



Volutid shells as settlement substrates and refuge in soft bottoms of the SW Atlantic Ocean

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Abstract. In this contribution we highlighted the importance of the gastropod *Adelomelon ancilla* (living and empty shells) as settlement substrate for the sea anemones *Antholoba achates* and *Isotealia antarctica* in soft bottoms of the SW Atlantic Ocean. Fifty percent of the sampled shells of *A. ancilla* presented at least one epibiotic anemone and up to a maximum of 6 anemones were reported in one living individual. *Adelomelon ancilla* shells are the first settlement substrate reported for *I. antarctica*. We also recorded the use of empty shells by *Pagurus comptus* and *Propagurus gaudichaudii*, as far as the less frequent record of other invertebrates and gastropod egg cases attached to the empty shells. These results are compared with the epibiotic organisms recorded on *Odontocymbiola magellanica*, another volutid species that shares the same habitat.

Key words: *Adelomelon ancilla*, *Odontocymbiola magellanica*, epibiosis, *Antholoba achates*, *Isotealia antarctica*, shell use

Resumen. Valvas de volutidos como sustrato de asentamiento y refugio en fondos blandos del Océano Atlántico Sudoccidental. En este estudio se destaca la importancia del gasterópodo *Adelomelon ancilla* (organismos vivos y valvas vacías) como sustrato de asentamiento para las anémonas *Antholoba achates* e *Isotealia antarctica* en fondos blandos del Océano Atlántico Sudoccidental. El cincuenta por ciento de las valvas analizadas presentó al menos una anémona epibionte y hasta un máximo de 6 anémonas fueron registradas en un individuo vivo de *A. ancilla*. Las valvas de *A. ancilla* serían el primer sustrato de asentamiento conocido utilizado por *I. antarctica*. También se registró el uso de valvas vacías por *Pagurus comptus* y *Propagurus gaudichaudii*, y se registraron otros invertebrados epibiontes menos frecuentes, así como el uso de estas valvas vacías para la deposición de cápsulas de huevos de varios gasterópodos. Estos resultados se comparan con los organismos epibiontes reportados sobre *Odontocymbiola magellanica*, otra especie de volutido que comparte el mismo hábitat.

Palabras clave: *Adelomelon ancilla*, *Odontocymbiola magellanica*, epibiosis, *Antholoba achates*, *Isotealia antarctica*, uso de valvas

Introduction

The Patagonian scallop fishing grounds are highly productive areas located in the shelf-break front of the SW Atlantic Ocean (Acha *et al.* 2004). These regions are characterized by the presence of soft bottoms (Parker *et al.* 1997), high species richness (Bremec & Lasta 2002, Bremec *et al.* 2003) and a very diversified epibiotic community (Schejter

& Bremec 2007, Schejter *et al.* 2011a,b). In this community the most important component in terms of biomass is the Patagonian scallop *Zygochlamys patagonica* (King 1832), which plays an important role as ecosystem engineer (Gutiérrez *et al.* 2003, Schejter & Bremec 2007). This pectinid species is also responsible for the main flux of energy from primary producers to benthic habitat (Bremec *et al.*

2000, Schejter *et al.* 2002, Botto *et al.* 2006). Echinoderms and other mollusks, such as several gastropod species are also important components in terms of abundance and biomass of this ecosystem (Escolar *et al.* 2009). Sessile organisms in this benthic system represent about 50% of the total richness of the area (Schejter & Bremec 2009). In this sense, among the studied species of this community, the Patagonian scallop hosts more than 50 epibiotic taxa (Schejter & Bremec 2007, López Gappa & Landoni 2009), the hairy triton *Fusitriton magellanicus* hosts at least 56 epibiotic taxa (Schejter *et al.* 2011 a,b) and the spider crab *Libidoclaea granaria* hosts at least 8 epibiotic taxa (Schejter & Spivak 2005). Sea anemones (registered as “Actiniaria”) were infrequent epibionts only recorded on the mentioned mollusks.

