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THE INDIAN VARIETIES AND RACES OF THE GENUS *TURBINELLA*.

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(Plates X—XII).

Like the species represented by mankind, that of the Indian conchs belonging to the genus *Turbinella* is not an ideal one composed of a single predominant variety; on the contrary both are excellent types of the collective species comprising in each instance a number of well-marked forms, whereof the principal are approximately co-equal in taxonomic value and thus constitute strongly characterized varieties or sub-species.

The species was first described by Linnaeus under the name of *Voluta pyrum*, but unfortunately this name was given to a form which, in my opinion, is not the central one, but is a variety probably thrown off by a stock which resembled more closely one of the other existing varieties. However, as it is at present difficult to prove the truth of this hypothesis, and as, after all, names are but labels with which we ticket things and ideas for ease of reference, this is of comparatively small importance.

Including Linnaeus' type as one, I distinguish five well-marked sub-species or varieties, namely:—

(*a*) var. *obtusa*, var. nov.,
(*b*) var. *acuta*, var. nov.,
(*c*) var. *fusus*, Sowerby,
(*d*) var. *globosa*, var. nov., and
(*e*) var. *comorinensis*, var. nov.

The first three I consider equally important and equal in classificatory value; regarding the two last, I am as yet somewhat doubtful as to whether they have sufficient stability of form to be considered more than strongly marked local races of limited permanence; I incline, however, to think both will prove to be good varieties. The names now given to all these are new except that of *fusus*. I had hoped to give Gmelin's name *rapa* to the variety I call *acuta*, but this proved impossible as I find Gmelin's *rapa* to be no more than an inflated and less obtuse form of the variety described by Linnaeus.

I did not arrive at this conclusion of specific identity without difficulty, for if the more emphatic individuals of each form only be compared, unity of species seems impossible. Fortunately I have had the opportunity of comparing thousands of shells from the principal Indian localities where *Turbinella* is found, and from the

results of this study I have found it impossible to draw any hard and fast line separating specifically any of the main assemblages. Finally, I arrived at the conclusion that while the two most important forms, which I term *obtusa* and *acuta* respectively, constitute merely varieties of one species, their varietal characters were at no long distant period in process of such permanent fixation that the establishment of separate species would have been accomplished had not geological changes brought the two varieties into close intermingling before the fixation of specific characters was completed.

Each of the five varieties into which I divide the species, if judged by isolated individuals in which are strongly developed the special characteristics and proportions found in their respective shells, may assuredly be classed without difficulty by the closet naturalist as a distinct and well-marked species. Strangely enough this has not happened, for though a considerable number of species have been erroneously created through the study of individual shells, all such are based upon the forms and local races of the single variety *obtusa*. Thus

Voluta gravis, Dillwyn,
Turbinella clavata, Schub. and Wagn.,
Turbinella napus, Lamarck,

are bad species founded upon specimens of the form *typica* of *T pirum obtusa*, while Lamarck's *Turbinella rapa* represents form *rapa* of the same variety and probably was based upon a large specimen of this varietal form from the neighbourhood of Madras. Certainly the shell figured by Reeve as *T rapa* in Vol. IV of his *Conchylogia Iconica* represents precisely such a shell.

The first four of the varieties I now propose to define are inhabitants of the coastal waters of Ceylon and of Continental India; the fifth (*T pirum fusus*) is found in the Andaman Islands.

The following key to the five varieties defines the principal characteristics of each:—

Spire elongate; shell widely fusiform. Breadth in length, 1·75 to 2.	Shoulder angular, prominent.	(1) var. *fusus*, Sowerby.
	Shoulder rounded, low.	(2) Profile of whorls in spire convex, var. *acuta*, var. nov.
		(3) Profile of whorls in spire nearly straight, var. *comorinensis*, var. nov.
Spire short; shell either globose or top-shaped. Breadth in length under 1·75.	Spire moderately short; shell globose; periostracum rough and thick.	(4) var. *globosa*, var. nov.
	Spire often very short; shell inclined to be top-shaped; very wide at shoulder. Periostracum thin and little sculptured in small and medium-sized shells.	(5) var. *obtusa*, var. nov. With two forms:— (*a*) *typica*, (*b*) *rapa* (Gmelin).

I will now discuss in detail the main characters distinguishing these varieties, together with those of the shells from different localities, the local variations being due in the main to differences in the abundance of food supply, and in the character of the environment, particularly in regard to the degree of exposure to unfavourable

conditions, such as surf action, prolonged spells of turbid, mud-laden water, and scarcity of food.

1. Variety **obtusa**, var. nov.

Judging the importance of the co-varieties of *Turbinella pirum* from the numerical standpoint, this variety is entitled to first place. It is the form which furnishes all but a fraction of the produce of the great fisheries in the north of Ceylon and along the Indian Coast of Palk Bay and thence from Point Calimere to Pulicat Lake. Out of a total annual production in this region of about 15 lakhs of shells, this form contributes 13 lakhs. Its habitat lies entirely northward of a line curving into Palk Bay from a point about the middle of the north coast of Mannar Island to another on the Indian mainland a few miles west of Pamban (Plate XII). The significance of this peculiar line of demarcation will be explained later.

The characters of this variety fluctuate within considerable limits, from a form with a well-marked though short spire to one where it is extremely abbreviated with whorls much telescoped. It was the latter which Linnaeus described and which therefore has to be considered the type of the species. To this form I will therefore apply the term *typica*, while for the other extreme the term *rapa* will be appropriate as it was a shell of this form to which Gmelin (1790) applied the specific name *rapa*.

The length of both forms compared with varieties *acuta*, *fusus*, and *comorinensis* is markedly short in comparison with the breadth, due to (*a*) an emphatic telescoping of the whorls of the spire, and to (*b*) a considerable inflation of the body whorl. The former forces the shoulder high up and imparts to the shell a distinctive top-shape suggesting stunting, which contrasts sharply with the handsome free growth and wide spindle shape of var. *acuta*. The periostracum in small and medium shells is usually thin and weak with a distinct tendency towards smoothness; the spiral rows of prominences or nodes and the lines of low periostracal ridges are poorly developed, very much less than in *acuta*; it is seldom that more than a trace remains of any except the shoulder nodal row. Young shells of this variety are often richly flecked with chestnut spots, but this is a very variable character and many shells otherwise exactly similar to the spotted ones are almost or quite spotless, and a uniform white. With increasing size spotting tends to be suppressed, and full grown shells seldom show the slightest trace of spots.

Between the two extremes of shape seen in this variety a perfect range of gradation can be traced, and, although when the extremes be placed side by side their differences appear so well-marked as to appear to justify separation, I am unable to split it up as these extremes are not localized and intermediate forms are always easily found linking them up.

It is difficult to distinguish any clearly defined local races of this variety; the more important ones are those of (*a*) Tirupalagudi, (*b*) the Coromandel Coast, and (*c*) Nayinativu.

(*a*) *The Tirupalagudi race.*—These shells are found off the villages of Tirupalagudi, Tondi and Mudirampatnam in the south-west angle of Palk Bay, and come from

beds in $2\frac{1}{2}$ to $4\frac{1}{2}$ fathoms where they are subject to the influence of rough seas and muddy water during the greater part of the year. They are distinctly stunted in general appearance and a proportion have the apex so greatly abraded as to be almost flat in the apical region. The apical angle of those living in depths of $2\frac{1}{2}$ fathoms averages 104·64° as against 102·52° for those in $4\frac{1}{2}$ fathoms. The extremes however range between 85° and 134°, between which perfect gradation is always to be seen in every batch of shells (Plate X, fig. 5).

