Aquaculture Research, 2005, **36**, 721–724 doi: 10.1111/j.1365-2109.2005.01249.x

SHORT COMMUNICATION

Polychaete infestation in cultured abalone (*Haliotis rufescens* Swainson) in Southern Chile

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Polychaetes are among the most diversified invertebrates infesting calcareous substrates such as mollusc shells and crustaceans carapaces (e.g. Martin & Britayev 1998; Lleonart, Handlinger & Powell 2003). In Southern Chile, polychaete infestation is a recurrent phenomenon among native (*Aulacomya ater*, *Ostrea chilensis*, *Concholepas concholepas* and *Crepidula* sp.) and introduced bivalves and gastropods (*Crassostrea gigas*, *Haliotis rufescens* y *H. discus hannai*) (Rozbaczylo & Carrasco 1996; Sato-Okoshi & Takatsuka 2001; Bertrán, Vargas & Quijón in press). However, despite the ecological and economic importance of many of these molluscs, particularly for aquaculture, their relationships with infesting polychaetes remain mostly unknown.

The aquaculture of the abalone, *H. rufescens* Swainson 1822, in Southern Chile represents a prime example. Since its introduction in 1977, the aquaculture of this species underwent feasibility assessment until its consolidation as a productive and growing industry set on a littoral fringe between 41° and 46°S (Owen, DiSalvo, Ebert & Fonck 1984; Godoy & Jerez 1998). Unfortunately, knowledge on infesting polychaetes has lagged far behind that growth, as demonstrated by the lack of applied studies beyond the taxonomic review of a few species (Sato-Okoshi & Takatsuka 2001). In fact, no published research has assessed spatial variation in polychaete composition or occurrence among the cultures of the area. This study employs univariate and multivariate methods to explore the abundance and composition of polychaetes infesting the shell of abalones from two representative areas of Southern Chile.

Two samples of 18 and 39 abalones were collected from aquaculture facilities located in Puerto Montt (41°30′S, 72°50′W) and Castro-Chiloé (42°30′S, 73°40′W). After measuring shell length, the specimens were preserved in a 10% sea water–formalin solution and kept in individual plastic containers. Shells were then treated with 5% HNO_3 (12 h) for decalcification and 5% $NaSO_4$ (12 h) for acid neutralization. All the worms were then carefully removed, counted and identified to genus or species level using standard identification keys for the polychaetes of the region.

For data analyses, polychaete density and number of species per abalone shell were used as response variables whereas site (Puerto Montt versus Chiloé, discrete variable) and abalone shell length (continuous variable) were used as independent factors. Preliminary ANCOVA's integrating both factors identified significant interaction terms (i.e. regression slopes differed between sites; cf. Fig. 1a), and therefore a separate analysis for each area was required. Between-site comparisons of worm densities and species richness were carried out using ANOVA ($y = \mu + \text{site} + \varepsilon$ where y refers to each response variable, μ is a mean constant, site refers to locations and ε refers to the error term) after checking the corresponding assumptions. These comparisons were made with the complete sample of abalones, and then separating infestation based on immature (≤ 5 cm shell length) and mature abalones (> 5 cm). The relationships between abalone shell length and each response variable were analysed with regression analyses for each site ($y = \mu + \text{shell length} + \varepsilon$). Polychaete species

