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NOTA TÉCNICA / *TECHNICAL NOTE*

Limpet shell modifications at intertidal hydrothermal vents *

Modificações na concha de lapas em fontes hidrotermais de superfície

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ABSTRACT

Calcareous organisms are known to be sensitive to acidified seawater, and they have been reported as potential sentinels for ocean acidification studies. Limpets are among the organisms that characterise intertidal zones, and in the Azores can also be found at sites with shallow water hydrothermal activity, where the acidity of seawater in the vicinity of hydrothermal vents is naturally higher due to CO_2 release. During an occasional intertidal survey on the occurrence and abundance of intertidal algae we found limpets with abnormal shells, and specimens of *Patella candei gomesii* (Patellidae) collected under such conditions exhibited weak and almost transparent shells with reduced shell thickness.

Keywords: Hydrothermal vents; *Patella candei*; Acidification; Shell erosion; Azores.

RESUMO

Os organismos calcários são conhecidos por serem sensíveis à água do mar acidificada, e têm sido apontados como potenciais sentinelas para estudos sobre acidificação do oceano. As lapas estão entre os organismos que caracterizam a zona intertidal e nos Açores, podendo também ser encontradas em locais com actividade hidrotermal de superfície, onde a acidez da água do mar na proximidade das fontes hidrotermais é naturalmente mais elevada devido à liberação de CO_2. Durante uma visita ocasional para avaliar a ocorrência e abundância de algas no intertidal encontraram-se vários espécimes de Patella candei gomesii (Patellidae) com conchas aberrantes, na proximidade de fontes hidrotermais. Estes indivíduos, colectados sob tais condições exibiam conchas frágeis, quase transparentes, com espessura muito reduzida.

***Palavras-chave**: Fontes hidrotermais; Patella candei; Acidificação; Erosão de conchas; Açores.*

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1. INTRODUCTION

Shallow water hydrothermal activity is common along the shores of volcanic regions like the Azores. Studies conducted at marine hydrothermal vents in the Azores (Cardigos *et al.*, 2005; Colaço *et al.*, 2006; Wallenstein *et al.*, 2009) concluded that the gaseous discharge from the vents is dominated by CO_2 (90%), with low levels of H_2S, H_2 and CH_4, while the fluids are generally warm, rich in dissolved sulphide (S), H_2, CH_4 and Pb, and poor in Fe and Mn. In such environments seawater is naturally acidified due to the CO_2 flux released from volcanic activity and marine organisms that live there (e.g. coralline algae, corals, echinoderms or molluscs, among others) are chronically exposed to conditions that promote the dissolution of their calcified structures/components (Hall-Spencer *et al.*, 2008; Marshall *et al.*, 2008; Martin *et al.*, 2008). The limpet *Patella candei gomesii* Drouet is common at Azorean intertidal shores, occurring also nearby shallow water hydrothermal vents. The present study firstly reports the occurrence of erosion in shells of *Patella candei gomesii* as a result of its exposure to natural acidified seawater by hydrothermal activity conditions.

2. MATERIALS AND METHODS

Specimens of limpets exhibiting abnormal shells were found next to shallow water hydrothermal vents during a survey on the occurrence and abundance of intertidal coralline algae. Sampling took place in the summer 2009 at Porto Formoso (37º49'18.8"N, 025º27'25.2"W, Fig. 1) on São Miguel island (Azores; Portugal). Four specimens were collected with a chisel and preserved in 70% ethanol. The marginal thickness (MT), central thickness (CT), length (SL), width at the apex (SW) and height (SH) of each shell was measured with a Vernier caliper to the nearest 0.02 mm, and its conicity (SH/SL) and base ellipticity (SW/SL) calculated.

3. RESULTS AND DISCUSSION

The collecting spot at the hydrothermal vent location is characterised by a warmer and acidic environment (higher temperatures and lower pH) when compared with the surrounded marine environment. Temperature values range from 17.1ºC in April and 24.4ºC in July and pH from 6.5 to 5.5 (Couto *et al.*, 2010; unpublished data), where

