

## ASIATIC SUCCINEIDAE IN THE INDIAN MUSEUM.

By H. SRINIVASA RAO, M.A., *Officiating Assistant Superintendent,  
Zoological Survey of India.*

(Plate XXVIII.)

The distinguished French malacologist Morelet wrote as follows of the Succineidae : “ Les animaux sont plus variés dans cette famille que leurs coquilles, et peutre fourniraient-ils de meilleurs caractères si ce moyen d’appréciation était à la portée des naturalistes.”

With this statement my own observations are in full agreement and in the following notes I have discussed in detail only those species in which the radula as well as the shell is available for study, or those in which the shell is very distinct. I have also included short notes on other species in the collection of which the anatomy is not known.

In dealing with the Indian species in the collection I have had the advantage of studying some amount of material from Europe and America accumulated in the collection by workers on Indian malacology. But the European forms are unfortunately in a much worse state of confusion than the Indian material as regards their mutual relationships. Until recently the mere collection of shells and their naming without reference to the soft parts or the habits of the animals have been the recognised methods of studying this group, with the result that our knowledge of these animals is as incomplete as ever before.

So far as I am aware zoological literature does not furnish a single instance of a complete account of any one European species, at least as regards those systems of organs which are most likely to be useful for taxonomic purposes.

Deshayes<sup>1</sup>, in 1831, first gave a short account of the anatomy of *Succinea putris* (Linn.) = *Helix putris* Linn. In 1912 Rieper<sup>2</sup> described the reproductive system of *Succinea* more or less completely, giving a brief review of anatomical work done, chiefly on the genitalia, since Deshayes’s time. A systematic study of the jaw and radula in addition to the genitalia was never attempted except in the case of a few species. Baudon<sup>3</sup> put the then known species of *Succinea* under three groups according to the texture of the jaw. He was followed by Hazay<sup>4</sup> in 1880 who erected four groups with reference to the texture, colour and shape of the jaw in various species. Westerlund<sup>5</sup> gave a more complete account of these groups, including all the known species and varieties under the four sub-genera *Neristoma* Klein, *Amphibina* (Hartm.), *Lucena* Oken, *Oxyloma* Westerl., all based on characters in the jaw.

---

<sup>1</sup> Deshayes, *Ann. Sci. nat.* XXII, p. 345, pl. ix (1831).

<sup>2</sup> Rieper, *Ann. Soc. Roy. Malac. Belgique.* XLVII, p. 125, pl. iii & iv (1912).

<sup>3</sup> Baudon, *Journ. Conchyliol.* XXV, p. 128, pl. vi-x (1877).

<sup>4</sup> Hazay, *Malakozool. Blätt.* III, p. 43, pl. iii-ix (1880).

<sup>5</sup> Westerlund, *Fauna Paläarktischen. Binnenconch.* V, pp. 1-17 (1885).

As regards the radula there are practically no European references except one in Lehmann's *Die lebenden Schnecken und Muscheln* (1873). The American species of this family have, however, received better treatment in this respect, chiefly at the hands of Bland and Binney<sup>1</sup>, whose monograph on the Land and Fresh-water shells of North America is well known.

The Asiatic species, like the European, have been mostly established on shell characters, but there is less confusion as regards their mutual relationship owing to the fact that several of them bear distinctive characters in the shell as well as in the soft parts.

Outside Indian limits, the anatomy of the Japanese *Succinea horticola* Reinhardt has been described by Jacobi<sup>2</sup>. Before 1918 the only Indian species of which anything was known about the soft parts were *Camptonyx theobaldi* and *Lithotis rupicola*, two rare species restricted to Western India.

In fact the literature on Indian Succineidae is very scanty, and it seems that far less attention has been paid to this family than to the aquatic groups of the Pulmonata. The late Dr. Annandale, who for some years before his death had been working on the Indian fresh-water gastropods, laid stress on the indispensability of anatomy and bionomics in taxonomic work. This fact was, however, never impressed on the earlier malacologists who worked in India on fresh-water molluscs, although Stoliczka and latterly Blanford and Godwin-Austen were convinced of the importance of anatomical characters in the land-snails. We thus owe our present confusion in this family to the all-too-brief descriptions of species based on a single or a few old and discoloured shells, to the inadequacy of accurate figures, and to the almost total absence of observations on the anatomy and habits of the animals.

In 1918 Annandale<sup>3</sup>, in his report on the Fauna of the Inlé Lake, gave a short account of the habits of *Succinea indica* Pfeiffer with figures of the shell, jaw and radula. He was followed by Amin-ud-Din<sup>4</sup> who published a more or less complete account of the anatomy and habits of four Indian species. From his account it seems clear that the jaw, radula and genitalia afford important characters for the classification of the species.

The present account is admittedly incomplete owing to the fact that several of the species in our collection are represented by dry shells, with the remains of the animal only in a few cases. From these I have been able to extract the jaw and the radula, which are here figured. There are other species recorded from Calcutta which I have been unable to rediscover, perhaps owing to the fact that they are cryptic in their habits. I have placed together as many facts as I could gather from previous accounts, in addition to my own observations on the anatomy and habits of the group.

---

<sup>1</sup> The works of these authors have been published jointly and individually in the volumes of the *Amer. Journ. Conch.* and in *Ann. Lyc. Nat. Hist.* New York.

<sup>2</sup> Jacobi, *Journ. Coll. Sci. Tokyo.* XII, p. 82, pl. vi, figs. 116-119.

<sup>3</sup> Annandale, *Rec. Ind. Mus.* XIV, p. 105, pl. x, figs. 10-11; pl. xi, figs. 5-6 (1918).

<sup>4</sup> Amin-ud-din, *Rec. Ind. Mus.* XXII, p. 592, text-figs. 20-28 (1921).

The late Dr. Annandale gave me invaluable suggestions in the course of this work. My thanks are due to Dr. B. Prashad for going through the proof with me.

The Indian Succineidae comprise four distinct genera *Succinea* Draparnaud, *Indosuccinea* gen. nov., *Lithotis* Blanford, and *Camptonyx* Benson, each of which has distinguishing features in the shell and also in the soft parts so far as they are known. The genus *Camptoceras*, about the systematic position of which there has been much confusion, was rightly referred to the family Planorbidae by Walker<sup>1</sup>; and Annandale and Prashad<sup>2</sup>, after a careful examination of the jaw, radula and penis-sheath of the Indian species, have confirmed Walker's view.

The genus *Camptonyx* was established by Benson on the peculiar form and texture of the shell, but he was doubtful about its true relationship, though he suggested it might eventually be referred to the Helicidae or the Ancyliidae, or might prove to be the type of a new family. None of his surmises proved correct. Woodward<sup>3</sup>, who examined the animal in more detail, did not express a definite view about its affinities. Gray<sup>4</sup>, curiously enough, thought that the genus was closely allied to the genus *Otina* from a similarity of habits and external features, and even suggested the inclusion of the two genera under the family Otinidae. But the habits of the two genera, even according to his description and reasoning, are not so similar as he seems to make out.

From the description of its habitat by Theobald, who first discovered the type-species, and from a careful comparison of its jaw and radula with those of the species of the other genera, it is clear that *Camptonyx* belongs to the Succineidae. The other three genera also are undoubtedly to be included in this family.

The members of this family may be recognised by the following characters :

*Shell*.—Imperforate, usually oval, rarely cap-like, relatively thin and translucent, never smooth, but rarely with prominent sculpture; spire much shorter than the last whorl, never sharply conical, whorls rapidly increasing; aperture oval or oblong, with a thin columellar fold not reflexed beyond the columellar margin of the aperture.

*Alimentary system*.—The jaw is chitinous, and consists of an anterior cutting piece, which may be variable in shape and texture, and a broad accessory plate behind it, also variable in form and texture. The radula is very variable both in size and form of the teeth, and the number in each transverse row. The central is usually a conical tooth with or without lateral denticles. The laterals have, as a rule, only two cusps, while the marginals may have two to seven. The alimentary canal is fairly long with the stomach and greater part of the intestine in the visceral hump. A short oesophagus leads to a spacious crop which communicates with the stomach. A pair of compact salivary glands with short ducts are present. A pair of caeca opens at the junction of the stomach and the intestine. The intestine lies coiled over the stomach. The

<sup>1</sup> Walker, *Occ. Papers Mus. Zool. Univ. Michigan*, No. 64, pp. 1-6, pl. i (1919).

<sup>2</sup> Annandale and Prashad, *Journ. Asiat. Soc. Bengal*, N. S. XVI, p. 30 (1920).

<sup>3</sup> Woodward (in Benson), *Ann. Mag. Nat. Hist.* 3rd Ser., I, p. 338 (1858).

<sup>4</sup> Gray, *Ann. Mag. Nat. Hist.* 3rd Ser., I, p. 406 (1858).

rectum is short and leads to the slit-like anus on the right side of the pulmonary chamber.

*Respiratory system.*—The pulmonary chamber occupies the anterior portion of the body-whorl and communicates with the outside by a minute rounded aperture anterior to the anal slit, and has a thin membranous roof.

*Kidney.*—This organ is a rectangular, usually yellowish body forming the posterior boundary of the pulmonary chamber.

*Genitalia.*—These consist of a compact hermaphrodite gland occupying the apex of the spire, a convoluted duct into the distal half of which open two to three seminal vesicles, and which divides into male and female ducts below the level of the albumen gland. The spermatheca, the prostate, the uterus and the penis are variable in form and size. The penis has a single retractor muscle. The male and female openings may be separate or united, but are always close together on the right side of the base of the head.

