Reproductive Biology and Shell Site Preference in *Hipponix conicus* (SCHUMACHER)

(Gastropoda: Hipponicidae)

BY

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(1 Plate; 5 Text figures)

THE BONNET LIMPET, *Hipponix conicus* (SCHUMACHER, 1817) is found commonly on the surface of other gastropod shells over a very wide geographic range from East Africa, through the Indo-Pacific to Japan, the Hawaiian Islands and the Tuamotu Archipelago. In Australia it is found from Western Australia to Victoria and Tasmania as a common commensal on the shells of the haliotids *Haliotis ruber* LEACH, 1814, *H. improbulum* IREDALE, 1924 and *H. laevigata* DONOVAN, 1808 and on *Pleuroploca* and *Pterynotus*. The observations which follow were made on *Hipponix conicus* individuals taken from series of *Haliotis improbulum* collected at Port Willunga during 1963, and at West Island during 1964-1965, and from specimens of *H. laevigata* and *H. improbulum* collected at Flinder's Island and Reef Heads in June and July, 1968. Museum specimens of *Pleuroploca australasia* (PERRY, 1811) and *Pterynotus triformis* (REEVE, 1845) were used for recording the distribution of *Hipponix conicus* on these gastropods.

BEHAVIOUR AND MORPHOLOGY

In South Australian specimens of *Hipponix conicus* the shell is brown externally and sometimes on the interior lip, and the interior may be white or white with a central area of brown. The animal is relatively immobile on the surface of the host, the shell margin assumes the contours of the host surface, and the host shell becomes eroded beneath each individual. *Hipponix conicus* is, however, capable of a limited amount of movement at any stage of life. HARTLEY (1958) illustrated eroded tracks on the surface of *Haliotis ruber* showing that the limpets move slowly, the rate being determined by the rate of growth of the host shell since mature *Hipponix* are almost invariably found at the haliotid shell margin. Similar eroded tracks were found on South Australian host haliotids (Figure *3*) [E] and Figure *4* shows a track produced by a male on the surface of a female, such as was reported by CERNOHORSKY in 1968 for a Pacific male. In a few cases on South Australian host shells, especially when a sharp decrease in epifauna showed that the host had made sudden and rapid growth, the *Hipponix* individuals failed to "keep up" and were found in a row at a distance from the host shell margin. In Figure *3* the large female has not quite kept pace with the *Haliotis* margin.

The animals of *Hipponix conicus* were cream in color with blue-black tentacles and proboscis. As has previously been noted for *H. antiquatus* (LINNAEUS, 1767) by YONGE (1953), *H. conicus* is not a ciliary feeder as are related members of the Capulidae and Calyptraeidae, but searches for food particles by lifting the anterior margin of the shell and groping about with the extensible and very mobile proboscis.

The radula is similar to that figured by CERNOHORSKY (1968) for Fijian specimens but the first lateral cusp of the median tooth is more prominent and overlaps the basal plate; in addition the central tooth has at least 5, and sometimes even 7 lateral cusps and the denticles of the marginal teeth may be more pronounced.

Reproduction in *Hipponix conicus*

Hipponix conicus has been reported to be a protandrous hermaphrodite (CERNOHORSKY, 1968), thus showing a reproductive pattern comparable to that which has long been known for the members of the related families

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[E] Editor's note: Figure numbers in *Italics* refer to illustrations on halftone plates, whereas Roman numbers refer to illustrations in the text.

Capulidae and Calyptraeidae (Conklin, 1897; Coe, 1942, 1944; Orton, 1909).

Observations on the position occupied by the sexual stages were made using the series of specimens collected at Port Willunga in June, July and August of 1963. The position and size of individuals on the haliotid shells were recorded and if they were 2 mm or more in length their sex was determined by microscopic examination of pieces of gonadal tissue to check for the presence of developing or mature sperm or ova. In individuals less than $2\frac{1}{2}$ mm in length, and in those between $2\frac{1}{2}$ and 16 mm which were more than 3 mm away from females, no developing sperm or ova could be found. With the exception of one large male which was 17 mm long, all specimens over 16 mm were females. All in the $2\frac{1}{2}$ - 16 mm range which were in contact with, or within 3 mm of a female, were males (Figures 2 and 7). It appears that the presence of a female induces adjacent individuals to develop as males, and that isolated individuals do not spontaneously become males. Mature females may be solitary but the fact that no solitary males were found suggests that these females had not passed through a functional male phase, although some did possess a rudimentary penis.

