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[*N.B.*—An asterisk (*) preceding a line denotes a new variety on sub-species ; a dagger (†) indicates a new species ; a double dagger (‡) a new genus or sub-genus ; synonyms are printed in italics.]

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ON THE REPRODUCTIVE PROCESSES AND DEVELOPMENT OF *PILA GLOBOSA* (SWAINSON).

PART I.—COPULATION AND OVIPOSITION.

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(Plates I, II.)

CONTENTS.

1. INTRODUCTION.

In a recent monograph on the "Anatomy of the common Indian Apple-Snail, *Pila globosa*, Prashad (**4**, 1925) writes," No observations have hitherto been published regarding the copulation or oviposition of any Ampullarid and I have not been able to observe these phenomena myself." He, however, quotes the following paragraph from a manuscript of Mr. V. V. Ramanan preserved in the Connemara Library at Madras :—

" The *Ampullaria globosa* (*Pila virens*) Swainson invariably goes to the banks of the pond, puddle or river in which she lives for the purpose of spawning. She selects a place a few inches above the water margin, burrows underground till her shell is just visible above the mud and deposits her ova. So to speak, she incubates, after gathering the bunch of eggs within the folds of her mantle and foot and till the rather soft and transparent jelly-like substance of her spawn turns in a few hours considerably thicker, and each egg becomes invested with a pure white calcareous shell. After the operation is over, she returns to the water."

This account of oviposition is unfortunately very incomplete as well as incorrect in several details, while no published account exists of the copulation of an Ampullarid.

The embryology of this type has also been incompletely worked out. Carl Semper's work (**7**, 1862) on the embryology of an allied species, *Pila polita*, was published in 1862 and although, considering the fact that the work was carried out sixty-six years ago, it is an admirable piece of research, yet it is inadequate and out of date for our present day requirements, while the illustrations leave a great deal to be desired. Later, Brooks and McGlone

(**1**, 1908) worked out the origin of the lung of *Ampullaria depressa* but unfortunately their work is very fragmentary and needs amplification.

Since *Pila* is now studied as a type of the Gastropoda in almost all the universities of India, Burma and Ceylon, it is necessary to have as complete and correct a knowledge as possible of this form. I, therefore, undertook to study its breeding habits and development and this paper is the result of my observations and work both in the field and in the laboratory extending over a period of about a year.

I am describing copulation and oviposition in this first part of my paper and will publish the embryology of this type in part II at a subsequent date.

I am deeply indebted to my friend Dr. Baini Prashad for acquainting me with the literature on the subject and sending me reprints of several memoirs from his private library. He has also kindly read through my manuscript and made helpful criticism.

2. BREEDING SEASON AND THE INFLUENCE OF WARMTH AND MOISTURE.

The Apple-snail, *Pila globosa*, breeds at the beginning of the rainy season. In a hot and dry country like India, it is *moisture* that makes the greatest difference in the life of aquatic and semi-aquatic animals, and *Pila*, like many other typical Indian forms, is adapted for life in surroundings where there is a prolonged period of drought alternating with three to four months of heavy rains. The monsoon in Northern India blows, off and on, for about four months, *i.e.*, June, July, August, and September, and it is only in these months that ponds and puddles are formed in large numbers. In the upper Gangetic valley October to June are practically dry, there being very little rain during these nine months. Of these, May and June are the hottest and driest, and the hot winds (the *loo*) blow during these two months for the greater part of the day ; the land gets absolutely parched and baked, as it were, and the temperature goes up to between 110°F. and 118°F. in the shade. In Lucknow, the moisture-bearing current breaks in towards the end of June or the beginning of July and brings life to the parched land. The first few inches of rain are rapidly absorbed by the dry ground, but later, as the monsoon continues, innumerable ponds and puddles are formed all over the country-side and animal life shows its activity at its best.

Pila globosa is found in large numbers in the ponds during the monsoon and in bigger ponds hundreds of specimens can be obtained right up to December. But as the ponds dry up, the animal burrows underground and I have dug up specimens of *Pila* as deep as four feet under the ground in March and April. Whenever specimens are needed for class-work in March and April, they are always obtained by digging the ground in places where ponds and puddles are formed during the rains. This aestivation or summer-hibernation of *Pila* is an adaptation not to *temperature* but to *drought*.

Warmth and moisture are the two essential conditions for the development of the eggs of this animal and it is only during the monsoon that these conditions are fulfilled and hence breeding takes place at this time of the year. In Europe the land is moist during the greater part of the year and there is a good deal of humidity in the air at all times, but it is the warmth that is absent in autumn and winter and hence animals hibernate during these months to tide over the intense cold of the winter months. In Northern India and also in other parts

of the Indian Empire, on the other hand, it is warm during the greater part of the year but practically eight to nine months are dry and there is little moisture either in the air or on land. All ponds and puddles, teeming with life during the monsoon, dry up during the succeeding months to be filled up again with water and accompanying animal and vegetable life at the onset of the next monsoon. In the tropics, therefore, it is the *moisture* that largely determines the conditions of animal life and it is not at all surprising, therefore, that animals ordinarily passing a certain period of their life in water (fresh-water or amphibious animals) make the most of the monsoon months and breed at this time of the year, when both moisture and warmth are available.

Very little is known of the physiological condition of these animals at the time they aestivate in hot and dry seasons.

3. THE COPULATORY ORGANS AND THE PROCESS OF COPULATION.

Immediately at the onset of the rains, the apple-snail comes to the surface of the ground after its prolonged aestivation and sexual activity begins at once. Copulation takes place either in water or on land at the edge of the pond. The male which is, as a rule, smaller than the female and has the body-whorl of its shell less swollen, creeps up on the top of the shell of the female and takes up its position on the right side of the head of the female. In this position, the foot of the male is firmly attached to the outer side of the shell of the female and the two shells are set in such a way that the aperture of one is opposed to that of the other (Pl. I, fig. 1). The female has her foot and head generally fully extended and protruded out of the shell, so that her mantle-cavity is wide open and the left trumpet-shaped siphon is kept constantly working. While the greater part of the foot of the male rests on the body-whorl of the shell of the female, a small anterior portion of the foot extends beyond the margin of the shell and the male thus takes a secure position on the shell of the female. The pair having been set in this position, the male thrusts out its white or light blue penis and inserts it into the mantle-cavity of the female.

Apple-snails readily copulate in an aquarium in the laboratory, either floating in the water (Pl. I, fig. 1) or attached to the glass-side of the aquarium (Pl. I, fig. 2). My observations on copulation are based mainly on snails pairing either in the aquarium or on the muddy ground in the frog-pond of my laboratory. The female creeps along the glass-side of the aquarium and comes up near the surface of the water, while the male mounts on the female, takes up its proper position and inserts its penis-sheath and penis into the mantle-cavity of the female. The whole process can be easily observed through the glass-side of the aquarium and Pl. I, fig. 2 shows the copulating snails attached to the side of the aquarium. Pairing specimens either floating in water or lying on the ground can be picked up and their copulatory mechanism examined. The mouth of the shell of the female is easily kept open by pressing the operculum against the shell with the thumb of the left hand and, by doing so, the white or light blue penis-sheath is easily seen inserted into the mantle-cavity of the female. Further, by moving aside the foot of the female with a section-lifter in the right hand, it is seen that the inserted penis-sheath is a flattened structure measuring about half an inch in width. It is curved into an arch and is inserted

more than an inch into the mantle-cavity of the female. There the rectal opening is readily seen, while the female generative opening, lying close to it, is completely surrounded by the penis-sheath. The penis itself is not visible in copulating specimens, as it is completely covered on the underside by the penis-sheath. A fact of practical interest, however, is that the male continues to stick to the female and does not usually retract its penis-sheath and penis when pairing specimens are handled during the copulatory act. In fact, all the details mentioned above can be easily observed by holding the copulating pair in the left hand and manipulating the different structures with a section-lifter in the right hand.

During copulation, which lasts for several hours (I have seen pairs copulating for three hours), the female, with its head and foot generally extended, feeds freely on water-weeds in the pond or the aquarium, but the male keeps its head generally retracted and puts out only its penis-sheath and inserts it into the mantle-cavity of the female.

While the penis-sheath can be seen enveloping the female generative aperture, the rôle of the penis in the process and the exact mode of transmission of the spermatic fluid from the male generative aperture to the female opening cannot be made out by a direct observation of the copulating pairs, and consequently I resorted to other methods of research. I tried several methods. The first was to break portions of the shell of several males in order to expose the penis-sheath and keep such males with females in an aquarium. The shells of the females were also broken so as to observe more easily the terminal portion of the vagina and the female generative aperture. I expected to see the exact mode of transference of the seminal fluid from the male genital aperture to the base of the penis and also the insertion of the penis into the vagina. But unfortunately my expectations were not fulfilled as the snails with partially broken shells refused to copulate, probably because the males could not secure a good position on the female, the shell of the latter having been broken at the place where the male takes his seat.

Attempts were then made to kill and fix rapidly copulating pairs in sexual congress and these were partially successful. I dropped several copulating pairs in strong formalin in order to fix them at once but they always contracted and separated. I next tried to narcotise several pairs with chloroform and chloral hydrate respectively, but the male and the female invariably separated and no observations on the mechanism of copulation could be made. The last method I tried was electrocution of copulating pairs. This quick method was successful and I was able to kill a couple of pairs in a condition of sexual congress and thereby make out the exact details of the process of copulation. One such electrocuted pair is shown in Pl. I, fig. 4, and with the help of this figure we can follow the condition of the copulating organs in pairing specimens and the mechanism of copulation.

The structures of the male animal directly concerned in copulation are (1) the terminal papilla of the vas deferens bearing the male generative aperture, (2) the penis-sheath, (3) the hypobranchial gland, and (4) the penis. In the female, on the other hand, the generative aperture, together with the terminal portion of the vagina, are the only structures that take part in copulation. Prashad (**4**, 1925) has described these structures in non-copulating specimens, and it is interesting to note that, at the time of copulation, the disposition of the structures and their proportions are markedly different from what they are in a non-copulating individual.

Figs. 5 and 4 on Pl. I show these structures in non-copulating and copulating male specimens respectively. Fig. 5 is taken from Prashad's paper (**4**, 1925) and fig. 4 is drawn from copulating specimens killed by electrocution and fixed in formalin.

The last part of the vas deferens terminates in a prominent structure, the genital papilla, lying close to the rectum. The genital papilla bears the male generative aperture at its free end and consists of two parts,—(1) the basal part, which is opaque white in colour and has thick walls and (2) the apical part, which is thin and transparent and consists of two membranous folds closely pressed together. It is the apical part which opens into the mantle-cavity through the male generative aperture. The whole papilla (Pl. I, fig. 4) bears a strong resemblance to the claw of the Carnivora : the basal thick-walled portion resembling the bony lamina around the base of the claw and the apical part resembling the horny claw itself.

This genital papilla is a very important structure as it serves to establish a communication between the male generative aperture and the base of the penis, thereby conveying the spermatic fluid from the male genital aperture to the penis. Prashad (**4**, 1925) just mentions this papilla :—" The terminal glandular part of the vas deferens runs along the rectum to terminate in a small papilla, about a quarter of an inch behind the anus. The papilla is free and lies over the rectum." But he gives no details of this structure and does not even show it in his diagram (Fig. 15, **4**, 1925). Evidently he could not realise its importance in the act of copulation. Fig. 6 on Pl. II shows a transverse section passing through the basal part of the genital papilla and the rectum, and it is clear from this diagram that the genital papilla is not free but is closely attached to the rectum and its connective tissue encloses the latter structure. The thick connective tissue surrounding the vas deferens in the genital papilla consists of a close net-work, the meshes of which are formed of blood-spaces and blood-vessels, while the trabeculae of connective tissue contain elastic fibres and bundles of plain muscle-fibres. The vas deferens itself is a thin-walled tube with an inner lining of ciliated epithelium but it is surrounded by a thick coat of connective tissue, which reminds one of the spongy and erectile tissue of the mammalian penis. In fact, the genital papilla is a kind of miniature second penis.