It is well known that shells of living mollusks and also empty shells are important substrate resources in soft bottoms of benthic communities (McLean 1983). Besides the Patagonian scallop, the other important shell producers in the shelf-break frontal area of the SW Atlantic Ocean -where the Patagonian scallop fishing grounds are located- are the hairy triton *Fusitriton magellanicus* (Röding 1798) (Schejter *et al.* 2011 a,b) and the volutids *Adelomelon ancilla* (Lightfoot 1786) and *Odontocymbiola megalanica* (Gmelin 1791) (Bremec & Lasta 2002, Bremec *et al.* 2003). *Coronium acanthodes* (Watson 1882) is less frequent than volutids (Bremec *et al.* 2003) and only rare findings of *Provocator corderoi* (Watson 1882) were registered in the scallop beds (Bremec *et al.* 2012). The other gastropod species commonly registered in the area by means of the scallop by-catch studies (*Marginella warreni*, *Trochita pileolus*, *Falsimargarita iris*, *Neactaeonina argentina*, *Epitonium magellanicum*, *Calliostoma* sp. and *Admete* sp., among the most frequently recorded species, see Bremec *et al.* 2003, Zelaya *et al.* 2011) are considerably smaller in size, and hence, their contribution in biomass is not significant. However, empty shells of many of these small gastropod species are known to play an important role as refuge in this benthic community in the early developmental stages of *Sympagurus dimorphus*, a frequent hermit crab in the study area commonly associated with *Epizoanthus paguricola* (Schejter & Mantelatto 2011).

In this study, we identify and describe associations of the two main volutid species registered in the area as well as the encrusting organisms found attached to empty shells. We also registered the use of these empty shells by hermit crabs.

Material and methods

Sampling, identification and quantification of living volutids and empty shells of *Adelomelon ancilla* and *Odontocymbiola magellanica* (and their epibionts and other associated organisms) were done onboard the RV “Capitán Cánepa” in a research cruise that aimed to analyze reproductive features of the Patagonian scallop *Zygochlamys patagonica* during November 1-6, 2006. Twenty seven sites located between 38°04.91' and 39°24.98'S and 55°25.16' and 56°14.72'W, at depths between 83 and 130 meters were sampled with a non-selective dredge of 2.5 m mouth aperture (10 minutes tow at an average speed of 3.6 knots). Volutids were retained in the dredge as part of the by-catch. Total catch was analyzed and all the volutids were sorted. Epibionts were registered and quantified onboard. Actiniaria species were preserved and identified by Dr. Adriana Excoffon at Laboratorio de Cnidarios, Universidad Nacional de Mar del Plata. Individuals considered juveniles of both species were kept in a separate category (named “juveniles”) to avoid specific misidentifications, given the similar morphologies presented by both species which are more difficult to distinguish during juvenile stages (Urrea *et al.* 2007, Wiggers & Veitenheimer-Mendes 2008).

Student's t - test was used to compare shell lengths of the gastropod hosts (living *A. ancilla*, *A. ancilla* empty shells and juveniles of both species) with and without epibiotic anemones to establish preferences for shell size. Statistical analyses were done using the software Statistica 7.

Results

From the 27 sampled sites, 17 were positive for the presence of volutids (*A. ancilla*, *O. magellanica*, volutid juveniles and/or empty shells), and of them, 14 were positive for the presence of living *A. ancilla* and 8 for living *O. magellanica*.

In total, 85 living volutids (49 *Adelomelon ancilla*, 14 *Odontocymbiola magellanica* and 22 juveniles) were sampled. From the total studied gastropods, 56.4 % of the individuals were found associated with sea anemones. Two anemone species were recorded: *Antholoba achates* (Drayton 1846) (only in *A. ancilla*) and *Isotealia antarctica* (Carlgreen 1899) (in both volutid species) (Tables I and II, Fig. 1). Only on *A. ancilla* were registered simultaneously both anemones (Table II). Anemones attached to shells varied from 1 to 6 individuals / shell (Figs. 1 and 2). The majority of the *A. ancilla* were registered with 1 or 2 anemones attached (80.3%), although a small percentage (14.3%) presented 3. One individual (180 mm total shell

height TSH) was found carrying 4 anemones (3 *I. antarctica* + 1 *A. achates*), another individual (160 mm TSH) was found with 5 anemones (all *I. antarctica*) and another one (178 mm TSH) with 6 anemones (5 *I. antarctica* + 1 *A. achates*) (Figs. 1 and 2).