The gonad of the male (Figure 8) was white and the penis large and elongate and capable of extension well beyond the margin of the male shell, as was observed for *Hipponix antiquatus* by Yonge (1960). Many of the males situated on females had eroded a channel in the edge of the female shell (Figures 5 and 6) allowing communication between the two. The erosion of the female shell shows that the notches are made from the male side (Figure 6). It was not uncommon for a female to carry two males and have a shell notch for each one. Males were usually attached on the right anterior margin of the female shell. This position is the one closest to the opening of the oviduct, and the shell notch would allow copulation to occur without the margins of the male and female shells being raised. Such communication channels were never observed between a female and an adjacent male.

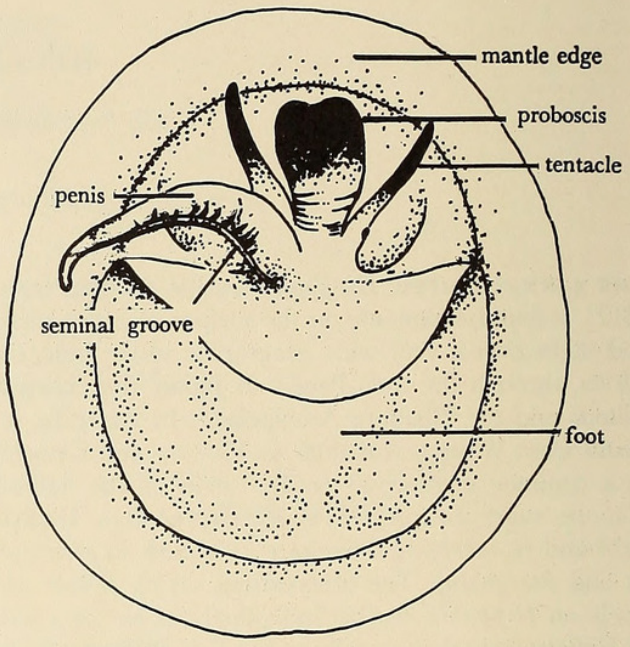

Figure 8

Male *Hipponix conicus*: ventral view with the anterior foot membrane turned back to show the head region

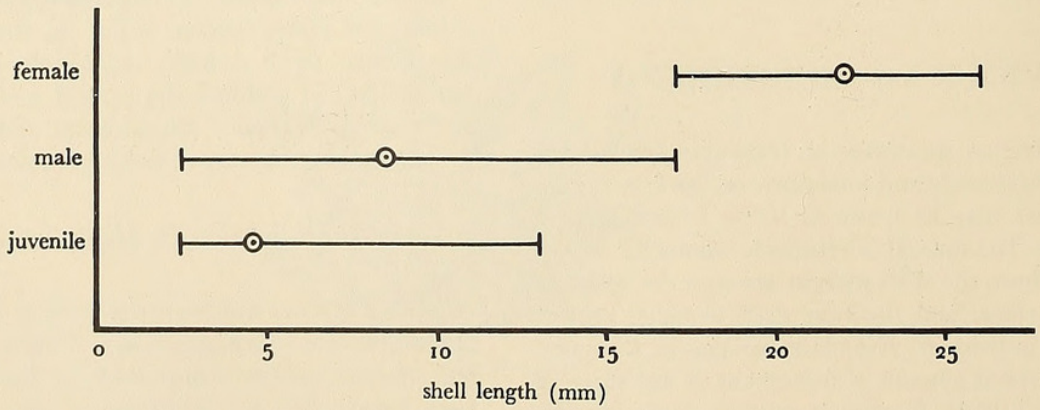

Figure 7

Shell length (mean and range) of juvenile, male and female individuals of *Hipponix conicus*

In mature females (Figure 9) the gonad is a rich yellow in color and a rudimentary penis may be present. Eggs are deposited in 5 to 10 elongate brood sacs which lie in the left side of the mantle cavity and are attached to the left anterior part of the foot. From 9 to 24 embryos develop in each sac and the whole brood is at the same stage of development. A number of females were solitary, there being no scars to indicate where a male might have previously been; some of these solitary females had brood sacs with developing embryos.

