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Shell-Borers in the Oyster, *Striostrea margaritacea:* Pests or Symbionts?

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Abstract

The extent of infestation of the oyster, *Striostrea margaritacea*, by shell-borers in Natal was assessed in specimens collected in the surf zone and from a subtidal wreck. Two species of shell-borer were found; a burrowing sponge of the genus *Cliona* and a spionid polychaete of the genus *Polydora*, probably *P. websteri*. The incidence of *Cliona* was similar in both oyster populations and favoured occupation of the left valve. *Polydora* infestation was greater in oysters on the wreck, as was double infestation by both borers. *Polydora* appeared to favour both valves equally. Shell-thickening was observed in the wreck oysters and in surf oysters relocated on the wreck; this was thought to be related to the higher incidence of borer infestation at this locality. In the literature these borers are invariably associated with consequences detrimental to the host, so the gonad state of both oyster populations was compared to obtain an index of their welfare. Despite the higher infestation of borers in oysters on the wreck, they manifested no detrimental effects; indeed their reproductive condition was better and they spawned for a longer period than oysters found in the surf. Other differences between the two oyster populations and their environments were considered and it was concluded that some measure of symbiosis is at work. The shell-borers gain the phoretic advantage of shelter from their hosts, and possible interactions which procure improved condition in heavily infested *S. margaritacea* bear further investigation.

Keywords: oysters, *Striostrea margaritacea*, shell-borers, *Cliona*, *Polydora*, parasites/pests, symbiosis

1. Introduction

The oyster, *Striostrea margaritacea*, is an ostreid of the subfamily *Crassostreinae* and tribe *Striostreini* according to a revision of the family by Harry (1985). It occurs on rock reefs along the south and east coast of South Africa (Day, 1969), typically in strong surf in the shallow subtidal zone (Kilburn and Rippey, 1982). An artisanal fishery is dependant on this species in the province of Natal and it has been the subject of a biological study since 1986.

Material was gathered for the study from discrete zones harvested on a four-year rotation cycle by commercial gathers as well as from an oyster-encrusted wreck in the Durban bight which is closed to this form of fishing. This wreck was considered to be representative of unharvested oyster beds in deeper water not accessible to the gatherers, who work only up to their wading depth. Growth of the oysters proved to be a difficult parameter to measure and small, commercially-harvested specimens were fixed in cages and relocated on the wreck to permit regular growth measurements.

Previously it had been observed that commercial and wreck specimens appeared to differ in their shell thickness (pers. obs.) as well as the extent to which their shells were infested with boring-organisms. Growth in the relocated specimens now also manifested an interesting phenomenon; no initial growth was measured but the shells became more robust before linear growth commenced (unpub. data). Growth of newly-settled oysters in the cages was, on the other hand, rapid from the outset. It did not prove possible to measure shell thickening in wreck specimens satisfactorily because of the highly variable shell morphology in this species, but the question arose as to whether it might be related to borer-infestation. The extent to which the wreck and surf populations of oysters are infested with shell-borers was thus investigated as part of this on-going study, as well as the impact the infestation has on their welfare.

2. Materials and Methods

Monthly random samples of two dozen oysters were purchased from commercial oyster-gatherers for analysis in the laboratory. Parameters measured and assessed which are of relevance to this study were right valve length (mm), reproductive state and the extent of infestation by boring organisms. The internal surface of both valves was examined for the latter purpose and graded according to the following index:

Grade 0.	No infestation.
Grade 1.	Evidence of a light infestation, covering up to one-third of the inner surface of the valve examined.
Grade 2.	Evidence of a moderate infestation, affecting between one- and two-thirds of the valve inner surface.
Grade 3.	Evidence of a heavy infestation affecting over two-thirds of the valve inner surface

Separate records were kept of the degree of infestation for each valve and for the complete shell. X-ray analysis would have been necessary to provide an absolute measure of infestation but the above method provided a satisfactory index of the visible effects of infestation which affect oyster marketability.

Samples of a similar magnitude were randomly collected in about 5 m of water on the wreck of the "Ovland" off Durban, at monthly intervals or when weather and sea conditions permitted. These were analysed as above.

A total of 824 specimens were examined in this way. The identity of shell-boring organisms was established from freshly preserved (4% formal-saline) material.

3. Results

The *S. margaritacea* shells were found to be infested by two organisms. Characteristic mud blisters on the inside of the shells were connected with burrows in their matrix occupied by the spionid polychaete, *Polydora*, probably *P. websteri*. Small circular pits in the matrix of the shells, evident as transparent spots on their inner surface and frequently as openings on the outer surface, were caused by the sponge, *Cliona* sp. The difference in shell damage caused by these two organisms is evident in the x-ray reproduced in Fig. 1.