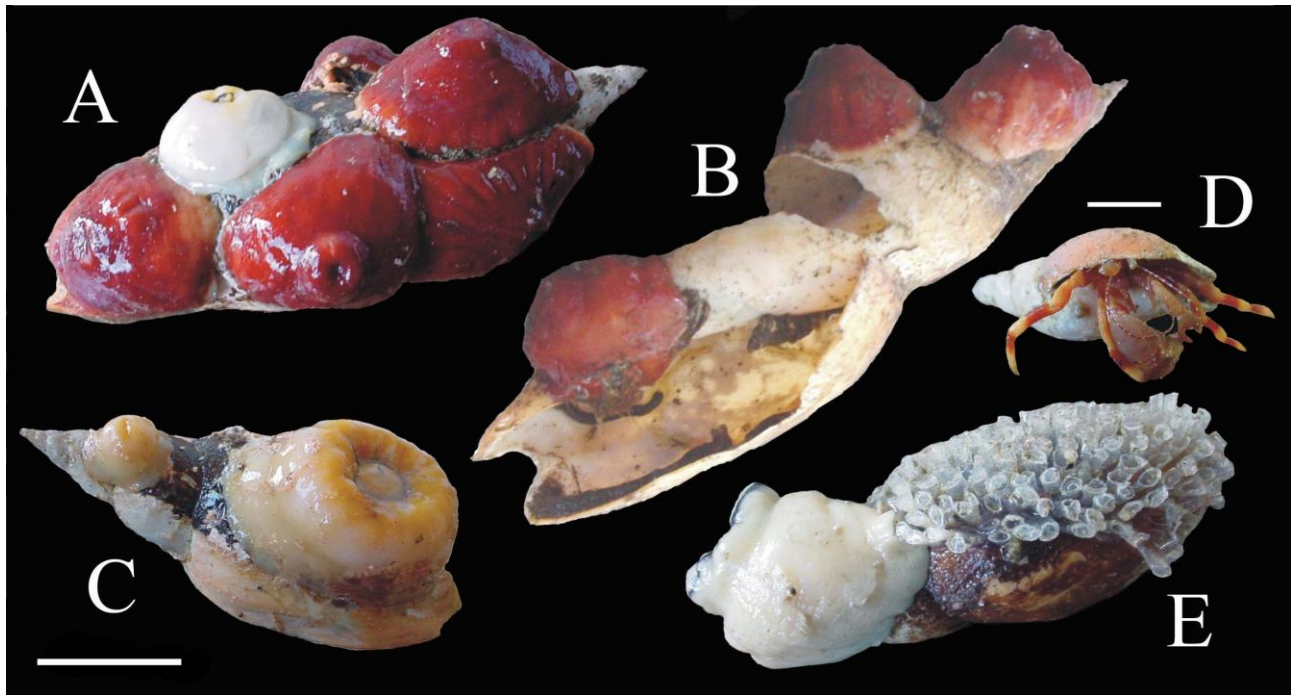


Figure 1. *Adelomelon ancilla* shells. A. living individual with 5 *Isolealia antarctica* and 1 *Antholoba achates*, B. empty shell with 3 *I. antarctica*, C. living individual with 2 *A. achates*, D. juvenile shell inhabited by *Pagurus comptus*, E. empty shell with 1 *A. achates* and egg cases of the gastropod *Fusitriton magellanicus*. General Scale bar for A,B,C,E: 40 mm. Scale bar for D: 7.5 mm

Only one individual of living *Odontocymbiola magellanica* (out of 14) was found associated with one *Isolealia antarctica*. Fourteen juvenil volutids (out of 22) were found associated with *Antholoba achates* (Table I).

Additionally, a total of 76 empty shells were sampled (48 *Adelomelon ancilla*, 7 *Odontocymbiola magellanica* and 21 juveniles) (Table II). Empty

shells of juveniles lacked epibiotic anemones. Only 1 *O. magellanica* shell was found carrying 1 *I. antarctica*. The majority of the *A. ancilla* shells presented only 1 anemone attached (70.8%); however, a small percentage presented 2 anemones attached (16.7%) or 3 (12.5%) (Table I, Figs. 1 and 2). One empty shell of *A. ancilla* was found with one anemone *Actinostola crassicornis* attached.

