

## X. A REVISION OF THE INDIAN SPECIES OF *MERETRIX*

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(Plates IV-VII.)

### PRELIMINARY.

The genus *Meretrix* was split off from *Cytherea* to accommodate a number of strongly marked species distinguished characteristically by the possession of an elongate and finely striate (or granulate) posterior lateral tooth—the *nympha* of older writers—in each valve. They frequent estuaries and none of those found on the coasts of Continental India live beyond the influence of land drainage; they have about an equal tolerance with the backwater oyster (*Ostrea virginiana*) for an occasional declension in the salinity of the water of their habitat. They can also endure considerable increase in salinity. This tolerance is of limited time-duration in both cases. Within my knowledge both of the common species can survive, at least for some days, a lowering of salinity to 1.010 S.G. and again can endure a concentration during the dry season that may reach as high as 1.030 S.G. How long such extremes can be borne we do not know, but it appears certain that vitality is lowered in either case and if the abnormal conditions be not modified within a certain period, widespread death supervenes in the beds. The optimum range of salinity favoured ranges from 1.025 to 1.027 S.G.

My attention was directed to this genus during an investigation of Indian mollusca of economic value; the examination of large numbers of these shells showed that great variation exists and when attempting to identify the various forms it became apparent that this liability to vary widely, both in form and colouration, has resulted in great taxonomic confusion and the undue multiplication of species. Examination of the Indian Museum collections, kindly placed at my disposal by Dr. Annandale, emphasized the need for a revision of Indian species and the consideration of what value and limits should be placed upon the many variations which obviously exist.

The material which has furnished the data for this revision was derived in the main from the shell collections in the Indian Museum, especially that obtained during the zoological survey of the Chilka Lake, and from extensive collections which I have

made specially for this enquiry at Sonapur (Ganjam district), Pulicat Lake, Palk Bay, Tuticorin, and the Tambraparni delta, and from the prolific backwaters of the Malabar district where these shells flourish in greatest abundance.

The chief conclusions at which I have arrived are that no multiplicity of species exists; that there are indeed only three really good species of *Meretrix* living in the waters of Continental India, namely *M. meretrix*, *M. attenuata*, and *M. casta*, and that while the two former exhibit great variation in colouration, they are remarkably stable in size and shape when mature, whereas the third species exhibits a marked susceptibility to the influence of environmental conditions, resulting in the production of numerous varieties and local races. The conditions in east coast backwaters being very different from those on the west coast, it results that the main varieties of *M. casta* are similarly divergent, those of the east coast being usually true to the type within narrow limits, whereas those of the west coast, even when living within the same estuary, may exhibit as many as three well-marked variations, connected by a host of intermediate forms, merging so insensibly into one another that it is practically impossible definitely to allocate many to one particular group.

Another notable fact brought out is the peculiar *discontinuity of distribution* shown by one of the species (*M. attenuata*) and by one variety of another (*M. casta* var. *ovum*). The former is known only from specimens from the Nicobar Islands and from Gwadar, on the Baluchistan coast; whereas in the case of *M. casta ovum*, we find it (a) widely distributed in the backwaters of the west coast of India, and (b) on the west coast of the Malay Peninsula and in Arakan. What may be the explanation in the case of *M. attenuata* we cannot at present say: possibly it is a decadent form once more widely distributed; if so, palaeontology may be able to assist. With regard to *M. casta ovum* the similarity of climatic and physical conditions between the west coasts of India and the Malay Peninsula probably supplies the reason. Between these two localities lies the east coast of India, an area differing greatly in climate, particularly in rainfall, from either of the other two. Hence I believe that the formation of the varietal form is due to the influence of divergent environment. That in two widely separated localities, having however similar physical features and climate, a parallelism of form should be maintained by the variety is significant, and seems to be an instance where the influence of similar environment in the production of identical varieties is indicated.

The following key to the Indian species and varieties summarises my conclusions:—

#### GENUS *MERETRIX*.

1. *Pallial sinus* very shallow and without an acutely projecting ventral horn.
  - A. Anterior cardinal tooth of left valve distinctly notched; size of shell large, usually attaining over 60 mm. in antero-posterior length.

	Species.	Characteristics.	Sections.
Valves trigono-sub-orbicular.	<i>Meretrix meretrix</i> (Linn.)	Valves with or without obscure and discontinuous broad rays; vulva obscure, margin indefinite.	1. Type.
		Valves without rays; vulva dark, very conspicuous, with clean-cut margin.	2. Var. <i>impudica</i> (Chemnitz).
		Colour uniform chestnut..	3. Var. <i>castanea</i> (Lamarck).
		Valves rayed with numerous continuous bands of dark colour, some broad, others narrow.	4. Var. <i>auro-ra</i> , var. nov.
		Valves rayed with two wide brown bands, often incomplete.	5. Var. <i>morphina</i> (Lamarck).
		Valves concentrically zoned either with solid or with zig-zag chevron-shaped dark bands.	6. Var. <i>zonaria</i> (Lamarck).

B. Anterior cardinal tooth in left valve entire; length of shell usually less than 50 mm.

Valves usually trigono-cordate; sometimes ovate to oblong.	<i>M. casta</i> (Chem.)	Shells large and ventricose, cordate; without colour bands, except rarely upon the umbones.	1. Type.
		Shell ovate to oblong with or without two obscure and often imperfect radial bands; hinges elongate; umbones nearly medium, curved straight inwards, usually eroded.	2. Var. <i>ovum</i> (Hanley).
		Shell corbiculiform; extremely thick; hinge short; teeth very stout. Sub-fossil only.	3. Var. <i>sarpaensis</i> (Preston).

H. Pallial sinus deep, almost semi-circular, with a ventral horn ending in an acute point.

Valves sub-cuneate.	<i>M. attenuata</i> , Dunker.	Shell concentrically zoned with chevron-shaped markings.	1. Type.
		Shell unicoloured, except occasionally on the umbones.	2. Var. <i>flava</i> , var. nov.

### 1. *Meretrix meretrix* (Linn.).

1758. *Venus meretrix*, Linn., *Syst. Nat.*, 10th ed., p. 686.  
 1782. " " *seu impudica*, Chemnitz, *Conch. Cab.*, Vol. VI, pl. 33.  
 1835. *Cytherea meretrix*, Lamarck, *Anim. sans. Vert.*, 2nd ed., Vol. VI, p. 300.  
 1835. " *impudica*, Lamarck, *ibid.*, p. 299.  
 " " *castanea*, Lamarck, *ibid.*, p. 299.  
 " " *zonaria*, Lamarck, *ibid.*, p. 299.  
 " " *graphica*, Lamarck, *ibid.*, p. 300.  
 " " *morphina*, Lamarck, *ibid.*, p. 300.  
 1864. " *graphica, castanea, zonaria, impudica, and morphina*, Reeve, *Conch. Icon.*, XIV, *Cytherea*, figs. 1, 6, 9, 10 and 12.  
 1869. *Meretrix meretrix*, Römer, *Monographie der Molluskengattung Venus*, Linne, Band I, Sub-genus *Cytherea*, p. 27, pl. viii, all figs.  
 1915. " *casta*, Preston (in part), *Rec. Ind. Mus.*, Vol. XI, p. 300.  
 " " *ovum*, Preston, *ibid.*, p. 300.  
 1916. " *meretrix*, Annandale and Kemp, *Mem. Ind. Mus.* Vol. V, p. 351.  
 1916. " *ovum*, Annandale and Kemp, *ibid.*, p. 352.

