



NEW RECORD OF CALYPTRAEID HOSTS FOR THE PEA CRAB *CALYPTRAEOTHERES GARTHI* (FENUCCI, 1975) (DECAPODA, PINNOTHERIDAE) IN ARGENTINA

BY

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ABSTRACT

Calyptraeotheres garthi (Fenucci, 1975) is one of nine species of Pinnotheridae occurring in Argentina and the only species of that genus located in this region. This species can be found from the San Matías Gulf, Argentina to Río Grande do Sul, Brazil where it lives in symbiotic association with limpets of the family Calyptraeidae. Currently, two species of limpets have been reported as hosts of this species: *Crepidula protea* (d'Orbigny, 1841) and *Crepidula argentina* Simone, Pastorino & Penchaszadeh, 2000. We report here four more species of limpets serving as hosts of *C. garthi*, namely *Bostrycapulus odites* Collin, 2005, *Crepidula cachimilla* Cledon, Simone & Penchaszadeh, 2004, *Crepidula plana* Say, 1822 and *Trochita pileus* (Lamarck, 1822). Thus, this pinnotherid appears to be, as others members of the family, a generalist symbiotic species since it dwells on almost all the potential limpet species reported for Argentina. However, there are notable differences in prevalence of *C. garthi* on each host, which suggest that the symbiont might prefer species of *Crepidula* over the others genera (*Trochita* and *Bostrycapulus*). Additionally, there exists an apparent relationship between host size and prevalence (e.g., *Crepidula cachimilla*, the limpet with the highest prevalence, is clearly larger than the others hosts). Perhaps it is premature to conclude that the size of the host might be of benefit for the symbiont, but it is a hypothesis worthy of being explored.

RESUMEN

Calyptraeotheres garthi (Fenucci, 1975) es una de las nueve especies de la familia Pinnotheridae que se encuentran en Argentina, y es la única especie del género presente en esa región. Se distribuye

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desde el Golfo San Matías, Argentina hasta Río Grande do Sul, Brasil y establece asociaciones simbióticas con lapas marinas de la familia Calyptraeidae. Hasta el presente, dos especies de lapas marinas han sido reportadas como hospedadores de ésta especie: *Crepidula protea* (d'Orbigny, 1841) y *Crepidula argentina* Simone, Pastorino & Penchaszadeh, 2000. En el presente trabajo se reportan cuatro hospedadores más de *C. garthi*: *Bostrycapulus odites* Collin, 2005, *Crepidula cachimilla* Cledon, Simone & Penchaszadeh, 2004, *Crepidula plana* Say, 1822 y *Trochita pileus* (Lamarck, 1822). Por lo tanto, este cangrejo pinotérico, al igual que otros miembros de la familia, es una especie de simbiote generalista, ya que habita en casi todos los hospedadores potenciales de Argentina. A pesar de ello, existe una notable diferencia en la prevalencia de *C. garthi* en cada lapa marina, lo cual sugiere que el pinotérico tendría preferencia por las especies de *Crepidula* por sobre las de otros géneros (*Trochita* y *Bostrycapulus*). A su vez, existe una aparente relación entre el tamaño de la especie hospedadora y la prevalencia (e.g., *Crepidula cachimilla*, el hospedador con la mayor prevalencia del pinotérico es claramente más grande que los otros). El tamaño del hospedador podría beneficiar al cangrejo simbiote, sin embargo esta hipótesis debe ser explorada en más detalle en el futuro.

INTRODUCTION

The family Pinnotheridae De Haan, 1833 is composed of approximately 302 species of small-sized crabs (De Grave et al., 2009), commonly known as pea crabs, living in symbiotic association with a variety of benthic invertebrates, such as molluscs, ascidians, annelids, echiurans, echinoderms, and other crustaceans (Schmitt et al., 1973). Some of these associations are considered to be commensalistic (Wells & Wells, 1961; Boschi et al., 1992; Grove et al., 2000) but in some other cases the relationship has been reported to be parasitic (Stauber, 1945; Bierbaum & Ferson, 1986; Takeda et al., 1997; Chaparro et al., 2001; Sun et al., 2006).

