J. mar. biol. Ass. India, 1991, 33 (1 & 2) : 374-378

PERIOSTRACUM OF THE GASTROPOD *HEMIFUSUS PUGILINUS* : NATURAL INHIBITOR OF BORING AND ENCRUSTING ORGANISMS

S. Ananda Kumar* and K. Ayyakkannu

Centre of Advanced Study in Marine Biology, Porto Novo 608 502, India

Abstract

The gastropod *H. pugilinus* has a thick pale greenish brown coloured periostracum which inhibits settling and growth of many borers and epizoans. The inhibitory effect of periostracum to borers and epizoans contributes to the snail's energetic efficiency by reducing the energy utilised for shell repair caused by borers and reduces the weight of encrusters and other epizoans carried during the snail's movement. Moreover, the periostracum forms an obstacle to borers and hence to shell damage. Further, it acts to protect the snail from its predators by way of camouflage by trapping mud and sand in between the hairs. Thus in the molluscs a superior antifouling system can be established through a clear understanding of encruster inhibitor properties. In the present study the morphology of the periostracum of *H. pugilinus* was observed with SEM and had been discussed. It's functional significance was correlated with occurrence and abundance of various epizoans, encrusters and borers found associated with *H. pugilinus*.

Introduction

The Periostracum is the outermost uncalcified coating of molluscan shell, the primary function of which is the deposition of inorganic phase to the shell. It is secreted by the mantle at the growing edge of the shell. These structures are commonly found in the Hipponicidae Capulidae, Trichotrophidae, and Cymatidae. It is present in archegastropod Neogastropod and Opisthobranchs also (Clarke, 1976). Clarke (1976) suggested the involvement of the periostracum in the secretion of gastropod shells. Gastropod periostracal structures have in general, been little analysed for their functional significance other than in relation to shell calcification (Bovelander and Nakahara, 1970). Bottjer (1977) attributed secondary functions rather than calcification process to the periostracum owing to its great structural variety. The mostly accepted one is that the periostracum protects the calcified gastropod shells against dissolution by acidic waters and boring organisms (Clarke, 1976 ; Abbott, 1968). This paper summarizes the structural and functional significance of periostracum in the species *H. pugilinus*. Preliminary observations made with the specimens collected from dredge hauls showed that a number of specimens lost at least some of their periostracum and that shell portion without periostracum seemed to be occupied by a greater number of borers and epizoans, than those with intact periostracum (Pl. I A). Subsequent investigations led to the conclusions given in this report. These investigations clearly show that the thick periostracum of *H. pugilinus* functions so as to significantly inhibit the settling and growth of many epizoans with relatively large calcareous skeletons like barnacles and oysters as well as many borers that penetrate into the calcareous shell causing damage to the latter. This inhibitory property

* *Present address :* Department of Zoology, V.H.N. S.N. College, Virudhunagar 626 001, India.

may contribute to increased energetic efficiency and increased resistance to predators for *H. pugilinus*.

The authors are greatly thankful to Dr. K. Krishnamurthy, CAS in Marine Biology for providing all facilities and Mr. P. Santharoopan, RSIC, IIT, Madras for his help in scanning studies.

Materials and Methods

The specimens of *Hemifusus pugilinus* for the present investigations were collected along the Porto Novo Coast using trawl net. The distribution of this species in this coast is confined between three and thirteen fathom lines. The periostracum in this species is quite thick and can be readily peeled off the shells with forceps. For scanning electron microscopy, small strips of periostracum were mounted in various orientation on Aluminium stubs, thinly coated with gold to prevent charging effects and observed in S-180 stereoscan. Investigations on periostracal inhibition of epizoans and borers are based on specimens of *H. pugilinus* dredged from the coast of Porto Novo during October 1984-September 1985.