Juveniles are released when about 1 mm in length. They settle on the haliotids, particularly round the anterior margin, and the young shell is smooth until it is about 3 mm long when the ribbing characteristic of an adult shell begins to develop. The young individuals are red-brown and clearly show the spiral protoconch; with increasing size the protoconch is eroded off the top of the shell.

During 1964 - 1965 over a period of 16 months, females from the West Island collections were checked for the presence of brood sacs. Samples ranged in size from 4 to 12 individuals and the resulting picture of the reproductive cycle can only be regarded as approximate. The results do show, however, that *Hipponix conicus* breeds throughout the year and they suggest that there is a peak of reproductive activity in the late winter (Figure 10). Three collections at Port Willunga in June, July and August of 1963 support the suggestion of a late winter reproductive peak as does a single collection of 12 females from Reef Heads in August, 1968.

Position of *Hipponix conicus* on the Host Shell

On *Pleuroploca* and *Pterynotus* no site seems to be particularly favored. In a few cases the host may carry an

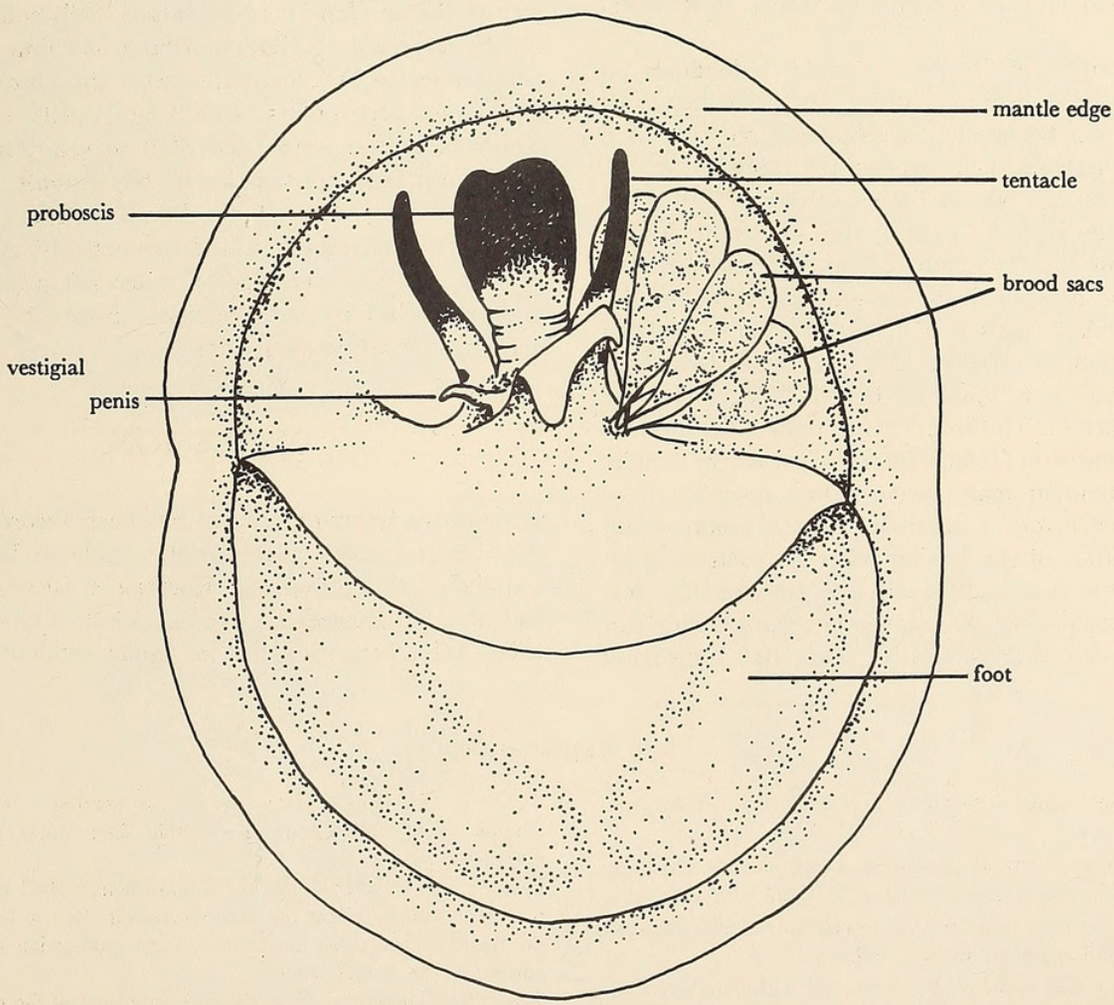

Figure 9

Female *Hipponix conicus*: ventral view with the anterior foot membrane turned back to show head region and spawn

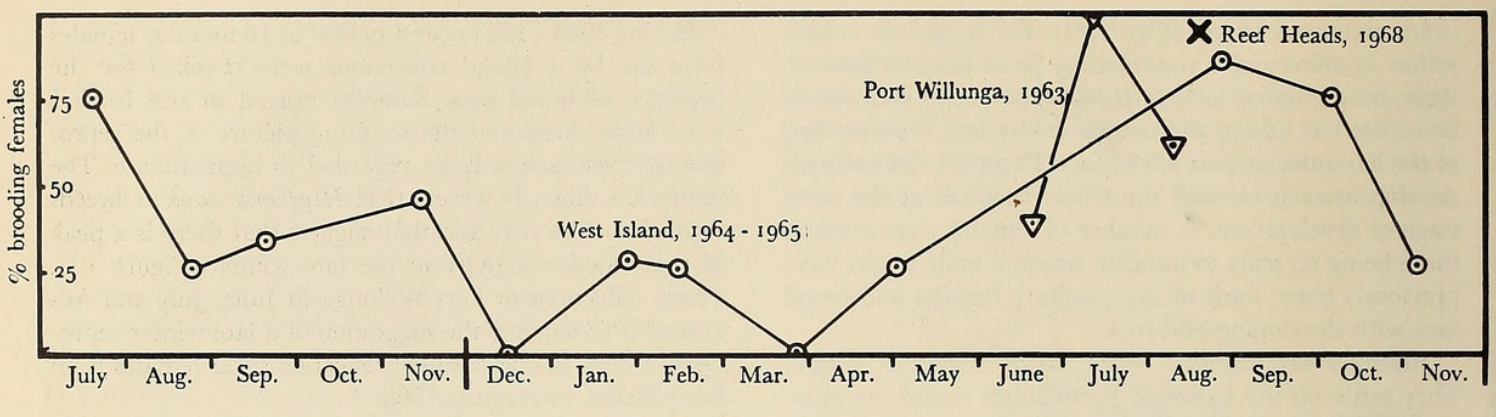

Figure 10

The annual reproductive cycle shown by brooding females