This species is easily distinguished from *M casta* and its varieties by the greater superficial dimensions of its valves when fully grown, by its less ventricose and more compressed form, particularly marked in young specimens, and by the delicacy and comparative weakness of the hinge region. Apart from these differences, an unfailling distinction is found in the form of the anterior cardinal tooth of the left valve. In *M meretrix* this tooth has the summit distinctly notched, recalling in some degree the bifid form characteristic of *Tapes*; in *M casta* it is invariably entire. Apart from colouration, this species is remarkably stable in form and general proportions; how it could be confounded with *M. casta* and *M. casta satparaënsis* by Preston is difficult to understand. That it was, is shown by reference to the specimens identified by this authority now in the Calcutta Museum and by reference to the article cited above, where Preston gives the size of one individual as  $73 \times 67$  mm., a size never attained by *M. casta*, whereas these are the normal adult dimensions in the case of *M. meretrix*.

*Outline and size of the valves.* The valves are sub-trigonal and vary from a broadly cordate to a sub-orbicular form, the anterior angle being always well-rounded while the posterior is distinctly but bluntly angular. It is exceedingly difficult to describe in words the form of the shell in the different species and varieties of this genus sufficiently clearly to convey an adequate comprehension of the differences between them. Hence reference must be made to the figures which accompany this note. The dimensions of the shell attained by *M meretrix* when fully grown are remarkably constant; the largest noted (Tuticorin) is  $77 \times 65 \times 42\frac{1}{2}$  mm. thick; others from the same locality measure  $77 \times 64 \times 41$  mm. thick and  $74 \times 65 \times 40$  mm., while three from the outer channel of the Chilka Lake measured respectively  $73 \times 67$  mm. (M. 9582/2),  $68 \times 60\frac{1}{2} \times 42$  mm. (M. 9762/2), and  $65 \times 58 \times 40\frac{1}{2}$  mm. (M. 9763/2). The average of size at full maturity for the valves appears to range from 58 to 60 mm. in depth by 65 to 70 mm. in length. Shells of these dimensions are those most commonly found when collecting; the animal at this size has reached its limit of growth and this again coincides closely with the age-limit of its life. Having spawned after attaining this size, its vitality appears to ebb and I have noted the death of large numbers at Tuticorin after the September spawning; during October the sand flats in the lagoon are thickly dotted with dead and gaping shells of full-grown size. It is noteworthy that small and medium-sized dead shells are conspicuous by their absence, although living individuals are present in their usual numerical proportion beneath the surface of the sands. The average ratios between length, depth and thickness as deduced from the average of 20 large and medium-sized individuals from 8 localities is 100 to 85.56 (depth) and 57.89 (thickness).

*Colour varieties.* Of the various colour varieties, the three principal (apart from the type), *viz. impudica, castanea* and *aurora*, are all of very definite and stable colouration, and so well defined

in their respective markings that unless one has opportunity to examine a large number of individuals from one locality where the various colour forms are present, it can readily be understood how Lamarck and others came to make separate species of simple colour varieties. As long ago as 1835, Deshayes and Milne-Edwards pointed out that Lamarck was in error in doing so in regard to what are merely colour varieties of the large species of *Meretrix* which Linnaeus termed *Venus meretrix*. They pointed out that in any extensive collection of the large species of *Meretrix* gradations can be readily traced between Lamarck's species. To quote their own words:—

“ On nous demandera sans doute sur quoi nous nous fondons pour faire de tels changements, et nous répondrons sur l'observation: en examinant en effet un grand nombre d'individus parmi lesquels se trouvent toutes ces espèces de Lamarck, nous avons trouvé à la charnière et l'impression parallèle des caractères spécifiques constants, et de plus nous avons vu de nombreux passages entre les variétés. Dans quelques individus, nous avons même observé sur une seule coquille les dispositions de couleurs d'après lesquelles Lamarck avait fait deux espèces.”

This conclusion is undoubtedly correct for even in the case of var. *impudica*, where in the vast majority of cases there is no difficulty in separating at a glance this variety from the type, there are occasional individuals where an intermingling of the colour designs proper to *impudica* and the type bridges the gap; others show hybrid markings connecting with varieties *morphina* and *zonaria*.

The least emphatic of the colour varieties is that which I term *morphina*. Occasionally a shell well-marked with two distinct rays is found, but the variety has none of the stability of *impudica* and *aurora* and gradations to the type and to the var. *impudica* are so frequently met with that it scarcely deserves to be treated separately; true *zonaria* is seldom seen in specimens from any Indian locality, but among immature shells of var. *impudica*, individuals are often to be found with well-zoned bands coinciding with Lamarck's description and the figures by Römer and by Reeve of *Cytherea zonaria*; Lamarck's var. *graphica* is also very rare in India and may, I consider, be fused with *M. zonaria*.

*Habitat and distribution.* *M. meretrix* has a restricted and most definite habitat. It is purely an estuarine and backwater species, never found to my knowledge in the open sea. Its home is in the sands adjacent to the main channels leading from backwaters to the sea. It lies buried in a shallow burrow or pit with only the extreme posterior point projecting above the surface when the tide is in, covering these sand flats. At low tide when the sands are uncovered it withdraws entirely below the surface and is then most difficult to locate.

When young this *Meretrix* is extremely active, preferring to live in estuarine sands swept by rapid currents. The foot is large and very muscular; by a variety of movements it is able to make its way

rapidly over or through the sand and so is able to recover its position and foothold whenever dislodged from its temporary burrow. Its favourite mode of progression is to protrude the foot considerably, bend it into a deep curve with the point pressed against the sand close to the shell, then by suddenly straightening the foot the shell is jerked in the opposite direction. By a variation of the movement it can also throw its shell over upon the opposite valve.

With increase of size, individuals gradually move to more sheltered sands and become sluggish and sedentary in their habits.

Spawning occurs about the beginning of September at Tuticorin; probably also about May.

It is common in the outer channel of the Chilka Lake; in the Cuddalore estuary (S. Arcot), at the entrance to the Silavathurai Lagoon, Tuticorin, in the delta of the Tambraparni, and near the mouth of the river at Tellicherry in Malabar. I have also collected it in the sub-fossil condition from shell-pits in the Surla swamps of the Sonapur backwater, Ganjam, and from the sub-fossil shell strata at Korampalam, Tuticorin; there is little doubt that it lives at the mouths of the majority of estuaries and backwaters in Southern India. The type form and the variety *impudica*, both pale in colouring, are about equally common at Chilka and Tuticorin, *i.e.* on the East Coast. In the Tellicherry river the dark-coloured heavy-rayed variety *aurora* is the only form seen.