This great range in the angular index of the spire is due largely to the fact that

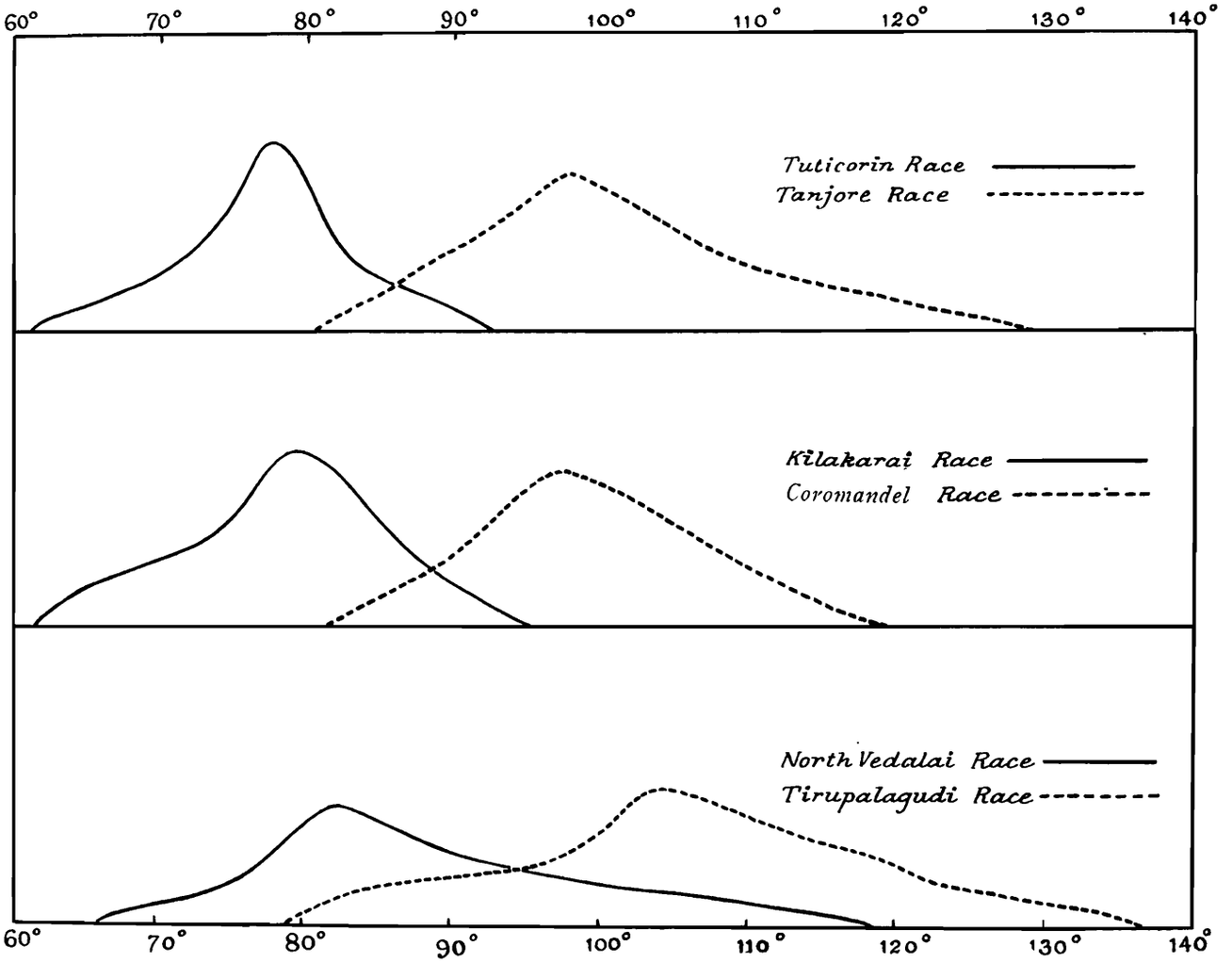


FIG. 1.—Diagram showing by smoothed curves the respective ranges of the apical angle in three local races of *T pirum acuta*, compared with three of *T pirum obtusa*.

this *obtusa* race marches with a corresponding border race of variety *acuta*, living south-eastwards, off Pillaimadam and North Vedalai, villages a few miles west of Pamban Pass. The commingling and overlapping of the two varieties that ensues is clearly seen upon reference to the apical angle chart given as text-fig. 1.

(*b*) *The Coromandel race* is found along the length of the Coromandel Coast, from Point Calimere to some distance northward of Madras. It is closely akin to the Tirupalagudi race, but is larger in average size, usually less stunted in apical development and in large specimens often exhibits a strong and vigorous development of

periostracum. Shells here grow to 7 inches in length by 4·5 inches in diameter, giving a ratio of length to breadth of 1·555, whereas I have seldom seen Tirupalagudi shells more than 5 × 3·15 inches—a ratio of 1·587. Typical shells are shown on Plate X, fig. 6, and Pl. XI, fig. 7.

A marked characteristic of many of these shells is a coating of some foreign organic substance upon the periostracum. This extraneous skin gives the shells a dark, blotchy, and dirty appearance. It appears to be due to the presence of a crusting hydroid allied to *Hydractinia*, but as I have not yet examined it in the live condition, I cannot say positively what it is.

This form also crosses to Ceylon, where, among the many islands around Jaffna, conditions are so diverse that merchants distinguish quite a number of trade varieties, separated by differences in weight, size, and shape (Pl. XI, fig. 8). These approximate more or less to races (*a*) and (*b*) but one may be described separately as worthy of remark. This is :—

(*c*) *The Nayinativu race.*—These shells, fished off the island of Nayinativu, are remarkable for the large size and heavy weight attained, ranging up to 6·9 × 4·25 inches (breadth in length, 1·62) with a weight of 2 lb. 2 oz. (Nos. 1 and 7 in fig. 8, Plate XI). The periostracum is thick, the first and the second or shoulder nodal row usually fairly well developed. This form approaches closely to short, stout, aged examples of var. *acuta* and goes far to prove the specific identity of the *obtusa* and *acuta* forms. I should also remark that similar approximation to the *acuta* form is also to be found amongst the largest sizes of the Coromandel race. Among these we get many shells closely similar to those from Nayinativu, with others having the spire greatly telescoped and distinctly top-shaped in form.

Taken generally the larger the shell grows, the less emphasized are the varietal differences, so that when the largest specimens of *obtusa* and *acuta* are ranged alongside one another, it is impossible to draw any definite line of demarcation between them.

On the other hand, the medium sizes, from 3 to $4\frac{1}{2}$ inches in length, show the greatest amount of divergence, and it is never impossible to separate an average group of *obtusa* from one of *acuta*, though selected individuals can usually be found to bridge the interval.

2. Variety **acuta**, var. nov.

Next in numerical and commercial importance to variety *obtusa* comes the elegant form which I distinguish under the above name. Its habitat marches at the head of the Gulf of Mannar with that of the type. It is to be noted particularly that it passes northward out of the Gulf at two points, the first at Pamban Pass beyond which it spreads fan-like east and west, and the second through the channels of Adam's Bridge, whence it passes west along the whole of the N. E. and N. coasts of Rameswaram Island and eastward to the north coast of Mannar Island in the vicinity of Talaimannar. To the south, on the Ceylon side, it spreads over the Pearl Banks in fair numbers as far south at least as Dutch Bay, and then in diminishing

numbers to the neighbourhood of Colombo; on the Indian side it reaches Manapad Point, somewhat south whereof it marches with the varieties *globosa* and *comorinensis*. It again appears on the shores of the Kathiawar Peninsula in considerable numbers.

This variety is found in greatest profusion on sandy beds off Tuticorin at depths generally from 7 to 10½ fathoms. It is also found in shallower water, but there it is not nearly so numerous as in deeper water and the shells are less vigorous and well grown. From these beds from 2 to 3½ lakhs of shells are annually fished, with less than a quarter of a lakh from all the rest of the Gulf of Mannar ground.