almost complete covering of *Hipponix* (Figure 1); this whelk even had juvenile specimens attached to its operculum.

The distribution of *Hipponix conicus* individuals on haliotids showed a definite pattern. In order to record the distribution, the number of *Hipponix* on each of 6 sectors of the haliotid shell was counted (see Figure 11). Three size classes of bonnet limpet were recorded separately: $<$ 5 mm long, 5 - 16 mm, and $>$ 16 mm. All females were in the $>$ 16 mm group. In this way the distribution on haliotid shells was established for 54 *Haliotis improbulum* shells (761 *Hipponix conicus*) from West Island, and for 8 *Haliotis laevigata* shells (840 *Hipponix conicus*) from Flinder's Island. The results are shown in Figure 11. The anterior and right-hand margins are the only places on *Haliotis improbulum* where females and their attendant males occur. Only juveniles were found on other sectors of the shells; greater numbers and wider distribution of the smaller size class containing juveniles suggests that individuals are progressively lost as they increase in size. On *Haliotis laevigata* female distribution showed a peak on the front and right-hand margins of the shell although some were found in all other sectors. Three *Haliotis improbulum* shells collected with the *H. laevigata* at Flinder's Island had limpets present only on sector IV, comparing with the more restricted distribution seen on the West Island shells. For all size classes of bonnet limpet, distribution was less restricted on *Haliotis laevigata* than on *H. improbulum*.