Pinnotherids are commonly associated with more than a single host species (McDermott, 1962; Kruczynski, 1973; Boschi, 2000; McDermott, 2005). For instance, the pea crab *Pinnixa chaetoptera* Stimpson, 1860 has been recorded inside of polychaete tubes as well as in burrows of Callianassidae (cf. Schmitt et al., 1973; McDermott, 2005). Also *Tumidotheres maculatus* (Say, 1818) is frequently found inhabiting the mantle cavity of at least 10 species of mussels but may as well be found within oysters, clams and scallops (McDermott, 1962; Kruczynski, 1973; Fenucci, 1975; Narvarte & Saiz, 2004). Likewise, *Dissodactylus crinitichelis* Moreira, 1901, a common ectoparasite of echinoderms, has been observed to be associated to at least six species of sand dollars (Queiroz et al., 2011). Although there are examples where only one host is known, for instance *Austinixa behreae* (Manning & Felder, 1989) living in burrows of *Callichirus major* (Say, 1818), in general, pinnotherids appear to be generalist organisms with the capability of colonizing hosts with striking size differences and/or Bauplan. Reasons behind this apparent lack of host specificity have not been explored, at least not in Argentinean host-pinnotherid systems. Furthermore, there is no information supporting the

hypothesis that pea crabs could choose among different hosts and what might be the benefits of such choice.

As is the case with many species of decapods from Argentina, information about the biology (e.g., reproduction, growth and relationship with their host) of the pea crabs is scant. The exception seems to be *T. maculatus* in which many aspects of the life history and crab-host relation have been studied (Welsh, 1932; McDermott, 1962; Pearce, 1964; Costlow & Bookhout, 1966; Bierbaum & Shumway, 1988; Narvarte & Saiz, 2004). Effects of the pea crab on economically important hosts makes *T. maculatus* a target for such studies. On the other hand, the information on any of the other Argentinean pea crabs is limited to only a few studies (Fenucci, 1971; Gómez-Simes, 1993; Alves & Pezzuto, 1998; Ocampo et al., 2011; Queiroz et al., 2011). The main reason for such lack of information is probably because they cause no harm to any economically important species.

Calyptraeotheres garthi (Fenucci, 1975) is one of the nine species of Pinnotheridae occurring in Argentina and the only species of that genus present in this country (Fenucci, 1975; Boschi, 2000; Torres, 2006). This species can be found from the San Matías Gulf, Argentina to Río Grande do Sul, Brazil (Martins & D’Incao, 1996), where it lives in symbiotic association with limpets of the family Calyptraeidae (cf. Fenucci, 1975; Campos, 1999). These limpets are characterized by a protandric hermaphroditic life cycle where the small and mobile male grows and develops into a sessile female (Kükenthal, 1925).

The most basic information regarding any pinnotherid crab, including *C. garthi*, is the list of hosts that it can colonize. Such information will be useful to understand for example patterns of distribution, population genetics, or evolution of the parasite/host system. Currently, two species of limpets have been reported as hosts of *C. garthi*: *Crepidula protea* (d’Orbigny, 1841) (cf. Parodiz, 1939; Fenucci, 1975; Martins & D’Incao, 1996) and *C. argentina* Simone, Pastorino & Penchaszadeh, 2000 (formerly *C. unguiformis*, see Simone et al., 2000) (Fenucci, 1971, 1975; Simone et al., 2000). A third unidentified species of *Crepidula* was reported by Fenucci (1975). We report here four more species of limpets serving as hosts of *C. garthi*. Additionally, we provide data pertaining to some aspects of the crab/limpet relationship, such as prevalence per host. Finally, we discuss why *C. garthi* presents an unequal prevalence on its different calyptraeid hosts.

