First pair of pleopods of males with margin of endopod entire and not bilobate, second pair with *appendix masculina* and subequal endopods.

Telson slightly longer than sixth somite, not including terminal spines; dorsal spines very small but distinct, the proximal pair located approximately in the mid length of the segment and the distal pair at ¾ of the length of the telson; terminal spines very different in length and width, the most lateral pair is shorter than the 2 remaining pairs, intermediate pair wider and slightly longer than the mesial pair. Uropods characteristic of the genus.

Material examined. 4 males, 2016-Dec-10 (CL 1.19–1.58 mm), 1 ovigerous female 2016-Dec-10 (CL 2.36 mm with bopirid isopod) and 1 non-ovigerous female, 2016-Aug-29 (CL 2.39 mm). The six specimens were found in association with the crinoid *Nemaster grandis sensu lato* at 15 m depth.

Type locality. Jan Thiel Beach, Curaçao, Netherlands Antilles.

Geographical distribution. Jan Thiel Beach, Curaçao (Chace, 1956); Neguange Bay, Santa Marta, Colombia (Críales, 1984) and Chichiriviche de la Costa, Vargas State, Venezuela (present study).

Remarks. The specimens of *P. crinoidalis* collected at Chichiriviche de la Costa fit in almost entirely with the description made by Chace (1969). However, the ovigerous female presented 10 spines in the dorsal margin of the rostrum, instead of the 9 spines described by Chace (1969). Moreover, different color patterns were observed, which apparently depend not only on the crinoid host but also on the sex of the shrimps (Figs. 3, 4).

Ecological aspects. The six specimens of *P. crinoidalis* were found associated with crinoids of the species *N. grandis* (*sensu lato*) (Fig. 1). This supports the observations from different authors who argue that this association appears to be species-specific (Chace, 1969; Críales, 1984; De Grave, 2014); however, if nominate *Nemaster* cf. *grandis* is actually another species, then this hypothesis should be rejected, but the color patters of the shrimps are remarkably different from each other and each color morph correspond to its specific (also different colored) host. During the course of this investigation we believed that we had several species of *Periclimenes*, but the morphology of the shrimps did not support this idea. Further studies using molecular analysis would be necessary to clarify if they are the same species or a species complex instead.

According to the observations of one of the authors (GC), while this crinoid is relatively abundant in Chichiriviche de la Costa in depths ranging from 5–18 m, the number of shrimps per host seems to be low (2–6 shrimp per crinoid, sometimes no shrimps were observed); however, this observation could be a underestimation of the real abundance due to cryptic coloration of *P. crinoidalis* (Fig. 2), as it has previously been suggested by Chace (1969).

Although the type of association between the echinoderm and the shrimp is not analyzed in the present study. Bauer (2004) considers that the invertebrates that host shrimps not only provide refuge, but are also source of food; this author explains that in the case of the echinoderms, symbionts feed on epithelial cells when they detach to be replaced by new ones. Additionally, Bauer (2004) suggests that in the case of the crinoids, the shrimp symbionts can be cleptocommensals, feeding on the material filtrate of the water and concentrate on the ambulacral grooves with lead to the host´s mouth.

Records of decapods associated with echinoderms in Venezuela are scarce (Tab. 1) and the available information is contained in unpublished works (Lira, 2004; Castro-Guillén *et al*., 2005; Núñez, 2013; Gómez-Maduro *et al*., 2016) and publications of faunal inventories (Chace, 1956; Haig, 1956; Gore, 1974; Rodríguez, 1980; Blanco-Rambla and Liñero, 1994), with very little or no description about the kind of association.

Figure 1. Crinoid *Nemaster grandis*, in Chichiriviche de la Costa, Vargas State.

Figure 2. Mimicry of the shrimp *Periclimenes crinoidalis* associated with the crinoid *Nemaster* cf. *grandis*, in Chichiriviche de la Costa, Vargas State, Venezuela.