It was noted that on the Flinder's Island shells the central parts of the shell which are not used by *Hipponix conicus* with the exception of occasional juveniles, were occupied by the related hipponicid limpet *Antisabia foliacea* (Quoy & Gaimard, 1835).

DISCUSSION

Consecutive hermaphroditism has been recorded among the Mesogastropoda in the families Scalidae, Ianthinidae, Capulidae, Calyptraeidae (Fretter & Graham, 1962) and the Hipponicidae (Yonge, 1960; Cernohorsky, 1968). It has been studied in particular detail in *Crepidula*

Plate Explanation

Figure 1: Large numbers of *Hipponix conicus* on *Pleuroploca australasia*.

Figure 2: *Haliotis improbulum* bearing a large female *Hipponix conicus* individual with a male situated on her anterior shell margin and another (completely covered with a bryozoan colony) adjacent to her; all other individuals were juvenile.

Figure 3: The track eroded on the surface of a *Haliotis improbulum* shell by a solitary advancing female which has not quite reached the haliotid's anterior margin.

Figure 4: A female *Hipponix conicus* bearing a smaller male. Erosion of the ribbing on the female shell marks the path of movement by the male.

Figure 5: The interior view of a large female shell which carries two male individuals at the anterior margin (the lower margin in the figure); each male has formed a communication notch in the margin of the female shell.

Figure 6: The dorsal view of the female shell of figure 5 showing erosion of the shell by the males (the male shells have been removed).