Results

Gastropod periostraca show great variations from species to species in thickness, colour, flexibility and strength. The colour is usually brown, but may show variations depending upon the habitat. In the present collection the colour is greenish brown owing to the presence of algae in between the hairs of the periostracum of the shell. The periostracum tends to tear readily along the line of transpiral ridges of the shell, conforming to the contours of the underlying shell which in *H. pugilinus* is more or less smooth. The surface of the periostracum is covered externally by numerous papillae (Pl. I B) which makes it velvety both in appearance and to touch. These papillae appear to consist of layers drawn out from the major body of the periostracum. Projecting periostracal structures include shingles, hairs, hairlets and raised lamellae (Bottjer, 1982). The periostracum in many gastropods is secreted as thin strips which overlap towards the aperture and are commonly appressed to the shell, but in some families such as Tubinidae, Hipponicidae, Capulidae, Trichotropidae and Cymatidae, these strips do not lie flat, but project at lesser angle so as to resemble shingles.

The periostracal hair which are the drawn out structures from the major body of the periostracum range in shape from rectangular strips to structures which taper from a triangular base to a point (Pl. I C). Hair may be attached to periostracal strips. Hairs are found in the Coculinidae, Hipponicidae, Capulidae, Trichotropidae, Cymatidae and Melongenidae (Bottjer, 1982). Hairlets can be stated as hair-like structures less than 1 mm long. Hairlets have a wide taxonomic distribution with occurrence in Vitrinellidae, Cerithidae, Columbellidae, Buccinidae, Melongenidae, Fasciolaridae, Capulidae, Strombidae, Cymatidae, Cancellaridae, Conidae and Tylodinidae. Hairlets are found attached to appressed periostracal strips.

Functional aspect

The percentage occurrence of borers and epizoans on different shell surface has been given in Table 1. The boring and epizoan fauna can be divided into three categories. 1. Organisms that become less common as the periostracum deteriorates. 2. Organisms that are limited to bare shell surfaces or become more common as the periostracum deteriorates. 3. Organisms which show no change in occurrence between shell surface types. Group A (Fig. 1) comprises the epizoans with either non-mineralized, lightly mineralized or completely mineralized skeletons as well as skeletons composed of sandgrains and shell fragments held together by organic cement.

Group B contains relatively large epizoans with calcified skeleton and borers that penetrate into calcareous substrates (barnacles, hydroids, serpulid worm tube, spinoid wormborings). The encrusting bryozoans and brachiopods come under the group C and attach regardless of the shell surface.

The presence of borings under the periostracum was examined by removing it (non-eroded) by immersing the shell in either potassium hydroxide or sodium hydroxide solution. The observation showed the presence of boring branches about 0.5 to 1 mm in diameter that appeared to be fungal (Colubic *et al.*, 1975). They probably get into the shell through the periostracum. However their destructive role was lesser than by spionid worms or algal grooves and borings.

Many *H. pugilinus* were found naturally with partially eroded periostracum. Sometimes even the entire periostracum had been eroded off, which appears to have been caused by abrasion during movement as well as by erosion by the growth of barnacles and oysters. The barnacles and oysters will grow only if they find at least some portion of the shell without periostracum. Their growth will be continued by intruding under the surrounding periostracum which initiates its removal further.

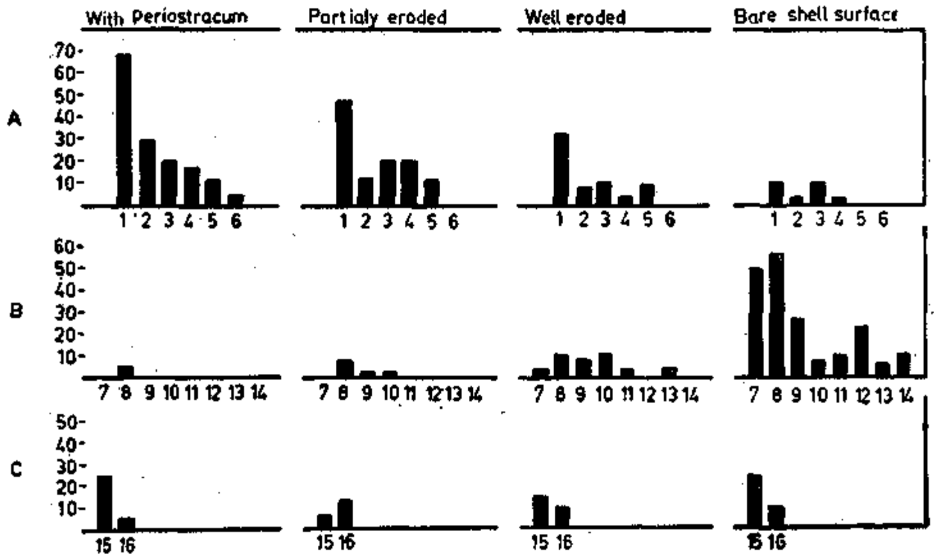

Fig. 1. Percentage occurrence of borers and epizoans on different shell surface of *H. pugilinus*.