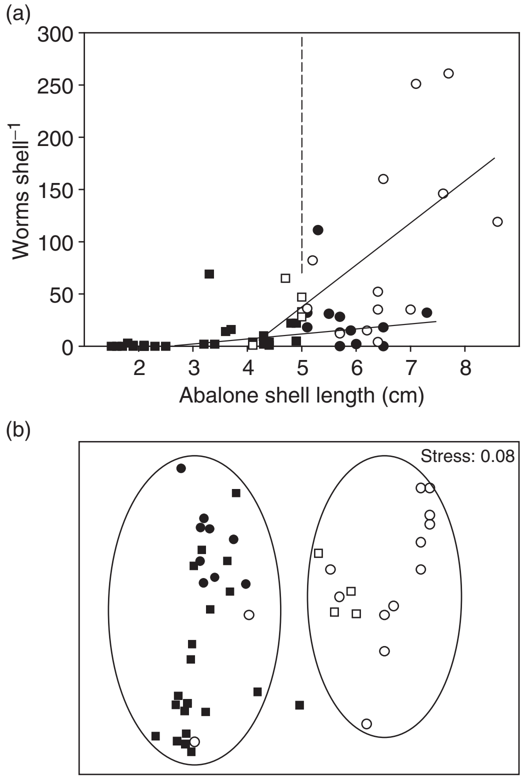

Figure 1 (a) Worms per shell in relation to abalone length (cm). Lines correspond to regression lines of abalones from Chiloé (filled symbols) and Puerto Montt (open) respectively. Squares and circles (and dashed line) make the distinction between immature and mature abalones respectively. (b) Multidimensional scaling plot of abalones based on worm species composition and density. Groups stand for sites and are based on the cluster analysis.

composition and abundance were also analyzed with Cluster (Bray Curtis Similarity) and multidimensional scaling (MDS) using PRIMER (Plymouth Routines in Multivariate Ecological Research; Clarke & Warwick 1994). Analyses of Similarity (ANOSIM) were also performed to verify the significance of the differences between sites (Puerto Montt vs. Castro) and between stages (immature vs. mature).

A total of 1867 polychaetes from seven species were collected (Table 1). Two boring polydorid spionids, *Dipolydora huelma* (Sato-Okoshi & Takatsuka 2001) and *Polydora rickettsi* Woowick, 1961 were the most abundant in Puerto Montt and Chiloé, respectively. They accounted for about 97% of the total number of polychaetes collected. Less abundant were species typically 'epibenthic' from the genus *Serpula* (2.14%) and from the genera *Cirratulus*, *Nicolea*, *Phyllodoce*, *Nereis* and *Potamilla* (each less than 1% of total abundance; Table 1). The occurrence of infesting polychaetes was 100% and 72% in Puerto Montt and Chiloe respectively. The total number of polychaetes (P) increased ($P<0.05$) with the length of the abalone shell (L), although there were obvious differences in slope between sites: $P = -166+39.8L$ (Puerto Montt) and $P = -6.30+4.68L$ (Chiloé) (Fig. 1, Table 2). The polychaete species richness and the density of *P. rickettsi* also increased with shell length ($P<0.05$), but this increase was significant in Chiloé only (Table 2). The degree of infestation also changed with the location of the cultures. Total density and species richness, as well as *D. huelma* density were all significantly higher in Puerto Montt ($P<0.05$). Instead, the density of *P. rickettsi* was higher in Chiloé although this difference was significant only for large (mature) abalones.

As shown by the MDS plot, between-site and size-related differences were not restricted to total density and species richness but included species composition and relative abundance as well (Fig. 1b). Based on the similarity of the polychaete assemblages, the analysis clustered abalones from Puerto Montt (open symbols) and segregated them from most of those from Chiloé (black symbols) (ANOSIM GlobalR = 0.651; $P<0.001$). Although the distinction of assemblages associated with immature and mature abalones was less obvious in the MDS (squares vs. circles), the differences between them were also significant (ANOSIM GlobalR = 0.350; $P<0.001$).

Our results suggest that the infestation by polychaetes assemblages, primarily boring species like polydorids and epibenthic species such as *Serpula* sp., varies significantly with the location of the cultures and increases with the size of the abalone shell. These results coincide with the higher level of infestation detected in larger abalones of a different species (*H. discus hannai* Ino 1953) growing in land-based tank cultures in Northern Chile (Radashevsky & Olivares in press) as well as in bivalves such as *Crassostrea gigas* (Cáceres-Martínez, Macias-Montes de Oca & Vasquez-Yeomans 1998) and *Vieyra tehuelche* (Ciocco 1990). The species of polychaetes found in this study belong to genera that have been reported to perforate the shells of abalone and other cultured molluscs elsewhere. Polydorids, the most abundant group of species in our samples, have been reported in oyster cultures in New Zealand and Eastern North America (Wargo & Ford 1993; Hadley & Bergquist 1997), and in the shells of abalones and other molluscs in Japan, (Kojima & Imajima 1982; Sato-Okoshi 1999), Tasmania (Lleonart *et al.* 2003) and Chile

Table 1 Abalone numbers and sizes, and polychaete infestation in Puerto Montt and Chiloé, for each corresponding stage of maturation (see text)