In addition to the foregoing, numerous examples of this shell from other localities are present in the Indian Museum collections submitted to me for identification; the particulars are as follows:—

Tavoy Coast, Burma (M. 398). 11 shells, comprising 6 of the type, 1 of var. *impudica*, 1 var. *castanea*, 2 var. *zonaria* and 1 var. *morphina*.

Malacca (M. 10487/2). All of type form.

Arakan (M. 10851/2 and M. 10855/2). 5 of var. *impudica*, and 1 small one of type form.

False Point, Orissa (M. 10845/2). 2 small specimens.

Trincomalie, Ceylon (M. 10842/2). 5 of var. *castanea*, 1 of var. *impudica*.

(?) Andamans (M. 10858/2). One fine example of var. *impudica*. There appears to be some doubt as to the origin of this shell as this is queried upon the label.

Bombay (M. 10836/2). 5 shells comprising 3 of var. *impudica*, 1 of var. *castanea*, and 1 of the type form.

#### (a) Type.

(Plate V, fig. 13.)

1835. *Cytherea mevetrix*, Lamarck, *Anim. sans. Vert.*, 2nd ed., Vol. VI, p. 300.

By removal of all forms distinctively or peculiarly coloured, we get a numerous residue which may be considered as representing the generalised central form, the type assemblage of the species. When the periostracum is present, the ground colour varies usually from a pale to a dark grey; frequently as at Chilka Lake it is of a pale straw colour, at others a light rufous yellow. This

general colour is modified considerably in the majority of individuals by raying, zoning and staining upon the shell substance in the umbonar region, and by a more or less extensive and well-defined dark area on the upper posterior portion of the shell, where it often forms a lanceolate blotch termed the vulva by Lamarck. The colour of this area varies from a dark cloudy olivaceous brown to a livid purplish brown, exhibiting much variation in tint and in intensity. In all cases in the type the edges of this patch are indefinite, merging insensibly into the adjacent ground colour, which is usually rather darker than the remainder of the shell.

In many individuals the umbones are minutely spotted with pale brown, seen only with the aid of a hand lens. There may also be concurrently a couple of narrow divergent and usually discontinuous brownish rays. These are sometimes well defined and conspicuous and may be composed of short straight bars or of minute chevrons. This umbonar raying seldom extends further than half an inch from the hinge; beyond that distance the raying either disappears, or in colour variety *morphina* is continued as two dull and usually diffuse broad bands, having the appearance of a stain within the substance of the shell, rather than surface markings as in the case of the colouring upon the umbones. These distal bands are most variable; sometimes they form two broad fairly well-defined bands reaching to the ventral margin; more frequently they are discontinuous and form blotches having only a vague radial arrangement; often they are entirely wanting.

In yet another series of colour variations there is distinct concentric zoning of the umbonar region. This may or may not occur in individuals with spotted and rayed umbones; there is infinite variety in these combinations. The zones are usually formed by the alternation of very narrow chestnut or livid tinted zones with grey or yellowish ones.

Römer was of opinion that Lamarck's *C. impudica*, as represented by the form shown in Römer's figs. 1-1c, pl. viii, of a pale coloured shell with a dark vulva *having sharply defined margin* and without decorated umbones, should be regarded as the true colour type of Linnaeus' *Venus meretrix*. He considered Lamarck's *C. meretrix* to be a closely connected variation of the type. Taking Römer's pale type and Reeve's *C. impudica* (*loc. cit.* fig. 10, pl. iii) with similar vulva and bold chevron-shaped umbonar markings as representing two colour designs common to the form, Römer claims these to connote the central or true type. I am convinced after examining several hundred specimens that this view is incorrect. By far the greater number, usually slightly over 50 per cent. (*cf.* next paragraph), are of quite different colour scheme, characterized by a pale indefinite tint with dark vulva *fading gradually at its margin into the ground colour* and with the umbones generally minutely dotted with brownish yellow; the variety coloured as in Reeve's figure of *C. impudica* is much less numerous, averaging not more than 25 per cent. of the total number. Hence it is more reasonable and convenient to constitute the

former group as the type and the latter as a variety, especially as there is nothing in Lamarck's description to contradict this. Further, Römer's figs. 1 to 1*b*, pl. viii are not even typical of the *impudica* variety in India, although they agree exactly with Lamarck's description. They evidently represent a pale and comparatively rare variation of the true *impudica* of which Reeve's figure, though coarse, is a better rendering.

The type form is particularly plentiful in the Tuticorin lagoon. Out of 117 adult individuals examined therefrom, 65 belong to this group, 22 to the closely related var. *morphina*, while 29 belong to variety *impudica*, one only to variety *castanea* and none to var. *aurora*; while of 32 large specimens from the Tambraparni delta, exactly half belonged to the type form with 8 to *morphina* and 8 to *impudica*. Among 17 from the Chilka Lake, the majority (9) were of the *impudica* variety, and only 4 out of the whole lot were of the type form. The four remaining Chilka individuals consisted of two var. *morphina*, one most typical and very beautifully rayed, the other obscurely rayed, and of two bridging the differences between varieties *impudica* and *morphina*; both showed the typical sharply defined *impudica* vulva, together with two well-marked radial bands of the *morphina* type. A notable feature among the Chilka and Tuticorin shells is the frequency with which the *impudica* variety shows conspicuous chevron-shaped markings, boldly painted on the umbonal region as shown in plate vii, fig. 39. Also from Arakan, Tavoy (Burma), Malacca, and Bombay.

Of the shells from Tellicherry and Trincomalie, none belonged to the type, all being variety *aurora* in the former case and chiefly to *castanea* in the latter.

#### (b) Variety *impudica* (Chemnitz).

(Plate V, figs. 14-18; plate VII, figs. 39 and 40.)

1782. *Venus meretrix* seu *impudica*, Chemnitz, *Conch. Cab.*, Vol. VI, pl. 33.  
 1835. *Cytherea impudica*, Lamarck, *Anim. sans. Vert.*, 2nd ed., Vol. VI, p. 299.  
 1861. " " Reeve, *Conch. Icon.*, XIV, *Cytherea*, pl. iii, fig. 10.  
 1915. *Meretrix ovum*, Preston, *Rec. Ind. Mus.*, Vol. XI, p. 300.  
 1916. *Meretrix ovum*, Annandale and Kemp, *Mem. Ind. Mus.*, Vol. V, p. 350.