The typical var. *acuta* is comparatively narrow and moderately elongate with a well-balanced spiral; the final whorl in mature shells shows no exaggerated inflation as in the *obtusa* type and there is no marked angularity of shoulder, the position of which would be difficult to trace were it not for the presence of a well-marked row (the second) of periostracal nodes. On removal of the periostracum, vestigial inequalities are found, coinciding with the bold periostracal nodal eminences. The angular index of the spire ranges from 62° to 91½°, with a mean of 77·8° The breadth in the length averages 1·83 in medium-sized specimens of 6 inches length, reduced to 1·75 in the case of the largest and stoutest size (7½ × 4¼ in.). Apart from the Kathiawar habitat, there are three well-marked local races:—(*a*) Tuticorin, (*b*) Kilakarai, and (*c*) Rameswaram.

(*a*) *The Tuticorin race.*—Taking freedom of growth as shown by the well-balanced spiral of the whorls, neither unduly lax nor stunted into a squat coil, the massiveness of the shell, the clean, strong development of the periostracum, the rapidity of growth, the large size attained both individually and on the average, and the great abundance in which they are found in spite of an annual thinning of their numbers that has run to an average of fully 250,000 during the past twenty centuries, the shells fished off Tuticorin and for about 30 miles north and south thereof, appear to represent the most vigorous strain of all. It may be taken as the typical local race of the central type of *Turbinella pirum*.

In representative shells the apical angle is low, averaging 77·8°, while the range in variation in this character, lying between 62° and 91·5°, is notably restricted, bespeaking a compact race living under uniform conditions. Periostracal growth is thick, bright olivaceous yellow in tint and obviously vigorously grown; the surface is normally clean and remarkably free from crusting growths, cleaner and brighter than in any other race I have seen. The development of the rows of periostracal nodes and nodules is correspondingly strongly marked. Usually there are six rows of nodules present, consisting of two shoulder rows, and four body rows. The second or anterior shoulder row is the only one strongly developed. In a five-whorl shell, the number of nodules in this row are usually 3 to the inch; they vary somewhat and I have some shells whereon the nodes are specially large and coarse numbering only 1·75 to the inch. The first shoulder row is usually present and well defined, but the nodules are generally less than half the size of those in the second row. Of the body rows, trace of all four series is nearly always present, but occasionally one is suppressed entirely—usually the fourth. They are not merely raised lines or ridges as

seen normally in var. *obtusa*, but are made up usually of parallel rows of distinct nodular elevations, miniatures of the coarse knobbed nodes of the shoulder row. In many large shells they gradually decrease on the body whorl as they approach the lip. When the periostracum is removed the position of the periostracal nodes in the shoulder rows is indicated by very slight eminences or swellings, which are the vestigial remains of strong shoulder knobs such as are seen in the related genera *Fulgur* and *Cynodonta*. Beneath each of the body rows a continuous obscure narrow band-like ridge, very feebly developed, can usually be traced; only in large individuals with coarse and thick periostracum are there indications of minute vestigial knobs at intervals upon these ridges; in young specimens slight furrows often take the place of these raised lines (Pl. X, fig. 1).

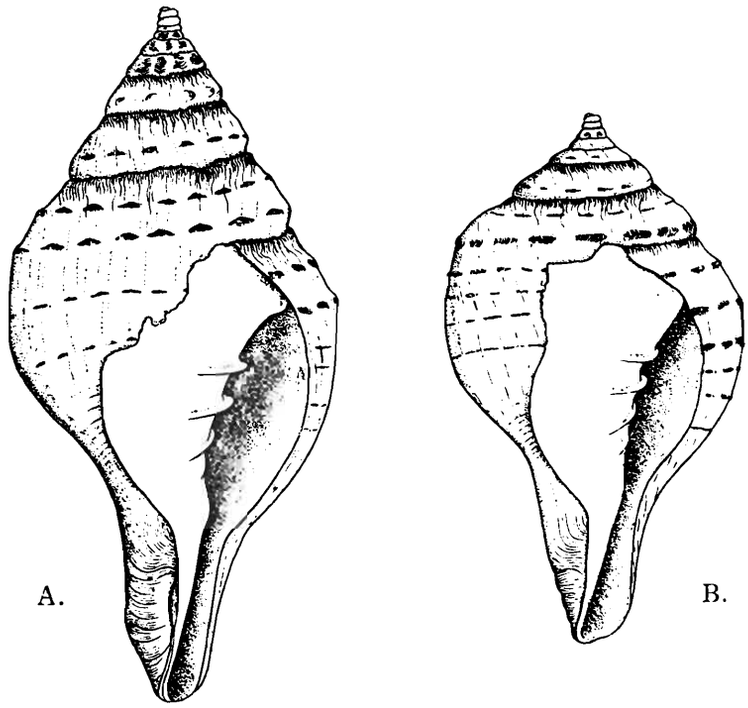


FIG. 2A.—Elongated example of *Turbinella pirum acuta* (Tuticorin race).
FIG. 2B.—Squat example of *T pirum acuta*, from same region.
Drawn from selected shells to show the extremes in form seen in this race.

In medium-sized shells, say under 6 inches in length, the ratio of axial length to the diameter of the body whorl ranges within narrow limits from 1·75 to 1·85. Hence the shell as compared with the two forms of *obtusa* is relatively narrow. In a few old shells of $7\frac{1}{2}$ in. in length the body whorl is considerably inflated, altering slightly the ratio of width to length, but in ordinary large individuals the more slender form is retained unaltered.

The colour of these shells is usually a pure porcellaneous white, more or less suffused with pale pink interiorly at the oral aperture Small shells sometimes show reddish spots, very variable in number and distribution.

The apex never shows wearing down due to abrasion such as is common in the Tirupalagudi race of *T pirum obtusa* (*typica*) and in var. *comorinensis* about to be

mentioned. This, together with the freedom from parasitic or symbiotic growths, shows that this race flourishes under very favourable conditions. Its principal and most favourable habitat is the wide stretches of sand interspersed between the rocky pearl banks off the Tinnevelly coast. Here tubicolous polychaets abound and these form the favourite food of the chank. Shells found upon or round the edges of the rocky banks in shallow water are less well-grown and often have symbiotic organisms upon them, chiefly corals, polyzoa, and algae. The columellar plicae in this race are moderate in size, very seldom markedly prominent and scarcely ever swollen or stout except in individuals living close to the littoral.

Sinistral forms are unknown on the Tuticorin banks so far as my information extends.

(*b*) *The Kilakarai race.*—This race inhabits the shallow water (2 to 4 fathoms) lying between the southern shore of Ramnad district from Valinukam Point to Pamban Pass, and the chain of coral islands lying parallel to this coast. In general outward appearance these shells resemble closely the Tuticorin race; the apical angle is much the same, ranging between 62° and 89°, with a mean of 77·9° (Plate X, fig. 2—upper 7 shells). The chief difference is that the resting phase appears to occur much more frequently and in these not only does the lip become thickened, but the columellar plicae frequently attain an abnormal stoutness and prominence, while some little distance from the lip a low blister-like swelling, approximately $\frac{3}{4}$ or 1 inch long by $\frac{1}{2}$ inch wide, is present. The extreme thickening of the sides of the oral aperture which takes place in the resting phase, constricts the opening considerably and distinguishes these shells markedly from the more regularly grown shells from Tuticorin, where a resting stage is comparatively infrequent till considerable age (size) be attained. The explanation appears to be that in the deep water beds off Tuticorin growth proceeds uninterruptedly the whole year round, owing to the protection afforded by a deep water habitat from any interruption in feeding or periodical shortage of food due to bad weather conditions; hence in the Tuticorin shells the resting phase seldom occurs until the individual is far advanced in life. On the Kilakarai coast, the shallow water habitat of the local race exposes them to much disturbance during the prevalence of the south-west monsoon; this entails difficult conditions of life and begets a condition where the forces of the mollusc are necessarily concentrated upon thickening its shell at the mouth. As a consequence a transverse section of a Kilakarai chank of this description shows an alternate series of thick and thin places in the walls of the whorls; this is a peculiarity which renders shells of this race of inferior value for bangle-making although the shell substance is hard and of good colour. These shells are largely employed as blowing conchs.