The incidence of *Cliona* and *Polydora* found in the shells of *S. margaritacea* is presented in Table 1. It is immediately evident that the incidence of *Cliona* was higher in the left (attached) valve than the right, being of the same order of magnitude in samples both commercial and from the wreck. The infestation of *Polydora* was much higher in wreck samples than in commercially collected material, with little difference between the valves in both samples. In both cases the infestation, when found, was usually graded as light.

Length frequency data of the oyster samples is presented in Table 2, together with the frequency of *Cliona* and *Polydora* infestation in the different size classes. The frequency of infestation was normal within the size frequency

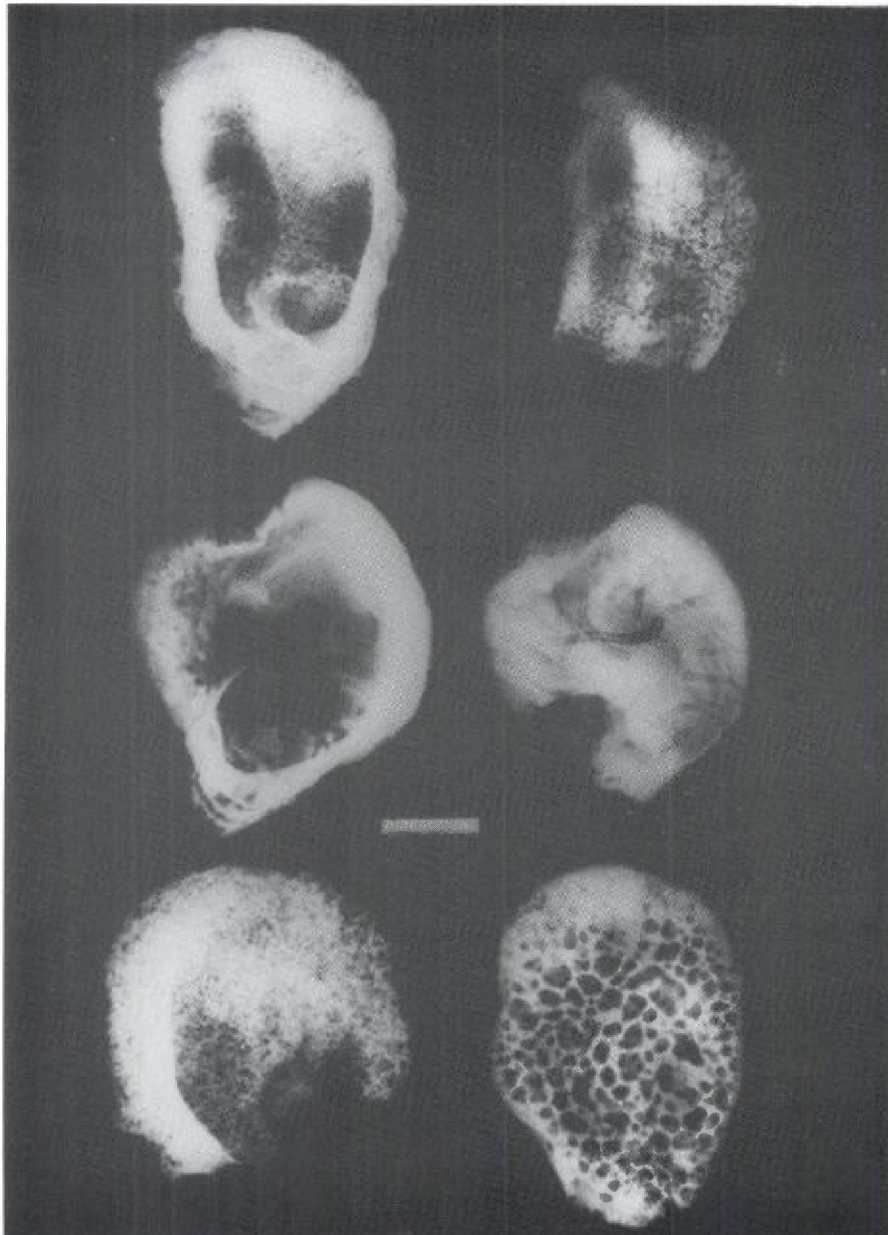

Figure 1. X-ray of left and right valves of *S. margaritacea* showing grade 3 infestations by *Cliona* (top and bottom shells) and a grade 2 infestation by *Polydora* (middle shell). The top right valve also includes a single *Polydora* burrow and the *Cliona* infestation in the bottom shell is particularly heavy. A bar of 2 cm length is included for scale.