The penis-sheath and penis proper are developed as outgrowths of the mantle and in the adult *Pila* are fixed to the inner surface of the mantle-edge, being absolutely independent of the male generative aperture. This fact characterises the whole family of Ampullariidae and must be emphasised here. In fact in *Pila*, as in marine Prosobranchiate Gastropods, the male generative aperture is *not* in direct continuation with the penis but opens separately into the mantle-cavity. The question, therefore, in *Pila*, as in marine Prosobranchiate Gastropods, is, " How is the spermatic fluid conveyed from the male generative aperture to the base of the penis ? " In marine Prosobranchiates it has been ascertained that there is a ciliated canal running from the genital opening to the base of the penis along the right side of the body and this canal serves to connect the male genital opening with the penis (**3**, 1927). But in *Pila* such a ciliated canal is absent and the transference of the spermatic fluid from the male pore to the base of the penis takes place in the absence of an intervening canal or channel. A careful examination of specimens, fixed at the time of copulation, reveals the fact that the transference of spermatic fluid in *Pila* is effected by an adjustment of the male generative opening and the base of the penis, in such a way that the apical portion of

the genital papilla is directed towards and is received into a pit formed at the root of the penis, between the hypobranchial gland and the penis-sheath (Pl. I, fig. 4). We have already seen that the genital papilla consists in large part of erectile tissue and that its apical part crosses over the rectum to approximate the base of the penis. The attachment of the penis-sheath and penis to the inner surface of the mantle brings their basal ends in close apposition with the male generative aperture. In fact, a mid-dorsal incision of the mantle-fold of a snail fixed at the time of copulation leaves no doubt whatever as to the close approximation of the apical end of the genital papilla with the base of the penis during copulation. The genital papilla, or the miniature second penis, therefore, serves to transfer the sperms from the generative aperture to the base of the penis proper, and from there the spermatic fluid is conveyed along the deep groove of the rod-like penis to the female generative aperture. The penis itself is a comparatively long and stout structure measuring about 3·8 cm. or one and a half inches in length in a copulating specimen. The relative length of the penis in copulating and non-copulating specimens can be judged from the fact that Prashad gives the length of the penis as *half an inch* only. The penis extends right up to the vaginal aperture and its terminal end is thrust into the vagina. In my electrocuted pairs, the base of the penis with the hypobranchial gland and the proximal portion of the penis-sheath are contained in the male, while the distal portions of the penis-sheath and the penis lie in the mantle-cavity of the female and the free end of the penis is inserted into the vagina (Pl. I, fig. 4). The penis-sheath is shaped like an elongated spout-like structure and envelopes the penis along its whole length. There is no doubt that it acts as a protective covering for the penis and may at the same time prevent waste of the spermatic fluid.

In a copulating male, in which the penis-sheath and the penis are fully extended, the hypobranchial gland forms the root of the penis. Its histological structure, as described by Prashad (**4**, 1925), lends colour to the view that its secretion is poured directly on the surface. What the nature of the secretion is and what function it subserves in the reproductive processes are questions still unsolved.

Lastly, we may refer to the question of the possible advantage of having the male generative aperture independent of the penis-sheath and the penis. The only alternative situation for the penis-sheath and penis would be in continuation with the vas deferens and the genital gland. In this position, they would undoubtedly be an obstruction in the mantle-cavity at all times and would not recevie an adequate supply of blood for the efficient discharge of their function. The origin of the penis from the inner surface of the mantle close to the so-called lung or pulmonary chamber ensures a copius supply of blood for its erection, and at the same time leaves the mantle-cavity relatively free to accommodate the head and foot when the animal retracts itself into the shell and closes it with its operculum.

4. OVIPOSITION.

Although *Pila* is a member of a completely amphibious clan, it shows an advance towards a terrestrial habit in its breeding activities. The typical amphibia almost always lay their eggs in water, while *Pila globosa* invariably lays her eggs on land[1] and never in water.

[1] Another species of *Pila*, *Ampullaria* (*Pila*) *depressa*, studied by Carl Semper (7, 1862) deposits her eggs in vertical rows on the stems of tall reeds and grasses above the surface of the water but close to it.

The female *Pila* selects a place in the bank of a pond a few inches to a few feet above the water margin, where she makes a hollow [1] in the ground to deposit her eggs. As a rule, egg-masses are deposited in sheltered places or hollows not only to protect them from enemies like rats and squirrels but also to protect them from the sun and consequent desiccation. The shell of the eggs is porous and unless evaporation is avoided by keeping the eggs sufficiently damp, the albumen inside dries up and the embryo cannot develop.

Oviposition takes place in a day or two after copulation, but it can be delayed by preventing the snails, which have copulated and have been fertilized, from going on land and keeping them instead in water in an aquarium in the laboratory. As soon as they are taken out of water and placed on land they commence oviposition. After keeping several fertilized females in water in a glass aquarium for a week, I took them out and placed them on moist ground in the frog-pond with the result that there was, so to speak, an " epidemic " of oviposition since all of them had been waiting to lay eggs.

During oviposition, the foot is thrown into a number of folds so as to discharge efficiently the function of depositing and collecting the eggs. In fact, it plays such an important part in the whole process of oviposition that it may rightly be termed the ovipositor [2] of the water-snail.

At the time of egg-laying, the greater part of the body of the female is extended out of the shell. The foot is fully protruded out, while the head and tentacles and also the left siphon are moderately extended. The base of the foot, instead of lying flat on the ground as in locomotion, contracts a little all round the edge forming a wavy border, and is arched in such a way as to form a saucer or dome-shaped structure. The dome-shaped foot receives the eggs as they are laid, works up the eggs into a mass and continues to grip the mass firmly during the whole period of oviposition. Further, the right side of the foot is deeply folded at two adjacent places in such a way that one of the two folds—the posterior one—forms a temporary obliquely vertical tube. The upper opening of this tube (Pl. II, fig. 9) lies on the outer sloping surface of the foot just outside the shell-opening, while the lower end opens out near the centre of the saucer-shaped sole of the foot. As shown in fig. 9, this temporary tube is really a deep channel formed by folding a part of the outer surface and edge of the foot. Approximately at an interval of a minute, a soft, flaccid rounded egg comes out of the vaginal opening, rolls out of the shell and passes along the outer surface of the foot into the upper end of this temporary tube. On its entrance into the tube the egg disappears from view for a few seconds until it comes out of the lower end of the tube into the saucer of the sole of the foot. It creeps or rolls along the surface of the sole of the foot and is readily placed along with the other eggs by the muscular contractions of the foot. As the egg comes out of the vagina, a peristaltic wave, no doubt due to muscular contraction of the foot, travels all the way from near the vaginal opening along the right side of the foot to the upper opening of the temporary tube, and from there through

[1] In the frog-pond in my laboratory, several snails laid their eggs on the moist ground without making a hollow at all, while others made shallow pits and deposited their eggs in them.

[2] The term *ovipositor* in the case of insects is used for " three pairs of chitinous styles at the end of the oviduct which form a strong, powerful apparatus for boring into the ground or into leaves, stems of plants, the bodies of insects or even into solid wood, so that the eggs may be deposited in a place of safety." In *Pila* the foot discharges a similar function; it collects the eggs, works them up into an egg-mass, holds the egg-mass until all the eggs are laid and then deposits the egg-mass into a hollow in the ground—a place of safety. Hence I have applied the term ovipositor to the foot.

the tube to the sole of the foot. It is by means of this wave of contraction that the egg is rolled along all the way from the female generative aperture to the sole of the foot.

It will thus be seen that the foot on its right-hand side forms a temporary tube for the conveyance of the eggs from the female generative aperture to the sole of the foot ; the sole of the foot rolls the eggs together to form the egg-mass and holds this mass until all the eggs are laid ; and that the whole process of oviposition is accomplished by means of the muscular contraction of the foot. The foot, therefore, efficiently discharges the function of oviposition and may justly be called the ovipositor of the water-snail *Pila*.

The body of the animal during this process is very much relaxed and specimens can be handled without their showing the usual movements of contraction. I handled several specimens which were laying eggs and found that none of them would relax the hold on her eggs with her extended foot. The instinct of self-presevation, so evident at other times, had now given place to the motherly instinct of egg-preservation and hence to race-preservation. Since the egg-laying specimens allow themselves to be handled, it was possible to make out the details of the whole process by direct observation.

Egg-laying goes on for several hours and usually takes place in the morning. In the laboratory frog-pond I invariably found snails laying eggs between seven and eight in the morning and they continued to lay for 4 to 5 hours.

As the egg is laid, its covering is very soft and sticky and it is due to this adhesive character of the outer covering that so many eggs are glued together to form the characteristic egg-mass of each snail (Pl. II, figs. 7 & 8).

Ramanan's observation that " the female, so to speak, incubates, after gathering the bunch of eggs within the folds of her *mantle* and *foot* " is, I am afraid, incorrect. In the first place, it is only the dome formed by the sole of the foot that envelopes the eggs and the mantle takes no part either in gathering the eggs or, as Ramanan supposed, in incubating them. In the second place, there is no incubation of eggs at all by the snail. For the purpose of development, moisture and warmth are the two requisites and these are admirably fulfilled by the weather during the monsoon months and no process of incubation on the part of the mother snail is necessary. As egg-laying extends over a period of 4 to 5 hours, it is necessary for the snail during this period to keep enveloping the eggs as they are being laid. As each egg is laid it is added to the previous mass, until the snail has laid all its eggs and the mass of eggs is arranged as compactly as possible. When egg-laying is completed, the snail leaves the egg-mass in a sheltered hollow and resorts to the water. There is no doubt that Ramanan was led to believe in the incubation of the eggs by the fact of the prolonged association of the foot with the eggs he observed. In fact, the foot is attached to the egg-mass for kneading together and adding new eggs as they are being laid to the pre-existing egg-mass and not for the purpose of incubation.

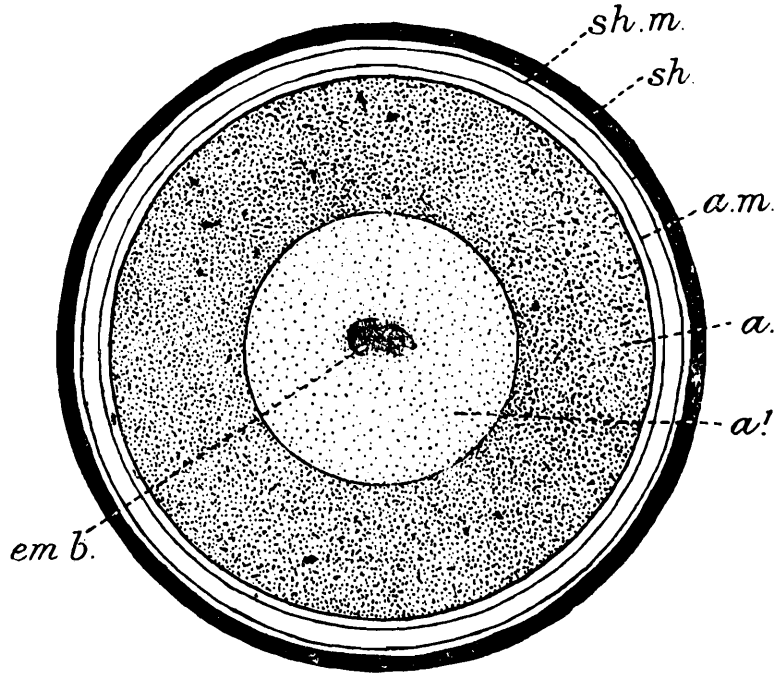
5. THE EGG.

Pila globosa, as Prashad writes (**4**, 1925), lays its eggs in masses in which the eggs are firmly attached to one another and together form a group of pure white calcareous shells. The egg-masses vary in size and weight and also in the number of eggs they contain. Prashad's estimate of the number of eggs in each mass as being two to three hundred is a very

modest one. The smaller egg-masses, weighing from ten to twenty grams each, do contain two to three hundred eggs, but the larger egg-masses, which one frequently comes across, weigh as much as 36 grams and contain as many as 700 to 800 eggs. Of course, egg-masses vary in size and the number of eggs they contain forms a continuous intermediate series between these two extremes.

In form, each egg is rounded but is slightly flattened at its points of contact with other eggs in the egg-mass. There is a white calcareous shell protecting each egg and forming a thin but opaque covering for the delicate structures within. The shell is lined internally with a very thin transparent shell-membrane, which is closely attached to the shell, and generally comes off in shreds along with pieces of the shell, when the egg is opened. On the removal of the shell, a milk-white sphere formed of thick solid albumen comes out of the egg. This albuminous sphere closely fills up the whole space inside the shell and comes out entire on opening the egg. There is a thin membrane which closely invests this albuminous sphere, and since this membrane lies immediately inside the shell-membrane, we shall distinguish it from the latter by calling it the albumen-membrane. It is difficult to make out this second inner membrane in a fresh egg, but in a boiled egg it can be easily detached from the underlying sphere of albumen. We may note here that while both the shell-membrane and the albumen-membrane are thin and transparent, the sphere of albumen inside is opaque.

On opening the albumen-sphere, it is found that the sphere is a hollow structure and that its cavity inside is filled with a transparent fluid also albuminous in nature. The impregnated ovum or oosperm lies floating in this transparent fluid. In cutting open an



TEXT-FIG. 1.—Diagrammatic representation of a section through an egg of *Pila globosa* showing a three days' embryo. *a.*, thick solid albumen ; a^1., fluid albumen ; *a. m.*, albumen membrane ; *emb.*, embryo ; *sh.*, calcareous shell ; *sh. m.*, shell membrane. (× 16.)

egg, the shell is removed first of all and then the sphere of solid albumen is opened by an incision with a needle. The fluid albumen filling up the cavity of the sphere flows out carrying the embryo with it. The embryo in its early stages is yellowish in colour on account of

the yolk-granules present in it, but as development proceeds the embryo becomes white and translucent.

The egg (Text-fig. 1) is about 5 mm. in diameter and the albumen sphere about 4 mm. in diameter. The wall of the albumen-sphere is a little more than 1 mm. in thickness.

