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Shell damage in the Tehuelche scallop *Aequipecten tehuelchus* caused by *Polydora rickettsi* (Polychaeta: Spionidae) infestation

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ABSTRACT

The different types of shell damage caused to the commercially valuable Tehuelche scallop (*Aequipecten tehuelchus*) by the polychaete *Polydora rickettsi* are described. X-rays, computerized tomography, shell sections, scanning electron microscopy, Energy Dispersive X-ray analysis (EDAX), mineralogical analyses and geometric morphometrics were applied to that end. Scallop shells presented three types of damage: (1) spots, (2) calcareous alterations, and (3) mud blisters. Microstructural alterations consisted of a simple conchiolin membranous layer in the case of spots, a series of interleaved layers of different degree of calcifications in calcareous alterations, and two different surface morphologies (muddy and mucous layers) in mud blisters. Damage was localized mainly along concentric growth rings, coincidentally with the location of most burrows, as shown by X-ray. Mineralogical analysis showed that in all cases (including non-infested shells) calcite was the calcium carbonate polymorph present. Geometric morphometrics showed that only 5% of shape variation was explained by infestation with *P. rickettsi*, irrespective of the type of damage. Number of worms per infested shell varied significantly among four beds. Left shells (upward-oriented) were significantly more affected than right shells, which are in closer contact with the bottom.

1. Introduction

Infestation by spionid polychaetes, particularly by members of the *Polydora*-complex, constitutes a serious problem for mollusc fisheries and aquaculture around the world (Lauckner, 1983; Cremonte, 2011). When the intensity of infestation is high, it is zfrequently associated with poor condition (Silina and Zhukova, 2009), shell damage, reduced growth rate (Silina, 2006), and increased mortality (Bergman et al., 1982). The worst type of damage is the formation of mud blisters which, because contained anaerobic metabolites like hydrogen sulphide, cause bad odour, turning molluscs unsuitable for the market (Galtsoff, 1964; Blake and Evans, 1973; Handley and Bergquist, 1997).

Tehuelche scallops, and other bivalves to a lesser extent, support a regionally significant artisanal fishery in San José Gulf, Argentine Patagonia (Ciocco et al., 2005). During recent years infestation of landed bivalves became a subject of concern to fishers, processing plants, the media and consumers. A previous study (Diez et al., 2011) identified *Polydora rickettsi* Woodwick, 1961, as the causative agent. Infestation was documented for Tehuelche scallops (*Aequipecten tehuelchus* (d'Orbigny, 1846), Pectinidae), ribbed mussels (*Aulacomya atra* (Molina, 1782), Mytilidae), false oysters (*Pododesmus rudis* (Broderip, 1834), Anomiidae), flat oysters (*Ostrea puelchana* d'Orbigny, 1842, Ostreidae) and stripped clams (*Ameghinomya antiqua* (King, 1831), Veneridae). *P. rickettsi* is a common shell borer in other regions as well, having been reported for the northeast and southeast Pacific Ocean and for some localities in Brazil (Radashevsky et al., 2006).

The assessment of infestation patterns in relation to season, location or host age requires the development of standards based on a damage typology (Cañete and Cárdenas, 2004; Silina, 2006), but there are few detailed studies of the structural alterations caused by shell-boring polydorids (e.g., Zottoli and Carriker, 1974; Sato-Okoshi and Okoshi, 2000) that can provide objective support for such a typology. The purpose of this study was to characterize infestation patterns of Tehuelche scallops by polydorids in San José Gulf (Argentine Patagonia), and to develop an objective typology of shell damage. To that end we utilized X-rays, computerized tomography, shell sections, scanning electron microscope, Energy Dispersive X-rays, mineralogical analysis and geometric morphometrics (GM, Márquez et al., 2010).

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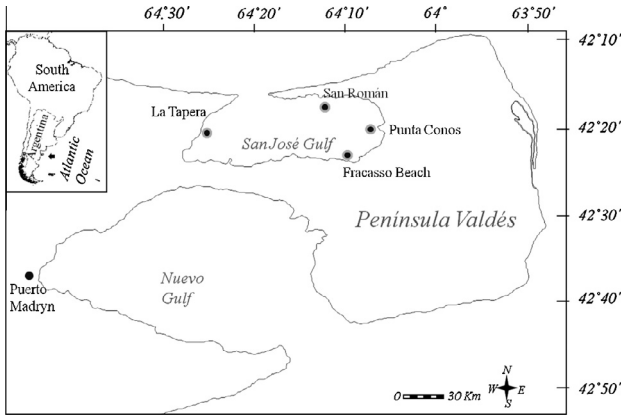

Fig. 1. Exploited beds of the Tehuelche scallop (*Aequipecten tehuelchus*) in San José Gulf, northern Patagonia, Argentina.

2. Materials and methods

2.1. Study site and sample collection

The study was conducted in San José Gulf (northern Argentine Patagonia), where Tehuelche scallops have been harvested by commercial divers since 1973 (Orensanz et al., 1991; Ciocco et al., 2005) (Fig. 1). During the summer of 2010, a total of 253 scallops of commercial size were collected from four exploited beds by divers: La Tapera, Fracasso Beach, Punta Conos and San Román (Fig. 1; Table 1). Scallops were transported to the laboratory and kept in aquaria up to 48 h before processing.