This is the variety by far the most abundant on the coasts of India. The periostracum is normally a pale grey colour, rarely pale cream or yellow; when removed, the shell appears porcelain white, except in the postero-dorsal region where the dark coloured lanceolate area, the vulva, occurs. This varies from very deep blackish brown to a more frequent bluish grey of varying intensity. Although albino individuals devoid of vulva and of umbonal marks are sometimes met with in the Chilka Lake, normally the vulva is well marked *with sharply defined margin*. The great majority of individuals show considerable decoration of the umbones; this most frequently takes the form of conspicuous chevron-shaped markings either arranged in zonal manner or limited

to two short radial lines. These markings are much more conspicuous in *impudica* than are the umbonal dots and rayed marks of the type. Fig. 39 shows a well-marked example of the zone pattern, while in fig. 18 we have a rare combination of the *impudica* colour scheme of clearly defined vulva with the discontinuous rayed blotching seen frequently in var. *morphina*. Young individuals of 15 to 18 mm. in length are frequently much decorated with dark chevron markings, such as are depicted in figs. 14 to 17, pl. V. Such conspicuously marked individuals are common in the outer channel of the Chilka Lake. They were incorrectly identified as *M. ovum* by Preston.

*Localities.*—Common in the outer channel, Chilka Lake (*Annandale* and *Kemp*); in the sands immediately within the mouth of Silavathurai lagoon, Tuticorin, and in the delta of the Tambraparni, Tinnevely district (*J. H.*). A sub-fossil valve from Surla shell-pits, Ganjam. Also Tavoy (Burma), Arakan, Trincomalie (Ceylon), Bombay and ? Andaman Islands; all in the Indian Museum collection.

*Dimensions.*—The largest Chilka specimen measures  $65 \times 57\frac{1}{4} \times 40$  mm., while the largest of the Tuticorin ones is  $74 \times 64 \times 40$  mm.

(c) Variety *castanea* (Lamarck).

(Plate IV, fig. 12.)

1835. *Cytherea castanea*, Lamarck, *Anim. sans. Vert.*, 2nd ed., Vol. VI, p. 299.  
 1906. *Meretrix castanea*, Standen and Leicester in *Ceylon Pearl Oyster Fisheries*, Pt. V, p. 293.

Distinguished from all other varieties by its uniform brown or chestnut colouration; the vulva is not sharply demarcated, but the colouring in this region is usually darker than over the rest of the shell. There are no definite umbonal markings to be made out. On some shells an obscure and irregular zoning can be observed due to some of the growth zones being darker in tint than adjoining ones.

This is a well-marked variety seemingly of rare occurrence as I have found a single specimen only at Tuticorin and another in the Tambraparni delta, while out of the whole Indian Museum collection of *Meretrix*, nine only are of this colouration. Of these latter two (No. 4788) are labelled Indian Ocean, one is included in a collection of 11 shells (M. 398) from the Tavoy Coast, Burma, another (M. 10836/2) is from Bombay, while so many as five (M. 10842/2) are from Trincomalie, Ceylon. Standen and Leicester also report this variety from Trincomalie and Tampalakam, so it would appear to be relatively more abundant there than in any other locality. Reeve records it from China and the Philippine Islands.

*Dimensions.*—The largest individual seen (Ind. Mus. coll. No. 4788) measures  $68 \times 61 \times 42\frac{1}{2}$  mm. Five other large specimens measure respectively :—

	<i>Millimetres.</i>	<i>Respective Ratios.</i>
Trincomalie (M. 10842/2)	$\left\{ \begin{array}{l} 64 \times 55 \times 39 \\ 60 \times 53\frac{1}{2} \times 36\frac{1}{2} \end{array} \right.$	=100 to 85.94 to 60.94
Tavoy (M. 398)		=100 to 89.17 to 60.83
Bombay (M. 10836/2)	$\left\{ \begin{array}{l} 59\frac{1}{2} \times 50\frac{1}{2} \times 33 \\ 49 \times 42\frac{1}{2} \times 31\frac{1}{2} \end{array} \right.$	=100 to 84.87 to 55.46
No. 4788 ( <i>ut sup.</i> )		=100 to 86.73 to 63.78
		=100 to 85.52 to 56.56
		=100 to 89.71 to 62.50
	Average of ratios	=100 to 86.99 to 60.01

(d) Variety *aurora*, var. nov.

(Plate IV, figs. 9-11.)

This is a strongly marked colour variety which rises to the importance of a local race in Malabar in the estuaries of the Anjarkandi and Tellicherry rivers, Tellicherry. The colouring consists of continuous bands of varying width and number radiating from the umbo to the ventral margin. The primitive number of these radial bands appears to have been two, as this agrees with the number of vestigial bands seen in other varieties of *M. meretrix* as well as in certain varieties of *M. casta*; also because the banding system in many shells can be resolved into two band groups representing the two original bands. In such (figs. 9 & 10) the two original bands become very wide as they approach the ventral margin, and in addition a number of narrow non-widening rays are intercalated in the space between the two great rays. From this well-defined pattern we pass to shells where the whole surface is covered with closely-set rays. The colour of the latter is dark purplish brown when the periostracum is present, otherwise it is duller and more livid in tint. Internally these shells are yellowish beyond the pallial line; within this they have a pale pinkish tinge when quite fresh. Like so many other coloured shells, all the species of *Meretrix* fade considerably with time and exposure to light and this must be allowed for when examining shells from an old collection. Sometimes young individuals of var. *morphina* show a suffused pinkish tinge in the substance of the shell and it is probably from such a stock that *aurora* has been derived.

Occasionally a broadly-rayed large specimen of *M. casta* var. *ovum* shows raying and a general superficial resemblance to *aurora*, but the absence of a pink colour within, the acuter posterior angle and the absence of a bifid anterior cardinal tooth in the left valve are clearly-cut distinguishing differences.

The largest of the Tellicherry specimens is 55 mm. long by 49 mm. deep; the majority average  $44 \times 39 \times 26\frac{1}{2}$  mm., equivalent to the ratios of 100 to 88.64 to 60.23.

(e) Variety *zonaria* (Lamarck).

1835. *Cytherea zonaria*, Lamarck, *Anim. sans. Vert.*, 2nd ed., Vol. VI, p. 299.  
 " " *graphica*, Lamarck, *ibid.*, p. 300.  
 1864. " " " Reeve, *Conch. Icon.*, XIV, *Cytherea*, pl. i, fig. 1.

1864. *Cytherea zonaria*, Reeve, *ibid.*, pl. iii, figs. 9a and b.  
 1869. „ *meretrix* var. *zonaria*, Römer, *Monog. der Molluskengatt. Venus*, Band I, sub-gen. *Cytherea*, pl. viii, fig. 1e. (*non* Römer's *graphica*, which I consider to pertain to the type form).

Lamarck's *zonaria* and *graphica* intergrade to such an extent that it is often impossible to differentiate between them, hence as they are at best merely colour varieties they are better merged into a single group. The main characteristic is that the more conspicuous markings form a zonal pattern characteristically of concentric rows of zig-zag lines, or more rarely, and this only in immature individuals, of concentric brown bands often broken and incomplete. In all cases these markings tend to be suppressed with increasing age.

(f) Variety **morphina** (Lamarck).

(Plate IV, figs. 5-8.)