6. MATERIAL AND TECHNIQUE.

In order to examine the details of the process of copulation, several male and female specimens were collected from a pond and brought to the laboratory. They were kept in an aquarium where they copulated either floating in water or attached to the glass side of the aquarium. Details of copulation were observed and recorded and photographs were taken of the copulating pairs *in situ*. Several pairs found copulating in a pond were separated and kept in the aquarium. Since their copulation had been interrupted, they copulated again in the aquarium.

Pairs *in coitus* were successfully killed by electrocution on a metal plate with the help of a battery and a small induction coil. They were fixed in 8 per cent. formalin, and after breaking the shells, the disposition of their copulating organs was examined. The genital gland and the attached portion of the rectum were dissected out and sectioned in order to make out their histological structure.

Impregnated females were kept on muddy ground in the frog-pond of the laboratory where they laid their eggs. They were taken out along with their masses of eggs and were photographed in the act of oviposition. The rôle of the foot in the process of oviposition was carefully determined by observing several females laying eggs. Egg-masses of several specimens were collected and weighed and the number of eggs counted in a few selected masses.

7. SUMMARY.

(1) After a prolonged period of aestivation during the dry months, *Pila* comes out at the onset of the rains and begins breeding at once.

(2) Copulation takes place in the water or on the ground at the edge of a pond. It lasts for three hours or more.

(3) The penis being a structure independent of the male generative aperture, the genital-gland acts as a minature second penis and effects the transference of the spermatic fluid from the male pore to the base of the penis proper. The ciliated canal, running from the male generative opening to the penis in marine Prosobranchiates, is absent in *Pila*.

(4) Both the penis-sheath and the penis are inserted into the mantle-cavity of the female and the free end of the penis enters the vagina. Impregnation is, therefore, internal.

(5) The genital-gland, like the penis, consists of vascular erectile tissue.

(6) Snails are killed in a copulating position by electrocution.

(7) Oviposition takes place within a day or two after copulation, and the foot acts as a very efficient ovipositor. There is no incubation of eggs by the snail as supposed by Ramanan.

(8) Eggs are laid on the ground and *not* in the water. They are laid in large masses in small hollows in sheltered places. Each egg-mass usually contains 200 to 300 eggs, but I have come across some very large egg-masses containing as many as 700 to 800 eggs.

(9) Each egg consists of a shell, a double shell-membrane, a thick layer of opaque white solid albumen and a core of fluid albumen in which the embryo floats.

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EXPLANATION OF PLATE I.

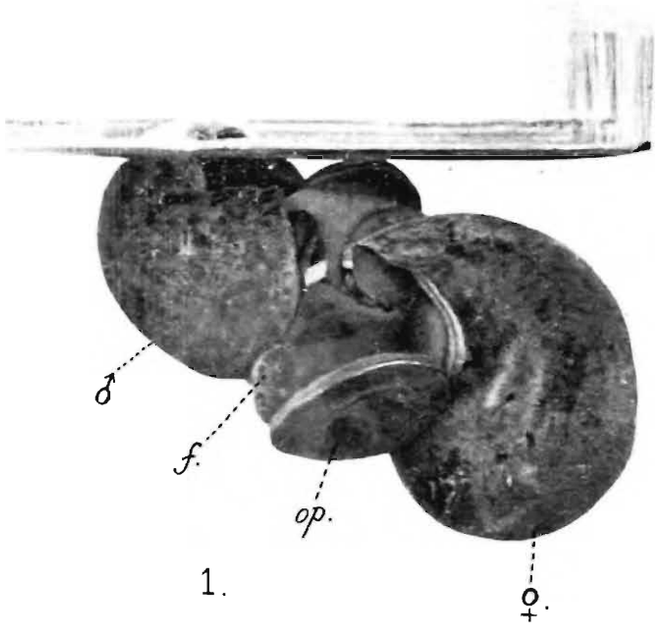
Fig. 1.—Photograph of a copulating pair of *Pila globosa* floating near the surface of the water in an aquarium. *f.*, foot of the female ; *op.*, operculum ; *s.*, siphon. (Natural size.)

Fig. 2.—Photograph of a copulating pair of *Pila globosa*, the female being attached to the glass side of the aquarium by its foot. The mantle-cavity of the female is open to receive the penis-sheath and penis of the male. A very small portion of the penis-sheath of the male (white) is seen exposed at the lower side of the figure, on the left of the foot of the female. *f.*, foot of the female attached to the glass side of the aquarium ; *m.c.*, mantle cavity of the female ; *p.s.*, small exposed portion of the penis-sheath of the male ; *t.*, one of the tentacles of the male. (Natural size.)

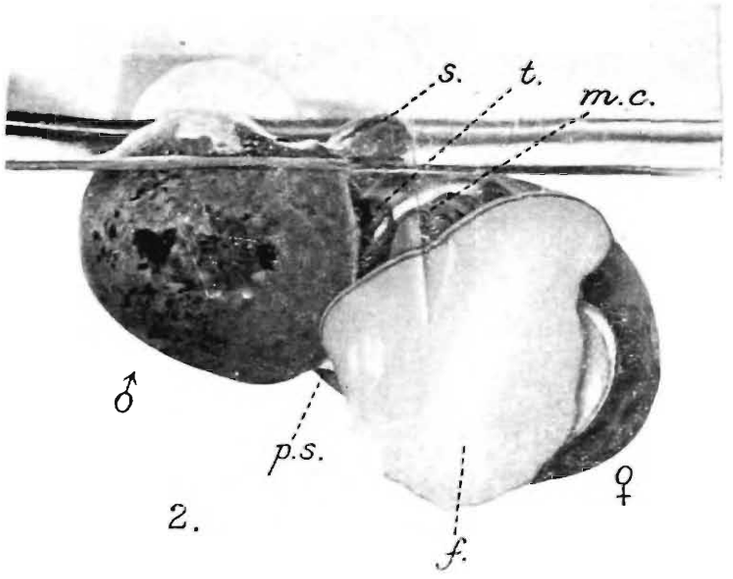
Fig. 3.—Photograph of the same copulating pair as shown in fig. 1, from the opposite side. The upper one is the male and the lower one the female and in the copulating condition lie almost parallel to each other. *op.*, operculum ; *f.*, foot of the male attached to the outer surface of the shell of the female. (Natural size.)

Fig. 4.—An enlarged diagram made from a photograph of a copulating pair of *Pila globosa* killed in the copulating condition, showing the disposition of the male and female copulatory organs, seen after breaking open the shells of the male and the female and exposing the mantle-cavity. *e.*, eye ; *f. o.*, opening of the vagina ; *g.*, gill ; *g.p.*, genital papilla ; *h. gl.*, hypobranchial gland ; *p.*, penis with its groove, *r.*, rectum ; *r. o.*, opening of the rectum ; *s.*, margin of the shell ; t^1., first pair of tentacles, or labial palps ; t^2., second or true pair of tentacles ; *v.*, vagina ; *v. d.*, terminal portion of the vas deferens. (× cir. $2\frac{1}{2}$.)

Fig. 5.—Penis and penis-sheath in a non-copulating specimen (from Prashad's Memoir, Plate XVI, fig. 12). *h. g.*, hypobranchial gland ; *p.*, penis ; *p. s.*, penis-sheath. (× 8.)



1.



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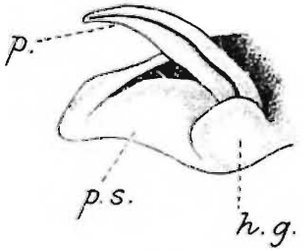

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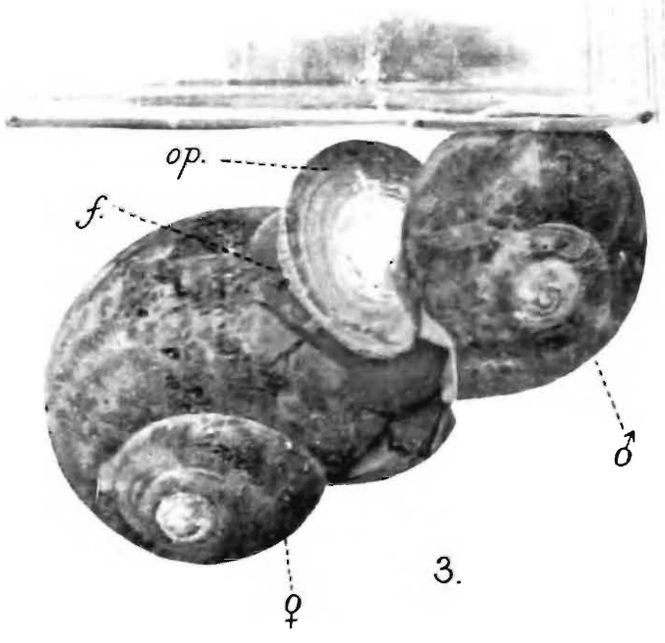
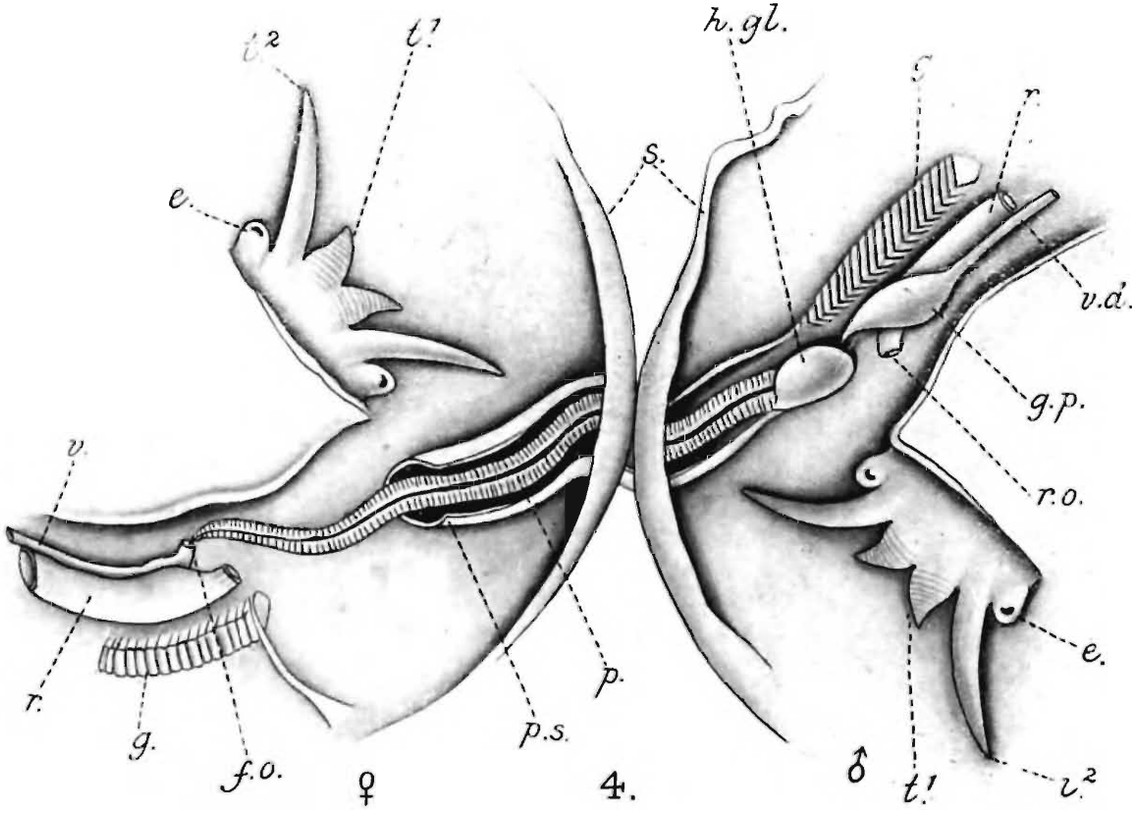


3.



4.

PILA GLOBOSA (SWAINSON).