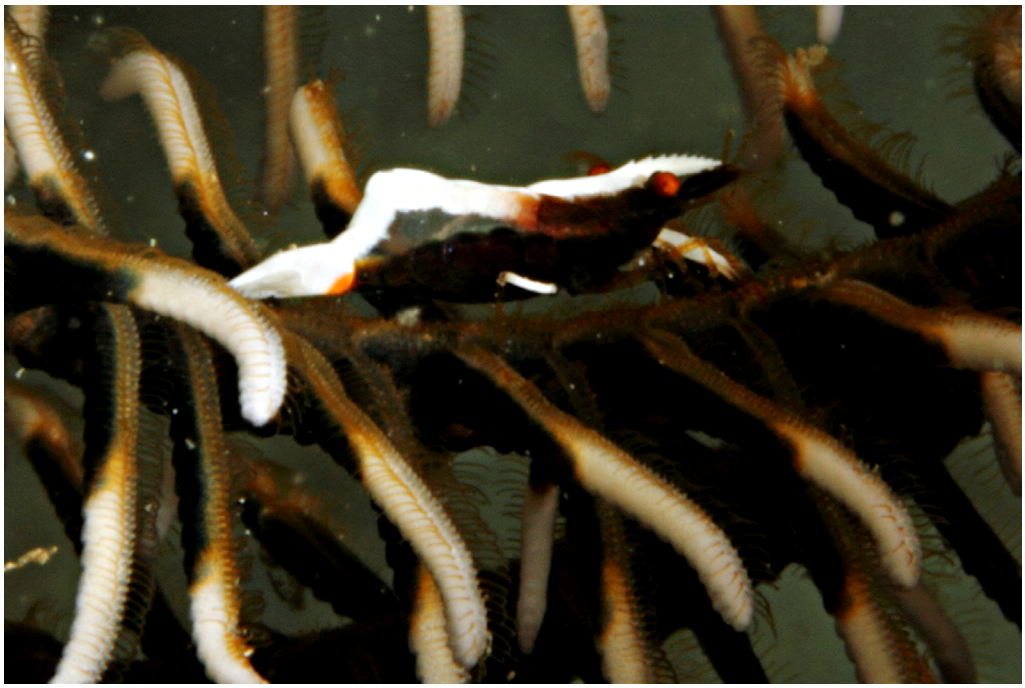

Figure 3. Ovigerous female of *Periclimenes crinoidalis* (CL 2.36 mm), associated with the crinoid *Nemaster grandis*, in Chichiriviche de la Costa, Vargas State, Venezuela.

Figure 4. Male of *Periclimenes crinoidalis* (CL 1.58 mm), associated with the crinoid *Nemaster* cf. *grandis*, in Chichiriviche de la Costa, Vargas State, Venezuela.

Up to date, 21 species of decapods associated 9 species of echinoderms (two indeterminated) have been reported for Venezuela (Tab. 1). Some of those associations could be accidental, because the crustaceans involved can be found in a great variety of other substrates [*Alpheus formosus* Gibbes, 1850; *Petrolisthes politus* (Gray, 1831); *Petrolisthes armatus* (Gibbes, 1850); *Madarateuchus vanderorsti* (Schmitt, 1924); *Calcinus tibicen* (Herbst, 1791); *Clibanarius tricolor* (Gibbes, 1850); *Damithrax hispidus* (Herbst, 1790); *Acanthonyx petiverii* H. Milne Edwards, 1834; *Mithraculus forceps* A. Milne-Edwards, 1875], while others seems to be obligatory [*Gnathophylloides mineri* Schmitt, 1933, *Teleophrys pococki* Rathbun,

Table 1. Decapods crustacean associated with echinoderms in Venezuelan waters.