Table I. Epibiotic anemones registered in living and empty shells of volutids. *An additional shell was registered with an *Actinostola crassicornis* anemone attached.

	<i>Antholoba achates</i>	<i>Isolealia antarctica</i>	<i>A. achates</i> + <i>I. antarctica</i>	Total
<i>Adelomelon ancilla</i> (living)	15	8	9	32
<i>A. ancilla</i> (shells)	7	14	1	23 *
<i>Odontocymbiola magellanica</i> (living)	0	1	0	1
<i>O. magellanica</i> (shells)	0	1	0	1
Juveniles (living)	15	0	0	15
Juveniles (shells)	0	0	0	0

Table II. Size of the gastropods with and without epibiotic anemones. * Significant differences

Species	with attached anemones		without anemones	
	length average \pm sd (mm)	N	length average \pm sd (mm)	N
<i>Adelomelon ancilla</i> (living)	153.31 \pm 20.65	49	157.71 \pm 13.80	17
<i>A. ancilla</i> (shells)	148.96 \pm 19.69	24	144.87 \pm 24.37	24
<i>Odontocymbiola magellanica</i> (living)	153	1	140.31 \pm 22.21	13
<i>O. magellanica</i> (shells)	159	1	120.17 \pm 46.56	6
Juveniles (living)	78.73 \pm 24.49*	15	46.57 \pm 11.39*	7
Juveniles (shells)			65.48 \pm 23.70	21

The size of specimens of *Adelomelon ancilla* and *A. ancilla* empty shells with anemones did not differ significantly from those of the same group without anemones (Table II). There was a significant difference in size of the specimens of juveniles with and without anemones (Table II).

Two empty shells of *A. ancilla* were found inhabited by the hermit crab *Propagurus gaudichaudii* while 6 juvenile shells were found inhabited by *Pagurus comptus* (Fig. 1). None of them presented sea anemones attached. Less frequent fauna (although not quantified) found attached to empty shells were *Alcyonium* sp., hydrozoa polyps and egg cases of the gastropods *A. ancilla*, *O. magellanica* and *Fusitriton magellanicus*.

Discussion

Although cnidarian-gastropod shell associations are better studied for pagurized shells (see Williams & McDermott (2004) for a general revision), some references could be also found on living gastropods, being descriptive the majority of them (Hand 1975, Pastorino 1993, Ates 1998, White *et al.* 1999, Luzzatto & Pastorino 2006, Mercier & Hamel 2008, Rodríguez & López-González 2008, Goodwill *et al.* 2009, Mercier *et al.* 2011). These associations were described as facultative, such as the association of *Allantactis parasitica* with several gastropod species in the NW Atlantic Ocean (Mercier & Hamel 2008, Mercier *et al.* 2011) or obligate, such as the association of *Isosicyonis alba* with *Harpovoluta charcoti* and *Provocator corderoi* or *I. striata* with *Harpovoluta charcoti* in Antarctic and subantarctic waters (Rodríguez & López-González 2008). In the present study, we registered the presence of 2 anemones (*Antholoba aachates* and *Isotealia antarctica*) associated with 2 volutid species (*Adelomelon ancilla* and *Odontocymbiola magellanica*) in SW Atlantic waters.