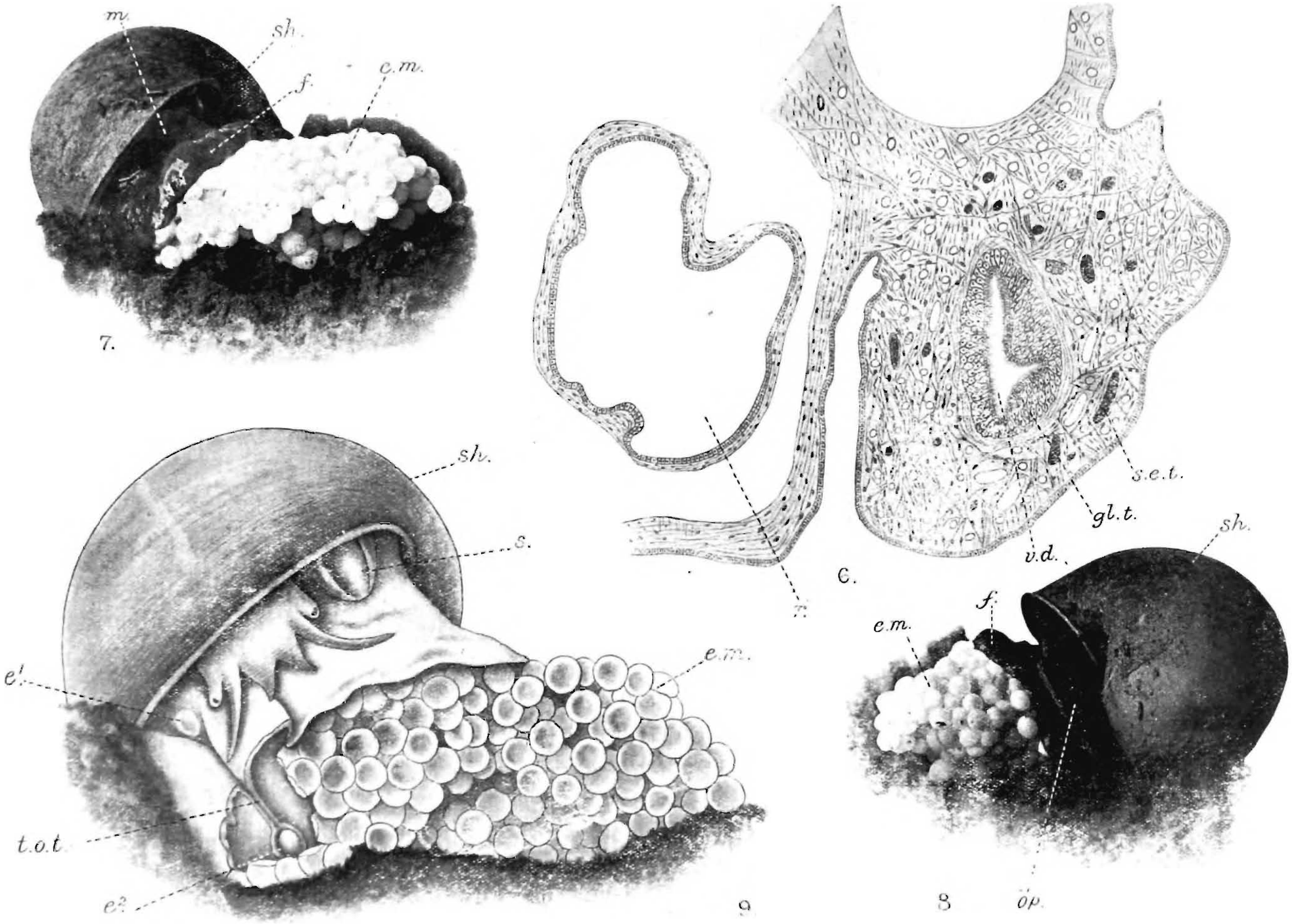
EXPLANATION OF PLATE II.

Fig. 6.—Section through the male papilla of *Pila globosa*, showing its spongy texture. *gl. t.*, glandular tissue immediately surrounding the ciliated vas deferens; *r.*, rectum; *s. e. t.*, spongy and erectile tissue which forms the greater part of the genital gland; *v. d.*, vas deferens. (× 44.)

Fig. 7.—Photograph of a female *Pila globosa* during oviposition, from the right side. *e.m.*, egg-mass; *f.*, foot partially enclosing the eggs; *m.*, mantle-cavity; *sh.*, shell. (Natural size.)

Fig. 8.—Photograph of the same from the left side; *e. m.*, egg-mass; *f.*, foot enclosing the eggs; *op.*, operculum; *sh.*, shell. (Natural size.)

Fig. 9.—Semi-diagrammatic representation of a female *Pila* laying eggs, showing the formation of the temporary oblique tube by the foot for conveying the eggs from the female generative opening to the sole of the foot. e^1., the soft flaccid egg just extruded from the vaginal opening and about to enter into the temporary oblique tube; $e.^2$, the egg as it comes out of the temporary tube on to the sole of the foot to be placed along with other eggs in the egg-mass; *e. m.*, egg-mass; *s.*, siphon; *sh.*, shell; *t. o. t.*, temporary oblique tube formed by the foot on the right side for the conveyance of the eggs. (× cir. 2.)



PILA GLOBOSA (SWAINSON).

REVISION OF THE ASIATIC SPECIES OF THE GENUS *CORBICULA*.

I.—The Indian species of *Corbicula*.

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(Plates III, IV.)

In spite of a number of monographs on the genus *Corbicula* that have been published within the latter half of the last century we are still far from possessing a clear knowledge of the species referred to this genus. The faulty and incomplete descriptions of the earlier authors are a source of constant difficulty and the absence of good figures makes it almost impossible to identify most of the species described by them ; the difficulty is further accentuated by the absence of properly designated types of the species described by various authors. In the case of the Indian species another source of confusion was the mistaken identification of the Indian forms by Chemnitz [1] and following him by later authors with the Müllerian species from China and Central Asia. The earlier authors further paid no heed to the great variation in the form of the shells and their sculpture, and often based new species on specimens of different ages with slightly different types of sculpture or even on differently coloured shells. In the genus *Corbicula* specific differences are not well marked, and the genus, as Blanford [2] rightly remarked, " appears to have been designed by a beneficent Providence for the amusement of species-makers." In this connection reference may be made to the beautifully illustrated monograph of the species of the genus from the province of Nanking and Central China by Heude [3], and which Pilsbry [4] rightly criticised as follows :— " In dealing with the Chinese species, Père Heude has attempted to name every local form, a task I believe to be practically impossible, and if accomplished the result would be absolutely useless to any other zoologist from the impossibility of again recognizing the forms." Haas [5] in speaking of these forms remarked " was aber die Gattung *Corbicula* anbelangt, von der ich viele Hunderte von Stucken vergleichen konnte, so fand ich nur die von unseren einheimischen Cycladiden bekannte Variabilität vor, durch welche eine Grundform, die alte Müllersche *C. fluminea*, oft bis zur Unkenntlichkeit verändert, aber stets durch Zwischenglieder mit der typischen Form verbunden ist. Ich muss demgemäss allen von Heude aufgestellten chinesischen *Corbicula*—Arten die Daseinberechtigung absprechen and kann ausser *V. fluminea* nur eventuell noch *C. largillierti* Phil. als Art anerkennen, da mir Zwischenformen zwischen dieser und jener noch nicht vorkamm." I have recently had a chance of examining most of the co-types or paratypes of Heude's species, and though the sweeping condemnation of Heude's species as suggested by Haas is

[1] Chemnitz, J. H., *Martini und Chemnitz Conch.-Cab.* VI, pp. 319-323 (Nürnberg, 1782).
[2] Blanford, W. T., *Journ. Asiat. Soc. Bengal*, XLIX, pt. ii, p. 222 (1880).
[3] Heude, R. P., *Conch. fluv. Nanking et Chine Centrale*, Fasc. X, pls. i-viii and descriptions (Paris, 1883).
[4] Pilsbry, H. A., *Annot. zool. Japon.* VI, p. 153, footnote (1907).
[5] Haas, F., *Ber. Mus. Natur. u. Heimatkunde Magdeburg*, III (Heft 4), p. 290 (1922).

not borne out by my work, there can be no question that the remarks of Pilsbry and Haas were fully justified. My results of the revision of the Chinese species will be published in a later paper in this series.

The present communication is one of a series, the first paper of which, on the Japanese species of the genus, was published in the " Memoirs of the Asiatic Society of Bengal " in 1924.[1] The delay in the publication of further parts is due to various causes, the main one of which was the getting together of sufficient fresh material and of the old collections for examination. I have now had the advantage of studying the entire collections in the British Museum (Natural History), London; Museum d'Histoire Naturelle, Paris; the Berlin Museum; Zoological Museum, Amsterdam; Stuttgart Museum; Senckenberg Museum, Frankfurt a/Main; Cambridge Museum; and, last but not least, the types in the Zoological Museum of Copenhagen. In addition, the extensive private collections of Monsieur P. Dautzenberg of Paris were generously sent to me for study in Calcutta. For the loans of these collections I have to thank the authorities of the various institutions for their generosity and in this connection I am indebted to Mr. G. C. Robson, Monsieur L. Germain, Dr. J. Thiele, Dr. L. F. deBeaufort and Dr. T. van Benthem Jutting, Dr. O. Buchner, Dr. F. Haas, and Dr. R. Spärck. The collections in the Indian Museum have within recent years been greatly enriched by large accessions obtained by exchange, while large series of fresh specimens have been collected from almost all parts of India, and my thanks are due to my colleagues in the Zoological Survey of India for collecting large series of specimens of the genus while out on survey work in different parts of the country.

Corbicula Meg. von Mühlfeldt.

1774. *Tellina* (in part), Müller, *Verm. Terr. Fluv. etc.*, II, p. 205.
1782. *Venus* (in part), Chemnitz, *Martini u. Chemn. Conch.-Cab.*, VI, p. 319.
1788. *Tellina* (in part), Gmelin, *Linne's Systema Naturae* (ed. 13), p. 3242.
1798. *Cyclas* (in part), Brugiere, *Encyclopéd. Method*, pl. ccci.
1801. *Cyclas* (in part), Lamarck, *Systema. Anim. sans Vertèb.*, p. 123.
1802. *Cyclas* (in part), Bosc, *Hist. Nat. Coquille*, III, p. 35.
1811. *Corbicula*, Megerle von Muhlfeldt, *Mag. Ges. naturf. Fr. Berlin*, V (1), p. 38.
1818. *Cyrena* (in part), Lamarck, *Hist. Nat. Anim. sans. Vertèb.*, V, p. 522.
1820. *Venulites*, Schlotheim, *Petrefac.* p. 200.
1821. *Corbicula*, Férussac, *Tabl. System. Anim. Moll. etc.*, p. xliii.
1825. *Corbicula* (subgenus of *Cyrena*) Blainville, *Man. Malacol.*, p. 552.
1830. *Cyrena* (in part), Deshayes, *Encyclopéd. Method.*, II, p. 49.
1830. *Corbicula*, Menke, *Synop. Method. Moll.*, p. 111.
1835. *Cyrena* (in part), Deshayes in Lamarck, *Hist. Nat. Anim. sans Vertèb.*, VI, p. 273.
1843. *Cyrena* (in part), Hanley, *Cat. Rec. Biv. Shells*, p. 92.
1846. *Corbicula*, Herrmannsen, *Index Gen. Malac.* I, p. 304.
1847. *Corbicula*, Gray, *Proc. Zool. Soc. London*, p. 184.
1854. *Corbicula*, Deshayes, *Cat. Conch. Brit. Mus.*, II, p. 220.
1857. *Corbicula*, Adams, H. & A., *Gen. Rec. Moll.*, II, p. 447.
1860. *Corbicula*, Prime, *Proc. Acad. Nat. Sci. Philadelphia*, XII, p. 267.
1869. *Corbicula*, Prime, *Amer. Journ. Conch.*, V, p. 127.

[1] Prashad, B., *Mem. Asiat. Soc. Bengal*, VI, pp. 523-529, pl. xxii (1924).

1872. *Corbicula*, Clessin, *Malakozool. Blätt.*, XIX, p. 160.
1877. *Corbicula*, Clessin, *Martini u. Chemn. Conch.-Cab.* (n. f.), *Cycladeen*, p.129.
1877. *Cyrena* (in part), Sowerby, *Conch. Icon.*, XX.
1884. *Corbicula*, Tryon, *Str. Syst. Conch.*, III, p. 185.
1887. *Corbicula*, Fischer, *Man. Conchyliol.*, p. 1091.
1891. *Corbicula*, von Martens, Weber's *Zool. Ergebn. Niederländ Ost.-Ind.*, IV, p. 108.
1903. *Corbicula*, Dall, *Trans. Wagner Free Inst. Sci. Philadelphia*, III, p. 1448.
1915. *Corbicula*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, p. 210.
1920. *Corbicula*, Prashad, *Rec. Ind. Mus.*, XVIII, p. 209.
1922. *Corbicula*, Germain, *Moll. terr. fluv. Syrie*, II, p. 92.
1927. *Corbicula*, Pilsbry & Bequaert, *Bull. Amer. Mus. Nat. Hist.*, LII, p. 185.

The above synonymy of the genus *Corbicula* includes references to most of the important works on the genus ; other references of minor importance will be found in the works cited. The genus was established by Megerle von Mühlfeldt in 1811[1], but, as is clear from the literature cited above, it was ignored by most workers till Férussac referred to it in 1820. It was, however, not till Gray's monumental work on the genera of Mollusca in 1847 that the genus was generally adopted.