Species of crustaceans	Echinoderm	Locality/Author
Gnathophylloides mineri Schmitt, 1933	Class Echinoidea *Lytechinus variegatus* (Lamarck, 1816) *Tripneustes ventricosus* (Lamarck, 1816)	Los Roques Archipelago (Chace, 1956), Mochima National Park (Vera-Caripe *et al.*, 2017)
Alpheus formosus Gibbes, 1850	Class Ofiuroidea Non-determined ofiuroids	Los Roques Archipelago (Chace, 1956)
Minyocerus angustus (Dana, 1852)	Class Asteroidea *Luidia senegalensis* (Lamarck, 1816)	Cubagua Island (Haig, 1956), Margarita Island, Los Testigos Archipelago (Gore, 1974)
Dissodactylus crinitichelis Moreira, 1901	Class Echinoidea *Encope* sp.	Miranda and Sucre States (Rodríguez, 1980)
Neocallichirus sp.	Class Ofiuroidea Non-determined ofiuroids	Jose, Anzoátegui State (Blanco-Rambla and Liñero, 1994)
Clypeasterophilus stebbingi (Rathbun, 1918)	Class Echinoidea *Clypeaster subdepressus lobulatus* Bernasconi, 1956	Margarita Island (Calderón *et al.*, 1996)
Petrolisthes politus (Gray, 1831)	Class Echinoidea *Echinometra lucunter* (Linnaeus, 1758)	La Tortuga Island (Lira, 2004)
Madarateuchus vanderorsti (Schmitt, 1924)	Class Echinoidea *Echinometra lucunter*	La Tortuga Island (Lira, 2004)
Dissodactylus sp.	Class Echinoidea *Mellita quinquiesperforata* (Leske, 1778)	Margarita Island (Castro-Guillen *et al.*, 2005)
Calcinus tibicen (Herbst, 1791)	Class Echinoidea *Echinometra lucunter*	Cepe Beach, Aragua State (Núñez, 2013)
Clibanarius tricolor (Gibbes, 1850)	Class Echinoidea *Echinometra lucunter*	Cepe Beach, Aragua State (Núñez, 2013)
Pagurus sp.	Class Echinoidea *Echinometra lucunter*	Cepe Beach, Aragua State (Núñez, 2013)
Petrolisthes armatus (Gibbes, 1850)	Class Echinoidea *Echinometra lucunter*	Cepe Beach, Aragua State (Núñez, 2013)
Acanthonyx petiverii H. Milne Edwards, 1834?	Class Echinoidea *Echinometra lucunter*	Cepe Beach, Aragua State (Núñez, 2013)
Teleophrys ornatus Rathbun, 1901?	Class Echinoidea *Echinometra lucunter*	Cepe Beach, Aragua State (Núñez, 2013)
Libinia sp.	Class Echinoidea *Echinometra lucunter*	Cepe Beach, Aragua State (Núñez, 2013)
Panopeus sp.	Class Echinoidea *Echinometra lucunter*	Cepe Beach, Aragua State (Núñez, 2013)
Damithrax hispidus (Herbst, 1790)	Class Echinoidea *Eucidaris tribuloides* (Lamarck, 1816)	Sucre State (Gómez-Maduro *et al.*, 2016)
Teleophrys pococki Rathbun, 1924	Class Echinoidea *Tripneustes ventricosus* (Lamarck, 1816)	Mochima National Park (Vera-Caripe *et al.*, 2017)
Mithraculus forceps A. Milne-Edwards, 1875	Class Echinoidea *Tripneutes ventricosus*	Mochima National Park (Vera-Caripe *et al.*, 2017)
Periclimenes crinoidalis Chace, 1969	Class Crinoidea *Nemaster grandis* A.H. Clark, 1909	Vargas State, present study

1924; *Dissodactylus* spp.], or even more species-specific [*Periclimenes crinoidalis* Chace, 1969; *Minyocerus angustus* (Dana, 1852); *Clypeasterophilus stebbingi* (Rathbun, 1918)].

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