MATERIAL AND METHODS

Specimens of five limpet species (family Calyptraeidae) were obtained from six sites in the western South Atlantic, both from the littoral of Buenos Aires (BA) and San Matías Gulf (SMG), Argentina (fig. 1, table I). *Crepidula cachimilla*

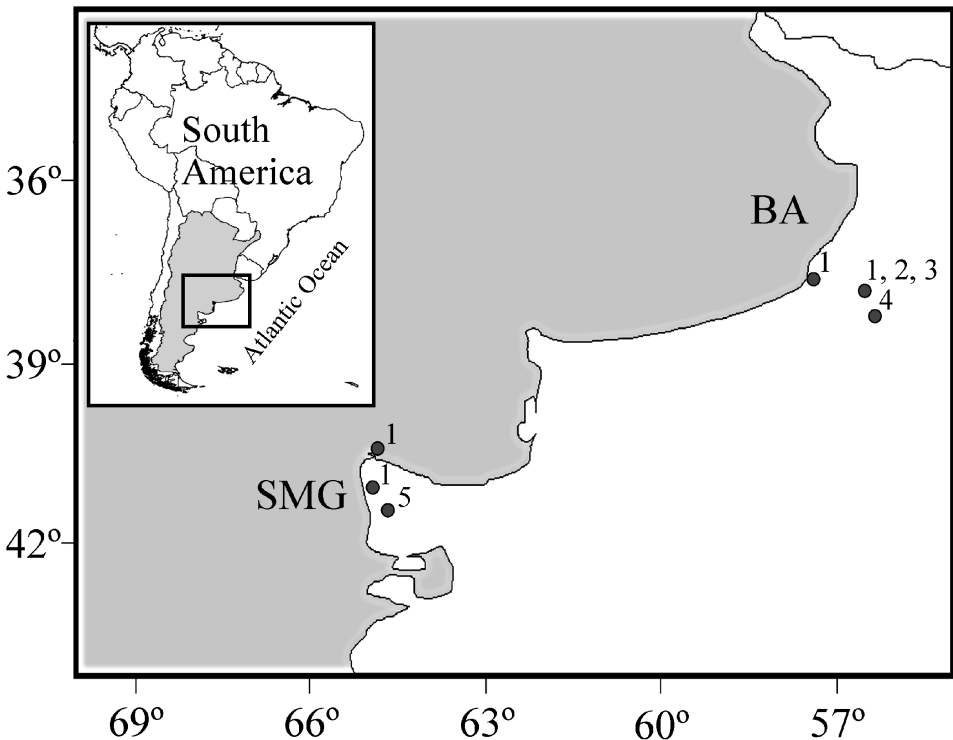


Fig. 1. Map of South America displaying the sampling sites of five limpet hosts of *Calyptraeotheres garthi* (Fenucci, 1975). The enlarged area shows two main collecting areas in and off shore Buenos Aires (BA) and San Matías Gulf (SMG). 1, *Bostrycapulus odites* Collin, 2005; 2, *Crepidula argentina* Simone, Pastorino & Penchaszadeh, 2000; 3, *Crepidula plana* Say, 1822; 4, *Trochita pileus* (Lamarck, 1822); 5, *Crepidula cachimilla* Cledón, Simone & Penchaszadeh, 2004.

Cledón, Simone & Penchaszadeh (2004) was collected from mussels captured by commercial vessels at SMG. The limpet *Bostrycapulus odites* Collin, 2005 was collected from both intertidal (by hand) and subtidal (by SCUBA diving or dredging) sites at SMG and BA. Finally, *Crepidula argentina*, *Crepidula plana* Say, 1822, and *Trochita pileus* (Lamarck, 1822) were collected by dredging at the subtidal zone of BA on board of the RV “Puerto Deseado” (see table I). With regard to the substrates, the limpet *B. odites* was found attached to the shell of live *Ostrea puelchana* d’Orbigny, 1842 (subtidal of SMG) whereas this limpet was found attached to stones everywhere else. The species *Crepidula argentina* and *Crepidula cachimilla* were found mostly attached to the mussel *Mytilus edulis* Linnaeus, 1758 and sometimes to the bivalve *Aulacomya ater* (Molina, 1782). The limpet *Crepidula plana* was found attached to the inner side of empty shells of the clam *Protothaca antiqua* (King & Broderip, 1835), the volutid snails *Adelomelon brasiliensis* (Lamarck, 1811), and *Zidona dufresnei* (Donovan, 1823).