(*c*) *The Rameswaram race.*—The individuals of this race grow to a smaller average size than either races (*a*) and (*b*), but as this average size is admirably adapted to provide bangles of diameter exactly suited to the requirements of Bengali ladies, and as they suffer much less from the defect of irregular growth due to the frequent occurrence of rest phases, these shells are actually more highly prized by bangle-makers than the larger shells of the Kilakarai race. Shell bangle-makers also state that the

shell substance of the Rameswaram material is harder and takes a better polish than even the regularly grown handsome Tuticorin shells. This is due to the slow rate of growth characterizing these shells; the depth at which they live, $4\frac{1}{2}$ to $5\frac{1}{2}$ fathoms, and the large amount of mud in suspension in the water around them, renders their habitat less favourable for growth than the deeper water and clean sands, densely stocked with polychaets, found in the Tuticorin area (Pl. X, fig. 3).

The mean apical angle is 83·3°, as against an average of 77·8° for Tuticorin and 77·9° for Kilakarai. The shells are decidedly shorter in the spire than either of the other two races and as already stated they scarcely ever attain a large size; $5\frac{1}{2} \times 3$ inches diameter is nearly a maximum for those fished in the offshore beds lying in $4\frac{1}{2}$ to $5\frac{1}{2}$ fathoms. It is notable that shells from inshore beds, 2 to 3 fathoms, grow to a larger size than those from the deeper beds. Except in the case of shells found in the inshore beds on rocky ground, the columellar plicae are not usually strongly developed, in this agreeing with the Tuticorin shells. Towards the west these shells spread along the shore of the mainland as far as Pillaimadam, a place eight miles west of Pamban Pass, where they begin to mingle with the Tirupalagudi race

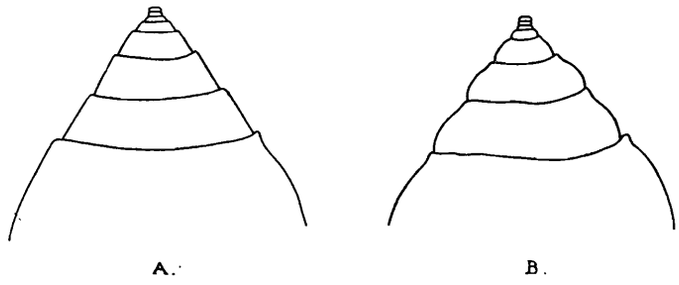


FIG. 3.—Spire of var. *comorinensis* (A) seen in profile for comparison with (B) profile of var. *acuta*, Tuticorin race.

of the type form, *T pirum obtusa*. On the east the former race continues as far as Talaimannar at the N.W. corner of Mannar Island. A few miles east of this they come into contact with the Ceylon form of the type variety. The Kathiawar race appears almost identical with the Rameswaram one and may be included with it. The approximation may be explained by the fact that the conditions of life in these two localities are much the same—the presence of much rocky bottom, and life in a sea muddy during much of the year.

3. Variety **comorinensis**, var. nov.

This variety is restricted to the extreme south of the Indian Peninsula; its range runs northward from Cape Comorin on both the east and the west coast for some 30 to 40 miles. It lives in shallow water exposed to heavy ground swells most of the year. The spire is rather short, with a mean index of 83° The outline in axial section is an elongated oval, the body whorl being elongated axially to a considerable extent (Pl. XI, fig. 9—upper 6 shells). It has the appearance of a stunted form of the Tuticorin shell and this was doubtless its origin. It has however developed

some special characteristics, one morphological, the other physical. The former lies in the peculiar way in which the uncovered portion of each whorl has a straight profile between the bounding sutures, whereas in var. *acuta* the profile of the exposed part of each whorl is more or less convex. The profile of the two forms may be represented diagrammatically as shown in text-fig. 3.

In *comorinensis* the edge of each succeeding whorl projects slightly beyond the one preceding, thus forming a slight collar; in *acuta* the edge does not so project. The physical difference of this form from others is its brittleness and comparative thinness. This renders it difficult to cut, as even a slight blow suffices to fracture it. The periostracum is inclined to be smooth, with weakly developed nodal lines. The first row is normally absent, as are also the body rows as a rule. The shoulder row alone is usually present, but with nodes very weakly developed. In some it is practically absent. In colour this variety is remarkable for its extreme whiteness, a point in its favour with bangle-makers, but much discounted by its fragility. It grows to a fair size, but is always light and comparatively thin.

Like some of the shells of var. *obtusa* fished in the shallows of the S.W corner of Palk Bay, a proportion of the present variety show the spire much worn down by attrition.

4. Variety **globosa**, var. nov.

The range of this variety coincides geographically with *comorinensis*, but it lives at a greater depth—*comorinensis* being essentially an inshore form. *Globosa* exhibits extreme inflation of the body whorl, an apex of abbreviated *acuta* form, a dense, coarse periostracum ornamented with more than usually prominent lines and nodal eminences, a heavy and thick shell, and a red tinge within the mouth. Its length compared with the diameter is markedly short, the diameter ranging between 1·5 to 1·7 in the length. Two typical forms measure respectively $6 \times 3\frac{1}{2}$ inches and $5 \times 3\frac{1}{4}$ inches. The apical angle ranges between 80° and 110°, with a mean of 92° The largest shells show very strong development of all the nodular rows, but whereas in the Turicorin shells of var. *acuta* the second shoulder row is normally conspicuously better defined than the others, in *globosa* the pre-eminence of this particular row tends to disappear and the tendency here is towards equality of the nodes in all the rows. There is usually scarcely any greater prominence of the shoulder nodes over those of the first row or those of the second upper body rows; of the latter there are usually four present (Pl. XI, fig. 9—the lower five shells).

5. Variety **fusus**, Sowerby.

This is confined to the Andaman Islands. In general form it differs from the continental varieties mainly in the shape of the shoulder portion of the whorls. In the Andaman individuals this is strongly marked in medium-sized individuals and distinctively angular; it is further emphasized by the great prominence of the shoulder row of periostracal nodes which are more protuberant than in any of the other

forms (Pl. XI, fig. 11). In fully adult specimens the angularity of the shoulder becomes considerably reduced and obscured and the difference between this form and *T acuta* is thereby much lessened (Pl. XI, fig. 10). The shell spiral is more lax than in any but a few of the most elongated Indian forms of *T pirum acuta*; its apical angle varies between 77° and 82° in the specimens I have examined. The second or anterior row of periostracal nodes is also strongly developed, though less than those of the first. Whether these two rows of periostracal nodes are equivalent to the first and second or to the second and third in *T pirum obtusa* and *T pirum acuta* I cannot decide. In both the latter the second row is usually the only one conspicuously developed, but in the majority of *T pirum obtusa* and a considerable proportion of *T pirum acuta*, the first row is either quite vestigial or actually suppressed; again in some specimens of *T pirum acuta* and *T pirum globosa*, the first row is quite strongly developed, only a little less prominent than the second. Besides these two prominent shoulder rows, there are three to four body ridges, low, moderately marked and continuous, not showing any sign of nodulation. The Andaman shell is pure white in colour and rather light in weight. The anterior canal is markedly elongated. In both shells examined the columellar plicae appear as three high, compressed ridges, with a fourth, anterior to the others, obscure and low as is usually the case in this species generally. In the fully mature individual the three large plicae are thick and truncate at the free edge; in the smaller, which has a thin and immature lip, thin and knife-edged.