Table 1. Incidence (%) of infestation of *Cliona* and *Polydora* in the shells of *S. margaritacea* from commercial samples (n=586) and the wreck (n=238). Percentages < 1 are marked +. When compared using the chi-squared test, the incidence of *Polydora* infestation was significantly greater in wreck samples than in commercial samples at the 99% confidence level (columns marked*).

	Commercial Samples			Wreck Samples		
Cliona infestation	Left valve	Right valve	Complete shell	Left valve	Right valve	Complete shell
Grade 0	57	80	53	53	93	53
Grade 1	33	12	38	38	6	44
Grade 2	7	4	6	9	1	3
Grade 3	3	4	3	0	0	0
Polydora infestation	*Left valve	Right valve	*Complete shell	*Left valve	Right valve	*Complete shell
Grade 0	75	86	68	15	30	11
Grade 1	24	14	31	59	59	64
Grade 2	+	0	+	19	8	20
Grade 3	+	0	+	7	3	5

Table 2. Right valve length frequency data (%) of the *S. margaritacea* analysed for *Cliona* and *Polydora* infestation, with frequency of such infestation (% of total sample) in the different size classes. Percentages < 1 are marked +.

Size classes (mm)	30 to 39	40 to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	% n
Commercial samples	**1**	**3**	**13**	**25**	**26**	**21**	**9**	**2**	**1**	+	**100**
Cliona infestation		1	4	12	15	10	3	+	+	+	47
Polydora infestation	+	+	3	7	9	9	3	+	+	+	32
Cliona and *Polydora* infestation		+	2	4	5	4	1		+	+	16
Wreck samples	**2**	**3**	**12**	**21**	**31**	**19**	**7**	**3**	+		**100**
Cliona infestation	+	2	5	8	16	11	3	+	+		47
Polydora infestation	+	1	12	19	26	18	8	3	+		89
Cliona and *Polydora* infestation	+	+	5	7	13	10	3	+	+		39

Table 3. Right valve length frequency data (%) of the *S. margaritacea* analysed for *Cliona* and *Polydora* infestation, with frequency of the degree of infestation (% of total sample) in each size class. Percentages < 1 are marked +.

Size classes (mm)	30 to 39	40 to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 to 109	110 to 119	120 to 129	% n
Commercial samples	**1**	**3**	**13**	**25**	**26**	**21**	**9**	**2**	**1**	**+**	**100**
Cliona infestation:											
Grade 1		+	3	9	12	9	2	+	+	+	38
Grade 2		+	+	2	2	+	+				6
Grade 3			+	+	+	+			+		3
Polydora infestation:											
Grade 1	+	+	3	7	9	8	3	+	+	+	31
Grade 2						+					+
Grade 3					+						+
Wreck Samples:	**2**	**3**	**12**	**21**	**31**	**19**	**7**	**3**	**+**		**100**
Cliona infestation:											
Grade 1	+	2	5	8	14	9	3	+	+		44
Grade 2					2	1					3
Grade 3											
Polydora infestation:											
Grade 1	+	1	8	15	19	14	4	2			64
Grade 2			3	3	5	4	2	1	+		20
Grade 3			+	+	2	+	1				5

distribution of the oysters. It is not only clear again that *Polydora* infestation was greater amongst wreck specimens, but so was double infestation of these oysters by both boring species. The distribution of the degree of infestation was also normal within the size frequency distribution of the oysters (Table 3).

Although reproduction of *S. margaritacea* is to be the subject of a separate publication, the monthly gonad state frequencies of the oysters are included here to provide an index of condition of this species in the two environments (Table 4). It is immediately apparent that oysters on the wreck are consistently more fecund than their commercially harvested counterpart.

4. Discussion

Sponges of the genus *Cliona* have attracted considerable study because of their boring activities in the shells of economically important molluscs (Cheng, 1967; Thomas, 1979; Webster and Greer, 1981; Pomponi and Meritt, 1985), the review of Lauckner (1983) being the most useful reference on the subject.

Table 4. Monthly gonad state frequencies (%) of commercially-gathered *S. margaritacea* (n=1029) and from the wreck (n=491), collected from 1986 to 1990. No data is presented for the wreck in December as weather and sea conditions have not permitted sample collection in this month.