Most of the earlier work on the genus consisted in the description of new species, and only in two cases attempts have been made to divide the species into groups or sections. The first of these is the work of von Martens, who when dealing with the molluscs of the East Indian Archipelago classified several of the Asiatic and Australian species of the genus into groups. The groups were based on external form and were, as he stated, " in dieser Gattung lassen sich hauptsachlich nach den aussern Umriss mehrere Artengruppen unterscheiden, welche sich in verscheidenen geographischen Gebieten wiederholen." These groups he called (i) Transversae, (ii) Tumidae, (iii) Triangulares, (iv) Subaequilaterae, and (v) Debiles. The groups run into each other and it is not always easy to assign species to the different groups. The groups are quite artificial and their definitions are not detailed enough to be of much value. It may also be noted that von Martens did not include in the above groups the large smooth-shelled form which up till now has been known as *C. woodiana* Lea which is confined to China, nor the South American Corbiculidae.[2]

The second attempt was that of Dall,[3] who in connection with his studies on the Tertiary Fauna of Florida suggested sections for both the recent and the fossil members of the genus. I will here consider only the sections suggested for the recent forms. He divided the genus *Corbicula* into subgenera as follows :— (i) the subgenus *Corbicula* for all the recent and fossil forms of the Old World, and including a fossil section—*Veloritina* Meek—from Bear River Cretaceous of Wyoming, North America, and (*ii*) the subgenus *Cyanocyclas* Férussac for the recent forms found in Central America, Mexico and South America. The subgenus *Corbicula*, in the case of the recent species, was further subdivided into three sections, (i) *Corbicula s.s.* with *C. fluminalis* (Müller) as its type and with the characters of

[1] Benson's name *Corbicula* which is referred to in Chenu, *Man. Conchyliol.*, II, p. 85 (1847), and in Tryon, *Str. Syst. Conch.* III, p. 177 (1884) is apparently a *nomen nudum* and was, so far as I can find, never published. In any case it is a synonym of *Cytherea* and has nothing to do with the genus under consideration.

[2] The subgeneric name for the American Corbiculidae is *Cyanocyclas* Férussac [*Dict. Sci. Nat.*, XII, p. 280 (1818)], and not *Leptosiphon* Fischer or *Polymesoda* Rafinesque as suggested by von Martens (*l. c.* p. 111).

[3] Dall, W. H., *Trans. Wagner Free Inst. Sci.*, III, pt. VI, pp. 1448-1450 (1903).

the genus, (ii) *Corbiculina* Dall with *Corbicula angasi* Prime as the type, and apparently differing from *Corbicula s.s.* in the very fine sculpture of the shell, the short nymphs with their opposing surfaces granulate and the very oblique cardinal teeth; the section was stated to have a wide distribution in India, Java, Madagascar and Australia; and (iii) *Cyrenodonax* Dall with *C. formosana* Dall as type, and characterized by its thin smooth shell, anterior end of the shell much larger than the posterior, and beaks situated in the posterior third. The section is monotypic and is based on a single species found at the mouth of the Tamusi River in Formosa.

In the present paper I have not attempted to refer the Indian species to any groups or subgenera, and propose leaving this over till my revision of all the Asiatic forms is completed.

The earliest reference to the Indian Corbiculas is by Chemnitz,[1] who in 1782 recorded under the name *Venus fluviatilis* a species from the streams of the Cormandel Coast; this, as is discussed below, is not the Müllerian *Corbicula fluviatilis*, but *C. striatella* Deshayes. I will not refer here in detail to the question of the synonymy of the Müllerian species, as I am dealing with them in another paper. It may, however, be noted that this inclusion of the Chinese species in the Indian list by Chemnitz was responsible for the greater part of the confusion in the synonymy and in our knowledge of the geographical distribution of the various Asiatic species. Philippi [2] in 1847 not only perpetuated the mistake of Chemnitz, but by his haphazard treatment of the Müllerian species introduced further confusion. Deshayes,[3] in 1854, was the first to describe the true Indian species of the genus. He described far too many species, a number of which have now to be included in the synonymy of his own forms, but probably with the small amount of material before him and the tendency of the times to consider small variations in shape, form or colour as specific differences, nothing else was to be expected. Prime in the years 1860-1869 in his well-known works on the Corbiculidae[4] described or figured a number of new species and collected together all the earlier references in his catalogues; unfortunately, however, the work was not critical and is not of great value. The Indian species were figured in Hanley & Theobald's Conchologia Indica[5] in 1875-76 and by Sowerby in Reeve's 'Conchologia Iconica'[6] in 1877. In 1877-78 the species were monographed by Clessin[7] in his work in the Conchylien Cabinet; this work is very unsatisfactory, and in spite of reference to Clessin's originals I have found it impossible in many cases to clear up some of the confusion created by him. His separate paper in 1887[8] on some new species is also far from satisfactory and shows a lack of critical detail. His descriptions and figures seldom tally and only in exceptional cases do the figures represent the shells figured. Blanford[9] in 1880, and von Martens[10] in 1899, each described a new species of *Corbicula* from the Indian area but did not deal with the other species.

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[1] Chemnitz, J. H., *Martini u. Chemnitz-Conch. Cab.*, VI, pp. 319-323 (Nürnberg, 1782).
[2] Philippi, R. A., *Abbild. Beschreib. Conch.*, II, pp. 75-77 (Cassel, 1847).
[3] Deshayes, G. P., *Cat. Conch. Brit. Mus.*, II, pp. 223, 224 (London, 1854).
[4] Prime, T., *Amer. Journ. Conch.*, V, pp. 127-138 (1869). References to his earlier papers are included in this monograph.
[5] Hanley, S. & Theobald, W., *Conch. Indica*, pp. 55, 62, pls. cxxxviii, clv (London, 1875-76).
[6] Sowerby, G. B., *Reeve's Conch. Iconica* XX, (under *Cyrena*) (London, 1877).
[7] Clessin, S., *Martini u. Chemn. Conch.-Cab.* (n. f.) *Cycladeen* (Nürnberg, 1874-79).
[8] Clessin, S. *Mal. Blätt.* (n.f.) IX, pp. 67-80, pls. i, iii (1887).
[9] Blanford, W. T., *Journ. As. Soc., Bengal*, XLIX, pt. ii, pp. 221, 222 (1880).
[10] von Martens, E., *Archiv. Naturgesch.* LXV, p. 47, pl. iv, figs. 7-9 (1899).

Preston's[1] treatment of the Indian species in 1915 in the 'Fauna of British India' was no improvement, while a number of the new species of the genus described by him do not belong to it. In his account Preston included the following 28 species from the Indian area :—*C. fluminalis* (Müller) with var. *holstiana* Schlesh, *C. fluminea* (Müller), *C. fluviatilis* (Müller), *C. parvula* Prime, *C. agrensis* Prime, *C. subradiata* Prime, *C. cashmiriensis* Deshayes, *C. trigona* Deshayes, *C. striatella* Deshayes, *C. huttoniana* Clessin, *C. subnitens* Clessin, *C. solida* Clessin, *C. nevilli* Clessin, *C. occidens* Deshayes, *C. iravadica* Blanford, *C. regularis* Prime, *C. bengalensis* Deshayes, *C. bensoni* Deshayes, *C. consanguinea* Prime, *C. sylhetica* Preston, *C. quilonica* Benson, *C. alberti* Preston, *C. inflata* Clessin, *C. picta* Clessin, *C. indica* Clessin, *C. regia* Clessin, *C. noetlingi* von Martens and *C. arata* (Sowerby), and in this work he did not refer to his new species *C. tribeniensis*[2] which he had described in 1911.

In revising the Indian species I find that *C. fluminalis* (Müller) occurs within the limits of the Indian Empire only in Northern Baluchistan[3] and may for the present account be left out of consideration ; I propose dealing with it later in the account of the Palaearctic species of Central Asia, etc. The var. *holstiana* Schlesh is wrongly referred to this species ; it is only a synonym of the widely distributed Indian species *C. striatella* Deshayes (*vide infra* p. 19). *C. fluminea* (Müller) with *C. fluviatilis* (Müller) as a synonym is a Chinese species and does not occur in India. *C. parvula* Prime, *C. agrensis*, Prime, *C. subradiata* Prime, *C. trigona* Deshayes, *C. huttoniana* Clessin, *C. nevilli* Clessin, *C. occidens* Deshayes, *C. regularis* Prime, *C. bengalensis* Deshayes and *C. consanguinea* Prime are synomyms of *C. striatella* Deshayes ; probably *C. indica* is also to be included in the synonymy of this species (*vide infra* p. 19). *C. regia* Clessin is not an Indian species ; it was described by Clessin from a specimen in the Paetel collection and was stated to be probably from India. Benson's original lot of this species, which I have seen, and from which Paetel's specimens came, are, however, all from Penang, Malay Peninsula. *C. quilonica* Benson[4] is not a *Corbicula* and is based on young shells of *Villorita cyprinoides* var. *cochinensis* (Hanley). In 1916 Preston[5] described a new species *Corbicula cochinensis* from Cochin backwaters. I have examined the type and large numbers of specimens of this supposed species and find that it is based on young shells of *Villorita cyprionoides* var. *cochinensis* (Hanley). I am unable to offer any remarks about *C. alberti* Preston, *C. inflata* Clessin and *C. picta* Clessin, as I have not succeeded in tracing the types of these species, and the descriptions and figures are far from satisfactory ; the species are certainly not Indian. No reference is necessary to Preston's *Corbicula* (*Velorita*) *satparaensis*[6] from the Chilka Lake, for, as the author himself later[7] pointed out, the species was based on worn shells of *Meretrix casta* (Chemn.).

In the following account I describe three new Indian species as *C. annandalei*, *C. assamensis* and *C. peninsularis*, and recognize as valid *C. striatella* Deshayes, *C. cashmiriensis*

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[1] Preston, H. B., *Faun. Brit. Ind. Freshw. Moll.* pp. 210–223 (London, 1915).
[2] Preston, *Rec. Ind. Mus.* VI, p. 40, fig. 3 (1911).
[3] See Annandale & Prashad, *Rec. Ind. Mus.* XVIII, p. 58 (1921).
[4] Prashad, B., *Rec. Ind. Mus.* XXII, p. 116 (1921).
[5] Preston, H. B., *Rec. Ind. Mus.* XII, p. 36, figs. 12, 12*a*, 12*b* (1916).
[6] Preston, H. B., *Rec. Ind. Mus.*, X, pp. 306, 307, figs. 22, 22*a* (1914).
[7] Preston, H. B., *Rec. Ind. Mus.* XI, p. 300 (1915).

Deshayes, *C. bensoni* Deshayes, *C. sylhetica* Preston, *C. noetlingi* von Martens, *C. arata* (Sowerby), *C. iravadica* Blanford, *C. solida* Clessin and *C. subnitens* Clessin from within the limits of India and Ceylon.

Corbicula striatella Deshayes.

(Pl. III, figs. 9—11.)

1782. *Venus fluviatilis*, Chemnitz (*nec* Müller) *Martini u. Chemn. Conch.-Cab.* VI, pl. xxx, fig. 321.

1854. *Corbicula striatella, C. Bengalensis*, and *C. trigona*, Deshayes, *Proc. Zool. Soc. London*, p. 344.

1854. *Corbicula occidens, C. Bengalensis, C. striatella* and *C. trigona*, Deshayes, *Cat. Conch. Brit. Mus.*, II, pp. 223, 224.

1857. *Corbicula occidens, C. Bengalensis, C. striatella, C. trigona* and *C. rivalis* (Adams, *nec* v.d. Busch, *non* Deshayes), Adams, H. & A., *Gen. Rec. Moll.*, II, pp. 447, 448.

1860. *Corbicula occidens*, Theobald, *Cat. Rec. Shells Mus. A. S. B.*, p. 140.

1860. *Cobicula Bengalensis, C. occidens C. rivalis* (in part), and *C. trigona*, Prime, *Proc. Acad. Nat. Sci. Philadelphia*, pp. 268, 272, 273, 274.

1860. *Corbicula regularis*, Prime, *Proc. Zool. Soc. London*, p. 321.

1861. *Corbicula parvula* [1], *C. subradiata, C. violacea* and *C. Agrensis*, Prime, *Proc. Acad. Nat. Sci. Philadelphia*, pp. 127, 128.

1863. *Corbicula Agrensis, C. occidens, C. parvula, C. regularis, C. striatella, C. subradiata, C. trigona* and *C. violacea*, Prime, *Cat. Corb.*, pp. 3, 4.

1863. *Cyrena occidens*, Hanley, *Photographic Conch.* pl. vi, fig. 5.

1864. *Corbicula striatella, C. subradiata, C. Agrensis* and *C. parvula*, Prime, *Ann. Lyc. Nat. Hist. New York*, VIII, pp. 74-76, figs. 22-25.

1866. *Corbicula occidens, C. Bengalica* and *C. trigona*, Prime, *op. cit.*, p. 220, figs. 51-53 and p. 221.

1867. *Corbicula consanguinea*, Prime, *op. cit.*, p. 417.

1869. *Corbicula Bengalica, C. consanguinea, C. imperialis, C. occidens, C. parvula, C. regularis, C. striatella, C. subradiata* and *C. trigona*, Prime, *Amer. Journ. Conch.*, V, pp. 128-137.

1872. *Corbicula occidens*, Mörch, *Journ. Conchyliol.*, XX, p. 342.

1875. *Corbicula occidens, C. striatella, C. Bengalensis* and *C. trigona*, Hanley and Theobald, *Conch. Ind.* pp. V, 55, 62, pl. cxxxviii, figs. 7-10, pl. clv, figs. 6, 7.