1835. *Cytherea morphina*, Lamarck (in part), *Anim. sans. Vert.*, 2nd ed., Vol. VI, p. 300.  
 1864. ? *Cytherea morphina*, Reeve, *Conch. Icon.*, XIV *Cytherea*, pl. iv, fig. 12.  
 1869. *Meretrix meretrix* var. *morphina*, Römer, *Monog. der Molluskengatt. Venus*, Band I, pl. viii, fig. 1g.

This is, I consider, a variety so indefinite in its markings that it might well be suppressed, and included under the type form. However, as its main character, which I consider to be the presence of two narrow divergent dark radial bands extending from the umbo to the ventral edge, is sometimes distinctly shown, I retain it for convenience to include all shells marked more or less clearly with two radial bands of dark colour. As the posterior margin (vulva) of the shell is sometimes darkly tinted, the shell then appears to be marked in a triradiate manner, which explains why Lamarck put *Venus triradiata*, Gmelin, as probably synonymous. Usually the ground colour of this shell when denuded of its periostracum is either pale or dark grey, but occasionally the shell is tinted yellowish or orange pink and such shells agree fairly well with Reeve's description: "ash white and orange flesh colour radiately tinged with violet, especially on the posterior side." Strangely enough Römer considered Reeve's *morphina* to belong to var. *graphica* which in the absence of zig-zag markings would cause confusion.

2. **Meretrix attenuata**, Dunker.

1858. *Meretrix attenuata*, Dunker, *Beschreibung und Abbildung neuer oder wenig gekannter Meeres-Conchylien*, p. 53, t. xvii, figs. 7-9.  
 1869. „ „ „ Römer, *Monog. der Molluskengattung Venus*, Band I, sub-gen. *Cytherea*, p. 36, t. x, fig. 4.

The two specimens (Nos. 4865 and M. 10833/2 of the Indian Museum collection) from the Nicobar Islands, and the larger one

(M. 10857/2) from Gwadar, Baluchistan, which have come under my notice, show this species to be a most interesting link between the species inhabiting the estuaries of continental India and those from further east, notably the giant Japanese *Meretrix* called "Hamaguri," *M. lusoria* (Chemn.). The true Indian species, except in the extreme forms of *M. casta ovum*, tend to assume shortness in the antero-posterior axis and incline either to a cordate or to a sub-orbicular outline. In *M. attenuata*, on the other hand, the shell is very definitely produced posteriorly into an acute angle, giving the shell a distinctly subcuneate outline, emphasized by the straightness of the sharply declivous margin between the hinge and the posterior extremity. In this elongation and straightness of the upper posterior margin *M. attenuata* approaches the large Japanese species, which however is considerably more elongated. These two species agree in nearly every detail of the hinge region; in both the anterior tooth is inserted on a shelf set at an angle of about 45 degrees to the ventral edge of the main hinge plate. No such great obliquity occurs either in *M. casta* or *M. meretrix*. Further, although the anterior cardinal tooth both in *M. attenuata* and the Japanese species is marked by a very slight striation on the apex, this is so obscure and weak as not to be observable except under a lens of considerable power; there is no approach to the sub-bifid form seen in *M. meretrix*.

This species is so rare in collections that the three specimens possessed by the Indian Museum deserve careful attention, especially as Dunker and Römer appear to have based their diagnosis upon a single specimen of unknown origin.

The smaller of the two Nicobar specimens agrees in almost all particulars with the described form and is almost of the same size, its dimensions being  $53 \times 43 \times 25$  mm. against Dunker's  $59 \times 40\frac{1}{2} \times 25$  mm. The colouration is almost identical with that of Dunker's and Römer's figures, the shell being covered with concentric bands or zones of broken chevron markings of a chestnut tint that remind one of the *graphica* form of var. *zonaria* in *M. meretrix*. The periostracum is thin, somewhat dull and olivaceous yellow. Internally the shell is white with violet staining along the posterior declivous margin. The hinge plates are malformed, due to the fusion of the anterior and median cardinals of the right valve. Apart from this, in one important point the hinge differs from the type description; Dunker states the nymphae are "*tenerrime granulatae nec denticulatae*," which Römer varies by saying "*tenerrime granulatae nec transversim sulcatae*." Now in this smaller Nicobar specimen the nymphae are quite distinctly marked by closely-set transverse ridges, each of which does however show signs of being composed of a row of fine granulations.

The larger of the Nicobar specimens and the single one from Gwadar in Baluchistan are quite differently coloured, but in all essential particulars otherwise agree. In both, the valves are virtually bereft of markings and are covered with a thin and pale

straw-coloured periostracum. Anteriorly there is a considerable amount of extraneous black staining, and on the umbones of the Gwadar shell are several imperfect zones of chevron marks. Internally the posterior declivous margin is characteristically stained violet.

In both, the nymphae conform more closely with Dunker's and Römer's descriptions than does the smaller Nicobar specimen; the transverse character of the striae has become obscured and the granulations are apparently irregularly disposed; only here and there can a faint suggestion of transverse disposition be seen. The second cardinal tooth of the left valve of the Gwadar shell is abnormally weak, and it is noteworthy that out of three specimens the cardinal tooth of two depart from the normal.

In all three specimens the pallial sinus is similar. It is strongly marked, deep and almost semicircular. The ventral horn ends in an acute and downwardly turned point approaching closely the form seen in *M. lusoria* but more inclined ventrally.

From the above it is obvious that both Dunker's and Römer's descriptions require amendment in two points, namely, sculpturing of the nymphae and the external colouration of the valves. From what I see in this species, reinforced by examination of a very large series of *M. meretrix* as also of several large *M. lusoria*, I am able to say that the sculpturing of the nymphae, in those species of *Meretrix* which attain relatively large size, undergoes distinct degeneration with increase of size and age. In young shells the nymphae are marked by coarse transverse ridges, very distinct and set comparatively widely apart. With advance in age the ridges decrease in prominence while increasing rapidly in number and become more closely set. Finally the ridges begin to break up into rows of granulations, and in the final stage, marking old age, the parallel arrangement in rows of the granulations may even disappear entirely, and nothing remain except an area closely set with extremely fine and exceedingly numerous minute granulations without pattern or order.

As there appear to be two distinct colour varieties of this species I propose to separate the nearly unicoloured form under the name *flava* diagnosed as follows:—

Var. *flava*, var. nov.

(Plate VII, figs. 41 and 42.)

Similar to the type in all particulars except in the external colouration of the valves, the zones of zig-zag markings characteristic of the latter being suppressed except sometimes partially upon the umbones; general tint pale straw colour due to the tint of the thin investing periostracum.

*Habitat.*—Nicobar Islands and Gwadar, Baluchistan (Indian Museum collection).

*Dimensions.*—The larger Nicobar shell, 63×50 mm.; Gwadar shell, 64×52×35 mm., the latter giving the ratio of 100 to 81·25 to 54·69.

### 3. *Meretrix casta* (Chemnitz).

(Plate V, fig. 22 ; plate VI, figs. 30-33.)