TABLE I
Detailed sampling information of five limpet hosts of *Calyptraeotheres garthi* (Fenucci, 1975) ordered by collecting site and host

Collection	Coordinates, date (depth, m)	Host species (N)	Host size range (mm)	Colonized hosts	P (%)	Number and sex of collected <i>C. garthi</i> (mean size mm ± SD)
SMG	40°43'28"S 64°56'13"W, April 2007 (0.5)	<i>Bostrycapulus odites</i> (187)	4.4-21.2	F 4, M 1	2.7	F 3 (3.9 ± 0.4)
	40°49'51"S 65°04'01"W, April 2009 (12)	<i>Bostrycapulus odites</i> (72)	5.2-22.6	F 4, M 0	5.5	M 2 (2.1 ± 0.2) F 3 (3.7 ± 0.3) M 1 (2.4)
	41°13'08"S 65°02'58"W, December 2007 (about 25)	<i>Crepidula cachimilla</i> (42)	17.1-44.8	F 27, M 1	66.7	F 28 (5.1 ± 2.3) M 3 (2.0 ± 0.7)
	38°02'10"S 57°31'29"W, January 2008 (0-3)	<i>Bostrycapulus odites</i> (221)	3.9-23.8	0	0	0
BA	38°15'51"S 56°59'96"W, September 2009 (62)	<i>Bostrycapulus odites</i> (68)	3.5-21.4	F 3, M 0	4.4	F 1 (1.9) M 2 (2.5 ± 0.6)
		<i>Crepidula argentina</i> (16)	7.1-25.6	F 4, M 1	31.2	F 3 (2.4 ± 1.0) M 2 (1.8 ± 0.1)
		<i>Crepidula plana</i> (17)	7.4-26.4	F 7, M 0	41.2	F 7 (3.0 ± 1.0) M 0
	38°18'63"S 56°58'99"W, September 2009 (72)	<i>Trochita pileus</i> (38)	2.0-19.5	F 1, M 0	2.6	F 1 (2.0) M 0

BA, Buenos Aires; SMG, San Matías Gulf; P, prevalence (%); N, number; F, females; M, males.