The following key will help the identification of the Indian genera from shells only:—

- A. Amphibious Succineidae with shell of very variable size, shape and texture; columellar fold thin, with a distinct smooth ridge ... .. *Succinea.*
- B. Terrestrial Succineidae usually with a thin shell; columellar fold without a smooth ridge.
  - 1. Shell with a transverse furrow on the inner surface of the upper part of the body-whorl.
    - a. Shell thin, cap-like, with the whorls of the spire loosely coiled; columellar fold very thin; aperture oblong or rounded, at any rate in the adult ... .. *Camptonyx.*
    - b. Shell somewhat thick, ovate; spire short and depressed with the tumid whorls tightly coiled; suture impressed; columellar fold relatively broad; aperture ovate ... .. *Lithotis.*
  - 2. Shell without a transverse furrow, very thin and fragile, elongate-ovate; spire short without impressed suture; columellar fold thin and minute ... .. *Indosuccinea.*

#### TERRESTRIAL SUCCINEIDAE.

##### **Camptonyx** Benson.

The affinities of this genus to the other genera in the family have been briefly discussed above. The form and texture of the shell are very distinct. This genus is represented in the collection by the type-species *Camptonyx theobaldi* Benson.

##### **Camptonyx theobaldi** Benson.

1858. *Camptonyx theobaldi*, Benson, *Ann. Mag. Nat. Hist.* Ser. 3, I, p. 336, pl. xii.

1876. *Camptonyx theobaldi*, Hanley and Theobald, *Conch. Ind.* p. 35, pl. 81, figs. 5, 6.

This species is represented in the collection by three shells from the type-locality. Nevill records thirteen shells from the same locality; all

but three apparently having been lost or given away. One of the shells has a tough strip of epiphragm attached to part of the margin.

*Measurements in millimeters.*

Height of shell.	Height of aperture.	Breadth of aperture.
5.5	5.0	4.6

I have extracted the jaw and radula from one of the three shells, but they do not quite agree with Woodward's figures. In my preparation of the jaw the anterior margin of the cutting piece bears no median process, and the cutting piece is a triangular structure with its apex directed backwards, and the apices of the very short arms rounded. There is a shallow median depression on the anterior margin. The sides of the basal plate are depressed. These structures are apparently subject to great variability.

In the radula the teeth are very small and do not exceed 65 in number in each transverse row. The basal plate of individual teeth is always higher than the cusps. The central is without lateral projections but has two depressions on the sides just below the cusp. The laterals have two cusps, the ectocone gradually increasing in size from within outwards. The marginals have 3 to 7 cusps of which the entocone is the largest. The approximate radular formula is 16·14·1·14·16. Though Woodward has figured the same number of teeth in one half of a transverse row as I have done, there is no essential agreement between the two figures. In his figure the central is much sharper and is without lateral depressions, and the laterals have only one cusp while the marginals have two. These striking differences in the jaw and radula seem to be sufficient to regard the shells in our collection as representing a new form of *C. theobaldi*, but for want of sufficient material to study the extent of variation I refrain from regarding these shells as distinct.

**Lithotis** Blanford.

This genus is represented in the collection by the type-species *L. rupicola* Blanford, and by *L. tumida* Blf. It is very distinct from *Succinea* in shell characters and is distinguished by the short depressed spire with the whorls not closely coiled, by the characteristic coarse sculpture, the broadly oval aperture, the well-defined relatively thick columellar fold continuous with the outer margin of the aperture above, and by the presence of an internal furrow commencing from about the middle of the outer margin and running transversely across the upper part of the last two whorls.<sup>1</sup>

The jaw and radula have no characteristic features and agree with those found in the genus *Succinea*.

Nothing is known about the genitalia or other organs.

---

<sup>1</sup> As very little is known about the anatomy of these animals it is difficult to say anything about the formation or function of the furrow, though Blanford observes that it may be a siphonal furrow. Such a furrow is not uncommon in terrestrial gastropods as for instance in the genus *Catantulus* (Cyclophoridae), but is never extended up to the spire as in *Lithotis*.

**Lithotis rupicola** Blanford.

1863. *Succinea (Lithotis) rupicola*, Blanford, *Ann. Mag. Nat. Hist.* Ser. 3, XII, p. 186, pl. iv, figs. 8-10.  
 1874. *Lithotis rupicola*, Binney, *Proc. Acad. Nat. Sci. Philadelphia*, pl. v, figs. 3-6.  
 1914. *Lithotis rupicola*, Gude, *Fauna Brit. Ind. Moll. Gastro.*, p. 458.

The shells collected by Blanford himself at Khandalla in Bombay Presidency and recorded by Nevill are in the collection. There is a certain amount of variability in the depth of the internal furrow. Young shells have a much deeper furrow than adult ones. The shell of this species approaches in some respects that of *Camptonyx theobaldi*, at any rate much more than *L. tumida*<sup>1</sup> does.

*Measurements in millimeters.*

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
7.5	6.8	5.2	5.0

The jaw of this species differs from that of *L. tumida* in the greater prominence of the median projection on the cutting margin. Binney's figure of the jaw of this species is incomplete, the accessory basal plate being omitted.

The radula of *L. rupicola* appears to be intermediate in features between that of *L. tumida* and *C. theobaldi*. The teeth are relatively narrow and are shorter than the basal accessory plate, and the marginals have an elongated cusp with two small denticulations on the outer side. The radula in this respect differs from that of *L. tumida*.

**Lithotis tumida** Blanford.

1876. *Lithotis tumida*, Hanley and Theobald, *op. cit.*, p. 35, pl. 81, figs. 8, 9.  
 1878. *Succinea (Lithotis) tumida*, Nevill, *Hand List Moll.* I, p. 214.  
 1914. *Lithotis tumida*, Gude, *op. cit.*, p. 459.

Shells collected by Blanford from the type-locality are still in the collection. They are all faded to a yellowish brown colour and have  $2\frac{1}{2}$  to 3 whorls. Though the shells approach in general form those of *Succinea* (especially a species like *S. bensoni* Pfr.) they can easily be separated from the latter by the characters mentioned under the genus.

*Measurements in millimeters.*

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
8.0	5.5	5.5	4.3

I have been able to extract the jaw and radula from the dried animal in one of the shells. The jaw is roughly a square with the cutting piece broad. The arms of the latter are almost horizontal and obtusely rounded

<sup>1</sup> Preston's *Lithotis japonica* from Lake Biwa is not a *Lithotis*, nor does it belong to the Succineidae. Annandale and Prashad (*Journ. As. Soc. Bengal.* N. S. XIV, p. 460, fig. 2, pl. xii, figs. 4, 5) have accepted it as the type of their genus *Omia* of the family imnaeidae.

at the apices. The anterior margin is raised into a median and two lateral convexities. The basal accessory plate narrows from behind forwards and has its posterior margin nearly straight.

There are about 40 radular teeth in each transverse row, the laterals and marginals being hardly distinguishable from one another. With the exception of 2 or 3 of the last marginals the teeth have uniformly two cusps. The right side of the radula exhibits some abnormalities while the left is normal. The cusps of the teeth are elongated, sharp and conical. The central has a median broad conical cusp with lateral projections. The approximate radular formula is 20·1·20.

### **Indosuccinea**, gen. nov.

The type-species of the genus was hitherto considered to be a *Succinea*. Amin-ud-din in dealing with the Manipur Succineas (*op. cit.* p. 593) placed this in a biological group distinct from that of the amphibious species, and also pointed out the differences in the anatomy of the members of the two groups. On a re-examination of the same material I find that the shell and the soft parts are sufficiently distinct, and that the erection of a distinct genus is necessary for the reception of this species.

The shell is relatively large, thin and fragile, and has a coarse sculpture with oblique striae. The spire is very short when compared to the body-whorl, tumid, and consists of  $1\frac{1}{2}$  to 2 whorls, the apical being minute. The suture is not impressed. The aperture is large, oval, pointed above and slightly inflexed near the lower end of the columellar fold. The columellar fold is thin and minute. The colour of the shell varies from amber to pale-yellow. The jaw is very strongly chitinised, broader than long, with the apical portion of the arms curved in the form of a beak. The centre of the anterior margin is as a rule straight, but may also be raised into minute prominences. The basal accessory plate has nearly straight sides and a concavity in the middle of its posterior margin.

The radular teeth are much more numerous than in *Succinea* and the central has a conical median and two accessory lateral cusps.

The roof of the pulmonary chamber is highly vascular and has well-defined branching blood-vessels.

The genitalia are remarkably different from those of any known species of *Succinea*. There are two stout, oval seminal vesicles with a distinct fecundation pouch. The prostate has a spiral torsion, and the vas deferens is short, opening into the more or less bulbous penis which has no retractor muscle. The ducts of the spermatheca, vagina and the penis have separate external openings, but they all open to the outside in a common slit-like aperture on the right anterior side of the body just below the tentacle.

Thus the very fragile nature of the shell, its characteristic shape, the highly vascular lung, the strongly chitinised jaw with beak-like extremities to the arms, the large number of marginals in the radula, and in the genitalia the spiral torsion of the prostate, the very short vas deferens with a small bulbous penis devoid of a retractor muscle, the spermathecal duct having a separate external opening instead of being con-

nected with the vagina, and above all the terrestrial habit are the distinctive characters of the proposed new genus.

*Type-species.*—*Indosuccinea semiserica* (Gould).

*Distribution of the genus.*—The type-species occurs only in Bengal and Burma, but there seem to be some closely allied forms, which probably extend the range of the genus into Indo-China and the Malay Peninsula.

### **Indosuccinea semiserica** (Gould).

1876. *Succinea semiserica*, Hanley and Theobald, *op. cit.*, p. 29, pl. 67, figs. 2,3.  
 1878. *Succinea baconi*, Nevill, *op. cit.*, p. 214.  
 1914. *Succinea semiserica*, Gude, *op. cit.*, p. 452.  
 1921. *Succinea semiserica*, Amin-ud-din. *Rec. Ind. Mus.* XXII, p. 592-600, figs. 21 (3a and 3b), 26 and 27.