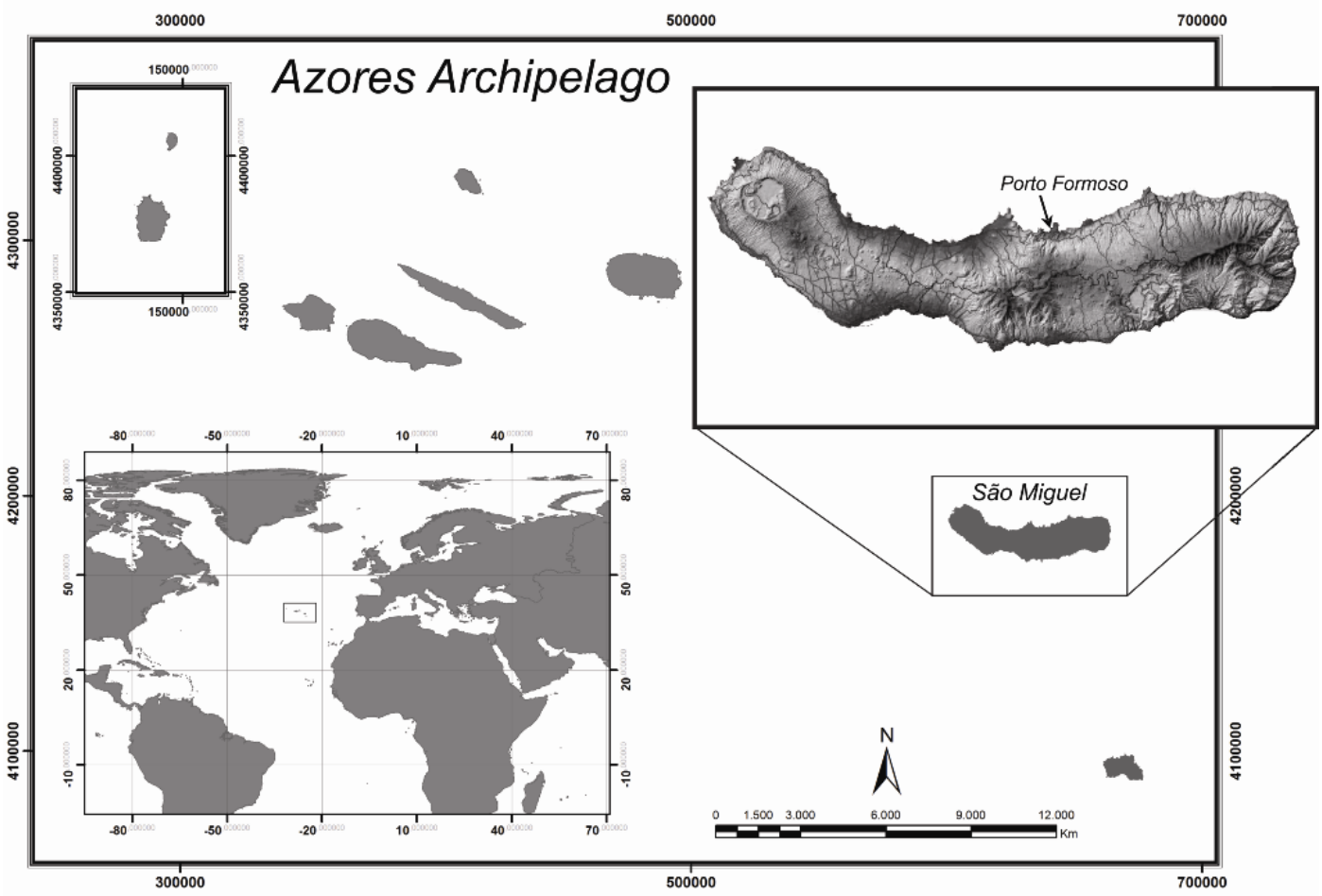


Figure 1. Azores archipelago; São Miguel Island, showing the hydrothermally active location (Porto Formoso) where samples were collected.
Figura 1. *Arquipélago dos Açores; Ilha de São Miguel, mostrando o local com actividade hidrotermal (Porto Formoso) onde as amostras foram colhidas.*

normal seawater temperature values in the Azores for the same months are 15.5 ºC and 21.1ºC in April and July, respectively (Instituto Hidrográfico, 2000) and the average pH of surface oceans is 8.07 (Royal Society, 2005).

Limpets usually exhibit strong and resistant shells (Cabral & Jorge, 2007) and resistant to the collection method. However, studied specimens presented weak and almost transparent shells (Fig. 2), in some cases allowing the visibility of internal structures. Some of the shells broke in the course of their collection (Fig. 2, B,C), suggesting a lower breaking stress as reported for other organisms living at acidic conditions (Tunnicliffe *et al.*, 2009). Similar effects have been reported by Hall-Spencer *et al.* (2008) for *Patella caerulea* Linnaeus and by Martin *et al.* (2008) for other calcified organisms in the Mediterranean Sea.