Very young specimens of this variety show the shoulder angle much less emphatic than in the adult, and thus approach closely to the *acuta* form.

The suture between the last two whorls is characteristically deep, and this is a disadvantage commercially, as it renders bangles cut from these shells easily broken, the deep suture forming an emphatic plane of weakness.

CONCLUSIONS.

Consideration and comparison of the foregoing and other facts lead me to the conclusion that the immediate common ancestor of all these varieties was a shell of the *acuta* form, having a moderate apical index and well developed periostracal sculpture arranged in spiral lines of discontinuous prominences or nodes. The Rameswaram and Kathiawar race seem to me the nearest to this form though both these probably have the periostracal sculpture less well-marked than in the ancestral form. Varieties *fusus*, *globosa* and *comorinensis* are all closely related to this ancient *acuta* form, whereas the typical *obtusa* is the most divergent and most changed form. Var. *fusus* has undoubtedly been long isolated from the rest of the species and under this isolation has developed special features which, being continued, have now become fixed. It is therefore a moot point as to whether it is not entitled to specific rank. It certainly is on the line that divides variety from species, and is an excellent instance of a local assemblage of individuals evolving differences—causes we much perforce ignore—which, becoming permanent, are in course of producing a new species.

Globosa and *comorinensis* are younger varieties and have not become so stabilized as *fusus* owing to non-isolation from the main mass of the *acuta* species.

The peculiar geographical distribution of *obtusa* and *acuta* (including also *globosa* and *comorinensis* under the latter) is again most illuminative on the influence of differences in environment upon separated groups of an originally united race in producing and stabilizing variations from the original stock. The geographical distribution of these two principal varieties as shown in the sketch plan on Plate XII will make this clear.

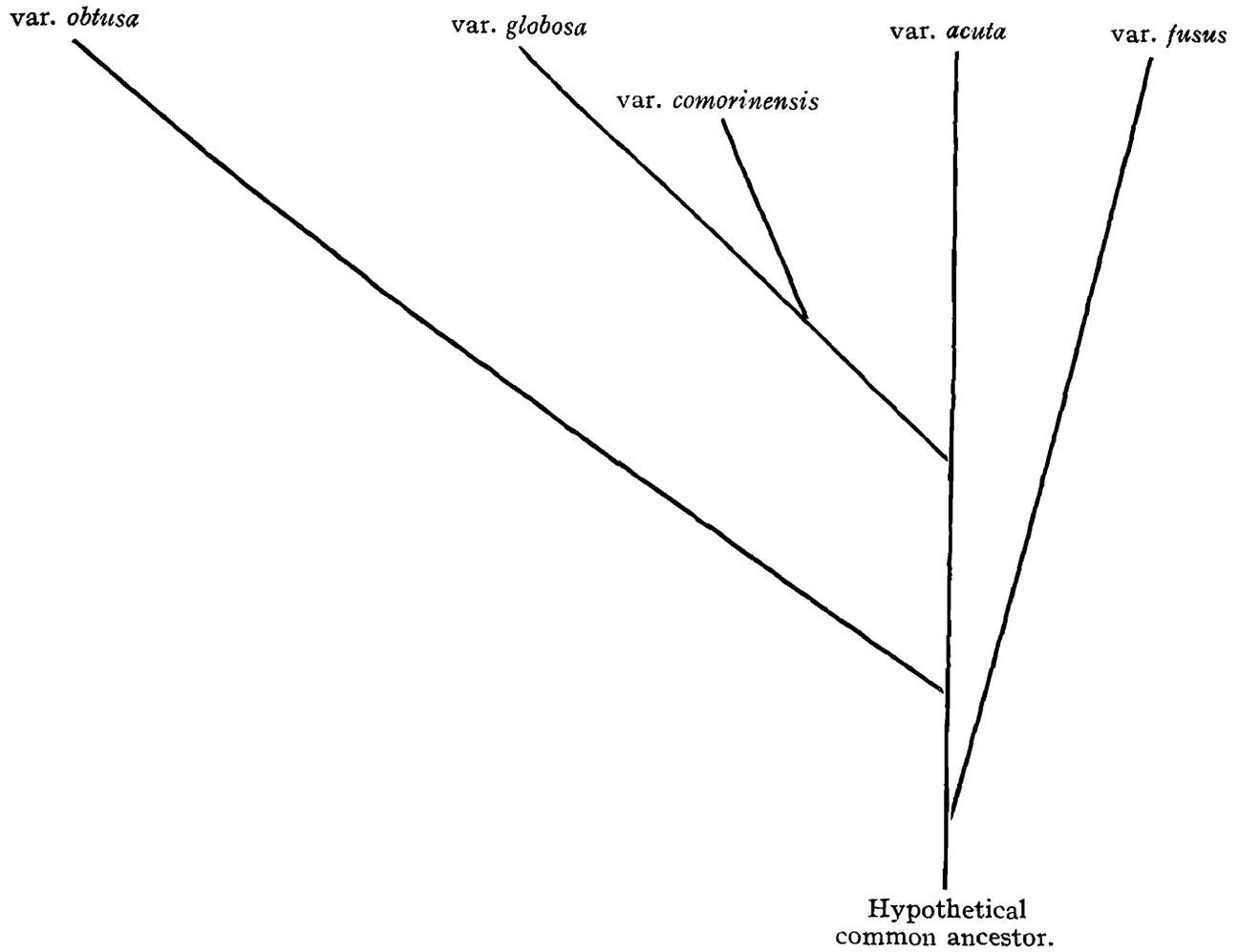
As is shown, the barrier formed by Rameswaram and Mannar Islands and Adam's Bridge very nearly forms the dividing line, *obtusa* being found entirely north of this line while *acuta* monopolizes the whole coastal waters of the Gulf of Mannar. But in addition the latter is seen to pass some distance beyond the barrier named and so to invade the territory of *obtusa*.

The hypothesis I present is this. We have incontestable evidence, chiefly furnished by the existing distribution of certain animals and plants in Ceylon and India, that the geological phase existing in the Gulf of Mannar and Palk Bay region antecedent to the present condition was that of a land barrier stretching continuously from India to Ceylon in the region now known as Adam's Bridge.

Further we have geological evidence that this phase was preceded by one where the level was even lower than it is now and when no land whatever existed between what is now the Gulf of Mannar and Palk Bay. During this phase of absolutely free communication from Cape Comorin to Madras, I think we have reason to believe that a single form of *Turbinella pirum* peopled the whole stretch of these coastal waters. The conditions would, so far as we can see, be little divergent anywhere along such a coastline and there would be no special localized conditions adequate to stimulate the evolution of well-marked varieties. Such uniform conditions disappeared immediately upon the formation of a continuous land barrier between India and Ceylon on the line Pamban—Rameswaram—Adam's Bridge—Mannar. Two isolated groups of the species would then be entailed; even connection by way of the east and south of Ceylon would be ineffective to keep up a connection between the isolated groups, because very deep water comes close to the land on parts of the E. and S.E. of Ceylon, and such deep water is as great a barrier to the dispersal of *Turbinella* as a land barrier, seeing that its larvae do not pass through a free-swimming stage. What we have seen happened in the case of the Andaman *Turbinella* happened again here. The shells in one or may be in both the localities cut off by the Indo-Ceylon barrier diverged from the common ancestor, and to-day we have two forms so strongly marked as to constitute distinct varieties. Had the land barrier not been broken down, these two varieties would assuredly have hardened into distinct species. With the breaking down of the barrier before this was effected, we get a mingling of the two main varieties and the possibility of the eventual suppression of one of them. Of this, I am, however, doubtful; I believe rather that the *obtusa* form has evolved characters fitting it to contend with certain conditions peculiar to Palk Bay and neighbourhood —of which muddy water is one—better than the *acuta* variety, which is more adapted

to deep water undisturbed by surface disturbances. If this be so, then the invasion of the Palk Bay region by *acuta*, by way of Pamban Pass and Adam's Bridge, will not prove successful; the two varieties will continue to crystallize their characteristics and will end, as they were undoubtedly doing up to the time the land barrier broke down, in becoming distinct species.