Our collection contains shells from the west and south of Burma, from the Mergui Is. and from Serampore, Calcutta and Chittagong in Bengal. There is also a good collection of preserved material from Rangoon taken by Dr. H. H. Marshall. The shells from Mergui are relatively small and thick and have the upper part of the body-whorl more tumid. The series from Burma are by far the largest in size. They are fragile and vary in colour from amber to pale-yellow or white according to the condition of their preservation.

#### *Measurements in millimeters.*

Height of shell	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
18.0	15.0	9.2	8.8

I refer to this species a single broken shell from Calcutta labelled *Succinea baconi* Pfr. It does not agree with Hanley and Theobald's figure of *S. baconi*. It, however, closely resembles one of the two shells from Chittagong which has a very short spire and a tumid body-whorl.

*Succinea cochin-chinensis*. Pfr. which is found in our collection is probably no more than a form of *I. semiserica*.<sup>1</sup> It has a shorter spire and a relatively broad aperture, but in other respects it is very similar to the latter species. The anatomy is unknown. *I. semiserica*, which is widely distributed in Burma, extends its range probably into Siam on the east and the Malay Peninsula on the south.

*Anatomy.*—The jaw is, as a rule, strongly chitinised, especially the cutting piece. The extremities of its arms are somewhat thick, dark, beak-like, and project backwards and inwards. The cutting piece is about as broad as the basal accessory plate and has its free margin deeply concave, while the middle portion of this margin at the bottom of the concavity is subject to some variability. It is usually a straight edge with very minute denticulations, but may also be raised into a median and two lateral prominences. The free margin when extremely worn out appears indented. It is often normal. The basal accessory plate has almost parallel sides while its posterior margin is concave in the middle.

<sup>1</sup> Morelet, *Series Conchyliol.* p. 243, pl. xii, fig. 4 (1875).

In the preparation of the jaw in the members of this family it is customary to use caustic potash for extracting it. While caustic potash certainly clears the muscle fibres attached to the jaw, it also seems to have some action on the delicate portions of chitin so that jaws prepared in this way do not retain their exact outline. As the form of the jaw is so important for specific differentiation, material should not be boiled too long in the caustic potash. Where the jaw is delicate the head of the animal may be allowed to soak in cold caustic potash for 12 to 24 hours, and then cleaned in water. The outline of the jaw is properly preserved. In fairly large forms as in *I. semiserica* the jaw may be cleared of its muscle fibres by soaking it in water and cleaned by means of a lancet and a needle.

The radula is a relatively broad ribbon with approximately 80 to 90 marginals, which is nearly twice the number found in any species of the genus *Succinea*.

Amin-ud-din's figure of the radular teeth does not appear to be quite accurate. I have examined his own preparations of the radula, and some of mine. His figures do not agree with either of them. The central and laterals of this species are very characteristic and differ from those of the species of *Succinea*. The central has a broad heart-shaped median tooth and a small lateral tooth on each side. In one preparation the central was very much reduced. This is apparently an abnormality which is not uncommon in whole longitudinal rows of certain radulae. The same phenomenon is probably widespread in other groups of the Pulmonata. In the Limnaeidae and Planorbidae, for instance, such abnormalities are common.

The laterals are less than ten in number and have their entocones usually broad and roughly dagger-shaped. The first few laterals have often two cusps while the remaining have 3 or 4 cusps, but the former may also have three cusps. The change from laterals to marginals in a transverse row is gradual, but the first few marginals can often be easily marked out by their sharp and narrow entocones. The marginals are aculeate in form and vary from 80 to 90 in number. There are, as a rule, four cusps, the entocone being the largest. The two middle cusps are sub-equal and smaller than the fourth.

The pulmonary chamber is large and has its dorsal wall thin and translucent. Patches of dark pigment may or may not be present on the external surface of the dorsal wall. The distinction drawn by Amin-ud-din between this species and those of the amphibious group in the translucence of the lung of one and the opaqueness in the others does not seem to be quite sound, for black pigment is present on the dorsal surface of the lung in species of both groups and is liable to disappear in equal degree in both. The more important distinction between *Indosuccinea* and *Succinea* would, however, be the very highly vascular nature of the lung in the former where thick branching vessels may be seen, and the minuteness of the vessels in the latter.

The kidney is relatively narrow and extends along the whole length of the posterior side of the lung. Calcareous concretions are present in the substance of the kidney in much smaller quantities than in some species of *Succinea*. Individuals of this species were taken between

July and September *i.e.*, during the rainy season in Burma. In certain species of *Succinea* taken during the cold weather in other parts of India these calcareous concretions have been found in great abundance. The free deposition of the particles is probably a result of low temperature of the atmosphere.

The genitalia have already been dealt with in the definition of the genus, but one more point remains to be stated. There are two stout ovate seminal vesicles (sometimes unequal in size) which open into two somewhat dilated tubes with which the hermaphrodite duct joins just before they enter the prostate. There is also a third narrow, compressed, thick-walled tube shorter than the seminal vesicles which also joins the ducts of the latter. This tube, presumably, corresponds to the fecundation pouch, which, in *Succinea putris*, is an enlarged sac below the seminal vesicles. There is no mention of this structure in Amin-uddin's account of this species. It is also to be found more distinctly in another species to be described hereafter.

### **Indosuccinea semiserica f. sthulasiras<sup>1</sup>, nov.**

This is a very delicate and small form of *I. semiserica*. The anatomy is exactly similar to that of the latter, but the shell has some distinct features. It seems advisable to regard it as a closely allied form. The shell is very thin and pliable and is of a dull amber colour and slightly shining. Its general outline is similar to that of *I. semiserica* but its spire and body-whorl are relatively tumid. The apex of the spire is very minute. The sculpture consists of conspicuous striae rather unevenly spaced. The most distinguishing feature of this form is the slight thickening of the shell in the spire and the upper part of the body-whorl. In life, the thickened portion is covered by a black deposit which when cleaned leaves a well-defined whitish, rough area.

#### *Measurements in millimeters.*

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
8.5	7.0	5.9	4.0

*Type-specimen*.—No. M <sup>12370</sup>/<sub>2</sub> Zool. Surv. Ind. (*Ind. Mus.*).

Several living individuals were taken by me on the leaves of a hedge-plant (*Lawsonia alba*?) in Ballygunge, Calcutta, in July 1923.

Professor Meggitt of the Rangoon University has since found several living specimens of this form in the vicinity of Rangoon. The thickened portion of his shells is less extensive and the black deposit less conspicuous.

### **Indosuccinea plicata** (Blanford).

1876. *Succinea plicata*, Hanley and Theobald, *op. cit.*, p. 29, pl. 67, fig. 8.  
 1878. *Succinea semiserica*, Nevill, *op. cit.*, p. 212.  
 1914. *Succinea plicata*, Gude, *op. cit.*, p. 448.

The shell of this species resembles that of *I. semiserica* in many respects, but differs from it in having a larger spire, in being relatively

<sup>1</sup> Derived from two Sanskrit words *Sthula* (=thick), and *Siras* (=head).

narrow, in having a characteristic coarse sculpture, and in being less fragile. Two shells from Arakan are typical and show the plications which distinguish this species from *I. semiserica*. The colour is variable. Shells from Bassein are pale yellow, while those from Tongoop in Arakan are corneous. Some of these have a white deposit of calcareous matter on the inside of the shell.

*Measurements in millimeters.*

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
19	16.5	11.0	9.0

The anatomy of the species is not known. From its great resemblance to the shell of *I. semiserica* it may be presumed that the anatomy is similar. The inclusion of this species in the genus *Indosuccinea* is, therefore, only provisional.

The species has been hitherto recorded only from Lower Burma, and has apparently a local distribution in that province like the closely allied *I. semiserica*.

AMPHIBIOUS SUCCINEIDAE.

**Succinea** Draparnaud.

This genus includes a large number of species of amphibious habitat, with shell of very variable size, shape and texture. The columellar fold is thin and has a distinct smooth ridge on its free margin. The radular teeth vary in number in different species and may be aculeate or quadrate in form. It is interesting in this connection to note that the species of *Succinea* seem to fall into two natural groups according as the marginals in the radulae are aculeate or quadrate in form. Those of which I have examined the radulae may be grouped as follows:—

GROUP I.	Intermediate.	GROUP II.
(Species with aculeate marginals).		(Species with quadrate marginals).
* <i>S. pfeifferi</i> var. <i>recta</i> Baudon.		<i>S. bensoni</i> Pfeiffer.
* <i>S. putris</i> var. <i>propinqua</i> Baudon.		<i>S. subgranosa</i> Pfeiffer.
* <i>S. debilis</i> Pfeiffer.	<i>S. girnarica</i> Theoba'd.	<i>S. rutilans</i> Blanford.
<i>S. yarkandensis</i> Nevill.		<i>S. gravelyi</i> , sp. nov.
<i>S. elegantior</i> Annandale.		<i>S. stoliczkae</i> , sp. nov.
<i>S. indica</i> Pfeiffer.		<i>S. godivariana</i> f. <i>vangiya</i> , nov.
<i>S. martensiana</i> Nevill.		<i>S. crassinuclea</i> f. <i>vitrea</i> Pfeiffer.

The marginals of *S. girnarica* are somewhat peculiar in that they are intermediate between the aculeate and quadrate forms of teeth.

The shell form in these two groups also seems to be distinct. In Group I the shell is generally of an elongately ovate form with a short spire and a relatively large body-whorl, whereas in Group II it is of a broadly ovate form with tumid whorls, and of relatively small size. *S. girnarica* has, however, an exceptionally large shell.

\* These species form part of the European material in our collection, but as their systematic position seems to be in doubt, I have included them here for purposes of comparison.