Discussion

The investigation with this species showed that many specimens of these gastropods had lost much of their periostracum and that shell portion without periostracum apparently had a greater number of borings and epizoans than those with intact periostracum. 135 specimens were examined for shell surface type as well as boring and encrusting organisms. These data were then normalized as percentage occurrence of the organisms for each shell surface type and were given in the Fig. 1. Observations made in the present investigation clearly show that these epizoans use periostracal hairs for attachment and for protection from mechanical disruption, and become less common as hair is eroded off.

Group C (Fig. 1) includes epizoans which show no change in occurrence between the shell types of *H. pugilinus*.

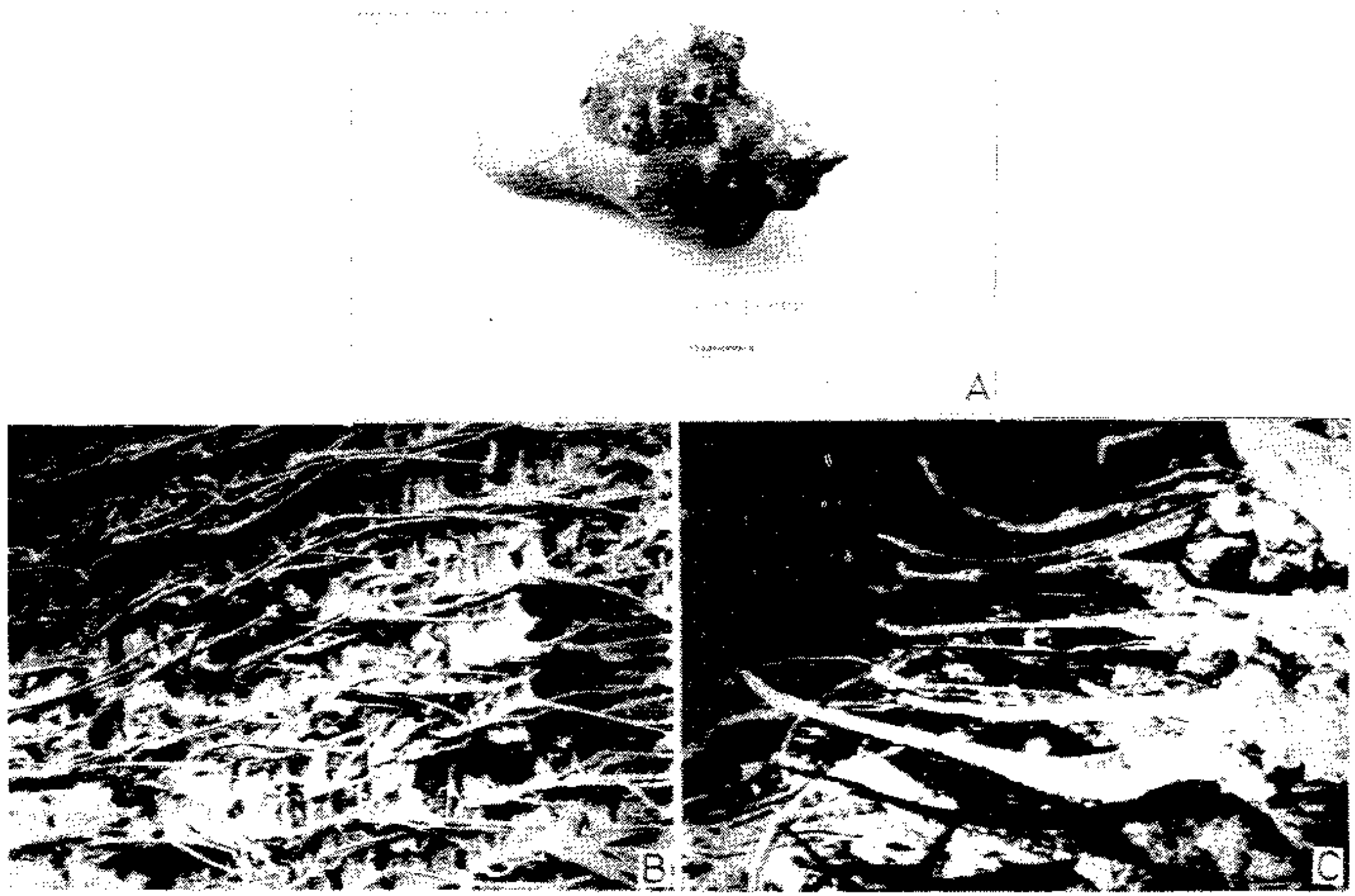

Plate I. A. *Balanus* attached shell with eroded periostracum. B. Structure of periostracum (low magnification) and C. Structure of periostracal hair (high magnification).

TABLE 1. *Percentage occurrence of borers and epizoans on different shell surfaces of* Hemifusus pugilinus (1) Shells with non-eroded periostracum (2) Shells with partially eroded periostracum (3) Shells with well eroded periostracum (4) Bare shell surface.

Group A	(1)	(2)	(3)	(4)
Seccamminid Foraminifera	67.5	48.1	32.5	10.0
Terebellid worm tubes ..	29.7	11.8	7.5	2.5
Sabellid worm tubes ..	20.0	20.0	10.0	5.0
Ascidians ..	17.0	20.0	3.75	1.8
Calcareous bryozoans ..	10.4	15.5	10.0	0
Juvenile bivalves ..	3.7	—	—	—
Group B				
Spionid worm borings ..	—	—	2.5	50·0