2.2. Shell damage

Scallop shells were observed macroscopically and under a stereoscopic microscope in order to typify damage. Pattern of infestation was described in relation to growth rings; formation of the latter has been described in detail by Orensanz (1986) and Orensanz et al. (1991). Some shells were then broken with pliers and hammer, and polydorids were removed and identified under light microscopy. Voucher specimens were deposited in the Invertebrate Collection of Centro Nacional Patagónico, Puerto Madryn, Argentina (CNP-inv-05-076 to 078, $n = 6$). Burrow shape and location in the shell were established using X-rays ($n = 20$). Computed Axial Tomography (CAT) serial scan slices (1 mm thick) made with a General Electric CT/e tomographer were used to determine the number of worms present in the mud blisters, and the structure of the latter. Tissue density was expressed in Hounsfield units (HU), which express radiodensity (radiation attenuation in different tissues) in a quantitative scale.

2.3. Shell microstructure

Shells were sectioned at different orientations using a low-speed saw and diamond blades. Sections 0.4-mm thick were obtained and mounted with cyanoacrylate adhesive. The exposed face of each section was polished and observed under a Philips XL 30 SEM, and EDAX was used to describe elementary composition in the most harmful types of damage. Additional infested shells were used for mineralogical analysis with X-ray powder diffraction (XRD) in a Philips 3020 goniometer.

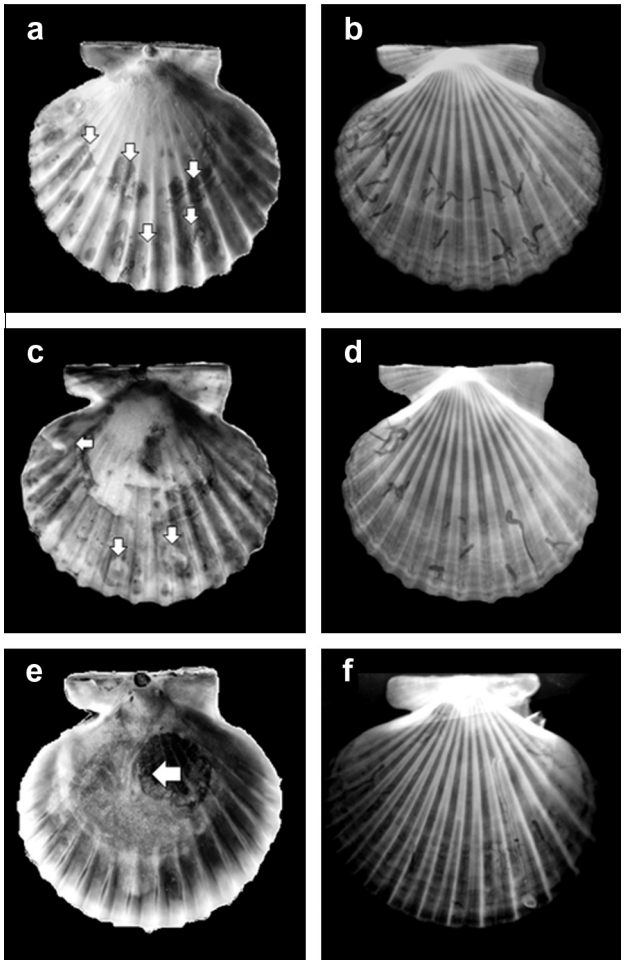

Fig. 2. Types of damage in scallop shells caused by *Polydora rickettsi*. (a–b) spots, (c–d) calcareous alterations, (e–f) mud blister. (a, c and e) macroscopic view, internal shell surface (arrows indicate damaged areas); (b, d and f) X-ray images of the same specimens, captured from the external shell surface.

2.4. Geometric morphometrics

After removing the soft parts, right shell outlines were digitized (concave side upwards) with a digital camera. To capture the individual form we used the landmarks configuration defined by Márquez et al. (2010). All specimens were digitized with the software TPS dig2. Landmark configurations were superimposed by generalized Procrustes analysis (Slice et al., 1996). To assess and control putative allometric effects, we computed the multivariate regression of shape (Procrustes coordinates used as dependent variables)

Table 1
Prevalence and intensity of *Polydora rickettsi* infestation of *Aequipecten tehuelchus,* by bed, San José Gulf. S: Spots, CA: Calcareous alterations, MB: Mud blister.

Beds	Latitude S	Longitude W	N (scallops)	Prevalence (%)	Intensity (range)	Type of damage (%)
La Tapera	42°20′	64°35′	63	27	1–8	S (25.4), CA (0), MB (1.6)
Fracasso Beach	42°25′	64°07′	64	90	1–8	S (84), CA (1.5), MB (4.7)
Punta Conos	42°20′	64°02′	83	100	1–30	S (65), CA (23), MB (12)
San Román	42°15′	64°12′	43	76.7	1–7	S (63), CA (4.7), MB (9)