The members of this genus differ from *I. semiserica* in the structure and arrangement of the different parts of the genitalia. The prostate is without spiral torsion and is followed by a long vas deferens which terminates on an elongated penis. The latter is provided with a retractor muscle. The duct of the spermatheca opens into the vagina. The male and female ducts are united for a short distance before opening to the outside.

The following Asiatic species in the collection are included under this genus :—

- |  |  |
|--|--|
| 1. <i>S. indica</i> Pfeiffer.                      | 13. † <i>S. ceylanica</i> Pfr.                         |
| 2. † <i>S. indica</i> f. <i>subfossilis</i> , nov. | 14. † <i>S. daucina</i> Pfr.                           |
| 3. <i>S. elegantior</i> Annandale.                 | 15. † <i>S. daucina</i> f. <i>hraswasikhara</i> , nov. |
| 4. † <i>S. collina</i> Hanley and Theobald.        | 16. † <i>S. snigdha</i> , sp. nov.                     |
| 5. † <i>S. tornadri</i> , sp. nov.                 | 17. <i>S. stoliczkae</i> , sp. nov.                    |
| 6. <i>S. girnarica</i> Theobald.                   | 18. <i>S. graveyli</i> , sp. nov.                      |
| 7. † <i>S. crassinuclea</i> Pfr.                   | 19. † <i>S. graveyli</i> f. <i>deccanensis</i> , nov.  |
| 8. <i>S. crassinuclea</i> f. <i>vitrea</i> Pfr.    | 20. <i>S. graveyli</i> f. <i>andamanensis</i> , nov.   |
| 9. <i>S. martensiana</i> Nevill.                   | 21. <i>S. rutilans</i> Blanford.                       |
| 10. † <i>S. hanleyi</i> Gude.                      | 22. <i>S. godivariana</i> Gude.                        |
| 11. <i>S. subgranosa</i> Pfr.                      | 23. <i>S. godivariana</i> f. <i>vangiya</i> , nov.     |
| 12. <i>S. bensoni</i> Pfr.                         | 24. † <i>S. limnaeiformis</i> , sp. nov.               |

† Those of which the anatomy is unknown are marked thus.

### **Succinea indica** Pfeiffer.

1914. *Succinea indica*, Gude, *op. cit.*, p. 447.  
 1918. *Succinea indica*, Annandale, *Rec. Ind. Mus.*, XIV, p. 105, pl. x, figs. 10, 11, pl. xi, figs. 5, 6.  
 1921. *Succinea indica*, Amin-ud-din, *op. cit.*, p. 601, fig. 28 ; p. 895, fig. 21 (4).

Of all the Asiatic species dealt with in this paper the present species seems to closely resemble the European *S. pfeifferi* Rösm. and *S. putris* Linn. and their various forms, many of which have, without any justification, been raised to specific rank by European authors only to add to the existing confusion. It seems to me probable that *S. pfeifferi* and various other closely allied species and varieties in published works are no more than forms of *S. putris* Linn. The latter species is itself subject to great variability. A reference to the series of figures of this species by Forbes and Hanley<sup>1</sup> will make this point clear.

Pfeiffer,<sup>2</sup> in his description of *S. indica*, observed that it is a form similar to *S. pfeifferi*, but held that it might be distinguished from the latter by the nature of the sculpture and the aperture. I have examined shells of both species in the collection, and also seen published figures of the same. The differences between the two species, if any, are very elusive especially owing to the great variability in size, form, texture and colour of the shells. I have extracted the jaw and radula of *S. pfeifferi*<sup>3</sup> from Candahar and Luchon (probably in Europe), and compared the drawings of these structures with those of *S. indica* from more than one locality. The general type of structure of the jaw and radula is the same in the two species. These structures are also subject to some variability the extent of which is difficult to determine without adequate material.

<sup>1</sup> Forbes and Hanley, *Brit. Moll.* IV, pl. cxxxi, figs. 1-5.

<sup>2</sup> Pfeiffer, *Mongraphia Helici Vivent*, III, p. 9 (1853).

<sup>3</sup> Lehmann, *Die Lebenden Schnecken und Muscheln*, pp 49-57, pl. ix, figs. 13-Cassell, 1873).

Most of the European species have been established on shell characters only, and so far as I could gather there is little or no account of the anatomy of these species. It is therefore difficult to understand their mutual relationships. Though the Indian Museum collection possesses shells of various species from Europe and America, they are not here dealt with owing to the difficulty of instituting correct comparisons with the Indian species which are better known in respect of their shells as well as of the soft parts.

Speaking of the external characters alone it seems clear that *S. indica* is closely related to a species like *S. putris*, allied forms of which are probably widely distributed in Europe and Asia.

The Indian Museum collection contains shells from Bhim Tal, Kashmir, Peshawar, Gurdaspur, and the Southern Shan States. This includes shells from Bhim Tal and Srinagar recorded by Nevill (*op. cit.*, p. 212). A few specimens in spirit from Peshawar and the Manipur valley collected by Dr. Annandale, and a few collected by Dr. Bains Prashad in Kashmir are also present.

When the collection is examined as a whole it is possible to distinguish two forms, the long-spined and the short-spined, but the two forms occur together in all the localities. The colour of the shell varies from a reddish amber or pink to pale yellow.

Shells from the type-locality are smaller than the type and are themselves variable in form. The spire is longer in some shells than in others. The aperture is subpyramidal while its base is evenly rounded in short-spined forms and slightly angulate on the collumellar side in long-spined ones. The latter agree with the figures of *S. indica* in *Conch. Ind.* The colour of the shells is pale yellow.

The specimens from Kashmir, Peshawar and the Punjab are more or less alike but not without the usual variability common to most fresh-water species of Pulmonates. For a proper appreciation of the variability in the shell of the present species it seems best to describe individuals from different localities separately. Shells labelled 'Kashmir' in our collection apparently come from Srinagar from where Nevill has recorded 30 specimens. They are of a pale lorn colour while those from the Dal Lake in Kashmir are reddish amber. The latter also differ from the former in being relatively narrow, in the greater height of the spire, in the convexity of the penultimate and body-whorls and in the deeper and more inclined suture. The shells from Kashmir as a whole are thinner than those from Bhim Tal in the Kumaon District.

Two specimens from a settling tank in the waterworks at Peshawar have a thick shell and are pale pink in colour. They agree in form with the Dal Lake specimens. Shells from Pancha Tirla tank in Peshawar, though small in size, have an elongated spire and a more tumid body-whorl. The sculpture is less coarse than in Kashmir specimens, and the colour varies from amber to pale yellow. The Punjab specimens have a shorter spire, but otherwise agree with the Kashmir individuals.

Shells from Srinagar agree both in size and form with the figure of this species recorded by Jickeli from Alexandria in Egypt.<sup>1</sup> The

---

<sup>1</sup> *Nova Acta. K. Leop. Carol. Akad.* XXXVII, No. I, p. 167, pl. vi, fig. 11 (1874).

species being so variable I have no doubt that the Egyptian example is at best a form of *S. indica* in spite of the differences mentioned by Jickeli between the Indian and Egyptian examples.

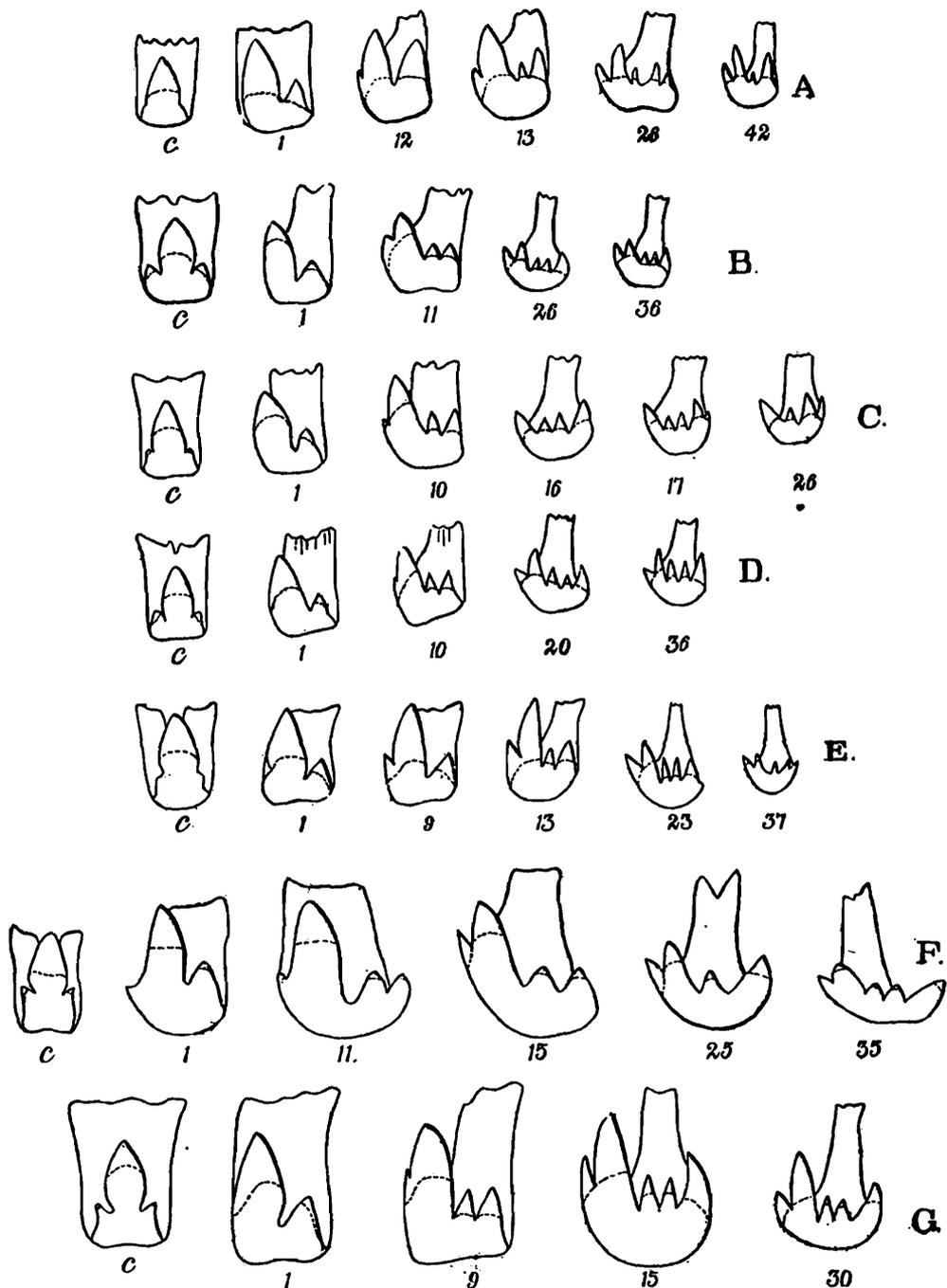


FIG. 1.—Radular teeth of Succineidae.