1876. *C. agrensis, C. consanguinea, C. Bengalica, C. imperialis, C. occidens, C. parvula, C. striatella, C. trigona* and *C. violacea*, Theobald, *Cat. Land. Freshwater Shells Brit. Ind.*, pp. 44, 45.

1877. *Cyrena occidens, C. trigona, C. striatella, C. Bengalensis* and *C. regularis*, Sowerby, *Conch. Icon.* XX, pl. xi, fig. 48, pl. xiii, fig. 48b ; pl. xi, fig. 43 ; pl. xi, fig. 49 ; pl. xi, fig. 50 ; pl. xv, fig. 76.

1877. *Corbicula bengalica* and *C. occidens*, Clessin in *Martini u. Chemn. Conch.-Cab.* (n. f.) Cycladeen, pl. 138, 139, 150, pl. xxvi, fig. 18.

1878. *Corbicula striatella, C. subradiata, C. parvula, C. agrensis, C. violacea* (*nec* Prime), *C. consanguinea, C. imperialis* and *C. trigona*, Clessin, *op. cit.*, I, p. 150, pl. xxxi, fig. 18 ; p. 167, pl. xxx, fig. 20 ; p. 174, pl. xxx, fig. 21 ; p. 174, pl. xxx, fig. 22 ; p. 175, pl. xxx, fig. 23 ; p. 180, pl. xxx, figs. 18, 19 ; p. 199 ; p. 203.

1883. *Corbicula Bengalensis, C. occidens* and *C. subradiata*, Paetel, *Cat. Conch.*, pp. 216, 217.

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[1] Clessin's reference under this species of Philippi's [*Abbild. Beschreib. Conch.*, II, p. 78, pl. i, fig. 7 (1846)] in *Martini u. Chemn. Conch.-Cab.* is certainly incorrect ; the description and figure in Philippi's work are of *C. pusilla* Parreyss.

1887. *Corbicula nevilli* and *C. huttoniana*, Clessin, *Mal. Blätt.* (n. f.) IX, pp. 70, 71 ; 77, 78 ; pl. ii, fig. 5 ; pl. iii, fig. 5.

1890. *Corbicula Bengalica, C. consanguinea, C. imperialis, C. occidens, C. parvula, C. secaduilabris,*[1] *C. striatella* and *C. subradiata*, Paetel, *Cat. Conch. Samm.* III, pp. 100-104.

1908. *C. fluminalis* Müll. var. *holstiana*, Schlesh, *Rec. Ind. Mus.* II, p.108.

1915. *Corbicula parvula, C. agrensis, C. subradiata, C. trigona, C. striatella, C. huttoniana, C. nevilli, C. occidens, C. regularis, C. bengalensis, C. consanguinea* and *C. alberti*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, pp. 212-220.

1921. *Corbicula occidens, C. striatella* and *C. subradiata*, Prashad, *Rec. Ind. Mus.*, XXII, pp. 612-614, fig. 32.

The above synonymy[2] is based on a careful examination of the types or authentically named specimens of the various species, and very large series of named and unnamed shells in the Indian Museum and other collections. In a few cases only, where it has not been possible to secure the types or authentically named material, I have had to rely on the figures and descriptions of these species.

The species has a very wide distribution and the shells from different areas appear very different in shape. It is this variation in form and shape, which changes to some extent with the age of the specimens, that is responsible for the large number of so-called distinct species included in the synonymic list given above. Various species, like *C. agrensis* Prime, *C. subradiata* Prime, *C. bengalensis* Deshayes, *C. parvula* Prime, *C. violacea* Prime, *C. nevilli* Clessin and *C. huttoni* Clessin, are all based on young shells of different ages, while *C. occidens* Desh., *C. trigona* Desh., *C. consanguinea* Prime, and *C. regularis* Prime appear to have been described from shells which only differ slightly in shape.

C. fluminalis (Müller) var. *holstiana* Schlesh also appears to me to be based on large sized specimens of this species. I have not been able to examine any named material of this variety, but specimens from the type-locality and other parts of the North-West Frontier Province, which I have seen, are all true *C. striatella*.

The species may be redescribed as follows :—

Shell thick, of large size, triangular-ovate in young to almost ovate-rounded in full-grown shells ; of a shining lemon yellow colour in young ; full-grown shells are much darker and often brownish. Upper margin arched, much more so anteriorly than posteriorly ; this becomes specially marked in full-grown specimens ; anterior side more produced than the posterior, regularly rounded ; posterior side broadly rounded in young shells, distinctly truncated in full grown specimens. Shells somewhat tumid with prominent umbones which appear very marked in older shells. Surface glossy with raised, concentric and regular ridges ; in full-grown shells the ridges on the posterior part of the shell become indistinct. Hinge strongly developed ; anterior cardinals longer and more arched than the posterior ;

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[1] Benson did not describe any species under this name, but I have seen specimens labelled as such and apparently distributed by Benson ; they are specimens of *C. striatella*.

[2] In addition to the forms included above I am of opinion that *C. mediocris* Prime which was described from specimens of unknown provenance [*Ann. Lyc. N. H. New York* VII, 481 (1862) and *id.* VIII, p. 414, fig. 68 (1867)], but later believed by Prime to have come from India [*Amer. Journ.-Conch.* V, p. 133 (1869)], is also probably synonymous with *C. striatella*. I have seen two specimens labelled as *Corbicula indica* Clessin in Dautzenberg collection from Calcutta. The species was described by Clessin [*Martini u. Chemn. Conch.-Cab.* pp. 143, 144, pl. xxv, figs. 21-23, 1877] as from " Ost-Indien." The specimens agree with Clessin's descriptions and figures. They are only full-grown shells of *C. striatella*. I have not succeeded in tracing the type of *C. indica* in any collection.

nymphal area prominent, broad and distinctly roughened. Muscle scars fairly deeply impressed and impinging on the cardinal teeth ; pallial line with a trace of a sinus. Interior of shell whitish or light purple in young to bluish purple in full-grown shells, somewhat irridescent. I give below the measurements of a series of large shells from Calcutta.

Measurements in millimetres.

Length ..	..	..	36	33·8	33·2	26·5	25·8
Maximum height ..	..	..	33·3	31·5	31·3	24·2	23
Thickness ..	..	..	21·7	21	19·5	16	14·7

Distribution.—This is the commonest Indian species of the genus and occurs practically all over India, from Peshawar in the north to Pondicherry and lower down south in the Madras Presidency and from Sindh in the north-west to Assam[1] ; it is also found in Burma. Deshayes's type-series consists of young shells only.

Corbicula cashmiriensis, Deshayes.

(Pl. III, figs. 14—18.)

1854. *Corbicula Cashmiriensis*, Deshayes, *Proc. Zool. Soc. London*, p. 344.
1854. *Corbicula Cashmiriensis*, Deshayes, *Cat. Brit. Mus. Conch.* II, p. 224.
1857. *Corbicula Cashmiriensis*, Adams, H. & A., *Gen. Rec. Moll.*, II, p. 447.
1860. *Corbicula Cashmiriensis*, Prime, *Proc. Acad. Nat. Sci. Philadelphia*, p. 269.
1869. *Corbicula Cashmiriensis*, Prime, *Amer. Journ. Conch.* V, p.129.
1875. *Corbicula Cashmirensis*, Hanley & Theobald, *Conch. Ind.* pp. v., 55, pl. cxxxviii, figs. 2, 3.
1876. *Corbicula Kashmirensis*, Theobald, *Cat. Land. Freshw. Shells Brit. Ind.*, p. 45.
1877. *Cyrena Cashmiriensis* (in Index *Cashmierensis*), Sowerby, *Conch. Icon.* XX, *Cyrena*, pl. xiii, fig. 60.
1877. *Corbicula Cashmirensis*, Clessin, in *Martini u. Chemn. Conch.-Cab.* (n.f.) *Cycladeen*, p. 166, pl. xxix, figs. 17, 18.
1883. *Corbicula Cashmiriensis*, Paetel, *Cat. Conch. Samm.*, III, p. 100.
1915. *Corbicula cashmirensis*, Preston, *Faun. Brit. Ind. Freshw. Moll.* pp. 213, 214.

The name of this species has been variously spelt, but the correct name, as originally published by Deshayes, is *C. cashmiriensis.*

The description of the species by Deshayes and by Sowerby is fairly complete, and it is only necessary to add a few notes to it.

The shell is somewhat triangular, the upper margins sloping and almost straight on the two sides of the medially situated umbones, the ventral margin is evenly arched. The specimens vary greatly in form, the younger and half-grown shells are not much broader than high and the ventral margin is greatly arched, but full-grown specimens are very much broader than high, and as a result the dorsal slopes are less steep and the ventral margin is also less arcuate ; the posterior side is drawn into a distinct beak which is truncated. The ribbing is very regular on the younger parts of the shell, with the ribs very prominent and regular ; on the older parts of the shell, however, the ribs are more closely placed, somewhat irregular, not so raised, and are quite indistinct on the posterior beak portion of the shell. The hinge is broad and strongly developed ; the nymphs are narrow and almost

[1] The species was also recorded as *Corbiculla (sic) occidens* and *C. ? sp. nov.* by Dalgliesh [*Journ. Bombay Nat. Hist. Soc.* XVII, p. 956 (1907)] from Tirhoot, Bengal.

smooth. The muscle scars are distinct but not deeply impressed, and the pallial line is without any sinus.

Measurements in millimetres.

Length	42·3	41·6	32·1	30·5	26·8	22·7	
Maximum breadth	33·2	33·4	26·4	25·8	22·2	18·8	
Height	25	22·2	17·5	15·6	14·4	17·6	

Distribution.—The species is confined to Kashmir and occurs in the River Jhelum and the waters connected with it. Preston, following the notes in "Conchologia Indica," stated that the species has also been recorded from Baluchistan and Avantipura. The first record is probably based on specimens of *C. fluminalis* (Müller), while the second is certainly incorrect; I have not seen any specimens from Ceylon which could be referred to this species.

Remarks.—The species is allied to *C. fluminalis* (Müll.), but is distinguished by the umbones being much less tumid, not meeting in the middle and not curving forwards, by the different type of hinge and the form of the shell.

Corbicula peninsularis, sp. nov.

(Pl. IV, figs. 13—16).

Shell of a large size, thick, triangular-oval; of a light chocolate-brown or even darker colour; young shells much lighter, almost lemon yellow. Surface very glossy, with broad, shallow ribs concentrically and regularly arranged; interspaces very narrow, almost linear and not at all deeply impressed, scarcely distinguishable in the lunular region; escutcheon with fine ridges, almost like minute striae. Upper slope very convex; anterior margin evenly curved and only slightly projecting; posterior side drawn out into a regular beak-like structure formed by the sudden bending up of the ventral border in its posterior third and becoming almost straight before reaching the posterior side; in some specimens, particularly half-grown individuals, the beak is not distinctly marked. Umbones prominent, tumid, somewhat curved inwards and forwards with, in fresh uneroded shells, deep ribs. Pallial line distinctly notched, much more so than in any other Indian species, muscle scars distinct, but not deeply impressed. Hinge strongly developed with the anterior laterals distinctly shorter than the posterior. Nacre shining white, sometimes with a bluish tinge.

Measurements in millimetres.

	Holotype.					
Length	29·8	27·4	26	23·5	20·6	19·5
Maximum breadth	24·5	23	23·2	21·8	19·4	18·9
Thickness	17	16·8	15·1	14·2	13·2	12·8

Holotype.—No. M $\frac{12833}{2}$ in the collections of the Zoological Survey of India (Indian Museum), Calcutta.

Distribution.—The species is represented by a good series from Bombay in the collections of the Zoological Survey of India. I have also examined a good series from the same place in the collections of the Museum d'Histoire Naturelle, Paris.

Remarks.—The species comes near *C. striatella* Deshayes, but is distinguished by its shape, much thicker shell and sculpture.

Corbicula annandalei, sp. nov.

(Pl. IV, figs. 11, 12.)

Shell rather thin, of small size, somewhat trigonal and of a shining light yellow colour, traces of brown are present on the posterior third of the shell. Upper margin sloping steeply, more so on the anterior than on the posterior side ; lower margin only slightly arched ; anterior side somewhat produced, narrow and regularly rounded ; posterior side comparatively short, somewhat truncate but regularly curved, and not forming a beak. Umbones prominent, greatly inflated and curved forwards. The glossy surface of the shell is sculptured with very minute, regular and concentric striae ; these become almost microscopic on the posterior third of the shell. Hinge very feeble, hinge-teeth normally developed ; nymphs very narrow, almost smooth. Muscle scars very shallow ; pallial line without any trace of a sinus. Interior of shell shining white, with traces of violet in the posterior third of the shell.

Measurements in millimetres.

	Holotype.	Paratype.
Length ..	14	11
Maximum height	12	10
Thickness	7·8	6·9

Holotype.—No. M. $\frac{5253}{1}$ in the collections of the Zoological Survey of India (Indian Museum), Calcutta.