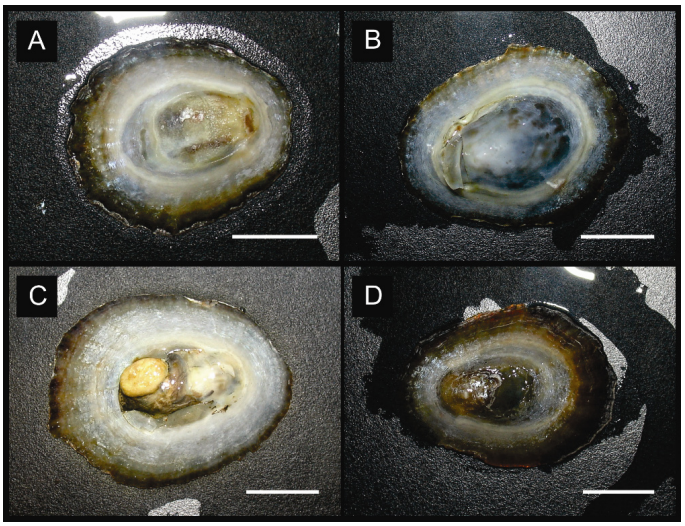


Figure 2. Dorsal view of *Patella candei gomesii* specimens exhibiting weakly calcified shells (A,B,C,D) and shells broken (B,C) during collection. (Scale bar – 1 cm).
Figura 2. *Vista dorsal de exemplares de Patella candei gomesii exibindo conchas pouco calcificadas (A,B,C,D) e conchas partidas (B,C) durante a colecta. (Escala – 1 cm).*

Concerning shell thickness, it can be observed a major reduction from MT to CT (Table 1), which is not normal for *Patella* genus (Cabral & Jorge, 2007). In specimen a) (Table 1) the CT value is more or less 10% of MT. Also, almost transparent and crushing weak shells, suggests erosion/dissolution or lack of biomineralization. Limpets appear to have thinner shells, however there is a lack of shell thickness values from limpets from outside the influence of the hydrothermal vents for comparison.

Additionally, no epibiont organisms such as crustose coralline algae were observed on the shells of specimens collected at the hydrothermal vent location, as is usual in limpets throughout Azorean shores.

On the other hand, no major differences were found in shell conicity (SH/SL) or base ellipticity (SW/SL) between specimens from the hydrothermally active location (Table 1) and when compared with limpets from outside the influence of the hydrothermal vents (Cabral & Jorge, 2007; Cúrdia *et al.*, 2005), suggesting that limpets did not change their shell shape as a result of exposure to hydrothermal activity. Increasing shell thickness with increasing size and age appears to be a strategy for maintaining the resistance of the limpet shell to applied compression forces (Cabral & Jorge, 2007). On the other hand, limpets, with thinner shells, are more exposed and susceptible to predation (Haugan *et al.*, 2006; Hall-Spencer *et al.*, 2008) and to wave action (Cabral & Jorge, 2007).

Organisms with calcareous structures and the habitats occupied by them have been considered as key type species and key type ecosystems for future research on the effects of ocean acidification (Haugan *et al.*, 2006). The present results, although preliminary, provide compelling evidence that limpets are sensitive to such environmental changes, and have an enormous potential to be used as sentinel organisms in further studies. It also shows how limpets could be affected by a future scenario of ocean acidification.

Table 1. Morphometry of *Patella candei gomesii* specimens. Dimensions (mm) and ratios. Values of MT and CT are "Mean (Min-Max)". MT – marginal thickness; CT –central thickness; SL – length; SW – width at the apex; SH – height; *na* – not available.
Tabela 1. *Dados morfométricos de indivíduos de Patella candei gomesii. Dimensões (mm) e ratios. Valores de MT e CT correspondem a "Média (Min-Máx)". MT – espessura marginal; CT – espessura central; SL – comprimento; SW – largura no vértice; SH – altura; na – não disponível.*

Specimens	SL	SW	SH	MT (*n*=4)	CT (*n*=5)	SH/SL	SW/SL
a)	26.34	22.24	6.52	0.77 (0.68-0.88)	0.08 (0.02-0.016)	0.25	0.84
b)	31.38	24.10	7.56	0.56 (0.48-0.60)	0.28 (0.08-0.70)	0.24	0.77
c)	31.20	24.00	*na*	0.80 (0.70-0.86)	*na*	*na*	0.77
d)	31.06	22.66	6.36	0.73 (0.68-0.80)	0.15 (0.02-0.40)	0.20	0.73

CONCLUSION

Shallow water hydrothermal vents are unique habitats with specific abiotic characteristics known to influence marine organisms. Limpets, a food resource at the Azores, were shown to be affected by these environments. Increasing knowledge on those areas will allow understanding processes and relations affecting biological communities creating tools for a proper management.

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