Memoirs of the National Museum of Victoria 1 May 1962
https://doi.org/10.24199/j.mmv.1962.25.12

THE LINNAEAN *HALIOTIS VARIA* IN AUSTRALIA.

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Text Figures 1-3.

Haliotis varia Linnè, 1758 is a very common shell along the north-eastern, northern and north-western coast of Australia. Iredale, 1928 briefly discussed the species as a whole, designated the Philippines as the type locality of *H. varia* s.s. and separated the Australian shells sub-specifically as *H. varia aliena.*

Recent examination of specimens from Australia and adjacent localities indicated strongly that there were definite clinal variations within the population of the sub-species and the species as a whole.

Before discussing populations it was first necessary to establish whether more than one species was involved. This was accomplished by a comparison of the soft parts of animals from all localities. This species has a rather narrow epipodium, which is strongly papilose and expanded. The tentacles are long and narrow as are the eye stalks. The snout is well developed. The epipendular processes are long and fine. Due to preservatives, the full colouration of the animal could not be determined, but all appeared to be a tan or light brown, with maculations of dark brown on the epipodium.

Thus it was found that regardless of the shape, form, colouration, or sculpturing of the shell, all animals were anatomically similar, and therefore only a single species referable to *H. varia* Linnè was present.

As Reeve, 1846, described a number of species which are obviously closely related to *H. varia* Linnè it was necessary to establish the identity of these names. The range of variation shown by the large number of specimens examined made it seem likely that selected specimens from the various localities could be matched with the Reeve species.

Such a selected series was sent to the British Museum (Natural History). Mr. S. P. Dance kindly compared these with the type specimens in the Hugh Cuming Collection upon which Reeve based his descriptions in Proc. Zool. Soc. and Conchologica Iconica. This established the fact that the Reeve species *viridis,* Here the shell becomes more rounded and wider than those in the Capricorns. Tiny nodes are found on a number of specimens, but the majority of shells lack this nodulation. The cording has now become nearly obsolete and the lamellae are much stronger. The number of specimens with the colour pattern of *semistriata,* is much reduced. Strong maculations and the concoloured phase, *pustulifera* are the common patterns. The basic colouration is now a rich, reddish brown, with cream or white markings.

The measurement formula 1·52 x 1 x ·20 x ·18.

Bowen, Queensland and adjacent coast: Like the closely related Keppel Island population, the material from this series was relatively smooth with strong lamellae. Here shells reach the broadest width-to-length ratio, and nearly all specimens exhibit small pustules or nodes. The colour form *semistriata* is absent while *pustulifera* is the dominant phase.

The measurement formula 1·50 x 1 x ·22 x ·20.

Townsville and Magnetic Island: There is so little separation between the mainland and island series, that they are placed together. With northward progression there is a definite trend for the shell to lengthen. Nodes are on almost all specimens and the lamellae are strong. The colouration of the shell is almost pure *pustulifera,* the rich red brown concoloured type. A few examples with maculations are found.

The measurement formula 1·55 x 1 x ·20 x ·18.

Cairns: Here the northern elongate type of shell is more evident. The small pustules present in the more southern populations are now starting to decrease, as well as the lamellae. The colouration is also changing to the maculated pattern; the rich red brown colouration being replaced with a dark brown.

The measurement formula 1·60 x 1 x ·18 x ·16.

Darwin: Here appears to be found the most elongate, arched specimens of the population. This is to be expected, as across the shallow Arafura Sea one finds nearly pure populations of an adjacent geographical race showing these characters. The rounded lamellae are nearly gone, with the cording now increasing in strength. The colour pattern is now either rayed or maculated. Tints of green make their appearance, with dark brown and white.

The measurement formula 1·75 x 1 x ·25 x ·24.

semistriata, concinna, papulata and also *pustulifera* Pilsbry, 1890, were all referable to colour phases of *varia* s.l. and *astricta* and *rubiginosa* of Reeve represented distinctive cording and sculpturing. Thus all these names sink into the synonomy of the Linnaean species *H. varia.*

To correlate the variation, some way of expressing the mean characters of the basic population must be found. The simple length, width, height of spire, and height of shell is here reduced to a formula, with the width of the shell represented by "1." Graphs are used to show the clinal nature of the types of colouration, sculpturing and proportions of shell. No attempt is made to make any evaluation, other than that listed above. Small series, pathological specimens, and those with vague localities were discarded because of the possibility of their abberant nature. However, they were considered in the broadest sense in summing up the variations. Juvenile shells were found to have little value beyond specific identification.