Algal borings and grooves	5	8	10.0	56.3
Barnacles ..	—	1.8	7.5	26.3
Hydroids ..	—	1.8	10.0	6.9
Spirorbis worm tubes ..	—	—	2.5	10.0
Polydora worm borings ..	—	—	—	23.1
Crepidula spp. ..	—	—	3.8	5.6
Oysters ..	—	—	—	8.1
Group C				
Encrusting bryozoans ..	25.2	5.5	15.0	23.8
Brachiopods ..	5.2	12.7	5.0	10.0

Group A. Organisms which become less abundant as the periostracum deteriorates.

Group B. Organisms which become more abundant as the periostracum deteriorates.

Group C. Organisms which show no change in the occurrence between various shell types.

Freshly collected specimens of *H. pugilinus* are commonly found covered with a thin layer of sediment that is trapped by the triangular periostracal hairs. This may inturn, inhibit the settlement of borers and epizoans which need hard substrate for their growth (Grant, 1966). Further, these projecting periostracal hairs may aid the possessor to escape from its predator (Bottjer, 1981) which rely upon visual perception, by way of camouflage in which process mud and sand particles are trapped in between the hairs. The fishes feeding on gastropods are cheated by the periostracum and raised lamellae which give a false appearence to the shell with great external sculptures (Palmer, 1977). The larger size of the shell owing to the presence of periostracum helps the snail to escape from its predator, which swallow their catches whole (Vermeioj, 1978). The flexible margin formed by the hairs and hairlets in Hipponicids and Capulids aid in adherence with regular hard substrates. The main function of periostracum is to inhibit the settlement and growth of epizoans.