Gonad state	Immature or inactive	Active	Developing	Ripe	Partially Spent	Spent
Commercial samples						
January	4	10	17	58	8	3
February		3	10	49	23	14
March	4		1	62	25	8
April	6	3	3	18	57	14
May	9		3	36	26	26
June	16	2		14	39	30
July	16			8	28	49
August	15	4	4	21	18	38
September	17	18		23	11	31
October	33	26	5	14	3	18
November	26	23	8	18	3	23
December	6	18	13	55	1	6
Wreck samples:						
January	8	22	24	38		7
February	4			75	21	
March				83	13	4
April		3		67	22	8
May				94	2	4
June	6	2	2	60	23	6
July	2			34	30	34
August	7	7	7	55	11	13
September	24	12		44	20	
October	6	33	8	8		44
November	9	18	12	39	8	13
December						

According to this review, the sponges penetrate the host shell by chemically etching away fine chips of calcium carbonate and conchiolin, creating pits with small ostial and oscular openings. They appear to accomplish this by means of enzymes, particularly carbonic anhydrase and one or more proteolytic enzymes. The species found on *S. margaritacea* was the yellow colour characteristic of members of the genus and typically favoured occupation of the left valve, probably because of the greater exposure of this valve.

Spionid polychaetes (mudworms) such as *P. websteri* have received even more attention (Cheng, 1967; Blake and Evans, 1973; Day, 1973; Dauer et al., 1981; Webster and Greer, 1981; Bergman, 1982; Kojima and Imajima, 1982; Hoeksema, 1983), but again Lauckner's (1983) review is the most useful. *P. websteri* also bores into molluscan shells by chemical means, but the active agents have not been identified. U-shaped tunnels are formed which are paved with mud and frequently terminate in a mud-filled blister on the inner surface of the host shell. *P. websteri* normally prefers the right valve, but this did not prove to be the case in *S. margaritacea*.

Both organisms are suspension-feeders and Dauer et al. (1981), showed that *P. websteri* feeds on bottom-deposits as well. Neither are thus considered to be true parasites but they are always considered to have negative effects upon the molluscs whose shells they infest. These effects range from weakening or disfigurement of the host shells to causing infection, debilitation and even death. The latter consequences appear to arise when the bivalve chamber is penetrated and the host is unable to wall off the invader (the process whereby mud blisters are formed) before the onset of detrimental effects. The greater infestation of wreck samples by *Polydora* in the present study could have resulted in the shell-thickening observed in these specimens, at a commensurate cost to their metabolism.

Relatively few oysters were infested by both *Cliona* and *Polydora*, this being greatest amongst wreck specimens (39%) and least amongst commercial samples (16%). Infestation by one borer does not appear to render the host more susceptible to the other. On the contrary, there may be a measure of competition between the two boring organisms.

The greater fecundity of wreck samples clearly shows that their larger infestation of mudworms, fairly often a double infestation with *Cliona*, was not accompanied by detrimental consequences. Their (reproductive) condition was actually better and this poses the question, why?

Specimens collected in the surf were often overgrown with algae while wreck oysters were frequently coated with bryozoa; both populations are thus subjected to fouling, albeit of a different sort. The only other possible difference between the populations is that food availability for surf oysters may be enhanced by more vigorous water movement in this zone, to their advantage. Yet this seems unlikely considering the abundance of suspended organic particles measured on a comparable inshore reef (Schleyer, 1981). An acceptable conclusion in this regard is that food availability, and therefore growth, limits neither population and both are successfully able to wall off their respective infestations.

The question thus proves a difficult one to answer. The finding that *S. margaritacea* with a greater burden of boring organisms, particularly of *Polydora*, are in better condition is insufficient evidence to conclude that they are of benefit to this oyster. Infested specimens certainly gain no protection from marine predators by their presence as *S. margaritacea* shells are so robust that they are only occasionally attacked by large Muricidae (Kilburn, pers. comm.*). However, some form of symbiosis is present in that the shell-borers gain the phoretic (Cheng, 1967) advantage of shelter from the host. Possible interactions which, in this specific case, procure an improved condition in the host, bear further investigation.

The improved condition could possibly be due to enhanced feeding by the oysters on mucus and material ejected from the *Polydora* burrows which usually open on the periphery of the valves. An alternative could be that the higher infestation in wreck oysters may stress them just sufficiently to stimulate a survival response of increased reproduction. If either or both of these possibilities prove to be the case, the relationship between these species then comprises a first step towards the development of a successful symbiosis.

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