Ino (1951), proved in his study of *Haliotis discus* Reeve, that diet is a very strong factor in the colouration of the shell. The colour variations in the present study indicate that there is a more or less geographical correlation. It would be interesting to learn whether there is also a distinct correlation of species of the marine algae on which the animals feed to geography, or whether chemical variations in the sea waters is the altering factor.

Discussion on Populations.

Capricorn Group: Series from individual islands of the group were so uniform that they were treated as a single population. Typical Capricorn example are rather broad, coarsely corded shells, with low rounded lamellae that are semi-obsolete. The sculpture-form, *astricta,* appears to be quite common, with only a few of the examples exhibiting small rounded nodes. The basic colouration is a dark reddish brown, with white or cream markings. The banded form, *semistriata* is the predominant pattern. The form *rubiginosa* occurred here, and, beyond question, is only a pathological shell.

The measurement formula 1·58 x 1 x ·20 x ·18.

Keppel Islands: Again, as with Capricorn shells populations from the various islands do not differ.

Broome: This form has a broader shell, with lamellae again present. A few specimens exhibit tiny nodes. In contrast the colouration is either maculated or rayed with green-brown and white. Very few banded or concoloured examples are found, and these are all of green tints.

The measurement formula 1·70 x 1 x ·24 x ·22.

Discussion

The significant factors are:—First, as one moves from south to north along the Queensland coast, the number of the pustules increase; the cording loses its strength and becomes almost obsolete. The shells become wider and more rounded. At Cairns the pustules decrease again and the shell becomes more elongate; the cording increases in strength. The peak of the elongate unsculptured shell is reached at Darwin; then the shell again changes to become wider and more heavily sculptured on the North-western coast.

Examples of *H. varia* s.s. from the Philippines, especially the eastern coasts, show a rather broad, heavily tuberculated shell. The tubercles are large and plentiful. The dominant colour pattern is either heavily maculated or rayed. This basic type of shell is found to range south along the coast of New Guinea and into the Solomons. Specimens available from Papua and New Caledonia show this similarity, but were too few in numbers to be considered for a comparison of populations. However, these few specimens appear to furnish the key to the problem.

Some selected localities within the range of the *varia* s.s. produce the following formulae:—

Okinawa, Ryukyu Islands, 1·39 x 1 x ·29 x ·30.

Batan, Luzon Island, Philippines, 1·35 x 1 x ·30 x ·32.

Biak, Northern New Guinea, 1·35 x 1 x ·28 x ·25.

Zamboanga, Mindanao Island, Philippines, 1·48 x 1 x ·30 x ·30.

Unlike all the other localities, the coarse, irregular tubercles were not present in the majority of the specimens from Zamboanga. A number of the shells were of the more elongate type, associated with the warm inner seas of Indonesia. However, in all of these localities there was no trace of the lamellae present in so many of the Australian specimens.

The Haliotids inhabit a rather specific ecological biome, shallow water with rock or coral formations, and it is quite possible that any expansive area without this habitat would be a physical barrier. Distributional evidence suggests that the intermingling of populations by the free swimming trochoforme is also restricted. This is probably due to the lack of strength of the trochoforme, which would prevent it from traversing great distances prior to final settlement. Thus adjacent populations are in contact only if conditions, such as shallow narrow seas, are favourable.

Thus it would seem that the clinal variation exhibited by the Australian shells is a logical and natural trend. Particularly as it seems likely that there is a genetic interchange between populations in New Caledonia and the Queensland coast, across the Coral Sea. This interchange is further suggested by the finding of typical New Caledonian species of this and other genera on the Queensland coast, and it is in such areas that *aliena* shows similar shell characters to *varia* s.s. Such a contact is still further indicated by the decrease in the pustules as one moves away from this probable area of contact.

The shallow warm waters of the inner Indonesian Seas produce a deep, very elongate, finely corded race; the *H. varia stomataeformis* Reeve* specimens from the north coast of Java were the most elongate and smooth of the entire species. The measurement formula 1·78 x 1 x ·25 x ·24. Contact with *aliena* would be made across the shallow waters of the Arafura Sea. Again, as one moves both south and west from this area of contact, the shells become broader and less elevated, with the decrease in the cording.

Thus it appears that the Australian sub-species of *aliena* Iredale, has an animal that is the same as the Indonesian and more northern races, but may be separated by shell features. These being chiefly the more elongate shell and the presence of lamellae, with the tubercles reduced in most cases to fine nodules.