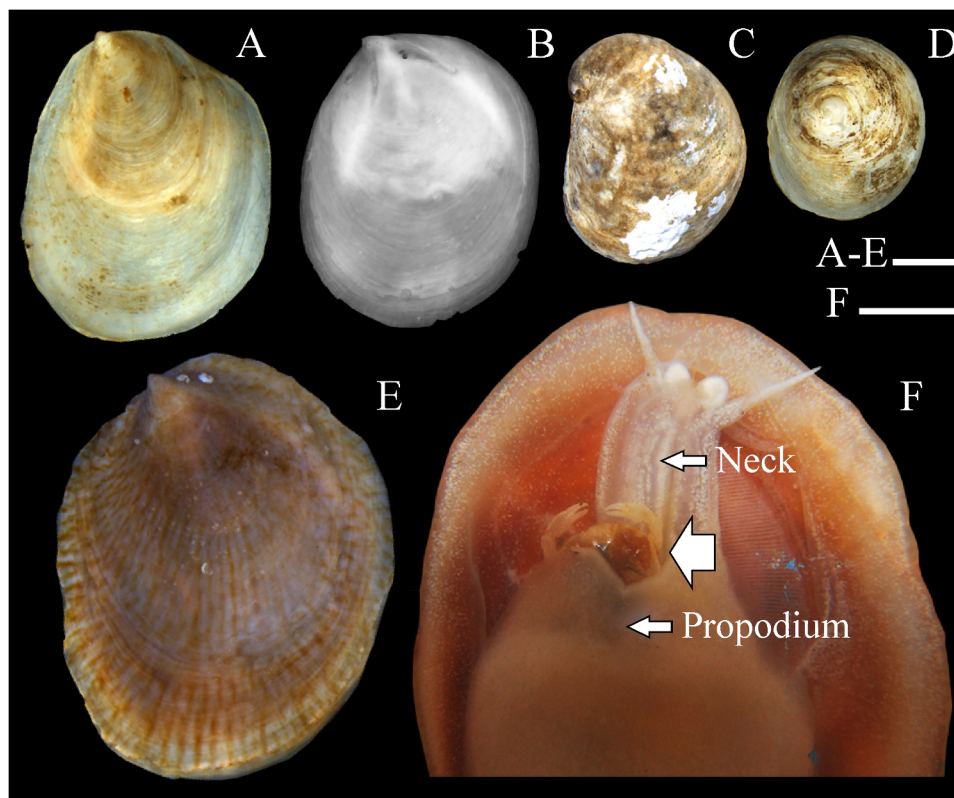


Fig. 2. A-E, dorsal view of five limpet hosts of *Calyptraeotheres garthi* (Fenucci, 1975). A, *Crepidula plana* Say, 1822; B, *Crepidula argentina* Simone, Pastorino & Penchaszadeh, 2000; C, *Bostrycapulus odites* Collin, 2005; D, *Trochita pileus* (Lamarck, 1822); E, *Crepidula cachimilla* Cledón, Simone & Penchaszadeh, 2004; F, detail in ventral view of *C. cachimilla* showing the pea crab *C. garthi* (arrow) positioned between the propodium and the neck of a female host; size bar = 5 mm. This figure is published in colour in the online edition of this journal, which can be accessed via <http://booksandjournals.brillonline.com/content/15685403>.

Lastly, *Trochita pileus* was found attached to the outer side of empty shells of *P. antiqua*.

The limpets were carefully detached of their substrates and individually fixed and preserved in 80% ethyl alcohol (EtOH). They were inspected to verify the presence of pea crabs back at the Marine Ecology and Genetics lab (EGEM), National University of Mar del Plata, Argentina. The crabs were identified based on the original description (Fenucci, 1975). For the limpets, on the other hand, the descriptions from the literature was used (Parodiz, 1939; Hoagland, 1977; Simone et al., 2000; Cledón et al., 2004; Collin, 2005); when necessary, identification was confirmed by the acknowledged expert. Crabs were sexed based on the presence or absence of gonopods (McLaughlin, 1980) while limpets were sexed based on the

presence or absence of a penis (Cledón et al., 2004; Collin, 2005). The shell length of limpets (longest axis) was measured with a digital calliper of 0.1 mm precision. The carapace width (CW) of crabs was determined under a stereomicroscope with the aid of a graduated eyepiece (0.01 mm precision). The prevalence of the pea crab in the hosts was defined as the number of hosts harbouring one or more crabs divided by the number of total hosts and expressed in percentage.

RESULTS

The pea crab *Calyptraeotheres garthi* was found living inside of all five species of the potential limpet hosts (fig. 2). Only one of these limpets, *Crepidula argentina*, has been recorded previously as host of *C. garthi* (cf. Fenucci, 1971, 1975; Simone et al., 2000). However, symbiosis of *C. garthi* on four other limpets, *B. odites*, *Crepidula cachimilla*, *Crepidula plana* and *Trochita pileus* is reported herein for the first time.

There appear to be some patterns on the prevalence of *C. garthi* dwelling on its limpet hosts. For instance, in all limpets the pea crabs were observed positioned between the neck and the propodium (fig. 2F). Also, *C. garthi* was principally observed associated to hosts in their female phase (table I), although in *B. odites*, *Crepidula argentina* and *Crepidula cachimilla* some pea crabs were found within limpet males (18.2%, 25%, and 3.7% respectively). The prevalence of *C. garthi* differed among host species, it was less than 6% in *B. odites*, 41.3% in *Crepidula plana*, 66.6% in *Crepidula cachimilla*, 31.2% in *Crepidula argentina* and 2.6% in *Trochita pileus*, which shows a trend to increase prevalence with increasing maximum size of the host (table I).