- A. *Succinea indica* Pfeiffer from Gurdaspur, Punjab.
- B. *Succinea indica* Pfeiffer from Srinagar, Kashmir.
- C. *Succinea indica* Pfeiffer from Peshawar (incomplete).
- D. *Succinea indica* Pfeiffer from Dal Lake, Kashmir.
- E. *Succinea yarkandensis* Nevill from Yarkand.
- F. *Succinea elegantior* Annandale from Manipur, Assam.
- G. *Succinea debilis* Pfeiffer from Mount Hermon, Palestine.

The Burmese shells which are relatively thick and much narrower than any of the Indian examples apparently constitute a distinct race for which I propose the name *shanensis*. Among these again short and long-spined forms occur. Our collection possesses a single shell

taken by Dr. Annandale at Thali-u on the Inlé Lake and two dead shells obtained by Dr. Hora in a field at He-ho. The former has a long spire which is well marked out from the body-whorl, with the suture oblique and moderately impressed, and has a dirty yellow colour. The latter are short-spired with the suture well-impressed, and whitish in colour.

*Measurements in millimeters.*

LOCALITY	Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.	Number of whorls.	REMARKS.
Bhim Tal (Kumaon) ...	14.0	10.0	6.5	5.5	2½	Longspired
	12.5	10.0	6.5	5.5	2½	shortspired
Srinagar } Kashmir ..	14.5	11.5	7.3	5.8	2½	
	Dal Lake }	13.5	10.2	6.5	5.5	2½
Peshawar (N. W. F. Pr.)	13.1	9.7	6.4	5.0	} 2½ to 2¾	
	12.2	8.5	6.2	4.5		
Gurdaspur (Punjab) ...	13.0	11.1	7.2	5.8	2½	
Inlé-Lake (S. Shan States)	11.1	8.2	5.8	5.0	} 2½ to 2¾	
He-ho (S. Shan States) ..	10.5	7.8	5.0	3.9		

The jaw and the radula, like the shell, are also subject to great variability, and the accompanying figures will indicate the degree of variability better than a mere description.

In the jaw the arms of the cutting-piece usually enclose a deep concavity and gradually broaden from behind forwards, the apex being rounded on one side. The median projection is prominent and may sometimes have accessory lateral protuberances, which probably appear as a result of wearing out of the cutting edge, or of accident. The basal accessory plate also varies greatly in shape, but is nearly always twice as broad as the distance between the anterior and posterior margins of the cutting-piece.

In the radula the central varies in size and form of the lateral denticulation. Specimens from Kashmir have prominent lateral denticulations on the central which are obsolete or sub-obsolete in those from Peshawar and the Punjab. The laterals are more or less uniform, while the marginals again show some variation.

The extent of variability in the shell, the jaw and the radula of this species seems to indicate that it is easily affected by environmental factors, such as the composition of water and the nature of the food available. But there are, presumably, other little-known factors which act on the species and bring about such frequent changes.

In the alimentary canal the stomach is large and spacious and lies at right angles to the crop. On the dorsal wall of the stomach at its junction with the intestine opens the large duct of the liver receiving

several short branches, while ventrally opens a pair of caeca. One of them is larger than the other and has oblique striations which are due, in fact, to the external appearance of the internal longitudinal folds. The smaller sac is stout, arched, and without striations. This is apparently an accessory caecum.

The kidney is broader than that of *I. semiserica* and has well developed longitudinal folds. The quantity of calcareous concretions in the substance of the kidney seems to depend upon the temperature of the atmosphere. For instance individuals taken in the month of January at Peshawar have practically no calcareous concretions in the kidney, while those collected in July at Kashmir have such large numbers of concretions that they more or less obliterate the internal folds of the kidney.

The genitalia agree somewhat with those of *S. elegantior*. The prostate is slightly more elongate than in the latter species. There is a pair of seminal vesicles opening into a fecundation pouch which sometimes carries two to three minute digitiform processes on one side. The hermaphrodite duct opens at the lower end of the pouch a little below the digitiform processes. The shape and size of the spermatheca, and the length of its duct are variable. The penis is elongate, broader distally, and carries at its apex a conspicuous finger-shaped appendix variable in size, at the base of which opens the greatly coiled lower end of the vas deferens. The penis, the appendix, and the terminal portion of the vas deferens are enclosed in a tough thin sheath which can be easily removed.

#### ***Succinea indica* f. *subfossilis*, nov.**

This form is closely allied to *S. indica* and has been found only in the Southern Shan States. The shell is small, elongate, and much narrower than that of *S. indica*. The spire is high and about  $\frac{1}{4}$  the total height of the shell, and has two whorls the apical being minute and papillate. The suture is oblique and well-impressed. The shell is relatively thick, coarsely sculptured, often having a plicate appearance. The aperture is narrowly elongate-ovate and has the columellar fold very thin, smooth and shining with a short minute polished ridge at its lower extremity. The colour is a pale brown or pink.

#### *Measurements in millimeters.*

Locality.	Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
Bottom of pool above He-ho gorge ...	12.0	9.0	5.8	4.8
Sand-like deposit on bank of He-ho gorge.	8.8	6.3	4.2	3.4

*Type-specimen.*—No. M  $\frac{12372}{2}$  Zool. Surv. Ind. (*Ind. Mus.*).

Comparing the dimensions of these shells with those of the living shells from the same district one finds that the sub-fossil shells are much

narrower. The present form differs from the true *S. indica* in its thicker shell, in colour, in the characteristic coarse sculpture and in its extreme narrowness.

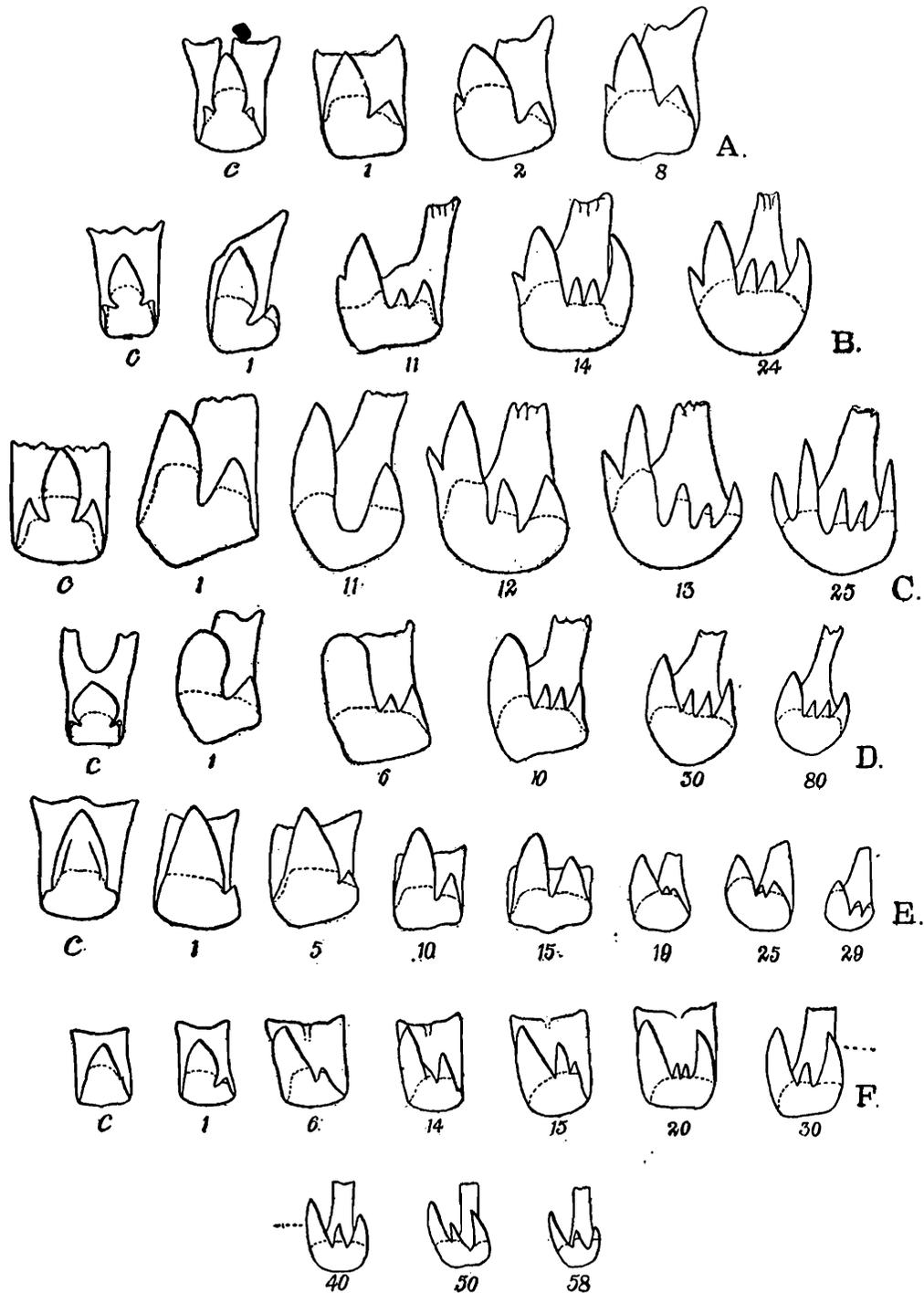


FIG. 2.—Radular teeth of Succineidae.