1782. *Venus casta*, Chemnitz, *Conch. Cab.*, Vol. VI, p. 349, pl. 33.  
 1835. *Cytherea casta*, Lamarck, *Anim. sans. Vert.*, 2nd ed., Vol. VI, p. 301.  
 1845. " *ovum*, Hanley, *Proc. Zool. Soc. London*, 1845, p. 21.  
 1869. *Meretrix casta*, Römer, *Monographie der Molluskengattung Venus*,  
 Linne, Band I, subgenus *Cytherea*, p. 31, pl. xii,  
 fig. 2.  
 " " *ovum*, Römer, *ibid.*, p. 38, pl. xi, fig. 4.  
 " " *exilis*, Römer, *ibid.*, p. 35, pl. xi, fig. 3.  
 1914. *Corbicula (Velorita) satparaënsis*, Preston, *Rec. Ind. Mus.*, X, p. 306,  
 figs. 22 and 22a, p. 308.  
 1915. *Meretrix casta*, Preston, *ibid.*, XI, p. 300 (not his large valve 67×73  
 mm. which is *M. meretrix*).  
 " " *ovum*, Preston, *ibid.*, p. 300.  
 " " *morphina*, Preston, *ibid.*, p. 300.  
 1916. " *casta*, Annandale and Kemp, *Mem. Ind. Mus.*, V, p. 351  
 (not their *M. ovum* which is *M. meretrix impudica*  
 juv.).

This species is exceedingly variable and ignorance of this fact has caused great confusion over its nomenclature ; in *M. meretrix* the variation is limited largely to the colour design of the valves ; in *M. casta*, the form of the shell and the proportionate development of the hinge elements are subject to a wide range of variation, apart from and in addition to much diversity in the surface colour scheme of the valves.

The form described by Chemnitz and by Lamarck under the name *casta* may be considered the type of the species, as the latter's definition accurately summarises the characters of the predominant form found in east coast backwaters and estuaries from the Chilka Lake to Tuticorin. According to Lamarck the shell is " cordato-rotundata, gibba, crassa, alba ; pube anoque ovatis, convexis, glaucescentibus ; intus violaceo maculata." Shells agreeing with this description never have well developed radial bands, but on some medium-sized individuals from the Chilka Lake (M. 10589/2 A and B) two short unmistakable rays can be made out on each umbo, and in one case I can trace one of these bands continued as a faint dusky clouding for a considerable distance towards the margin. In variety *ovum* from Malabar the rays are less frequently suppressed (pl. IV, figs. 3 and 4). Hanley's *Cytherea ovum* is a subequilateral variation, whilst Römer's *M. exilis* is nothing but a young stage of the same variety.

The distributional range of the type form is limited to the east coast of India, where it is found, often in densely stocked beds, in the majority of the backwaters and estuarine channels from Orissa to Cape Comorin. The sub-species *ovum* on the other hand is not found except in occasional and rare individual cases within these limits, but is exceedingly common upon the west

coast of India from Cape Comorin to Bombay and again on the west coast of the Malay Peninsula.

The type form attains a larger size than any of the local races of the living sub-species to be described later; in the outer channel of the Chilka Lake, where conditions seem particularly favourable to its growth, it attains a length of 51 mm. by a depth of 47 mm. while its thickness, due to its ventricose shape, is as much as 33.5 mm.

The following measurements of individuals of different ages from the three chief localities where the type is found exhibit the great breadth (depth) of the shell as compared with the length. In variety *ovum* the ratio is considerably less owing to its frequent greater elongation. The thickness of the complete shell shows little difference in the two forms. The dimensions are:—

		<i>Millimetres.</i>	<i>Respective Ratios.</i>
Chilka Lake	...	51 × 47 × 33.50	=100 to 92.16 to 65.70
Pulicat	...	44 × 38 × 28	=100 to 86.36 to 63.63
"	...	40 × 33 × 23	=100 to 82.50 to 57.50
Madras	...	39 × 32 × 21.25	=100 to 82.05 to 54.48
"	...	21.5 × 17.75 × 12.50	=100 to 82.56 to 58.14
"	...	20 × 17.75 × 12	=100 to 88.75 to 60.00
Average of ratios			=100 to 85.73 to 59.91

The outline of each valve is distinctly cordate (as shown in figs. 30-31), but this varies considerably even in the Chilka Lake individuals and some show a distinct tendency to elongation posteriorly; these connect with Hanley's *M. ovum* (pl. V, fig. 23).

The periostracum in most of the Chilka specimens is olive grey, thin and strongly adherent; smooth and inclined to dullness, it never possesses the brilliant varnish-like polish characteristic of that of *M. meretrix*. In a few Chilka shells it appears much stained with a deep rufous brown, and in one this passes into a blackish brown. Shells from the bed of Pulicat Lake and Ennur backwater scarcely ever retain the olive grey tinge which I believe to be the natural tint of the periostracum in this species; they are almost all deeply stained with rusty brown. The single Tuticorin shell obtained alive was olive grey.

Very marked variation is noticeable in the thickness of the valves, in the strength of the hinge plate, and in the size of the cardinal and lateral teeth in specimens from the east coast of India; the series shown on plate VI, figs. 30-33, illustrate the range in form better than any verbal description. In no case, however, is the shell and hinge so massive as in the sub-fossil variety described below as var. *satparaënsis*.

On the west coast of India from Travancore as far north at least as Bombay, a variety of *M. casta* is found in every estuary and backwater in such immense numbers that it has acquired a position of considerable economic importance among the fishing community, of whom hundreds engage in its collection during the dry season when the level of water is low in the channels. The

lower classes esteem it because of its cheapness and tastiness, and its shells, owing to their solidity, have considerable value to the local lime-burners as a source of lime. The inherent variability already noted as of considerable range on the east coast is greatly intensified on the west coast. This is due to two factors: (a) the much more diversified conditions under which the species exists on the latter coast, and (b) the vastly greater numbers of individuals involved.

On the west coast the rainy season is much more prolonged and the rainfall much heavier than on the east; as a consequence the backwaters, even close to their seaward entrances, have a low salinity for months in the year—during the height of the floods it is difficult to conceive of the water in even the lowest reaches being anything but wholly fresh. Hence, to survive requires in any estuarine mollusc marked power of adaptability to rapidly altering physical conditions. This quality is considerable in *M. casta* and is assisted by its numerical abundance, which furnishes the requisite numbers for the successful intervention of natural selection in the problem. The struggle for existence under these conditions is obviously a hard one and the west coast races of *M. casta* show the effects thereof in several characteristics. They seldom exhibit vigorous growth; dwarfing is the rule; extreme variations in form are to be counted as favoured if not induced by these conditions. Malformations are numerous and corrosion of the umbonar region is nearly always present. Complete adaptability has not even yet been attained; mortality is excessive every flood season, and the vast majority of each generation do not survive to a second year of existence.