DISCUSSION

There are eight species of limpets of the family Calyptraeidae distributed in Argentina (Parodiz, 1939; Hoagland, 1977; Simone et al., 2000; Cledón et al., 2004; Penchaszadeh et al., 2002; Collin, 2005; Pastorino & Urteaga, 2012): *Bostrycapulus odites* (sensu Collin, 2005; formerly *Crepidula aculeata* Gmelin), *Crepidula argentina*, *Crepidula cachimilla*, *Crepidatella dilatata* (Lamarck, 1822), *Crepidula plana*, *Crepidula protea*, *Trochita pileus* and *Trochita pileolus* (d'Orbigny, 1841). We excluded *C. unguiformis* Lamarck, 1822 from this list because distribution of this species has been restricted to the Mediterranean Sea and North Africa (sensu Hoagland, 1977). All the above limpets are potential hosts of *Calyptraeotheres garthi*.

Many pinnotherid crabs have been regarded as generalist organisms since the same species is capable of colonizing a wide variety of hosts with striking differences in size and/or build (Kruczynski, 1973; Schmitt et al., 1973; McDermott, 2005; Queiroz et al., 2011; see also examples of host specificity in Manning & Felder, 1989). The pea crab *C. garthi* may establish a symbiotic relationship with almost all the potential limpet host species reported for Argentina. Despite the wide spectrum of limpet species that *C. garthi* occupies, it seems to prefer species of *Crepidula* over the other genera. Six of the eight species of limpets listed above either have been reported or are reported here to be dwelled by *C. garthi*. Thus we update the list of hosts of *C. garthi* as follows: *Crepidula argentina*, *Crepidula protea*, *B. odites*, *Crepidula plana*, *Crepidula cachimilla* and *Trochita pileus*. Neither *Crepidatella dilatata* nor *Trochita pileolus* have been found occupied by this pea crab (table I).

We found that pea crabs positioned themselves within the mantle cavity of the host between the neck and a fold of the foot called propodium. In this position, the pinnotherid crab is able to feed on the mucus string that contains food that accumulated on the gill of the limpet (Chaparro et al., 2001; E. O. pers. obs.). The symbiont might be affecting also the reproductive output in all the observed hosts by occupying the brooding area, as it has been reported previously for *Crepidatella fecunda* Gallardo, 1979 parasitized by *Calyptraeotheres* sp. from the coast of Chile (Chaparro et al., 2001). It is noteworthy that we did not find brood capsules in any of the occupied hosts.

The observed tendency of the crab to occupy female limpets might be related to the life history of the host. Since all members of Calyptraeidae are protandric hermaphrodites undergoing metamorphosis at small sizes (Simone et al., 2000; Cledón & Penchaszadeh, 2001; Cledón et al., 2004) and female and male pea crabs establish association with their colonized host, even molting within the host (Christensen & McDermott, 1958; Pearce, 1964, 1966), then pea crabs potentially will likely dwell female host more often than male hosts. Furthermore, in the event when a crab colonizes a young male limpet that has not reached the size to change sex, the host will eventually undergo metamorphosis; thus the pea crab will be found almost always within a female host. A complementary study paper testing this hypothesis is now in progress.

We found that *C. garthi* occurs within six species of calyptraeid limpets, but we also found differences in prevalence depending on the host. Little is known about host species preferences in this pea crab/limpet system but it appears that the symbiont have greater success colonizing *Crepidula cachimilla*, followed by *Crepidula plana*, *Crepidula argentina*, *B. odites*, and *Trochita pileus*. A spectrum of factors has been postulated to explain differences in prevalence on other pinnotherid/host systems: availability of food and the abundance of hosts (Haines

et al., 1994), salinity (Kruczynski, 1973), depth (Kruczynski, 1974; Pregonzer, 1978; Narvarte & Saiz, 2004), host distribution along the beach (Houghton, 1963; Seed, 1969), presence or absence of competitors (McDermott, 2005) and sex and density of previously present congeneric specimens (Bell, 1984). Explanations for the apparent host preference of *C. garthi* are beyond the scope of this study but there is an apparent relationship between host size and prevalence. This is a hypothesis worth investigating.

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