Taxonomy

The above study has established the probable occurence of an Australian sub-species which Iredale arbitrarily called *aliena.* He did not consider whether an earlier name was available, which in fact it is. Reeve described *papulata* from Northern Australia and this name must take priority over Iredale's much more recent innovation. Thus the Australian sub-species becomes *H. varia papulata* Reeve, 1846 and *aliena* falls into its synonomy.

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* Reeve gave the locality of *H. stomataeformis* as New Zealand but it has not been recognized from there but shells from Indonesia exactly match Reeve's figure and description. Talmadge (1956).

Summary

A study based upon a series of shells indicated that *H. varia aliena* Iredale is a sub-species showing clinal variation within its populations. These populations are in what may be considered physical contact, and certain features are carried from one to adjacent groups. There is also strong indication of interchange of genetic factors with adjacent sub-species particularly at the geographical areas of contact; i.e., shallow, relatively narrow seas. This latter factor is probably the reason for the major variations within the range causing confusion in the taxonomy. The correct name of the Australian sub-species is *H. varia papulata* Reeve, 1846.

Acknowledgements

Appreciation is expressed to Mr. S. P. Dance of the British Museum (Natural History) for making the comparisons of certain specimens with the original material used by Reeve. To the many Australian collectors, who obtained both shell and animal, with accurate locality data, my heartfelt thanks. Without such material the study could not have been made.