Projecting periostracal structures are well developed in the mesogastropod families, even though they widely distributed among the families of archaegastropods (Turbinidae, Cocculinidae only) and neogastropods. The mesogastropods and neogastropods show more variation in shell sculpture than archaegastropods (Mortan, 1967). Among opisthobranchs the Tylodinidae alone has projecting periostracal structure. The property to inhibit the settlement and growth of epizoans had already been well documented (Scanland, 1979 ; Bottjer and Carter, 1980). In the same way Heptonstall (1970) suggested the functional significance of the periostracum of the cephalopod *Nautilus*. Jackson (1977) enumerated that the tentacles and nematocysts of cnidarians, avicularia of ectoprocta and toxicity of ascidians, cnidarians and sponges take place the role molluscan periostracum. As the epizoans and borers need a stable substratum (Grant, 1966), they usually do not get attacked on the shell, because of the presence of liable sandy coating which inturn is held in between the hair of periostracum. The periostracal hairs much like the artificial surface directly inhibit the settling and growth of epizoan and borers (Barnes and Powell, 1950). The presence of periostracum avoid the occurrence of *Balanus* as they preferentially avoid growing on a substratum densely covered with 1 mm long hairs (Warme, 1975). The occurrence of polychaete worms, clionid sponges and algal borers below the periostracum may be attributed to their ability to penetrate into the periostracum and other organic materials (Warme, 1975). It is possible that the relatively thick periostracum of *H. pugilinus* might inhibit these borers which are more adopt at penetrating calcareous substrates. The present study shows that the periostracum of *H. pugilinus* functions to inhibit settling and growth of borers and epizoans. Rittschoff *et al.* (1985) observed that neither seafish nor algae settle on corals such as the *Leptagiorgia virgulata* and *Renilla reniformis*. Latter it has been identified that the presence of three deterpenes was responsible for the inhibition. A very small quantity of these molecules (20.2 μg/ml) is enough to produce a repulsion of more than 50% of shellfish. This discovery opened the way for the development of antifouling paints. Hence the study of encrustor inhibition property as well as other functional and biochemical significance of gastropod periostraca will lead to the development of superior antifouling system.

REFERENCES

ABBOTT, R. T. 1968. *Seashells of North America.* Golden Press, New York, 280 pp.

BARNES, H. AND H. T. POWELL 1950. Some observations on the effect of fibrous glass surfaces upon the settlement of certain sedantary marine organisms. *J. Mar. Biol. Ass. U.K.*, 29 : 299-320.

BEVELANDER, G. AND H. NAKAHARA 1970. An electron microscope study of the formation and structure of the periostracum of a gastropod *Littorina littorea. Calc. Tiss. Res.*, 5 : 1-12.

BOTTJER, D. J. 1977. The functional significance of well-developed periostracum in bivalves and gastro pods. *Geol-Soc. Amer. Abstr.*, 9 : 244.

——— 1981. Periostracum of the Gastropod *Fubitriton oregonensis :* Natural inhibitor of boring and encrasting organisms. *Bull. Mar. Sci.*, 31 (4) : 916-921.

——— 1982. Morphology and function of projecting periostracal structures in the gastropoda (Mollusca). *3rd. North Amer. Paleont. Conve. Proc.*, 1 : 51-56.

——— AND J. G. CARTER 1980. Functional and phylogenetic significance of projecting periostracal structures in the Bivalvia (Mollusca). *J. Paleont.*, 54 : 200-216.

CLARKE, G. R. 1976. Shell growth in the marine environment : approaches to the problem of marginal calcification. *Amer. Zool.*, 16 : 617-626.

COLUBIC, S., R. D. PERKINS AND K. J. LUKAS 1975. Boring microorganisms and microborings in carborate substrates. *In :* R. W. Frey (Ed.) *The study of trace fossils.* Springler-verlag, New York. pp. 229-259.

GRANT, R. E. 1966. Spine arrangement and life habits of the productoid brachiopod Waagenoconcha. *J. Paleont.*, 40 : 1063-1069.

HEPTONSTALL, W. B. 1970. Buoyancy control in ammonoids. *Lethia*, 3 : 317-328.

JACKSON, J. B. C. 1977. Competition on marine hard substrata : the adaptive significance of solitary and colonial strategies. *Amer. Nat.*, 111 : 743-767.

MORTON, J. E. 1967. *Molluscs.* Hutchinson University Library, London. 244 p.

PALMER, A. R. 1977. Function of shell sculpture in marine gastropods, hydrodynamic destabilization in *Ceratosloma faliatom. Science*, 197 : 1293-1295.

RITTSCHOF, D. *ET AL.* 1985. *J. Chem. Ecolog.* 11 : 551. The world scientist, 23 : 34 (1988).

SCANLAND, T. B. 1979. The epibiota of *Area zebra* and *Area imbricata* a community analysis. *Veliger*, 21 : 475-485.

VERMEIOJ, G. J. 1978. *Biogeography and adaptation.* Harward University Press, Cambridge, 322 pp.

WARME, J. E. 1975. Borings as trace fossils and the processes of marine broerosion. *In :* R.W. Frey (Ed.) *The study of trace fossils.* Springler-Verlag, New York, pp. 181-227.