- A. *Succinea pfeifferi* Rossmässler from Candahar (incomplete)  
 B. *Succinea putris* var. *propinqua* Baudon from Burgos, Spain.  
 C. *Succinea pfeifferi* var. *recta* Baudon from Luchon, Europe.  
 D. *Indosuccinea semiserica* (Gould) from Rangoon.  
 E. *Succinea martensiana* Nevill from "Bazrahah."  
 F. *Succinea girnarica* Theobald from Girnar Hills, Kathiawar.

Two shells were obtained by Drs. Annandale and Gravelly in March, 1917 from the bottom of a pool above He-ho gorge, and three more in March, 1922 from a loose sand-like deposit on the banks of the same pool

by Dr. Sunder Lal Hora and myself. The former are pale brown in colour and appear to be water-worn, while the latter are pink and have the sculpture well-defined.

### **Succinea collina** Hanley and Theobald.

1876. *Succinea collina*, Hanley and Theobald, *op. cit.*, p. 30, pl. lxxviii, figs. 8, 9.

1878. *Succinea collina*, Nevill, *op. cit.*, p. 212.

1914. *Succinea collina*, Gude, *op. cit.*, p. 449.

This species is represented in the Indian museum by eight shells from Mahabaleshwar in Bombay and one from Torna Hills in Poona. This is one of the distinct Indian species readily recognised by its form, texture and colour. There are, however, some slight variations in the shell. The shell is of a greenish horny colour, and is covered by a thin membranous outermost layer which has a tendency to come off the underlying calcareous layer. It has a characteristic lustrous pearly layer on the inner surface of the shell.

A small shell in the series agrees more or less with the small tumid form figured by Hanley and Theobald. This is, presumably, a young shell. The single shell from Torna Hills, though slightly more tumid than the foregoing and lacking the colour and lustre of the typical shell, has the characteristic form of this species. The largest shell in the collection has the following dimensions in millimeters.

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
18.5	15.5	11.5	9.5

Gude's reference to 'var. *aurantiaca* v. *rufo-cornea*' is not clear to me. He regards the variety *aurantiaca* as very distinct in appearance from the type in point of colour, which by itself is an unreliable character for differentiation of even a variety.

### **Succinea tornadri**,<sup>1</sup> sp. nov.

The shell of this species is oblong-ovate, broadly conical at apex, moderately thick with close-set fine oblique striae. The spire is broad with a well-impressed oblique suture and has a papillate apex. There are three whorls in the spire, the last being broadest above. The aperture is somewhat broadly ovate with its apex more or less rounded, while the columellar margin, which is usually inflexed below the callus, has its fold very thin and broad with an elongated smooth and prominent ridge. The outer margin of the aperture is oblique and nearly straight. The colour of the shell is yellowish corneous.

*Type specimen*.—No. M  $\frac{12380}{2}$  in the Zool. Surv. Ind. (*Ind. Mus.*).

#### *Measurements in millimeters.*

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
15.2	11.8	9.5	7.0

<sup>1</sup> The word *Adri* in Sanskrit means a hill,

Three shells of this species were obtained by Blanford from the Torna Hills in Poona with those of *S. collina*. Nevill did not record these specimens in his Hand-List. They were regarded as a variety of *S. collina* by Blanford but never described as such. I find a label bearing his name with the shells.

The present species, though allied to *S. collina*, differs from it in having a more tumid body-whorl, in the outer margin of the aperture being straight and oblique, in having two complete whorls in the spire, in the less coarse sculpture, in the greater prominence of the lower extremity of the columellar ridge, in colour, and in the absence of pearly lustre on the inner surface of the shell.

### *Succinea girnarica* Theobald.

1873. *Succinea girnarica*, Sowerby in Reeve, *Conch. Icon.* pl. i, fig. 5a, 5b.

1914. *Succinea girnarica*, Gude, *op. cit.*, p. 451.

Shells of this species collected by Theobald from the Girnar Hills in Kathiawar and recorded by Nevill are still in the collection. One of the shells has its aperture closed by an epiphragm, and from another small shell in which the animal was dried and attacked by fungus I have been fortunate enough to extract the jaw and the radula.

The larger shells have a superficial resemblance to those of *S. collina*, but differ from it in colour, texture and sculpture, and in the less tumid penultimate whorl. The smaller shells, of which there are only three, resemble those of *S. rutilans*, but are easily distinguishable from the latter by the colour and texture of the shell.

#### *Measurements in millimeters.*

		Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
Largest shell ...	...	24·0	19·0	14·5	11·5
Small shell ...	...	8·5	6·8	5·5	4·9

The jaw is very distinct and differs from that of all other Indian species. It is longer than broad and the cutting piece is about  $\frac{2}{3}$  as broad as the accessory basal plate. The apices of the arms are broadly rounded and the concavity between them is relatively shallow and broadly truncated at the bottom. The accessory plate narrows gradually from before backwards and has its posterior margin more or less straight and transverse.

The radular ribbon is relatively broad and consists of moderately large teeth, the approximate radular formula being 44·14·1·14·44. The cusps of the teeth are shorter than the basal plate which is very much narrowed in the last few marginals as in *S. indica*. The central is broad and has a conical cusp with obsolete or sub-obsolete lateral teeth. The laterals have only two cusps of which the entocone is much larger. The marginals are very characteristic of this species, and appear to be intermediate between those of the aculeate and quadrate forms. They have two long incurved cusps with one, or rarely, two smaller and narrower cusps between them.

**Succinea elegantior** Annandale.

1921. *Succinea elegantior*, Amin-ud-din, *Rec. Ind. Mus.*, XXII, pp. 593-598, text-figs. 20, 21(1), 22, 23, 24.

Shells of this species are apt to be confused with those of *Indosuccinea semiserica*, for in general outline they seem to agree. The fine golden

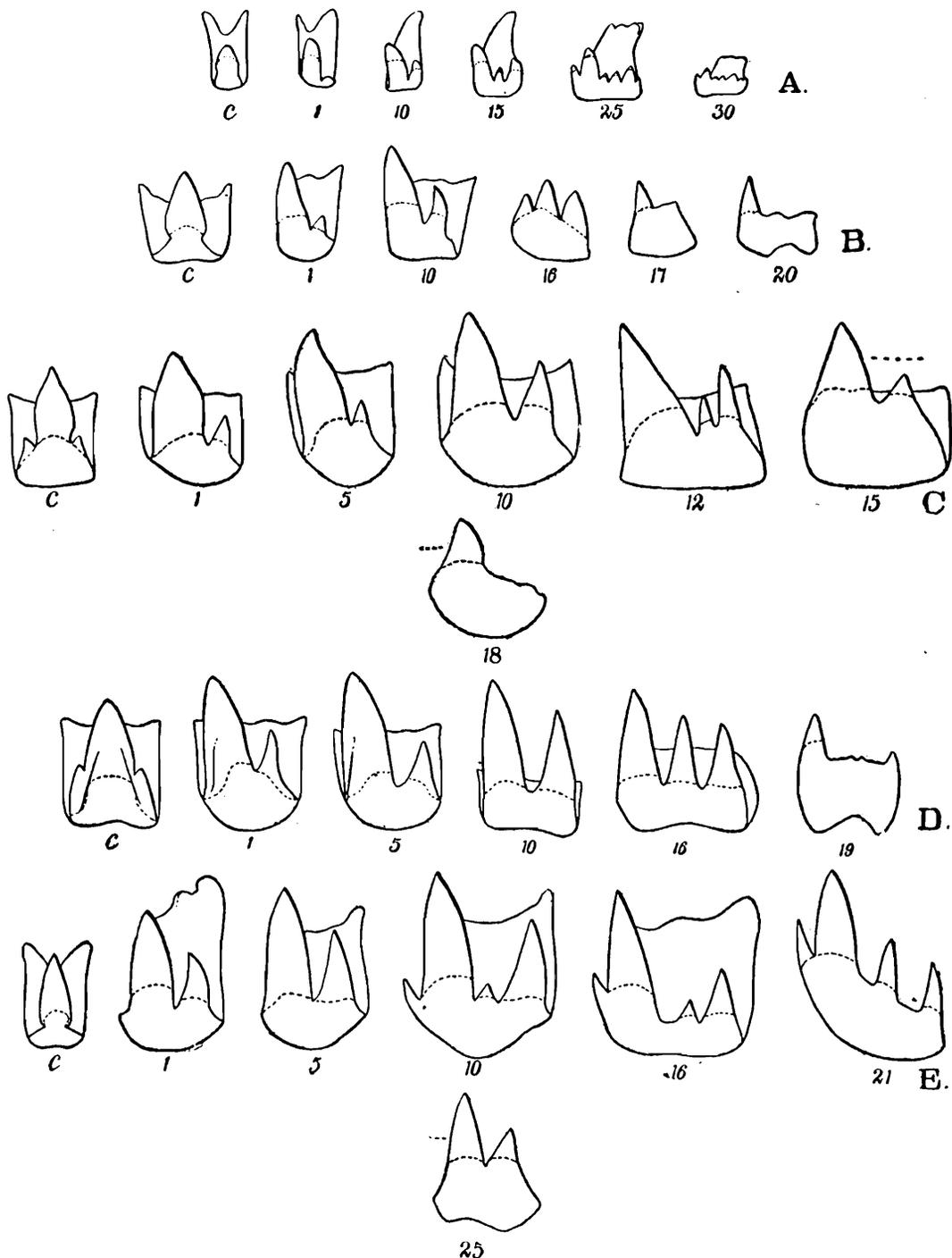


FIG. 3.—Radular teeth of Succineidae.