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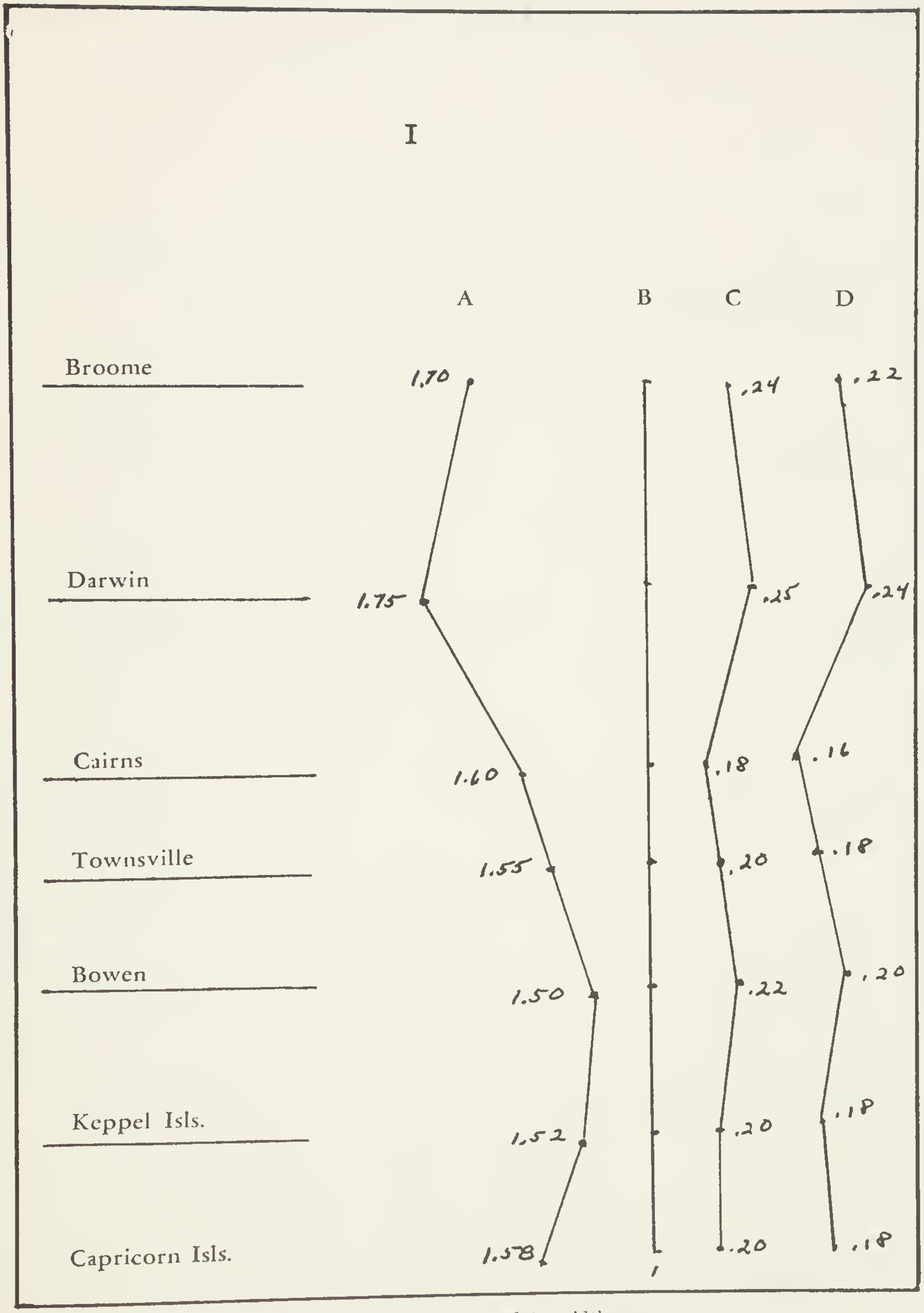
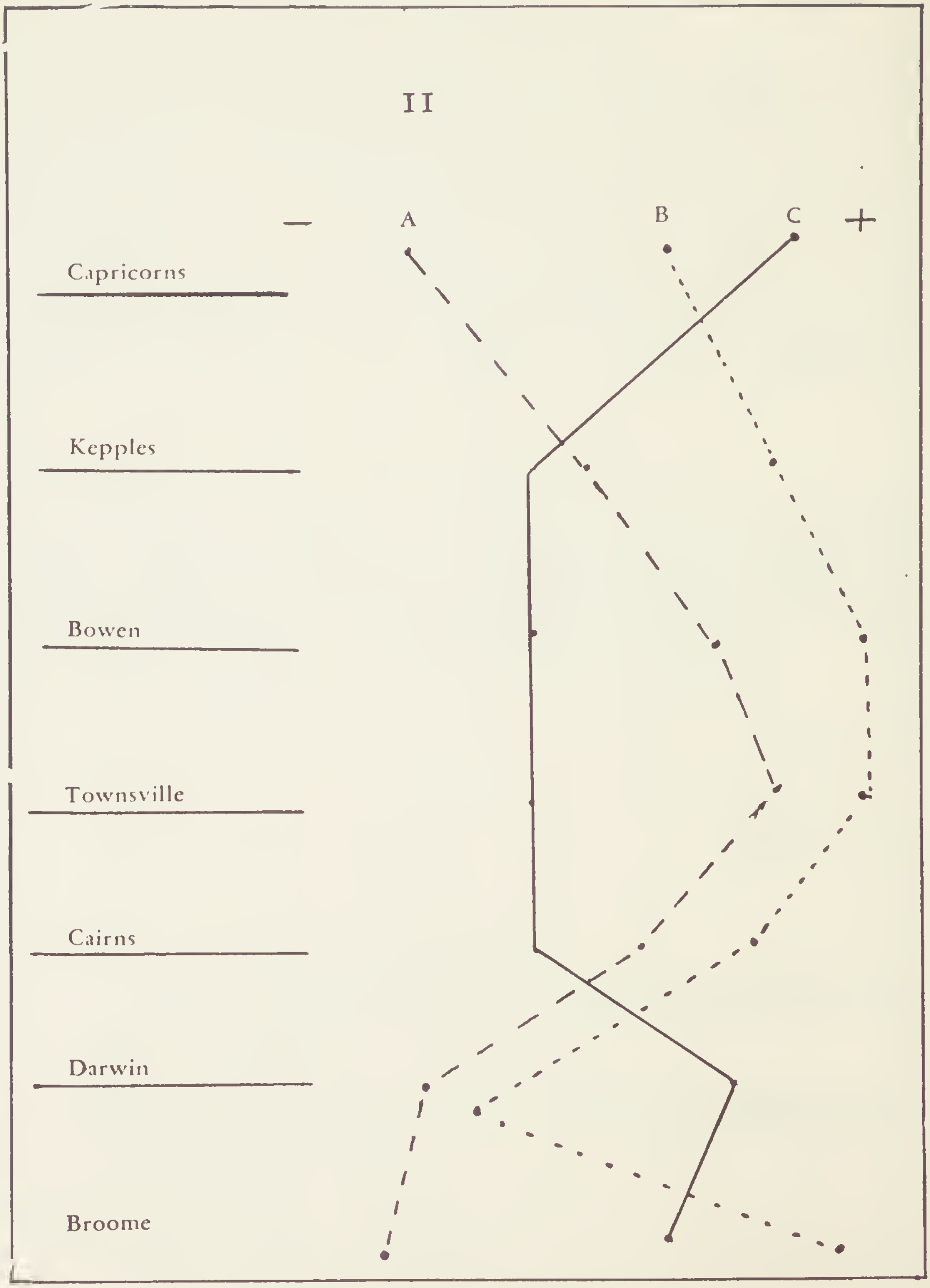
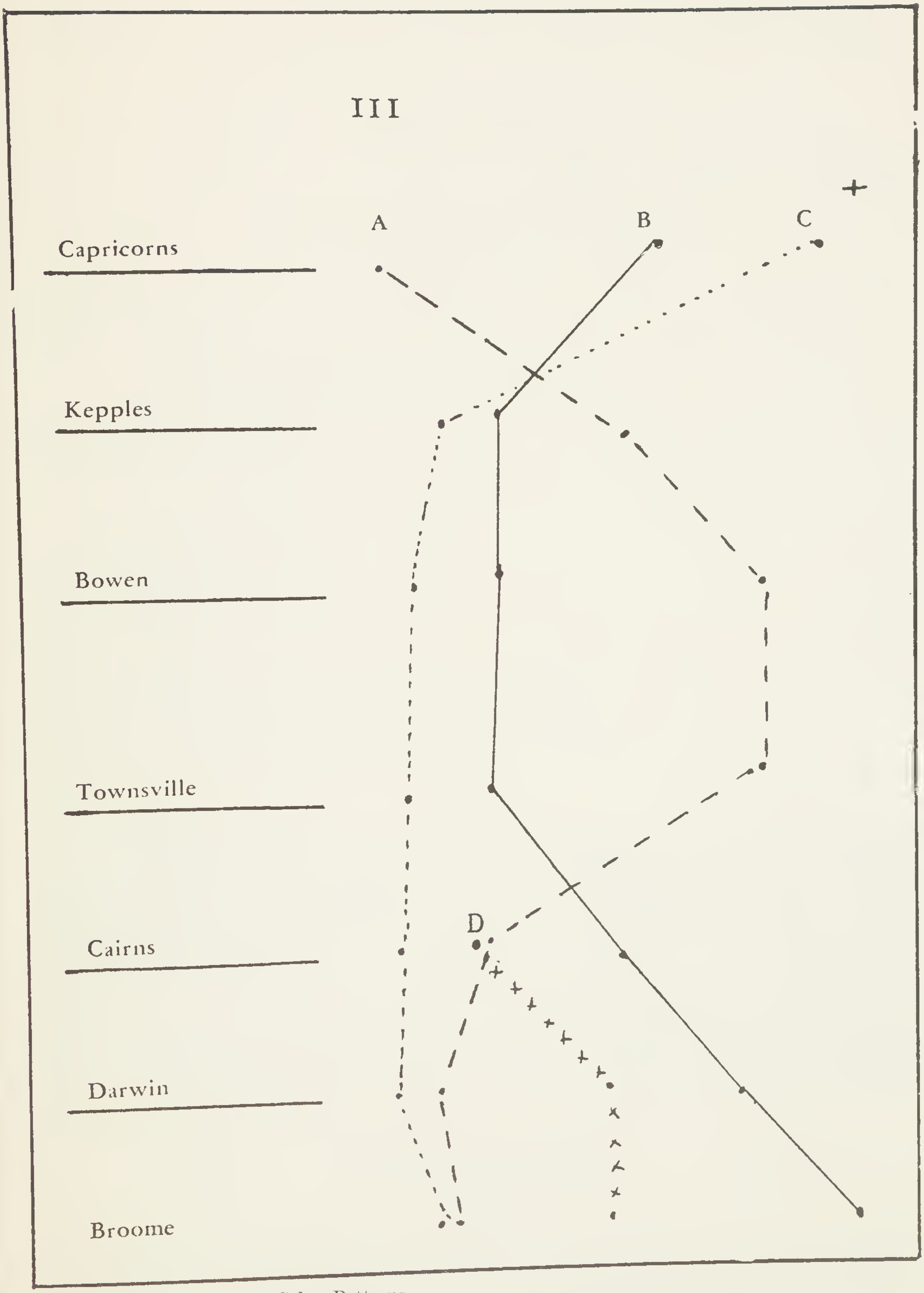


A = Length of shell compared to width.
B = Width of shell, compared to length.
C = Height of spire compared to width.
D = Height of dorsal surface compared to width.



Sculpturing—
A (- - - - - - - - - - -) pustules.
B (. . . . .) lamellae.
C (————————) cording.
+ = majority of lot.
— = minority of lot.



Color Patterns—
A (- - - - - - - - - - -) Concolored (pustulifera).
B (————————) Maculated.
C (. . . . .) Banded (Semistriata).
D (x x x x x x x x x) Rayed.
+ = majority of lot.
– = minority of lot.