Distribution.—Two shells of this interesting species were collected by the late Dr. N. Annandale from Vorkalay, Tranvancore State, South India ; these are the only specimens which I have seen.

Remarks.—The species is quite distinct from all other known Indian species of the genus, and is easily distinguished by the thin shell, its shape and the sculpture. The hinge is also different.

Corbicula assamensis, sp. nov.

(Pl. III, fig. 12).

Shell comparatively thin, of small size, ovate or triangular-oval in outline, of a shining light yellow colour with traces of light blue shining through the periostracum, posterior slope dirty yellow. Upper margin regularly arched, convex ; anterior side short and rounded ; posterior broad and distinctly truncate ; lower margin regularly arched in the anterior two-thirds after which it suddenly curves up to end in the truncated beak of the posterior side. Umbones not prominent, only slightly marked, eroded. Surface finely striated with distinct but not deep striae running regularly and concentrically. Hinge feebly developed, hinge-teeth normal ; nymphs narrow and almost smooth. Muscle scars distinct and fairly impressed ; pallial line without any sinus. Interior of shell dirty white with distinct traces of blue.

Measurements in millimetres.

	Holotype.	Paratype.
Length	12·2	9
Maximum height	10	7
Thickness	6·3	4·5

Holotype.—No. M. $\frac{3986}{1}$ in the collections of the Zoological Survey of India (Indian Museum), Calcutta.

Distribution.—The only two specimens, which I refer to this species, are from Assam; the holotype is from Phenchoogang Sylhet, Assam, while the exact provenance of the paratype is not known.

Remarks.—I have carefully compared the specimens described above as *C. assamensis* with all the known Indian species of the genus, but find them to be distinct. The species is allied to *C. striatella* Deshayes, but is distinguished by its thin shell, feebly developed sculpture, the hinge and the general form of the shell.

Corbicula bensoni Deshayes.

(Pl. IV, figs. 1—4.)

1854. *Corbicula Bensoni*, Deshayes, *Proc. Zool. Soc. London*, p. 345.
1854. *Corbicula Bensoni*, Deshayes, *Cat. Conch. Brit. Mus.*, II, p. 223.
1857. *Corbicula Bensoni*, Adams, H. & A., *Gen. Rec. Moll.* II, p. 447.
1860. *Corbicula Bensoni*, Prime, *Proc. Acad. Nat. Sci. Philadelphia*, XII, p. 268.
1869. *Corbicula Bensoni*, Prime, *Amer. Journ. Conch.*, V, p. 128.
1875. *Corbicula Bensoni*, Hanley & Theobold, *Conch. Ind.*, pp. v, 55, pl. cxxxviii, figs. 1, 4.
1876. *Corbicula Bensoni*, Theobald, *Cat. Land Freshw. Shells. Brit. Ind.*, p. 44.
1877. *Cyrena Bensoni*, Sowerby, *Conch. Icon.*, XX, *Cyrena*, pl. xi, fig. 44.
1878. *Corbicula Bensoni*, Clessin in *Martini u. Chemn. Conch.-Cab.* (n. f.) *Cycladeen*, p.198.
1883. *Corbicula Bensoni*, Paetel, *Cat. Conch.* p. 216.
1890. *Corbicula Bensoni*, Paetel, *Cat. Conch. Samm.*, III, p. 100.
1911. *Corbicula tribeniensis*, Preston, *Rec. Ind. Mus.* VI, p. 40, fig. 3.
1915. *Corbicula bensoni*, Preston, *Faun.. Brit. Ind. Freshw. Moll.*, p. 218.

Deshayes's description of this species is fairly complete, and it will be enough to refer to its distinguishing features. The shape is sub-trigonal, transversely ovate, and the thin shell with its very fine, almost microscopic striations distinguish it from all other species. All the specimens which I have examined are from the Ganges system round about Calcutta, except for a few specimens from Bhagalpore, Bihar, and one series from Chittagong, East Bengal. The species has also been recorded from the River Jumna, but I believe this to be a mistake.

Preston described some shells from Tribeni near Calcutta as a new species, *C. tribeniensis*, in 1911, but did not include it in his account of the genus in the "Fauna" Volume. I have examined the type and the cotypes and find that they are all specimens of *C. bensoni*.

Corbicula sylhetica Preston.

(Pl. IV, figs. 5, 6.)

1908. *Corbicula sylhetica*, Preston, *Rec. Ind. Mus.*, II, pp. 47, 48.

1915. *Corbicula sylhetica*, Preston, *Faun. Brit. Ind. Freshw. Moll.* pp. 218, 219.

Preston's description of the species is fairly complete and I have nothing to add to it. The species is closely allied to *C. bensoni* Deshayes and *C. iravadica* Blanford, but is distinguished by the shell being almost equilateral, very tumid, rather thicker than in these two species, and the striae still more minute.

I give below the measurements (*in millimetres*) of some specimens :—

Length	12	11	10·3	10	9	7·2
Maximum breadth	11·2	9·8	8·7	8·5	7·3	6
Thickness	8·8	9	6·2	5·7	5	4·3

Distribution.—All the specimens of this species, which I have seen, are from Phenchooganj, Sylhet, Assam.

Corbicula noetlingi v. Martens.

(Pl. IV, figs. 21—25.)

1899. *Corbicula regularis*, v. Martens (*nec* Prime), *Arch. Naturgesch.*, pp. 1, 46.

1899. *Corbicula Nötlingi*, v. Martens. *Arch. Naturgesch.*, p. 47, pl. iv, figs. 7-9.

1915. *Corbicula noetlingi*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, p. 222.

1918. *Corbicula noetlingi*, Annandale, *Rec. Ind. Mus.*, XIV, pp. 141, 142, pl. xix, fig. 12.

The description of the species by von Martens is not complete, and his comparison of the form of the shell as " von Gestalt einer venus oder eine Tapes " is rather unfortunate. The shells are very variable in form, almost subtriangular to elongate-ovate, and have the same shape as most other species of the genus.

The species may be redescribed as follows :—

Shell elongate-ovate, sometimes subtrigonal, moderately inflated, narrowly truncate and compressed posteriorly, broadly rounded anteriorly ; upper margin greatly arched anteriorly, posteriorly nearly straight and only slightly sloping ; ventral margins slightly arched. Umbones prominent but not very inflated, situated in the anterior half, pointing forwards and inwards. Anterior and posterior ridges only feebly developed, neither prominent. Sculpture consisting of numerous distinctly raised concentric ridges ; these become obsolete on the older parts of the shell particularly in the posterior half ; the interspaces between the ridges about 3-4 times as broad as the ridges. Colour olive-yellow to brown or even black, much darker in older than in young shells. Interior purple to violet ; hinge area much lighter. Pallial line and adductor muscle scars feebly impressed. Hinge teeth as in the genus, except that the anterior lateral of the right valve is greatly compressed and curved by the anterior adductor muscle scar impinging on it. Nymphs finely roughened.

Measurements in millimetres.

	He-Ho.			Bhakmio.			Meungyaw.						
Length	14·3	18·7	20·1	20·3	25·4	27·3	27·8	30·5	30·6	31·5	31·5	34·7	32·5
Maximum breadth ..	11·9	14·7	15·3	17·2	20·2	22·4	24·2	24·6	23·2	24·6	24·6	26·8	25·7
Thickness	8·2	9·8	10	12	14·1	14·5	14·8	17·4	16·5	17·2	17·2	16·5	17·6

Distribution.—The species was described by von Martens from a small pool near Hpaung in the Northern Shan States. Since then Annandale referred specimens from the Southern Shan States to the same species and I have seen a fair number of shells from other areas. The species appears to be widely distributed in the Northern and Southern Shan States, Burma.

Remarks.—There can be little doubt that, as von Martens pointed out, the shells of unknown provenance figured by Sowerby[1] in Conchologia Iconica as *Cyrena Moussoniana* is not Deshayes's species *Corbicula Moussoni* from Java, but it is impossible to be certain whether it is the same as was described by von Martens as *C. noetlingi* from Upper Burma. As will be seen from the synonymy given above von Martens's specimens, which he referred to *C. regularis*, are also to be included here.

Corbicula iravadica Blanford.

(Pl. IV., figs. 7—10.)

1876. *Corbicula Iravadica* (Blanford *mss.*) Hanley & Theobald, *Conch. Ind.* pp. v, 62, pl. clv, fig. 8.

1876. *Corbicula Iravadica* (=*C. pisum*) and *C. pisum*, Theobald, *Cat. Land Freshw. Shells Brit. Ind.*, pp. ii, 45.

1880. *Corbicula iravadica* Blanford, *Journ. As. Soc. Bengal*, XLIX, pp. 221, 222.

1889. *Corbicula irawadica*, T. Canefri, *Ann. Mus. Civ. Stor. Genova*, (2) VII, p. 355.

1890. *Corbicula Iravadica*,[2] Paetel, *Cat. Conch. Samm.* III, p. 102.

1899. *Corbicula irawadica*, von Martens, *Arch. Naturgesch.* pp. 47, 48.

1915. *Corbicula iravadica*, Preston, *Faun. Brit. Ind. Freshw. Moll.* pp. 216, 217.

As is clear from the synonymy given above, the species was not described by Blanford till 1880, though it was referred to in literature much earlier as *C. iravadica* and *C. pisum*; two names under which it was indiscriminately distributed by the author. A poor figure of the species was also published by Hanley and Theobald.

The species is very variable, and following Blanford's and Nevill's manuscript names in the collection in the Indian Museum I was originally inclined to separate it into distinct forms, but intermediate forms between the two types are found in the same area. I am, therefore, of opinion that the differences are not constant and are due to local conditions and age.

Blanford's description of the species is fairly complete, but the following additional points may be noted.

The shells are equivalve, ventricose, rather thin, concentrically striated, the striae being very minute and almost miscroscopic but regular; on some shells the striae are specially developed and as a result appear like raised ribs; the arrangement of the ribs, however, is never regular, the spaces between them being of the same width; on several specimens they are absent. The umbonal region is prominent; the lunule and the escutcheon regions are distinctly marked off by a darker colour, and in the middle of the escutcheon the two valves are raised as a narrow wing. The anterior slope is only slightly arched; the lower margin is dinstinctly arcuate behind the middle; the posterior

[1] Sowerby, *Conch. Icon.*, XX, *Cyrena*, fig. 97 (1877).

[2] In Paetel's Catalogue issued in 1873 this species is listed as *C. Blanfordi* Dkr. from Ava; this is, however, only a manuscript name.

margin is short and evenly arched. The nymphs are finely roughened. The ligament is very prominent.

Measurements in millimetres.

	Ava					Pegu	Bhamo		Thyetmyo
Length	11·3	10·2	11	10·4	8	9·2	12·8	10·2	10
Maximum breadth	9·1	8	8·2	8·3	6·5	7·5	10·5	6·1	8·2
Thickness ..	6·5	6	6·3	6	5	5·3	7·3	6	5·9

Remarks.—C. blanfordiana Nevill, which was never described, is also a synonym of this species All the specimens I have seen are from Upper Burma, round Ava.

Corbicula arata (Sowerby).

(Pl. IV, figs. 17—20.)

1876. *Corbicula arata* B (*mss.* name) Theobald, *Cat. Land Freshw. Shells Brit. Ind.* p. 44.

1877. *Cyrena arata*, Sowerby, *Conch. Icon.*, XX, *Cyrena*, pl. vii, fig. 93.

1883. *Corbicula arata*, Paetel, *Cat. Conch.* p. 216.

1890. *Corbicula arata*, Paetel, *Cat. Conch. Samm.* III, p. 100.

1915. *Corbicula arata*, Preston, *Faun. Brit. Ind. Freshw. Moll.* pp. 222, 223.

The description of this species by Sowerby, based on a single specimen, is not sufficiently detailed for the identification of the species and I, therefore, redescribe the species below. I have before me a specimen from the collection of the British Museum (Natural History), London, from Tenasserim labelled " Corbicula arata Benson Mss. typical-*fluminea* Müll," and three specimens belonging to the Indian Museum apparently presented by Blanford, who also sent the specimens to Hanley and from which the species was described by Sowerby.

Shell thin, trigonal, greatly inflated, obliquely and narrowly truncate, and compressed posteriorly, extended and rounded anteriorly, upper margin greatly arched ; lower margin evenly rounded in the anterior half to two-thirds, then becoming suddenly angulated and curving up to meet the posterior side. Beaks high, inflated, situated in the anterior half, pointing forwards and inwards. Posterior ridge narrow but sharp, anterior ridge not prominent. Sculpture consisting of relatively fewer, but distinctly raised concentric ridges which become somewhat angulate in the posterior third of the shell. Colour deep shining yellow. Interior creamy white or purple in adults, young shells either creamy white or with two purplish stripes running from the umbones to the ventral margin. Pallial line and muscle scars marked but not greatly impressed. Three cardinal teeth in each valve, none of which is divided ; the anteriormost of the right valve very reduced and almost in line with the outer anterior lateral. Right valve with 2 laterals anteriorly and two posteriorly, of these the posterior outer short and weakly developed ; left valve with only a single lateral anteriorly and posteriorly ; only the inner laterals of the right valve and the laterals of the left valve crenulated. Nymphs finely roughened.