Antholoba aachates is widely distributed in

the SW Atlantic Ocean (Argentina, Brazil), in the Pacific Ocean (Chile, Perú), in New Zealand waters and also in Antarctic waters (Orkney and Shetland Is.) (Fautin 1984, Riemann-Zürneck 1986, Haussermann & Forsterra 2005, Rodríguez *et al.* 2007, Gordon 2009), and hence, it is common species of the benthic community here studied (Bremec *et al.* 2008, 2012). This anemone has been previously registered associated with *Adelomelon brasiliiana* (Luzzatto & Pastorino 2006), with *Buccinanops cochlidium* (as *Phlyctenanthus australis* by misidentification, see Luzzatto & Pastorino (2006)) and it has been also found associated with living *Adelomelon ancilla* in the nor-Patagonian gulfs (Bigatti *et al.* 2009). Regarding non-mollusks associations in the SW Atlantic Ocean, it was registered living on *Libinia spinosa* crabs (Acuña *et al.* 2003). In the present study, we found *A. aachates* associated with *Adelomelon ancilla* either with living organisms and empty shells, but was not found attached to *O. magellanica*. Presumably, the record of *A. aachates* on 14 juvenile volutids would indicate that these juveniles would belong to *A. ancilla*, not to *O. magellanica*. However, this association, although common, was found in a lower percentage in this community (49% of the sampled gastropods) compared to the nor-Patagonian gulfs (98%, according to Bigatti *et al.* (2009)). Additionally, we recorded the co-existence of two different anemone species (*A. aachates* and *Isotealia antarctica*) sharing the same living gastropod in 16.3% of the sampled *A. ancilla* individuals. *Antholoba aachates* was also registered on 16.7% of empty shells of *A. ancilla*, but again, not on *O. magellanica* shells, fact that also highlighted the markedly preference association of this anemone for only one of the volutid species here studied, as previously mentioned by Bigatti *et al.* (2009). In the benthic community here studied, the only settlement substrate used by *A. aachates* is *A.*

ancilla.

The other anemone registered attached to volutid shells, *Isotealia antarctica*, is distributed in SW Atlantic, Pacific and Antarctic waters (Riemann-Zürneck 1986, Haussermann & Forsterra 2005, Rodríguez *et al.* 2007) and it is also a common species in this benthic community (Bremec *et al.* 2008, 2012). This anemone has been previously registered in a particular feeding association in Antarctica with macroalgae and sea urchins by Amsler *et al.* (1999), but nothing was mentioned before this study about settlement substrates in its distributional range. In this contribution we recorded the species attached to 34.7% of living *A. ancilla* and to 31.25% of empty *A. ancilla* shells. However, it was only recorded on one empty shell and one living *Odontocymbiola magellanica*, and hence,

anemones attached to *O. magellanica* (either living organisms or empty shells) are considered fortuitous findings. The maximum number of *I. antarctica* individuals associated to a single living *A. ancilla* was 5, although one specimen of *A. achates* was also registered sharing the same gastropod substrate (Figs. 1 and 2). However, contrarily to *A. achates*, *I. antarctica* was also found attached to many other organisms: *Fusitriton magellanicus*, *Zygochlamys patagonica*, *Coronium acanthodes*, *Aerothyris venosa* and empty tubes of *Chaetopterus* sp. (Schejter & Bremec 2009 and author's personal observations). In this sense, *I. antarctica* seems to be more generalist than *A. achates* choosing settlement substrates, and any solid available surface would be suitable. This is the first mention of settlement substrates used by *I. antarctica*.

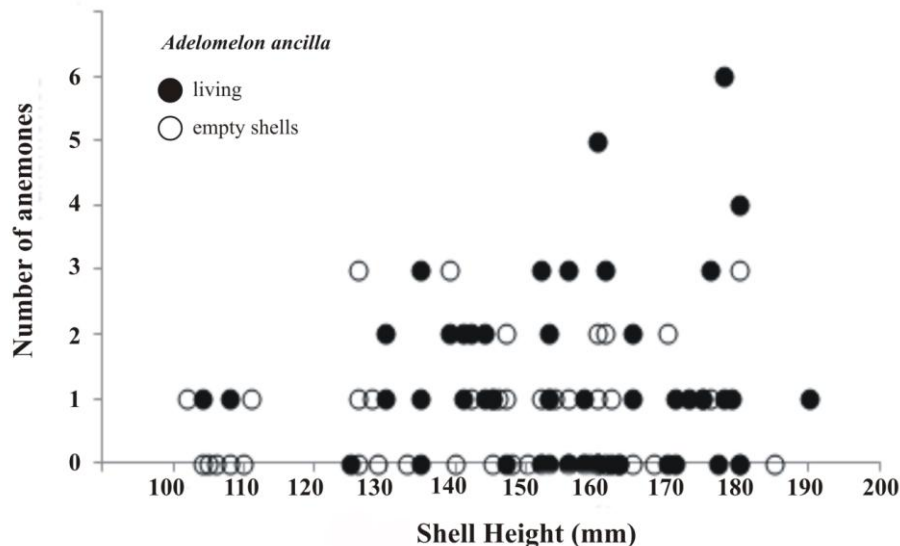


Figure 2. Number of attached sea anemones versus shell height of *Adelomelon ancilla*