- A. *Camptonyx theobaldi* Benson from Girnar Hills, Kathiawar.  
 B. *Lithotis tumida* Blanford from Singhur, Poona.  
 C. *Succinea crassinuclea* f. *vitrea* Pfeiffer from Port Canning, Bengal.  
 D. *Succinea bensoni* Pfeiffer from Bombay.  
 E. *Succinea subgranosa* Pfeiffer from Kumaon.

hue of the present species, its relatively narrow, less tumid spire, with an oblique suture distinguish it from the latter. The soft parts, however, closely resemble those of the other amphibious species.

The radular teeth, though relatively large, conform to the type in *S. indica*, but are stouter and stronger. The marginals are, however, distinct in that the secondary cusps are stout, short and rounded.

The jaw approaches that of *S. indica* in general form but differs from the latter in that the arms of the cutting piece are more or less horizontal and uniformly broad, and the median projection is much less prominent. The jaw is probably just as variable in form as in *S. indica*.

In the description of the alimentary system in the work cited no mention is made of the presence or absence of caeca at the junction of the stomach and the intestine. There is unfortunately no well preserved material in the collection to elucidate this point. They are presumably present as in the allied *S. indica*.

In figure 22 (a) of the work cited there is a very short pouch close to the base of one of the seminal vesicles which seems to correspond to the narrow compressed, elongated accessory sac described in *I. semi-serica*. All the three sacs open into the fecundation pouch from which start the uterus and the vas deferens.

The species has hitherto been recorded only from the lakes and swamps of the Manipur valley.

#### ***Succinea crassinuclea* Pfeiffer.**

1876. *Succinea crassiuscula*, Hanley and Theobald, *op. cit.*, p. 30, pl. lxxviii, figs. 5, 6.  
 1878. *Succinea crassiuscula*, Nevill, *op. cit.*, p. 212.  
 1923. *Succinea crassinuclea*, Annandale and Rao, *Rec. Ind. Mus.*, XXV p. 395.

Shells of this species recorded by Nevill in his Hand List are, with the exception of two from Kutch, still in the collection. There are also four large shells from Samole in Malwa, and a single shell from Simla, both collected by Taylor.

#### *Measurements in millimeters.*

Locality.				Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
Malwa	...	...	...	13·6	10·5	7·6	6·8
Calcutta	...	...	...	13·1	9·1	7·5	6·0
Simla	...	...	...	11·0	7·8	7·0	6·0
Salt Range	...	...	...	10·3	7·2	6·5	5·3
Karachi	...	...	...	8·6	5·3	5·5	4·0

The species is variable both in colour and form of the shell and is indistinguishable from *S. vitrea* Pfr. Examining specimens of the same size and growth of the two species together one finds it difficult to separate them. When they are, however, separately examined it is possible to find a few points of difference, but I am unable to agree with Gude (*op. cit.*, p. 455) that the points of difference are sufficient to justify the retention of *S. vitrea* as a distinct species.

The shells vary in colour from pale yellow or cream to pink, and also in the height of the spire and the tumidity of the body-whorl.

The dried remains of the animal seem to have been carefully removed from the shells, and no idea can be formed of the nature of the jaw and the radula.

The occurrence of the species from the Salt Range and Karachi in the extreme west, Simla in the north and Calcutta in the east seems to be an indication of its probable wide distribution in Northern India.

### *Succinea crassinuclea* f. *vitrea* Pfeiffer.

1876. *Succinea vitrea*, Hanley and Theobald, *op. cit.*, p. 29, pl. lxxviii, figs. 2, 3.

1914. *Succinea vitrea*, Gude, *op. cit.*, p. 454.

Individuals of this form, though closely resembling those of *S. crassinuclea* Pfr., can be distinguished by certain features in the shell. But they are, however, not sufficiently marked to raise the members of the present form to the rank of a distinct species.

This form has a more tumid and less oblique body-whorl than in *S. crassinuclea*, and a shorter spire which has, as a rule, only two whorls of which the apical is much less prominent than in the species. The shells from Calcutta are intermediate in character and have  $2\frac{1}{2}$  whorls in the spire.

The Indian Museum collection contains specimens from Calcutta, Port Canning and Dacca in Bengal, Patna in Bihar, and Roorkee in the United Provinces. All except those from Bihar have been recorded by Nevill. The form has also been recorded from Bombay, the Andaman Islands, and the Laccadives. It is, probably, more widely distributed than we know.

#### *Measurements in millimeters.*

Locality.	Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
Port Canning (Bengal) ... ..	9.0	7.1	6.0	4.8
Patna ... ..	7.8	5.7	5.0	4.3
Roorkee ... ..	9.8	8.0	6.8	5.1
Calcutta ... ..	11.0	7.8	7.2	4.8

The jaw and the radula have been extracted from the dried animal in one of the shells. They are distinct from those of other species, and a glance at the figures will enable one to appreciate the differences in the form of these structures in different species of the genus. The cutting piece of the jaw in the present form has its arms considerably short while its apices have a rounded posterior margin with definite angulation at the junction of the anterior and posterior margins. The striation on the cutting piece and the basal accessory plate is not conspicuous. The anterior margin of the former is depressed slightly and bears no prominences or tubercles. The basal accessory plate is sub-quadrate and narrows from behind forwards, and its posterior margin is also slightly concave in the middle.

The radula is ribbon-shaped with the number of teeth in each transverse row remarkably few. Individual teeth are relatively large in size and their cusps exceed, as a rule, the height of the basal plate. The central has a large median acuminate cusp with a prominent tooth on each side. The laterals vary in number to a limited extent but are never less than ten. The teeth are narrow and conical. The marginals are fewer in number than the laterals. The approximate radular formula is 4·14·1·14·4. There may be 12 to 15 laterals and 3 to 6 marginals on each side of the central.

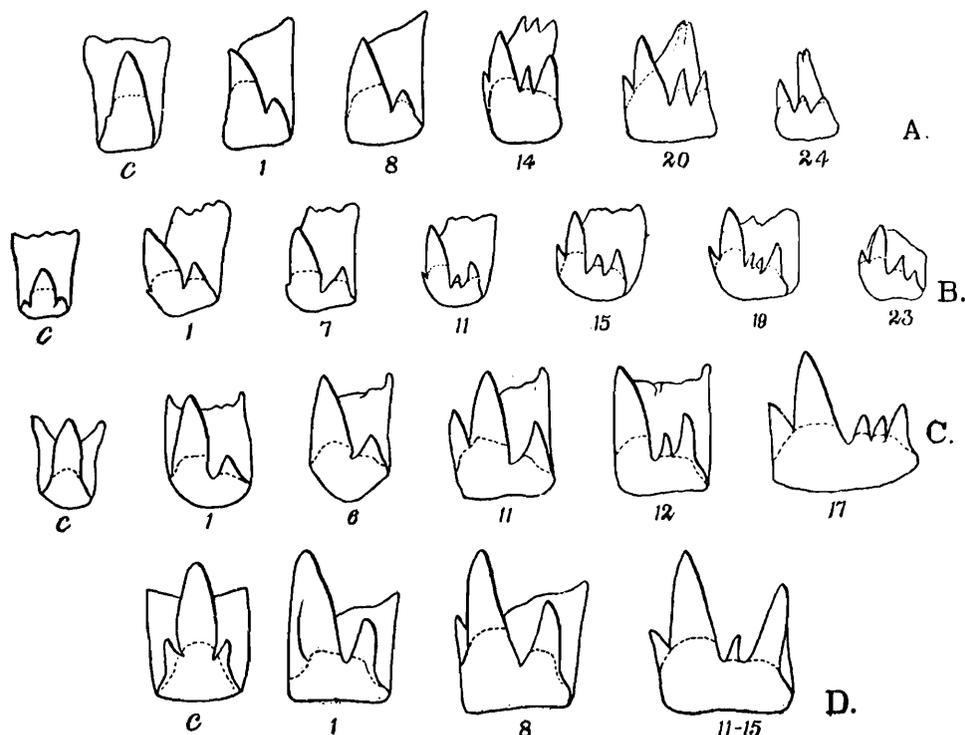


FIG. 4.—Radular teeth of Succineidae.

- A. *Succinea stoliczkae*, sp. nov. from 'Karnag.'  
 B. *Succinea gravelyi*, sp. nov. from Adyar, Madras.  
 C. *Succinea rutilans* Blanford from Manipur.  
 D. *Succinea godivariana* f. *vangiya*, nov. from Port Canning.

The radular teeth approach in some respects those of a form of *S. godivariana* Gude from Port Canning to be described further on, but differ from them in the absence of the small tooth at the inner base of the entocone of the outer laterals and of the marginals.

Until the anatomy of *S. crassinuclea* is known it is difficult to determine the exact relationship of the present form to the species mentioned. So far as the shell is concerned there is no doubt as to their close relationship.

#### ***Succinea martensiana* Nevill.**

1878. *Succinea martensiana*, Nevill, *Sci. Results Sec. Yarkand Expdn. Moll.* p. 5, figs. 30-31.