The phylogenetic relationship between the various varieties as indicated by morphological considerations supported by distributional and geological evidence may be represented as follows:—



The strongly marked periostracal layer in *acuta* may possibly be correlated to either or both of two reasons, the greater need to protect the shell in the Gulf of Mannar from the erosive effects of the coarse gritty sand characteristics of typical chank beds in that region or from the destructive burrowing of the tunnelling sponge *Cliona*. The thinness of the periostracum in the Coromandel race of *T pirum obtusa* may be correlated to a decrease in the activity of these noxious factors in the Coromandel Sea—a doubtful hypothesis—or it may be related to the accessory assistance rendered against such factors by the very frequent occurrence of a crusting hydroid (?) on the shells from this region; this adventitious coat certainly aids in the protection of the shell from corroding influences whenever it occurs. All these are however mere guesses in the present state of our knowledge of the subject.

The foregoing is an attempt to give a reasoned account of the varieties and races of one of the dominant molluscs of Indian seas and to offer a working hypothesis for the explanation of the origin of some of the varieties which exist; at the same time to define and demarcate the characteristics and limits of the chief varieties, a matter which till now has been in a distinctly chaotic condition.

APPENDIX.

NOTE ON THE GEOLOGICAL HISTORY OF *TURBINELLA* IN INDIA.

By E. VREDENBURG, *B.L., B.Sc., A.R.S.M., A.R.C.Sc., F.G.S., Superintendent, Geological Survey of India (communicated with the kind permission of the Director, Geological Survey of India).*

The genus *Turbinella* first appears in India in oligocene times, when it is represented by a handsome somewhat nodose species with a tall stepped spire, *Turbinella episoma* Michelotti, which was first described from the same geological horizon in northern Italy. As we trace the successors of this fossil into formations of later age, they do not show the slightest indication of any approach towards the " sankh " of India. The oligocene shell is at first succeeded, in miocene times, by *Turbinella affinis*, J de C. Sowerby, whose main distinction from *Turbinella episoma* consists in the slightly more effaced ornamentation, principally on the body-whorl. The difference in outward appearance is so slight that it would often be difficult to distinguish specimens relatively of both species but for the fact that the miocene form bears five columellar folds instead of three as in the oligocene fossil. During the miocene, *Turbinella affinis* was succeeded by two more forms, first, a hitherto undescribed species which may be named *T prœovoidea*, very closely related to *T affinis*, but in which the distinction from *T episoma* becomes much more clearly accentuated owing to a greater portion of the spire becoming nearly smooth, and lastly, in middle or upper-middle miocene times by a smooth form which corresponds so closely with *T. ovoidea* Kiener, of the coasts of Brazil, that it cannot be separated from it otherwise than as a variety. In *T prœovoidea*, the columella bears only four spiral folds, of which the most anterior one is apt, in certain specimens, to become indistinct. In the fossil variety of *T ovoidea*, three folds are especially well developed, a fourth anterior fold being always present, but often feeble. This is the only distinction from the living Brazilian shell in which, judging from the single specimen available in Calcutta, there is no indication of this fourth anterior fold. In their shape and ornamentation, the four Indian fossil forms constitute a connected series the evolution of which consists principally in the gradual obliteration of the sculpture, but the spire always retains its elongate outline which is much steeper even than in the most elongate varieties of the living Indian species.

The age of the Indian fossil specimens of *Turbinella ovoidea* is probably not older than "tortonian," that is middle miocene. The modern " sankh ' appears in a fossil condition in beds whose age must be at the limit of pliocene and uppermost miocene, along the Coromandel coast, at Karikal. The only specimen so far available from that formation is in a fragmentary condition and has not been figured, but is sufficiently preserved to have enabled Mr. Cossmann to refer it to one of the particular

varieties recognized by Mr. Hornell, the one corresponding with Gmelin's *Turbinella rapa*. According to Mr. Cossmann, "la spire un peu élevée, avec des nodosités transverses, très obsolètes, ressemble plutôt à celle de *T rapa*, qu'à la spire tout à fait déprimée de *T pirum*." (Faune pliocénique de Karikal, *Journ. Conch.*, Vol. L, 1902, p. 130). Mr. Hornell has observed specimens of the modern Indian species in pleistocene or sub-recent formations near Rameswaram and Tuticorin.

It has been above noticed that the oligocene species of India, *Turbinella episoma*, corresponds with a European fossil. The similarity between the oligocene faunas of India and of Europe is most remarkable, the percentage of European species in the case of the oligocene mollusca of north-western India, amounting to as much as 40 per cent, indicating that the seas of India and Europe constituted, at that time, portions of one zoological province. In the case of the lower miocene beds of India with *Turbinella affinis*, and in those with *T prœovoidea*, the faunistic correspondence with Europe is very feeble, and the points of resemblance between the faunas of both regions finally disappear completely when we reach the horizon of the beds with *Turbinella ovoidea*. The Indian Ocean and Mediterranean regions seem to have been as thoroughly disconnected in middle miocene times as they are at the present day. The presence of the Brazilian species becomes therefore all the more remarkable, and seems to indicate that, while direct communication was closed with the Mediterranean and eastern Atlantic, an easy interchange of species could nevertheless take place between the Indian Ocean and the regions now constituting the *western* Atlantic, or at least with the Caribbean Sea. It is worth noticing that *Turbinella ovoidea* occurs in a fossil condition in the Miocene of San Domingo, and it is highly interesting to recall, in this same connection, the observation made years ago by Duncan as to the extraordinary similarity between the lower miocene coral fauna of India and that of the West Indies. Naturally enough, Duncan was under the impression that the connection between India and the West Indies took place, in lower miocene times, across the Mediterranean and Atlantic. We find now, however, from a study of the mollusca, that the directness of the marine connection between India and Europe had been much impaired in lower miocene times, while in middle miocene times, when the communication was certainly completely cut off, we find a remarkable instance of specific identity with Brazil and the West Indies in the case of one of the commonest and most conspicuous mollusca. It should also be kept in mind that, in miocene times, the climatic conditions, throughout the Mediterranean region, had already become unfavourable to the growth of reef-building corals, and therefore, even had a free communication subsisted, the spread of these organisms through that region would no longer have been possible.

It may very well be therefore that, already in lower miocene times, we should look to the east of India for the free communication that allowed the intermingling of the coral faunas of India and of the West Indies.

In conclusion, the oligocene *Turbinella episoma* of India and Europe is not the ancestor of the Indian "sankh," or, if at all connected genealogically, the line of

descendance did not take place through its Indian miocene mutations. The genus did not survive into the miocene of Europe.[1] In the miocene of India, *Turbinella episoma* was succeeded by three related "mutations," *Turbinella affinis*, *Turbinella prœovoidea*, and finally *Turbinella ovoidea*, which latter spread eastwards as far as the West Indies. The latter species has survived to the present day along the coasts of Brazil, while, in India, at the end of the Miocene or beginning of the Pliocene, it was superseded by the totally different *Turbinella pirum*.

[1] As noticed by Bellardi (*Moll. terr. terz. Piem. e Lig.*, IV, p. 53) the attribution of a fragment of *Turbinella* to the Pliocene of Asti is probably due to an error of labelling.

EXPLANATION OF PLATE X.