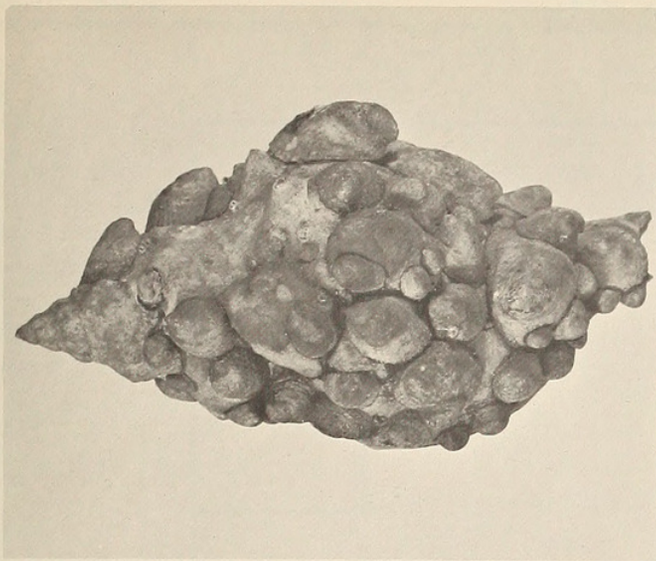

Figure 1

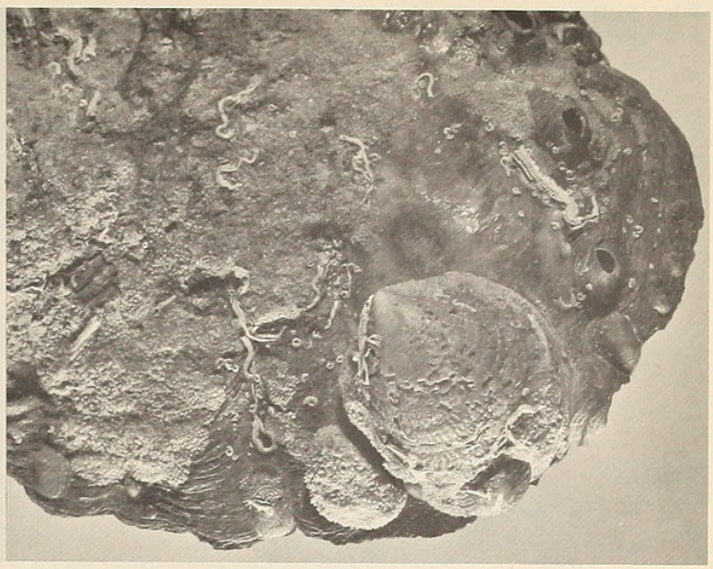

Figure 2

Figure 3

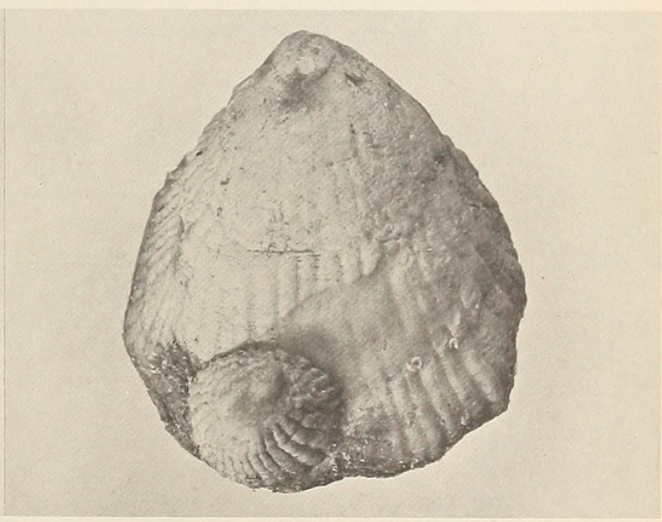

Figure 4

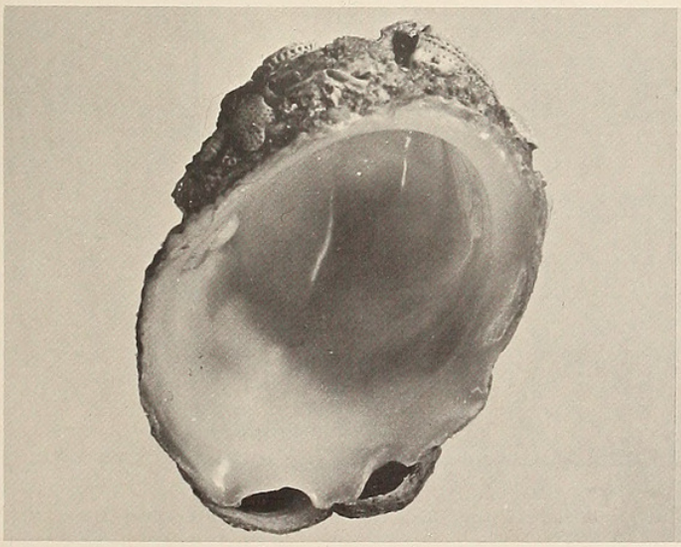