	Puerto Montt		Chiloé	
	Immature	Mature	Immature	Mature
Abalone				
N	5	13	27	12
Mean length (mm)	47.6 ± 3.9	66.1 ± 9.9	31.8 ± 12.0	58.6 ± 6.4
Length range (mm)	41–50	51–86	15–50	51–73
Infestation				
# worms shell^{-1}	34.80 ± 23.73	92.92 ± 88.27	6.85 ± 14.03	25.00 ± 29.63
# worm spp. shell^{-1}	2.40 ± 0.89	2.23 ± 0.73	1.00 ± 0.88	1.33 ± 0.89
Dipolydora huelma shell^{-1}	26.20 ± 16.49	88.61 ± 88.59	0.56 ± 1.12	0.50 ± 1.24
Polydora rickettsi shell^{-1}	6.20 ± 7.82	1.92 ± 3.64	6.07 ± 13.17	23.67 ± 29.77
Cirratulus sp. shell^{-1}	0.00 ± 0.00	0.38 ± 0.77	0.00 ± 0.00	0.33 ± 0.89
Serpula sp. shell^{-1}	2.40 ± 3.36	1.38 ± 1.89	0.15 ± 0.53	0.50 ± 1.16
Phyllodoce sp. shell^{-1}	0.00 ± 0.00	0.23 ± 0.83	0.00 ± 0.00	0.00 ± 0.00
Nicolea sp. shell^{-1}	0.00 ± 0.00	0.39 ± 1.12	0.00 ± 0.00	0.00 ± 0.00
Potamilla sp. shell^{-1}	0.00 ± 0.00	0.00 ± 0.00	0.03 ± 0.19	0.00 ± 0.00
Nereis sp. shell^{-1}	0.00 ± 0.00	0.00 ± 0.00	0.03 ± 0.20	0.00 ± 0.00

Values correspond to averages (± SD).

Table 2 Variation in polychaete infestation associated to shell length (regressions per each site separately) and site (Puerto Montt vs. Chiloé)

			Response variables				
Factors		DF	*Dipolydora*	*Polydora*	*Serpula*	*N* total	SPP total
Shell length	Site A	1,16	0.007	0.155	0.587	0.008	0.586
	Site B	1,37	0.080	0.037	0.062	0.038	0.025
Site	All sizes	1,55	0.000	0.101	0.001	0.000	0.000
	Mature	1,23	0.002	0.015	0.178	0.019	0.011
	Inmature	1,30	0.000	0.993	0.002	0.001	0.003

Response variables are density of the most abundant species, polychaete total density and species richness per shell. Numbers correspond to *P*-values in the corresponding regressions and ANOVAS.
DF, degrees of freedom.

(Sato-Okoshi & Takatsuka 2001; Bertrán *et al.* in press). Species of the genus *Serpula* have been found in the shells of abalones in Baja, California (Martínez & Orta 2000), whereas sabellid polychaetes have been collected from abalone shells in South Africa (Ruck & Cook 1998) and California (Leighton 1998; Kuris & Culver 1999).

Infestation by polydorids and other polychaetes on molluscs is usually harmful for the host's shell and flesh tissue condition (Kojima & Imajima 1982; Wargo & Ford 1993). Those effects, however, may vary from minor (insignificant) to massive abalone mortalities (cf. Lleonart *et al.* 2003). According to Kojima and Imajima (1982), 10 or more polydorids per shell can significantly decrease abalone growth. Even if those effects are not necessarily applicable to every species and condition, they should raise concern given the high occurrence (> 72%) and infestation rates reported here. The lack of published records on polychaete infestation calls for a more open policy by producers, managers and authorities (cf. Godoy & Jerez 1998) in order to support more research and reduce the vulnerability of this type of aquaculture in Chile. Research priorities should include: (i) documentation of polychaete composition infesting abalone shells on a larger geographical scale (at least Southern Chile), (ii) broad scale assessment of infestation effects and (iii) identification of assessment tools for aquaculture, e.g. studies on the relationship between infested shell area and abalone flesh condition.

Acknowledgments

The authors would like to thank the editor and two anonymous reviewers for helpful comments on an early version of this manuscript. This study was funded by Sub-Programa 45703926, Facultad de Ciencias, Universidad Austral de Chile.

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Keywords: abalone, polychaete infestation, Southern Chile