In the biological survey of such an estuary as that of the Balia-patam river in North Malabar, it is most significant to notice that only at the mouth are large and vigorous examples of *M. casta* found strictly comparable with the type form inhabiting the seaward channels of Chilka and Pulicat Lakes, where the duration of river floods is short and where tidal influence is never wholly lost except for a comparatively short period in each year. The most seaward beds in the Balia-patam estuary yield shells almost exactly similar to poorly grown east coast ones. In both, the ventricose and cordate form is emphasized; the colour of the Balia-patam shells is stained rufous red as in Pulicat shells, and the main distinctions to be noted in average shells are that the elongation of the posterior angle of the shell is slightly more pronounced, while neither the escutcheon nor the vulva or coloured area of the upper posterior region show more than a trace of the elevation or reflection in the median line, which is usually present in most east coast individuals. On the other hand, the differences between selected specimens of the east and the west coast forms are less than the differences between the extremes met with in purely east coast or in purely west coast shells.

In sheltered creeks where a fairly high salinity is maintained for several months after spawning, individuals grow rapidly and

retain their olive grey periostracum free of stain. These shells grow uninterruptedly, show no rest phases, become stout in substance, and show no corrosion of the umbones; not infrequently two radial lines, sometimes of chevron-shaped marks, are apparent in the umbonar region. The latter approximate to the colouration seen in young specimens of *M. meretrix* var. *morphina*, while the undecorated ones approach Hanley's *M. ovum*. These forms never seem to attain a larger size than 35 mm. in length, as they either die off when the great floods come or else become stained and corroded and pass thereafter as variations of the large form described from the seaward channels.

Further up the backwater, conditions become less favourable for *M. casta*; the bottom is less sandy and more muddy, the action of the rapid flow of the river current becomes a new factor, low salinity continues over a greater length of time, while, finally, the appreciable amount of organic acids present in the drainage from the hills and adjacent rice fields causes rapid corrosion of the shell, especially upon and around the umbones. One of the most marked effects of these altered conditions, and of the efforts made to give accommodation to them, is a change in the form of the shell. From being cordate and ventricose, the shape changes to one which is distinctly compressed laterally and of pronounced elongation in the antero-posterior axis. The young shells are almost almond-shaped, so extreme is the compression and accompanying elongation. With age they become blunter at either end and in their extreme phase exhibit a distinct convergence in outline and general shape to that of the freshwater mussel (*Lamellidens marginalis*). The umbones show considerable modification during these changes; in typical *M. casta* they are set obliquely, their apices directed forwards and inwards; in the riverine forms, now being noted, they are usually straightly incurved (*cf.* Hanley's *M. ovum*—"natibus recte incurvatis"), and as their points usually disappear through corrosion, this distinction becomes still more emphasized; even in cases also where the umbones originally were curved forwards, this appearance becomes obscured and is eventually lost by the effects of corrosion.

So greatly specialised is this form that it appears worthy of being given a varietal name, for the sake of clearness. As Hanley's *M. ovum* occupies a fairly central position in the chain of gradations to be grouped in the new variety, I propose to retain *ovum* as a suitable name for this assemblage. I must say, however, that no clear line of distinction can be drawn between this and the more estuarine forms. Every gradation can be found between both sections, and a complete series of examples can easily be formed, showing every step in the change from a short ventricose cordate form through a roundly ovate stage to an elongated somewhat laterally compressed elliptical form, totally unlike that standing at the other end of the series.

The substance of shells from west coast estuaries is distinctly thinner than that of those from the east coast, due possibly to a

smaller lime content in the west coast rivers. Here I should mention that much of the variation found in the form and proportions of the umbones and hinge region of *M. casta*, is due to the effect upon the size and relative relationship of these parts, caused by the exceedingly variable rates at which the shell increases in thickness under different conditions. Exceptionally rapid growth in thickness tends to produce a humped and corbicular shape, while rapid growth in length and breadth with slow deposits of lime salts give a compressed form with flat umbonar region. Under certain conditions not now prevailing, but which existed at the very recent geological period when the shell-pits of swamps round the margins of the larger backwaters of the eastern coast were being formed, the deposit of lime salts must have progressed at a greater rate than the most rapid now existing, for in these sub-fossil deposits we got an immensely massive form of *M. casta*. This shell at first sight appears so different in hinge form and in general shape from the type of *M. casta* that one does not hesitate to treat it as a different species. Hence we find Preston describing it as a *Cyrenid* under the name of *Corbicula (Velorita) satparaënsis*. He saw cause to modify this opinion later and in *Rec. Ind. Mus.*, XI, p. 300, he rightly assigned it to *M. casta*. In this I agree with him, after a comparison of a long series of young individuals of the massive form as opposed to those of the type. This gave conclusive evidence of identity, as the extreme comparative solidity of the variety is rapidly lost as we descend in the series till at last among small individuals of the type and of the variety, of  $\frac{3}{4}$  inch in length, we attain practical identity and it becomes impossible to differentiate the one from the other.

Another factor which has a determining influence in modifying the form of the shell is current action. In channels and creeks where the current is slow and weak, the inflated cordate and ovate forms persist; where the current is strong, the form tends to become abnormally elongate and flattened. Such condition and effect are seen wherever *M. casta* has managed to establish itself in the main channel of the west coast rivers at a relatively considerable distance from the sea. Elongation is particularly strong in case of young individuals. This change is an adaptation to counteract the danger which a rotund form such as that of the type would be subject to when exposed to strong current influence. The flattened form is less liable to be rolled along, just as this same general shape has similar utility in the case of *Donax cuneata* which lives in the surf-troubled sands of our beaches, where a rounded form would subject it to the peril of being rolled forwards and backwards on the beach with every alternate surfbreak and backwash.

*Distribution of M. casta (type).*—East coast of India, from the Chilka Lake to Tuticorin in backwaters and connecting canals. Also Ceylon and Singapore according to Römer; it certainly occurs in Ceylon, but I am very doubtful in regard to Singapore as all the specimens in the Indian Museum collection from this locality undoubtedly belong to var. *ovum*.

It also occurs sub-fossil at various places in the east coast of India from Ganjam to Tuticorin.

Below are descriptions of the two varieties which I now propose:—

(a) Variety **ovum** (Hanley).

(Plate IV, figs. 1-4; plate V, figs. 23-26; plate VI, figs. 34-38).

1845. *Cytherea ovum*, Hanley, *Pro. Zool. Soc. London*, 1845, p. 21.

1869. *Meretrix exilis*, Römer, *Monographie der Molluskengattung Venus*, Linn., Band I, p. 35.