The finding of *Actinostola crassicornis* attached to an empty shell of *O. magellanica* is considered a casual event, as it was registered just once. This anemone species is commonly registered in the scallop beds (Bremec *et al.* 2003) and it is part of the benthic assemblage that characterizes this ecosystem (Bremec & Lasta 2002). However, during routine sampling procedures through time it was never settled to any particular substrate (personal observations).

Whether the associations between gastropods and anemones would be beneficial for one or both of the members is still not clear, and it is not the objective of this study, although many authors suggested that it could be beneficial for both partners, as the gastropod would gain camouflage

and protection against predators while the anemone obtains increased mobility and sometimes increased access to food (Pastorino 1993, Luzzatto & Pastorino 2006, Mercier & Hamel 2008, Mercier *et al.* 2011). *Isotealia antarctica* was found to be generalist choosing settlement substrate, and although *Antholoba achates* was only recorded on *Adelomelon ancilla* shells in this community, it was registered using other substrates in other benthic communities (Carter Verdeilhan 1965, Pastorino 1993, Luzzatto & Pastorino 2006). This is not surprising since epibiotic relationships are predominantly facultative (Wahl & Mark 1999).

Empty shells of volutid species here studied were found to be inhabited by 2 hermit crab species: *Pagurus comptus* and *Propagurus gaudichaudii*. *P.*

comptus was known to inhabit shells of *Polinices uber*, *Photinula caeruleascens*, *Paraeuthria plumbea*, *Adelomelon* sp., *Margarella violacea* and *Priene rude* in the Straits of Magellan and in the south of the Beagle Channel in Chile (Soto *et al.* 1999) while it uses shells of *Tegula atra*, *Tegula tridentata*, *Prisogaster niger*, *Crassilabrum crassilabrum* and *Nucella calcar* in the intertidal zone of central Chile (Soto & George-Nascimento 1991). Regarding *P. gaudichaudii*, it was found to inhabit *A. ancilla*, *O. magellanica* and *Fusitriton magellanicus* shells in the outer Uruguay shelf (Carranza & Horta 2008), coincidentally with the gastropod species registered in this study and by Schejter *et al.* (2011b). Additionally, the empty volutid shells here studied were occasionally fouled by gastropod egg cases of *A. ancilla*, *O. magellanica* and *Fusitriton magellanicus*, the anthozoan *Alcyonium* sp. and hydrozoan colonies. These facts reinforce the idea that the shells of dead gastropods are also playing an important role as settlement substrates, as previously suggested by (McLean 1983).

In contrast to the other frequent gastropod of the benthic community, *Fusitriton magellanicus*, where the epibionts reach 56 taxa (Schejter *et al.* 2011a,b), the epibiotic richness observed on living species is reduced to two anemone species. Moreover, the frequency of presence in both volutids is markedly different, although *Adelomelon ancilla* and *Odontocymbiola magellanica* present a similar morphology of the shell, fact that provoked some misidentifications in the past (Urza *et al.* 2007). Bigatti *et al.* (2009, 2010) also stated similar feeding behaviors and pH of the salivary glands for both species in Golfo Nuevo, Patagonia, however denoting that a separated food niche is the main distinction between them. These authors also noted that the sea anemone *Antholoba aachates* was only found associated with *A. ancilla* (not with *O. magellanica*) with probably no benefit for the gastropod, probably impeding its motion, as hypothesized for *Adelomelon brasiliense* (Luzzato & Pastorino 2006). The cause of why these two sympatric volutids show conspicuous differences in the epibiotic fauna all along their distribution range remains unknown. More studies including chemical, behavioral and predation issues involving both basibionts and epibiotic anemones will help to understand the anemones' preferences.

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