Varieties of **Turbinella pirum** (Linn.).

Variety *acuta*.

FIG. 1.—Tuticorin race. Seven specimens showing range in form. × $\frac{1}{5}$.

,, 2.—Kilakarai and Ceylon Pearl Banks race. The seven upper figures are from Kalikarai, the three at bottom are from the Ceylon Pearl Banks off Marichchikadde and Dutch Bay. × $\frac{1}{5}$.

,, 3.—Rameswaram race. Six specimens. × $\frac{1}{5}$.

,, 4.—North Vedalai race. Eleven specimens. × $\frac{1}{5}$.

Variety *obtusa*.

FIG. 5.—Tirupalagudi race, showing range in form. Compare with the shells from North Vedalai (fig. 4) which march with this race of *obtusa*. × $\frac{1}{5}$.

,, 6.—Coromandel race. Specimens from off the coast of the Tanjore District. × $\frac{1}{5}$.

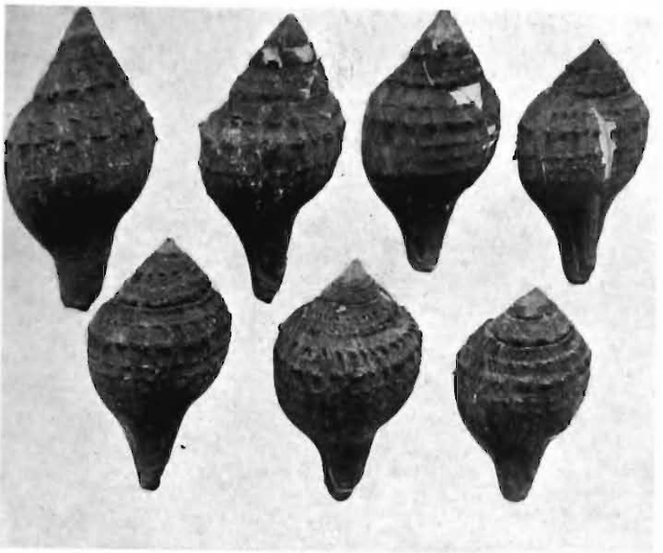


Fig. 1.

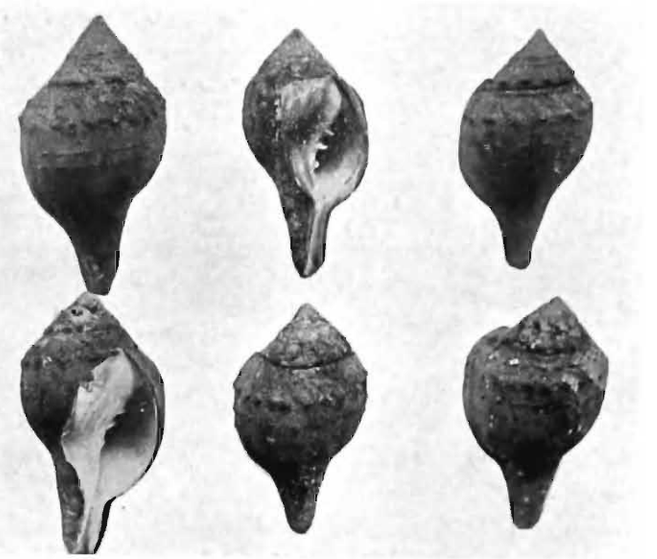


Fig. 3.

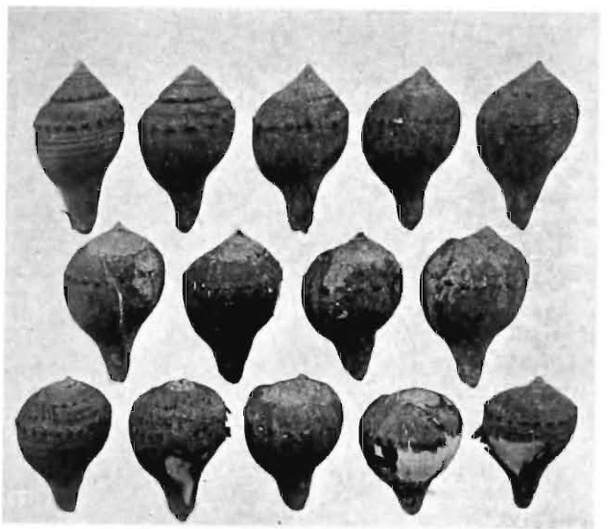


Fig. 5.

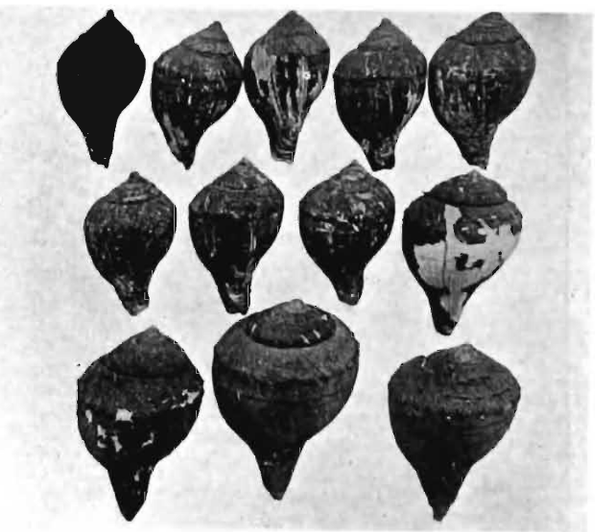


Fig. 6.

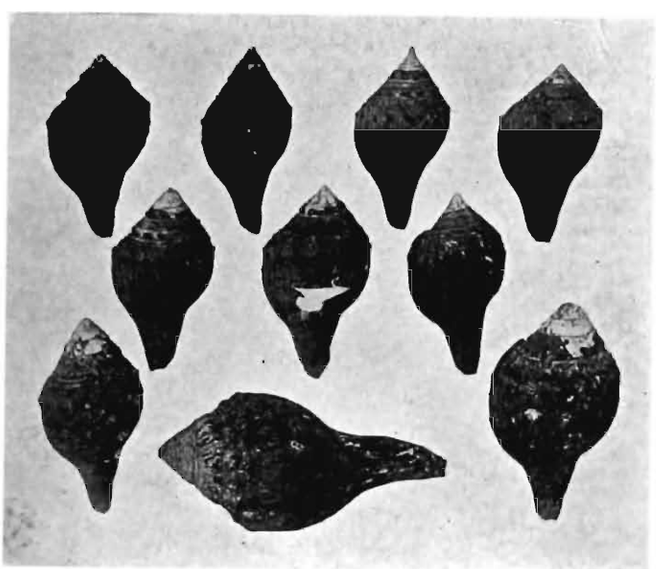


Fig. 2.

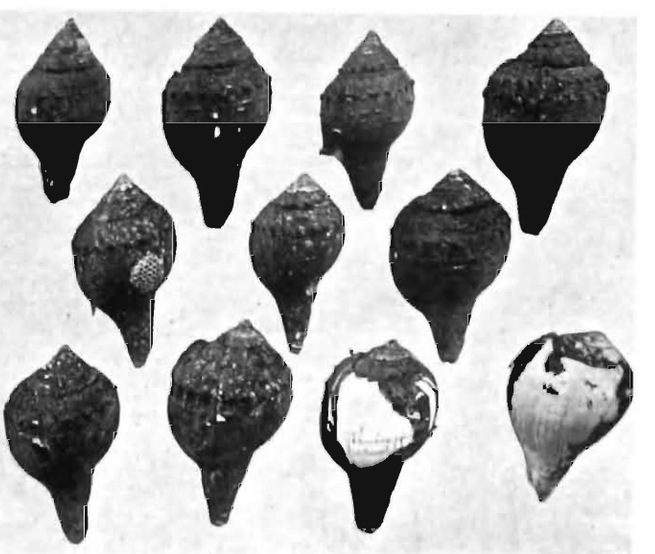


Fig. 4.

