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NOTE

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Ecological note on *Troglocarcinus corallicola* (Brachyura: Cryptochiridae) living in symbiosis with *Manicina areolata* (Cnidaria: Scleractinia) in the Mexican Caribbean

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Introduction

Coral reefs are considered the most diverse and productive ecosystems on the planet (Levinton 1982). Symbiotic interactions between phylogenetically unrelated organisms play a very important role in coral reef ecology (Carrera-Parra and Vargas-Hernández 1997), and stony corals host many organisms that live on their surface or within their skeletons (Abelson et al. 1991). Crabs are commonly associated with corals and may be totally dependent on coral for protection against predators, or as a food source either from coral mucus or trapped particulate material (Patton 1974; Castro 1976; Rinkevich et al. 1991). Cryptochiridae, or gall crabs as they are commonly known, are obligate symbionts of stony corals. These crabs can modify coral morphology by affecting growth (Simon-Blecher and Achituv 1997; Simon-Blecher et al. 1999). This, in turn, can alter local water flux and thus the movement of suspended particulate food (Abelson et al. 1991). Two forms of growth modification have been observed: depressions, called "pits," in massive corals, and flattened spheres, called "galls," made of two valves in branching corals. These two forms of coral growth modification are associated with the alimentary mechanisms of the crabs. Those feeders that form pits obtain food from material deposited in the depression while those that form galls are suspension feeders (Abelson et al. 1991).

In this note we present ecological and ethological data for *Troglocarcinus corallicola* Verrill, one of the two known species of gall crabs in the Mexican Atlantic which lives in symbiosis with the host stony coral, *Manicina areolata* Linnaeus. *Troglocarcinus corallicola* occurs throughout the Atlantic and is the most widely distributed of the Atlantic cryptochirids. In the western Atlantic, this species has been recorded in Bermuda and localities from southeastern Florida to Brazil. In the Gulf of Mexico it has been previously found in Barra del Tordo, Tamaulipas, and in the Veracruz Reef System, Veracruz. The species has been reported as a symbiont of several species of stony corals, including *M. areolata* (Kropp and Manning 1987).

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Methods

The study was conducted at the beginning of December 1999 at a site in the lagoon of Xahuayxol reef (18° 30' 15'' N, 87° 45' 32'' W), in the Mexican Caribbean. The study site was approximately 2,500 m^2 in size and ~1 m in depth. It contained 230–407 shoots/m^2 of *Thalassia testudinum* Banks ex Köning and a high density of *M. areolata* colonies (Ruiz-Zárate et al. 2000). Every coral colony of this species was inspected and all *T. corallicola* living within a coral were collected. During handling, coral colonies were kept in seawater using a floating rectangular basket and were returned to the bottom after collection of the gall crabs. To avoid injury to the corals, specimens of *T. corallicola* were removed from their pits with tweezers and fixed in a 10% formalin solution. Corals were divided into three size classes following the criteria of Ruiz-Zárate et al. (2000): juvenile, ≤ 3.5 cm long; small adults, 3.6–6.4 cm long; and large adults, > 6.4 cm long. These sizes do not necessarily correspond to sexual stages since we did not check gonad development. Some samples of algae growing around crab pits were also collected and fixed in a 4% formalin solution for later identification in the laboratory. Ten *T. corallicola* specimens were frozen for stomach contents analysis.

Results and discussion

This is the first record of *T. corallicola* for the Mexican Caribbean. One hundred and sixty colonies of *M. areolata* were examined of which 50 (31%), 51 (32%), and 59 (37%) were in the juvenile, small adult, and large adult size classes, respectively. 33 (21%) of the 160 colonies contained *T. corallicola*. Of these colonies, one colony (1%) contained a single male, 18 (11%) a single female, and 14 (9%) a male and a female (Fig. 1a). No coral colony was observed to have more than two gall crabs or two individuals of the same sex. None of the corals in the juvenile size class contained gall crabs. Eight (16%) of the small adult corals contained gall crabs (2% a single male, 6% a single female, and 8% a pair). 25 (42%) of the large adult corals contained gall crabs: 15 (25%) a single female and ten (17%) a pair (Fig. 1b). There was a clear relationship between host size class and the presence of gall crabs, but the number of gall crabs per colony was independent of the two adult coral size classes ($X_1^2 = 0.008$, $P > 0.90$, $n = 33$, d.f. = 1).

A total of 47 specimens of *T. corallicola* were collected from the 160 corals, of which 32 (68%) were females and 15 (32%) males, a 2.1:1 female-male sex ratio. A Chi-squared test showed significant deviations from a 1:1 sex ratio ($X_1^2 = 6.149$, $P < 0.02$, $n = 47$, d.f. = 1). When the data were analyzed by coral class size, small adults of *M. areolata* contained 7 female and 5 male *T. corallicola*, 1.4:1 female-male sex ratio, with no significant deviation from a 1:1 sex ratio ($X_1^2 = 0.333$, $P > 0.50$, $n = 12$, d.f. = 1), while large adult corals contained 25 females and ten males, 2.5:1 female-male sex ratio, with significant deviation from a 1:1 sex ratio ($X_1^2 = 6.429$, $P < 0.02$, $n = 35$, d.f. = 1) (Fig. 1c).