Measurements in millimetres.

Length	18·8	17·9	12·6	9·4
Maximum height	15	15	10·1	7·2
Thickness	11·4	12·1	7·8	5·4

Distribution.—The type was described from Tenasserim, Lower Burma, and the specimens, which I have seen, are all from the same locality.

Remarks.—The species is distinguished by its rather thin and greatly inflated shell, and the comparatively few distantly situated but raised ridges. The specimens referred to as *Corbicula Larnaudei* Prime by von Martens from Mee, a tributary of the Irawaddi in Upper Burma, probably belonged to this species. The distribution is, however, different and it is not possible to understand von Martens's remarks " mit flachen breiten Rippen, so breit order auch breiter als ihre Zwischenraume." Von Martens is certainly wrong in including *C. secaduilabris*, a manuscript name of Benson, under this species.

Corbicula solida Clessin.

1887. *Corbicula solida*, Clessin, *Mal. Blätt.* (n. f.) IX, p. 76, pl. iii, fig. 4.

1915. *Corbicula solida*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, pp. 215, 216.

I have not seen any specimens other than the type-shell of the species in the Morelet Collection in the British Museum (Natural History), London. The description of the species by Clessin is fairly complete, but the following notes may prove useful for the identification of the species.

The shell is small, thick, triangular, almost as high as broad, regularly and finely striate, anterior side rounded, posterior subtruncate, dorsal margin angulate, ventral very arched. The colour of the periostracum is light olive green.

The species is known from the unique type from Ceylon, exact locality not stated. It appears to be allied to *C. striatella* (Deshayes).

Corbicula subnitens Clessin.

(Pl. III, fig. 13.)

1887. *Corbicula subnitens*, Clessin, *Mal. Blätt.* (n. f.) IX, p. 77, pl. iii, fig. 5.

1915. *Corbicula subnitens*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, p. 215.

The type-specimen of this species is not available either in the Clessin collection in Stuttgart or in the Morelet Collection in the British Museum (Natural History), London. I have before me a single specimen from Ceylon, exact locality not stated, from the Nevill collection from which also the type of the species originated. This specimen though it differs in some respects from the description of *C. nitens* by Clessin is, in my opinion, to be assigned to it. I give below a description of this shell and reproduce photographs of it on plale III. The specimen is of a fair size being 21·4 mm. × 18·2 mm. × 12 mm.; moderately thick-shelled ; somewhat triangular, elongated in the antero-posterior direction, moderately swollen, subequilateral with the umbones situated about the middle ; upper margin angulate-arched ; anterior side rounded, posterior side broadly rounded, lower margin arcuate, but arching up behind the middle to meet the posterior side. Shell dark olive-yellow, distinctly marked, thick and not greatly raised ; concentric and regular ribs ; the ribs are absent in the lunular region and very minute in the region of the escutcheon. Umbones eroded, showing traces of fine ribs. Nacre dull whitish with traces of violet. Lateral teeth subequal, rather thin and sharp with the usual serrations ; ligament broad and prominent.

Remarks.—The species is allied to *C. striatella* (Deshayes), but the shell is thinner, more triangular and the hinge is not so strongly developed.

EXPLANATION OF PLATE III.

All the figures are reproduced from direct untouched photographs of natural size.

Corbicula striatella Deshayes.

Figs. 1-4. Young shells of various ages from Hoshangabad, Central Provinces.

Fig. 5. Half-grown shell from Sikkim; type of *C. occidens* Deshayes.

Fig. 6. Half-grown shell from Pondicherry; type of *C. striatella* Deshayes.

Figs. 7-8. Half-grown shells from Madras. The shells are more elongated and are not as high as in the case of shells from northern parts of India.

Figs. 9-11. A series of shells of various ages from Calcutta.

Corbicula assamensis, sp. nov.

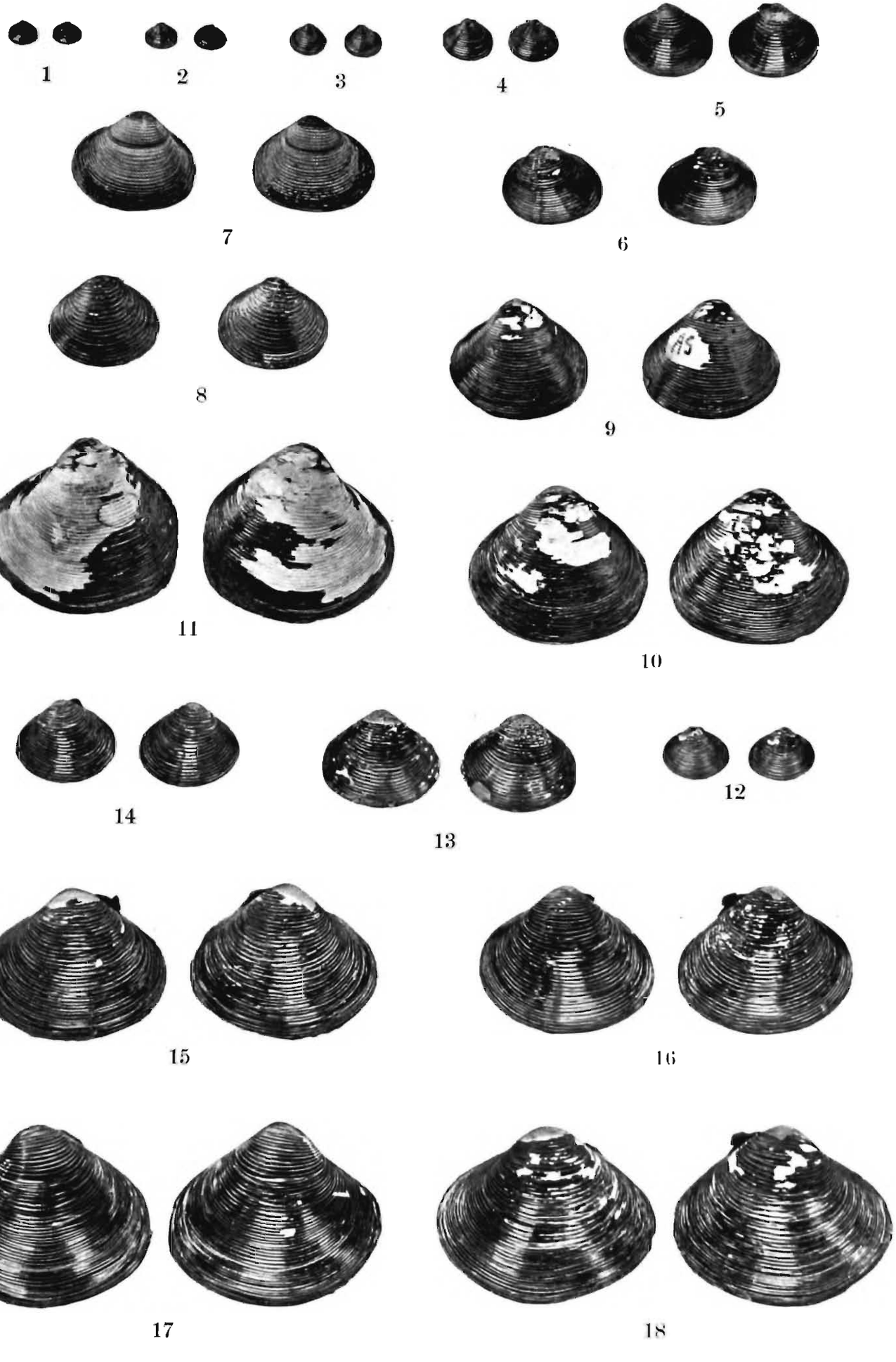
Fig. 12. Holotype from Phenchooganj, Assam.

Corbicula subnitens Clessin.

Fig. 13. A full-grown specimen from Ceylon.

Corbicula cashmiriensis Deshayes.

Figs. 14-18. Shells of various ages from the River Jhelum, Kashmir.



S. Mondul, Photo.

INDIAN CORBICULAS.

EXPLANATION OF PLATE IV.

All the figures are reproduced from direct untouched photographs of natural size.

Corbicula bensoni Deshayes.

Figs. 1-4. Shells of various ages from near Calcutta. Fig. 4 is of one of the type-series of *C. tribeniensis* Preston.

Corbicula sylhetica Preston.

Figs. 5, 6. Type and paratype of the species from Phenchooganj, Sylhet, Assam.

Corbicula iravadica Blanford.

Figs. 7-10. Shells of various ages showing variation in sculpture from Ava, Upper Burma.

Corbicula annandalei, sp. nov.

Figs. 11, 12. Holotype and paratype from Vorkalay, Travancore State.

Corbicula peninsularis, sp. nov.

Figs. 13-16. Shells of various ages from Bombay. Fig. 16 is of the holotype of the species.

Corbicula arata (Sowerby).

Figs. 17-20. Shells of various ages from Tenasserim, Lower Burma.

Corbicula noetlingi v. Martens.

Figs. 21-25. Shells of various ages from He-Ho and Meungyaw, Shan States, Burma.

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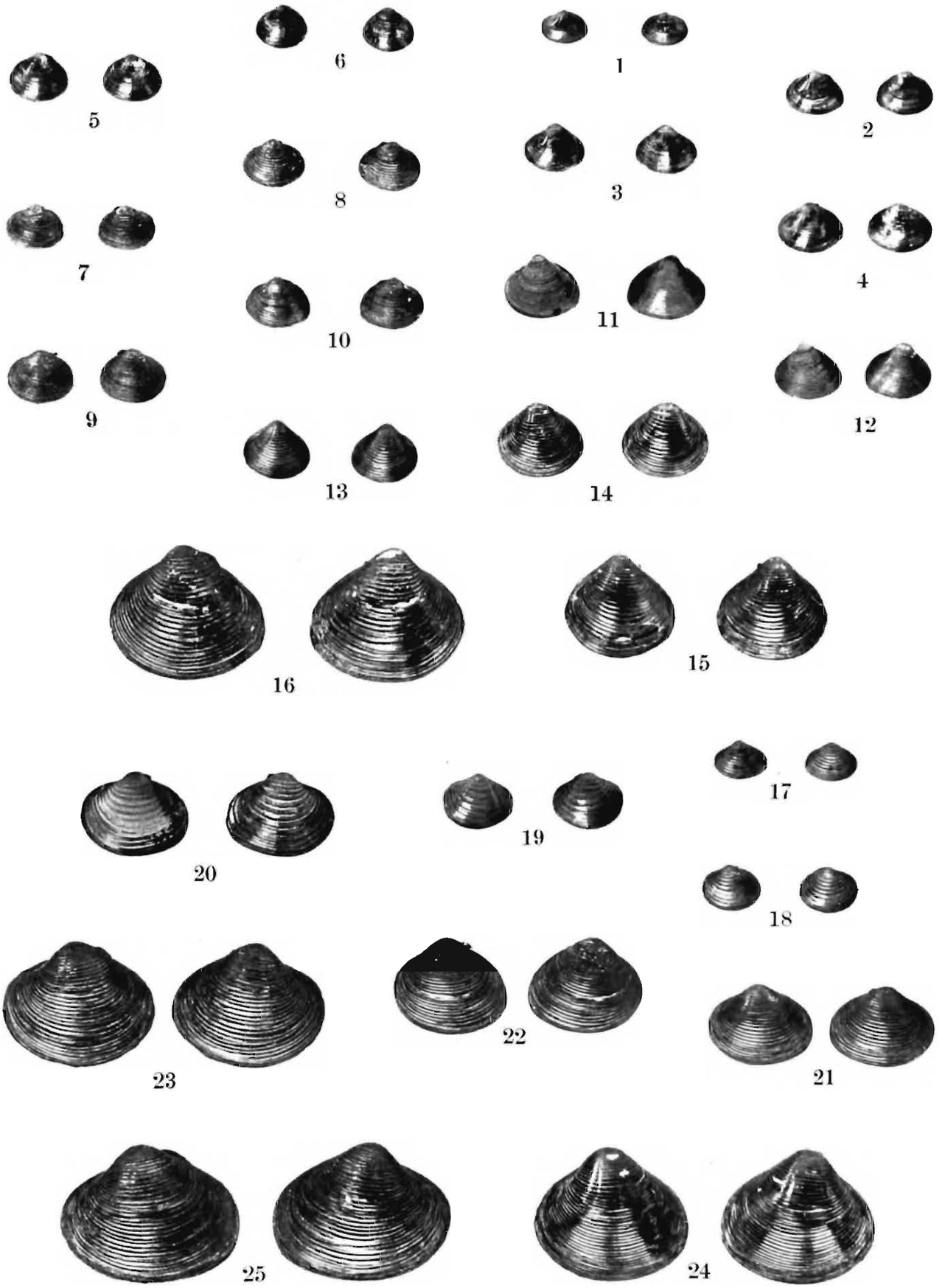

S. Mondal, Photo

INDIAN CORBICULAS.