Shell variable in form, ranging from elongate ovate to oblong, not usually inflated, moderately compressed, fairly solid, equi-valve, sub-equilateral, white, with or without two more or less complete narrow divergent brown bands radiating from the umbo to the ventral margin—these bands very frequent in young specimens but usually suppressed in the adult; covered with a thin, dull olive or yellowish grey periostracum often stained with brown; umbones centrally disposed, weak, not prominent, little curved or else bent straight inwards, the latter appearance commonly emphasized by corrosion which may extend to a considerable extent around each umbo; dorsal margin on each side of umbo inclined to convexity, thin and usually without reflected margin; ventral margin varies from convex to nearly straight, entire; anterior side rounded; posterior side produced rather more than the anterior, sometimes sub-angular, upper margin stained exteriorly with greenish grey; escutcheon ovate, sub-obsolete, interior surface white, stained violet along the upper posterior margin, also frequently along the ventral edge of the hinge plate, and sometimes above the anterior adductor scar; hinge as in the type except that it is weaker, narrower and more elongate in consonance with the lengthening of the entire shell; surface of the escutcheon flattened and not elevated along the median line as in the type; pallial sinus shallow as in type. Dimensions variable, usually not exceeding 43 mm. in length by 35 mm. in depth and 26 mm. in thickness in vigorously grown individuals, generally the size is smaller and  $37 \times 30 \times 22$  mm. may be taken as a fair average.

The main points of difference between this variety and the type are: (a) the more pointed outline of the posterior angle of the shell; (b) the frequent presence of radial banding; (c) the narrower and more elongated form of the hinge; (d) the flattened surface of the escutcheon as opposed to its convex form in the type, whereby in the latter the edge of the shell immediately above the anterior lateral dental pit in the left valve is reflected outwards as a prominent lip.

*Dimensions.*—The following table gives particulars of the length and breadth of the valves in 13 individuals from 6 different localities, with in addition the maximum transverse diameter of the entire shell in 14 instances. The relative ratios of these

dimensions have also been worked out to permit of accurate comparison.

	Millimetres.	Respective Ratios.
Malacca (M. 10847/2)	31 × 25	= 100 to 80·65
	30 × 25	= 100 to 83·33
	30 × 24	= 100 to 80·00
	31 × 25	= 100 to 80·65
Singapore (M. 10837/2)	49 × 39 × 28	= 100 to 79·59 to 57·14
Mahé	35 × 27½ × 20¼	= 100 to 78·57 to 57·86
	30 × 27 × 21¾	= 100 to 90·00 to 72·5
	41 × 31 × 25¼	= 100 to 82·93 to 61·58
Tellicherry	26½ × 19½ × 13	= 100 to 73·58 to 49·05
	37½ × 29 × 20½	= 100 to 77·33 to 54·67
	29 × 21¼ × 14¾	= 100 to 73·28 to 50·00
	33¼ × 26 × 18½	= 100 to 78·20 to 55·64
Mangalore	39½ × 31 × 22½	= 100 to 78·48 to 56·96
	37 × 32¼ × 22¾	= 100 to 87·16 to 61·49
	29¼ × 24¼ × 17¾	= 100 to 82·91 to 60·68
	27¼ × 22½ × 18	= 100 to 82·57 to 66·06
Madagara	39½ × 34½ × 26½	= 100 to 87·34 to 67·09
	38½ × 34¾ × 25	= 100 to 90·26 to 64·94
Average of ratios		= 100 to 81·49 to 59·69

The above figures bespeak a very considerable degree of variability among these shells, ranging in the ratios of the three dimensions from 100 : 73·28 : 50 to 100 : 90·26 : 64·94 in the case of two extreme forms. The average ratios deduced from the above 18 examples work out however at 100 : 81·49 : 59·69 which are not far removed from those of the type form—100 : 85·73 : 59·9. This approximation of the averages of the two groups furnishes contributory evidence in favour of the view that their differences are insufficient to warrant separation as distinct species; at the most, even when we take into consideration the divergences in outline, in the structure of the hinge and in the position of the umbones, the west coast group can be accounted only a variable variety of the type.

*Localities.*—The inner sections of tidal estuaries and backwaters on the west coast of India from Cape Comorin to Bombay. Very rarely from the east coast where higher saline conditions favour the predominance of the type form (No. 4792 Ind. Mus. coll., from Tinnevely, and some among No. 10588/2 from the beach at Vizagapatam; the latter are however probably of sub-fossil origin). It appears again on the western coastline of the Malay Peninsula, typical specimens coming from Malacca and Singapore (Ind. Mus. colln. M. 10847/2 and 10837/2). Further north, a specimen from Arakan (M. 10841/2), size 44 × 36·75 mm., appears to be intermediate between the type and this variety; in it the characters of the two seem fairly evenly balanced, but after careful analysis of each character, I am satisfied it should be assigned to var. *ovum*. Hence I expect that eventually it will be found that this variety is as characteristic of the whole of the eastern shores of the Bay of Bengal as it is of the west coast of Peninsular India.

(b) Variety *satparaënsis* (Preston).

(Plate V, figs. 19-21 ; plate VI, figs. 27-29).

1914. *Corbicula (Velorita) satparaënsis*, Preston, *Rec. Ind. Mus.*, X, p. 306.

Preston's description above cited is sufficiently accurate for the fully grown shell. Between this and the young form of about 25 mm. in length, where individuality as a variety is lost in identity with the type, there is a perfect series of gradations ; advancing from the early stage at which divergence begins we see the type form gradually altering in the ratio of length to breadth. With rapid increase in stoutness, the shell assumes a shorter and deeper form, the valves become highly convex or rather humped and the umbones strongly beaked, altering completely the general appearance.

*Dimensions.*—The largest valve I have seen is a water-worn one from False Point, Orissa (No. M. 10845/2 Ind. Mus.). This measures  $57\frac{1}{2} \times 53$  mm., giving a ratio of 100 to 92'15. Another particularly large one I obtained from the Surla shell-pits in Ganjam. This measures 57 mm. long by over 50 mm. deep, equivalent to the ratio of 100 to 87'72 (deposited in the Calcutta Museum). Five other shells from Korampalam shell-pits, Tuticorin, with their valves undisplaced, measured :—

<i>Millimetres.</i>	<i>Respective Ratios.</i>
$39 \times 38 \times 30\frac{1}{2}$	=100 to 97'44 to 78'21
$38\frac{3}{4} \times 36\frac{3}{4} \times 30$	=100 to 94'84 to 77'42
$31 \times 29\frac{3}{4} \times 23\frac{1}{4}$	=100 to 95'97 to 75'00
$30\frac{1}{4} \times 27\frac{3}{4} \times 22\frac{1}{2}$	=100 to 91'74 to 74'38
$43 \times 40\frac{1}{2} \times 32$	=100 to 94'19 to 74'42
Average of Ratios	=100 to 94'84 to 75'89

*Localities.*—This variety is common everywhere in the shell deposits of sub-fossil age on the borders of Chilka Lake, Sonapur backwater (Ganjam), Pulicat Lake and Sadras backwater (Chingleput) ; in shell-pits in the Mandapam Peninsula (Ramnad district) and also at Korampalam near Tuticorin ; a water-worn valve from False Point, Orissa.

Variety *satparaënsis* is found only in the sub-fossil condition ; no living individuals appear to assume this excessively stout form. This would seem to indicate that the conditions favouring an extremely rapid deposit of lime salts have deteriorated appreciably since the time the sub-fossil deposits were formed, or that the variety had found it a disadvantage to be possessed of special ability to secrete large quantities of lime in its shells.