Figure 5

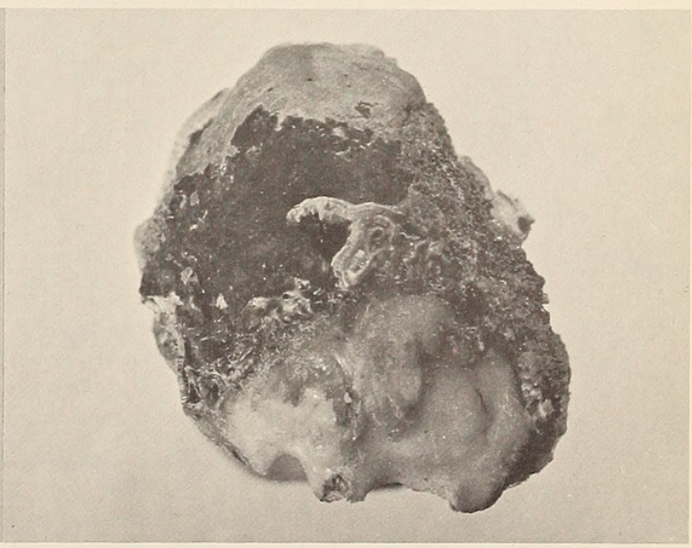

Figure 6

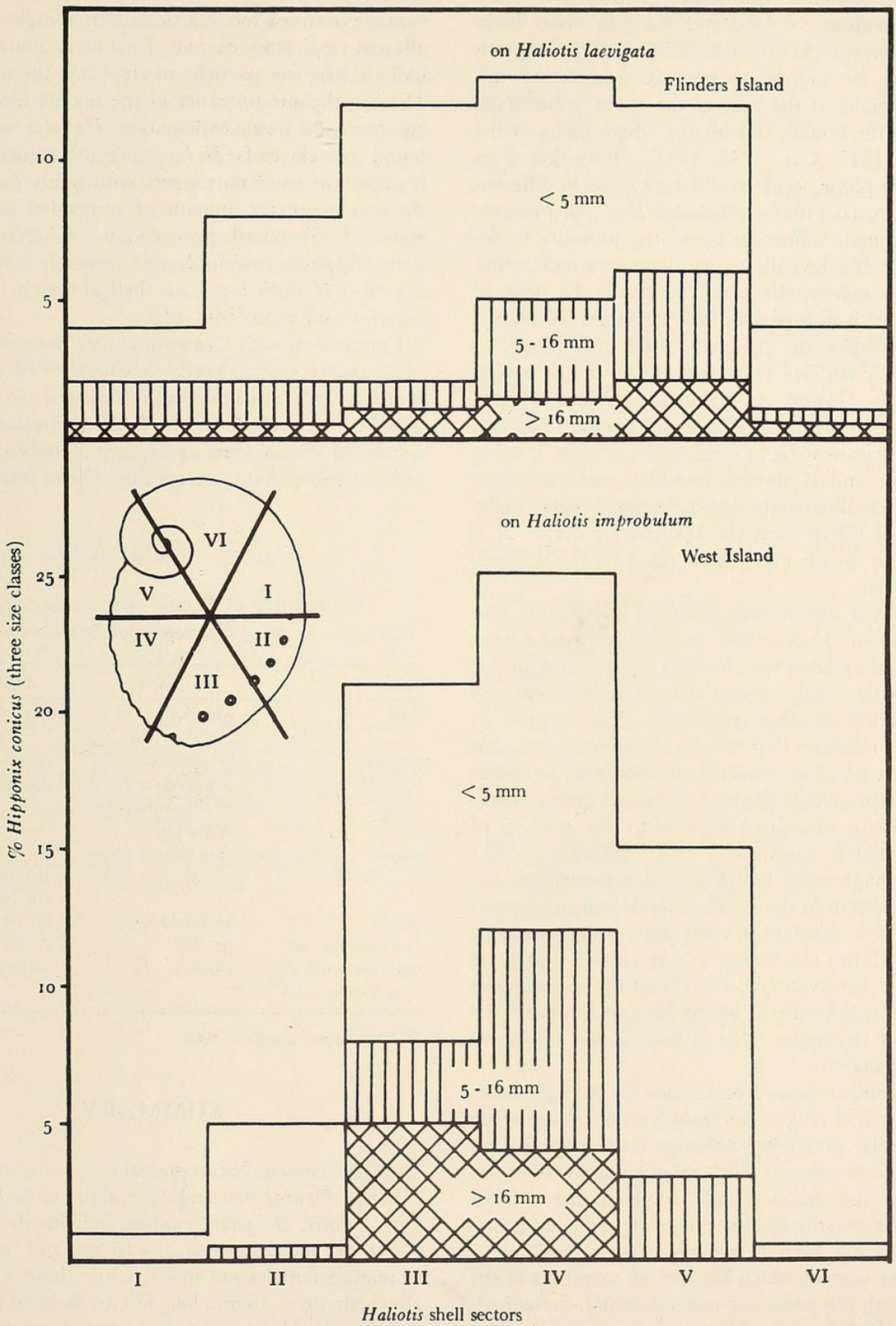

Figure 11

The distribution of *Hipponix conicus* individuals on *Haliotis* shells