RACES OF THE CHANK SHELL.

Photo-engraved & printed at the Offices of the Survey of India, Calcutta, 1916.

EXPLANATION OF PLATE XI.

Varieties of **Turbinella pirum** (Linn.).

Variety *obtusa*.

FIG. 7.—Coromandel race. Specimens from Chingleput and South Arcot Districts. $\times \frac{1}{5}$.

,, 8.—Examples from the Jaffna Islands and north-east coast of Ceylon. These also may be classed as of the Coromandel race. $\times \frac{1}{5}$.

Varieties *comorinensis* and *globosa*.

FIG. 9.—Var. *comorinensis*, represented by the upper six (smaller) examples. $\times \frac{1}{5}$. Var. *globosa*, by the five larger ones in middle and bottom row. $\times \frac{1}{5}$.

Variety *fusus*, Sowerby.

FIG. 10.—A fully adult individual showing very strong plicae and stout oral lips. $\times \frac{8}{5}$.

,, 11.—Back view of a younger specimen to show periostracal sculpturing and angular shoulder, the latter more marked here than in fully adult individuals. $\times \frac{8}{5}$.

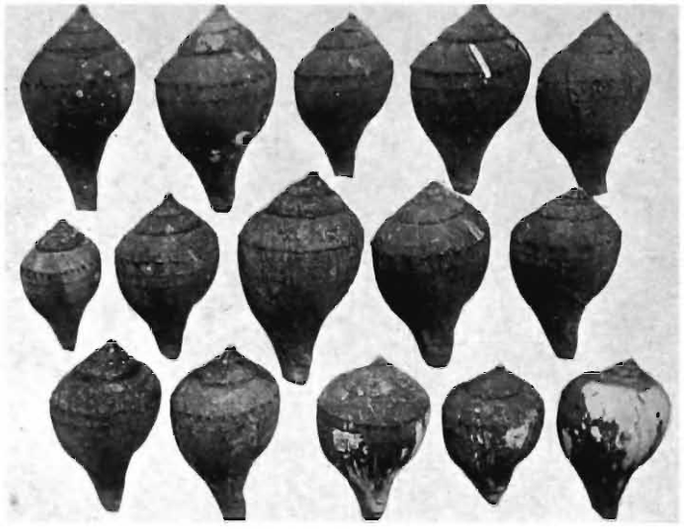


Fig. 7.

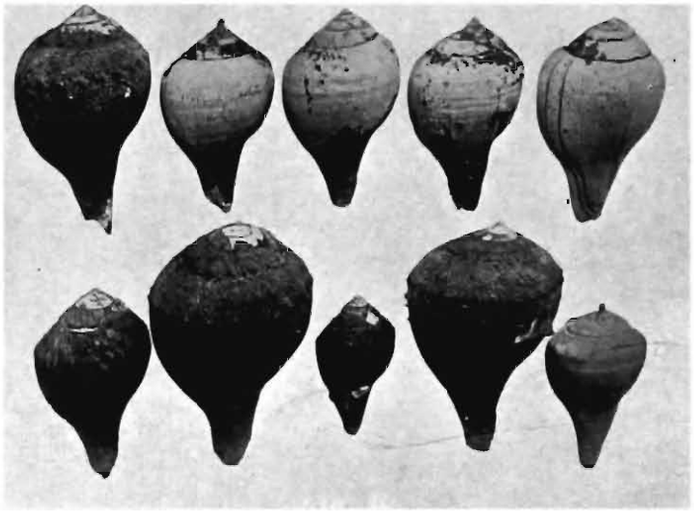


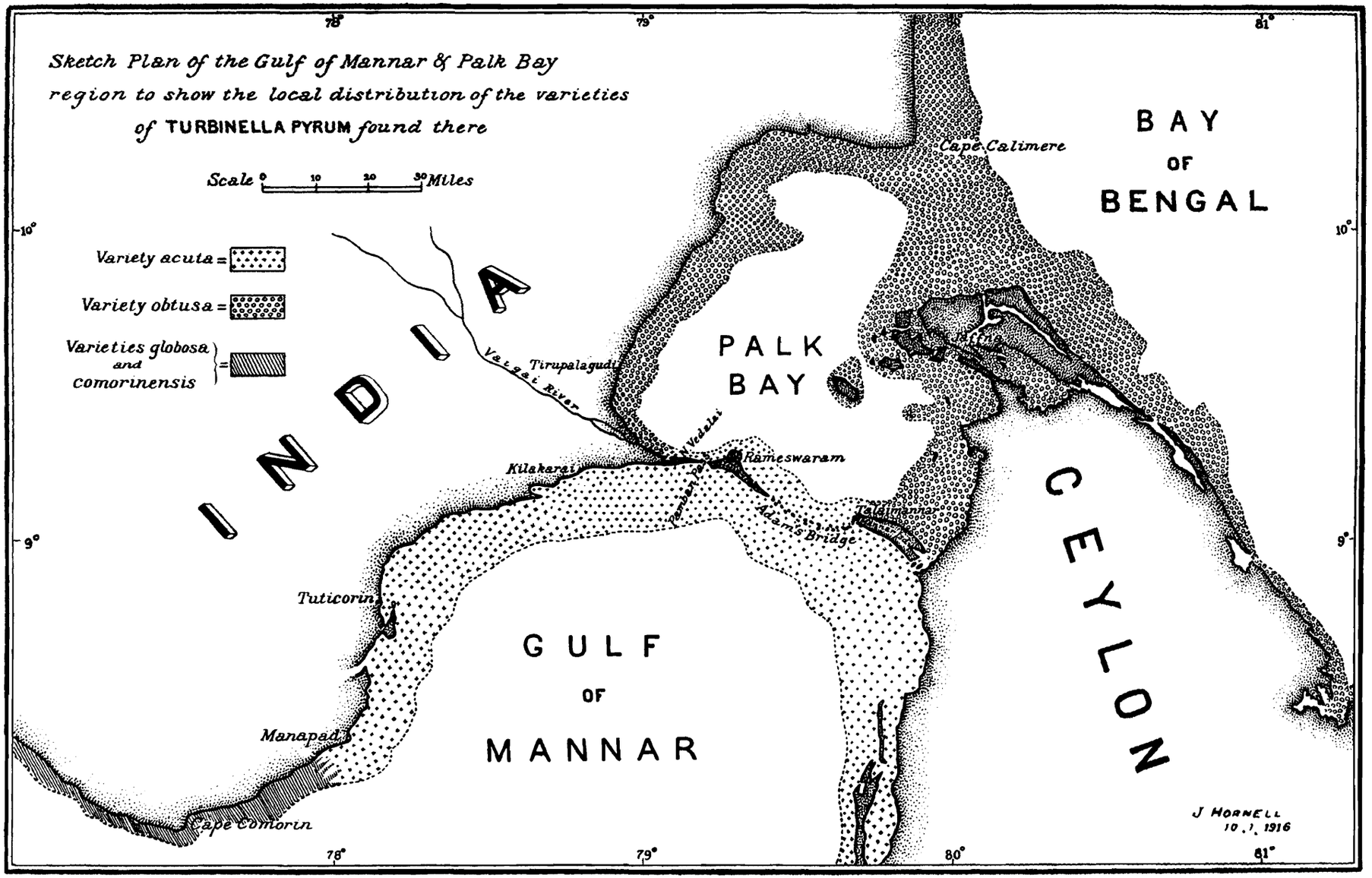
Fig. 8.

Fig. 10.

Fig. 9.

Fig. 11.

RACES OF THE CHANK SHELL.



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