18 of the 32 (56%) females were ovigerous, with embryos in different stages of development from initial to well developed stage. This is the first report of ovigerous females in December. Ovigerous females have been collected in January (Florida, Mexico, and Curaçao), March (Belize), May (Florida and Ascension Island), June (Florida Middle Ground, Mexico, and St. Helena), July (Florida and Ascension Island), August (Florida and Mexico), and November (Ascension Island) (Shaw and Hopkins 1977; Scotto and Gore 1981; Kropp and Manning 1987). These data and the present results suggest that *T. corallicola* is able to reproduce throughout the year but more research is needed to establish if there are some months with higher reproduction. In the small adult size class of *M. areolata* three

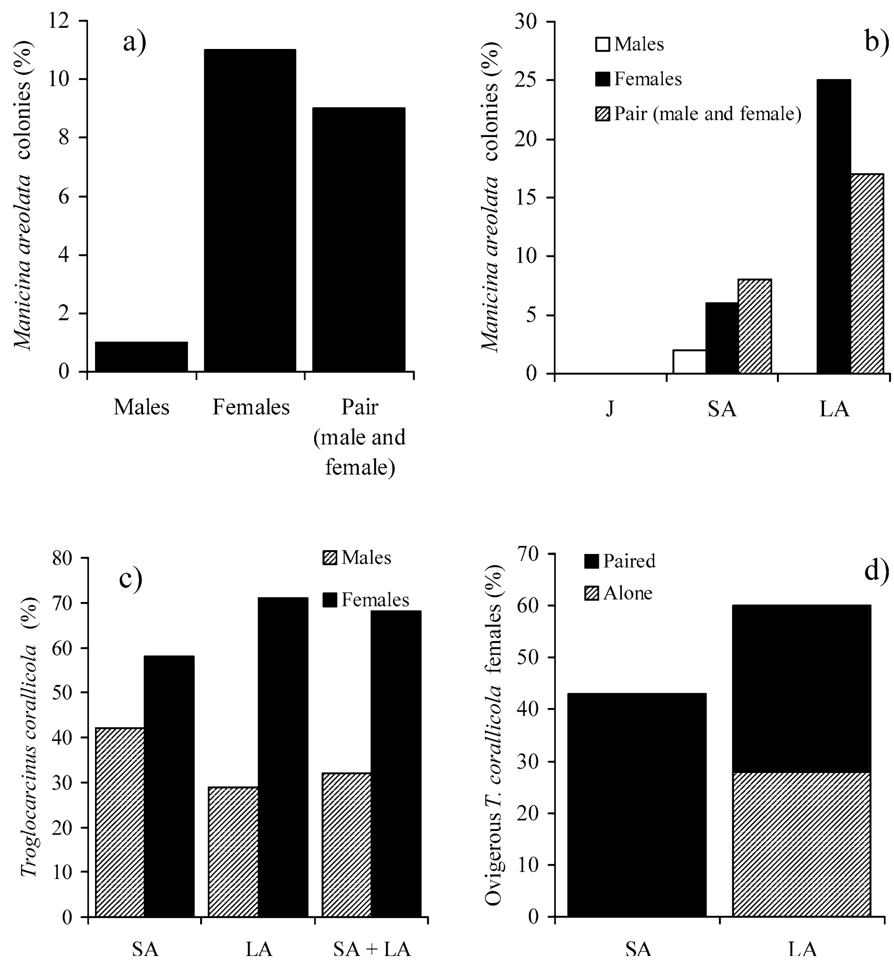

Fig. 1a Percentage of *M. areolata* colonies occupied by *T. corallicola* males, females, and pairs. **b** Percentage of *M. areolata* colonies occupied by *T. corallicola* males, females, and pairs, shown separately for different colony size classes. **c** Percentage of *T. corallicola* males and females in *M. areolata* colonies of different size classes. **d** Percentage of *T. corallicola* ovigerous females alone or paired with a male in *M. areolata* colonies of different size classes. *M. areolata* colony size classes are: juvenile (J), small adults (SA), and large adults (LA). See text for further information

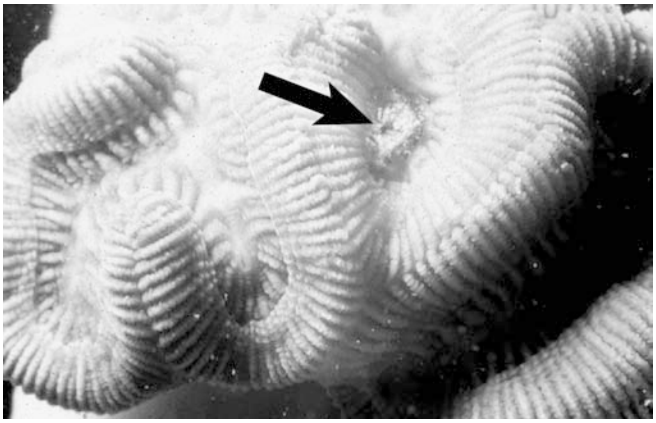

Fig. 2 A large adult of *Manicina areolata*. Note the gall crab pit (arrow) with the "pruned garden" on its opening. Photo by H. Bahena-Basave

of the seven (43%) females were ovigerous, and all were paired with a male, while in the large adult size class 15 of the 25 (60%) females were ovigerous and 7 of these were alone in the coral colony (Fig. 1d). This suggests that males move from one colony to another to mate. Kropp and Manning (1987) noted that there are records of free-living male gall crabs.

A "pruned garden" of filamentous algae was observed in all openings of the gall crab pits (Fig. 2). This led us to speculate that the gall crabs were obtaining food from the algae. Filamentous algae of the genera *Dichothrix* Zanardini and *Lyngbya* Agardh formed the "pruned garden" in pit openings. Analysis of the stomach contents of the ten frozen crab specimens revealed many green pigments and filamentous algae of *Lingbya* and *Symploca* Kützing genera. Some foraminifers and suspended material were also found in the guts and many eggs in one ovigerous female. Since *T. corallicola* forms pits in *M. areolata* colonies, this species must obtain food from material deposited in the depression (Abelson et al. 1991). Our results also suggest an alimentary use of the "pruned garden" in the pit openings.

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