I include this species in the present note with some hesitation. Our collection contains several dry shells of this species bearing the label "Bazrahath, March 1894." They agree exactly with the figures of the

species in the work cited. The precise geographical position of the locality noted in the label is, however, not clear. I have failed to find it in the Atlases and in the volumes of the Imperial Gazetteer. The species was discovered by Stoliczka at Sasak Taka and Pasrobat in Yarkand and first described by Nevill in his report on the Yarkand molluscs. In his Hand-List published in the same year as the Yarkand Report Nevill recorded shells from Yarkand and "Bazrahath" both collected by Stoliczka. It seems to me that shells from the latter locality were collected

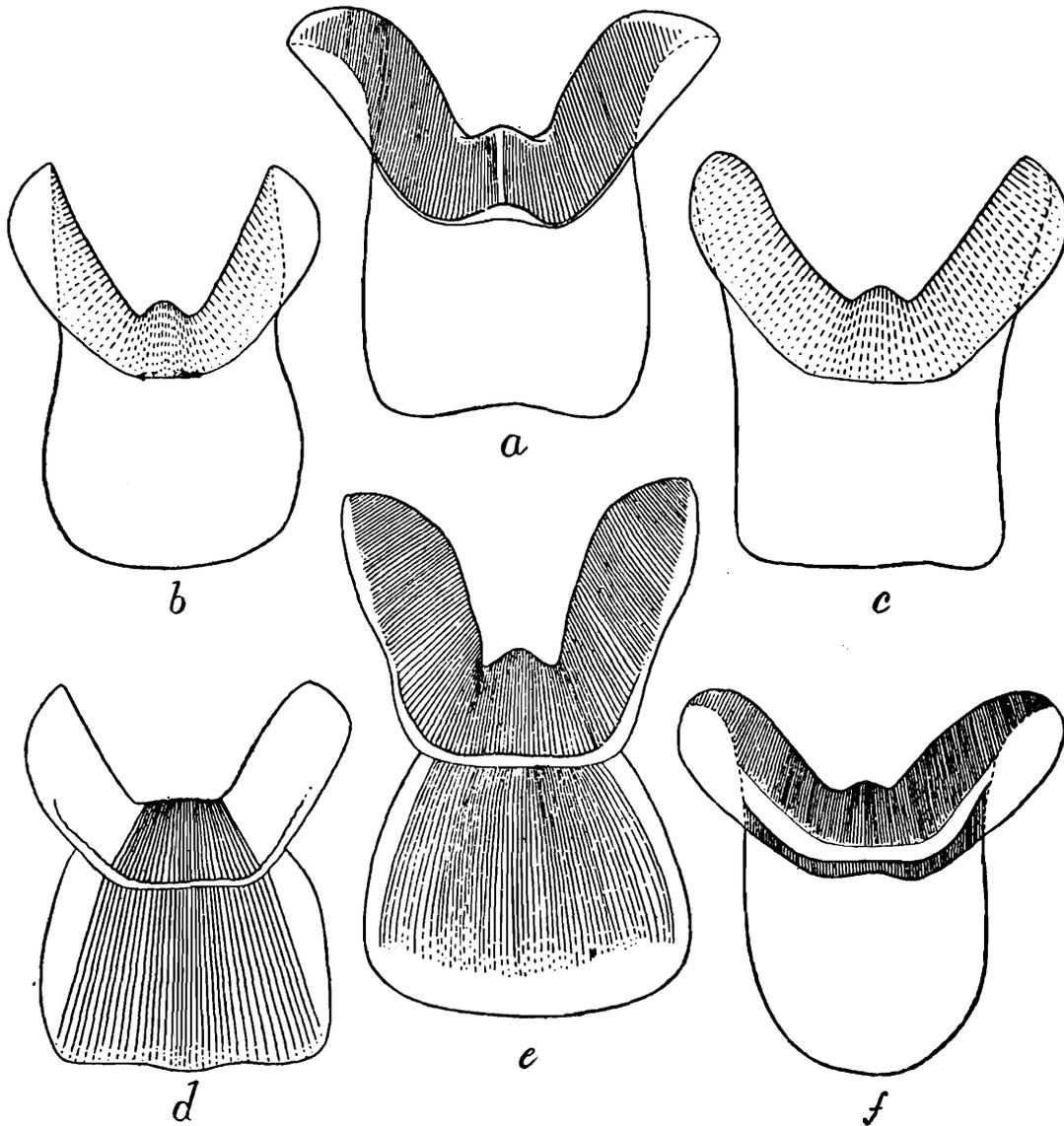


FIG. 5.—Jaws of Succineidae.

- a. *Succinea pfeifferi* var. *recta* Baudon from Luchon, Europe.
- b. *Succinea indica* Pfeiffer from Peshawar.
- c. *Succinea indica* Pfeiffer from Dal Lake, Kashmir.
- d. *Succinea pfeifferi* Rossmässler from Candahar.
- e. *Succinea putris* var. *propinqua* Baudon from Burgos, Spain.
- f. *Succinea yarkandensis* Nevill from Yarkand.

after the publication of the Yarkand Report and before that of the Hand-List. For if "Bazrahath" was in Yarkand, Nevill would not have failed to record shells from this locality in his Report. I believe that "Bazrahath" is a misspelling of Basirhat in the 24-Parganas in Bengal, especially when I find that "Sasak Taka" is spelt "Sasstekke" in the Hand-list.

*Measurements in millimeters.*

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
13.5	9.0	7.5	6.0
12.0	8.0	6.4	4.6
11.0	7.5	6.4	4.5
12.8	8.2	7.3	5.5

I was fortunate enough to find a single shell in the collection with a tiny bit of the dried animal which proved to be the anterior half containing the jaw and the radula. These structures were carefully removed by treatment with caustic potash.

Like the shell, the jaw and the radula are very characteristic of this species, and a comparison of the figures with those of the same structures of other species will show the distinctive features.

The jaw is fairly strongly chitinised, and is about as broad as long. The cutting piece is much better chitinised than the basal accessory plate and bears on its anterior margin three broad rounded prominences, one at the bottom of the concavity and two on the sides midway between the apex and the median prominence. The apex of the arms is bluntly conical. The posterior margin of the cutting piece is slightly depressed in the middle. The accessory plate has more or less parallel sides, while its posterior margin has a median concavity.

The radula is a broad ribbon consisting of fairly large teeth, which are stout and conical. The central has a stout cusp with an insignificant shelf-like projection near its base but has no definite lateral cusps. The laterals are more or less uniform in shape and have only two cusps. The ectocone is much smaller than the entocone in the first few laterals but show a progressive growth until the last lateral is reached, where the ectocone is many times larger than the entocone. The marginals are aculeate and half as numerous as the laterals. They have three cusps of which the entocone is the largest and the remaining small and equal in size. The approximate radular formula is 10.19.1.19.10.

Shells from "Bazrahat" are smaller and thinner than the type-series and do not have the characteristic yellowish brown colour on the inner surface of the shell. They have some resemblance to those of *S. girnarica* and the larger shells of *S. crassinuclea* in general form, but the peculiar irregularly malleated appearance and coarse sculpture, and the elongate scalariform spire with convex whorls, distinguish them from the shells of either species.

***Succinea hanleyi* Gude.**

1914. *Succinea hanleyi*, Gude, *op. cit.*, p. 455, fig. 141.

I refer to this species, with some doubt, a single broken shell from Pegu in Burma. It is smaller than the type and is of a pale colour. The whorls of the spire are more convex. The aperture and sculpture of the shell are similar to those of the type. The elongate columellar tubercle is very feebly developed. The author of the work cited considers that Hanley and Theobald's figure of *S. subgranosa* Hanley and Theobald is

referable to his species. The aperture of the shell figured by the latter is very different from that of the former. The species is apparently variable.

### *Succinea subgranosa* Pfeiffer.

1873. *Succinea subgranosa*, Sowerby in Reeve, *op. cit.*, pl. iv, fig. 24.

1878. *Succinea oblonga*, Nevill, *op. cit.*, p. 211.

There has been some confusion in distinguishing the members of this species from those of *S. oblonga* Draparnaud and *S. bensoni* Pfr. The specimens of the present species in our collection have been in obscurity until by careful examination they were separated from the species with which they were confused.

Shells from Kutch and Bombay collected by Stoliczka and Fairbank respectively were recorded by Nevill as belonging to *S. subgranosa*, but that they are really *S. bensoni* is shown in the account of that species below. Three shells from Kashmir labelled '*S. oblonga*' and recorded as such by Nevill are, in fact, *S. subgranosa*. The latter species has, no doubt, some external features in common with the former, but is distinct anatomically. I have extracted the jaw and radula of a specimen from Kumaon. The jaw of *S. subgranosa* is very different from that of *S. oblonga*<sup>1</sup>. I am not aware of any published figures of the radula or the genitalia of *S. oblonga*, but I presume that like the jaw they also are different.

I refer three shells from Ceylon to this species. They were found in a box containing shells of *S. ceylanica* Pfr. with which they do not, however, agree. They closely resemble shells of *S. subgranosa* from Kashmir and Kumaon.

#### *Measurements in millimeters.*

Locality.				Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
Kashmir	...	...	...	7.1	4.7	4.5	3.0
				7.3	3.8	3.6	3.0
Kumaon	...	...	...	6.0	3.2	3.0	2.6
Ceylon	...	...	...	6.1	3.6	3.8	3.0

The jaw is relatively less strongly chitinised and is broader than long. The cutting piece is uniformly striated, and the arms are gradually narrowed towards the apex and together form the arc of a circle. Its free margin is unindented. The basal accessory plate is slightly broader behind than in front and has a shallow depression on each side of the posterior margin.

<sup>1</sup> Hazay, *Malakozool. Blätt.*, III, pl. vi, fig. 19.

The radula consists of relatively large teeth, and the cusps are all long, sharp and conical. The central has a spear-shaped median cusp and is without lateral projections. The entocones of the laterals and

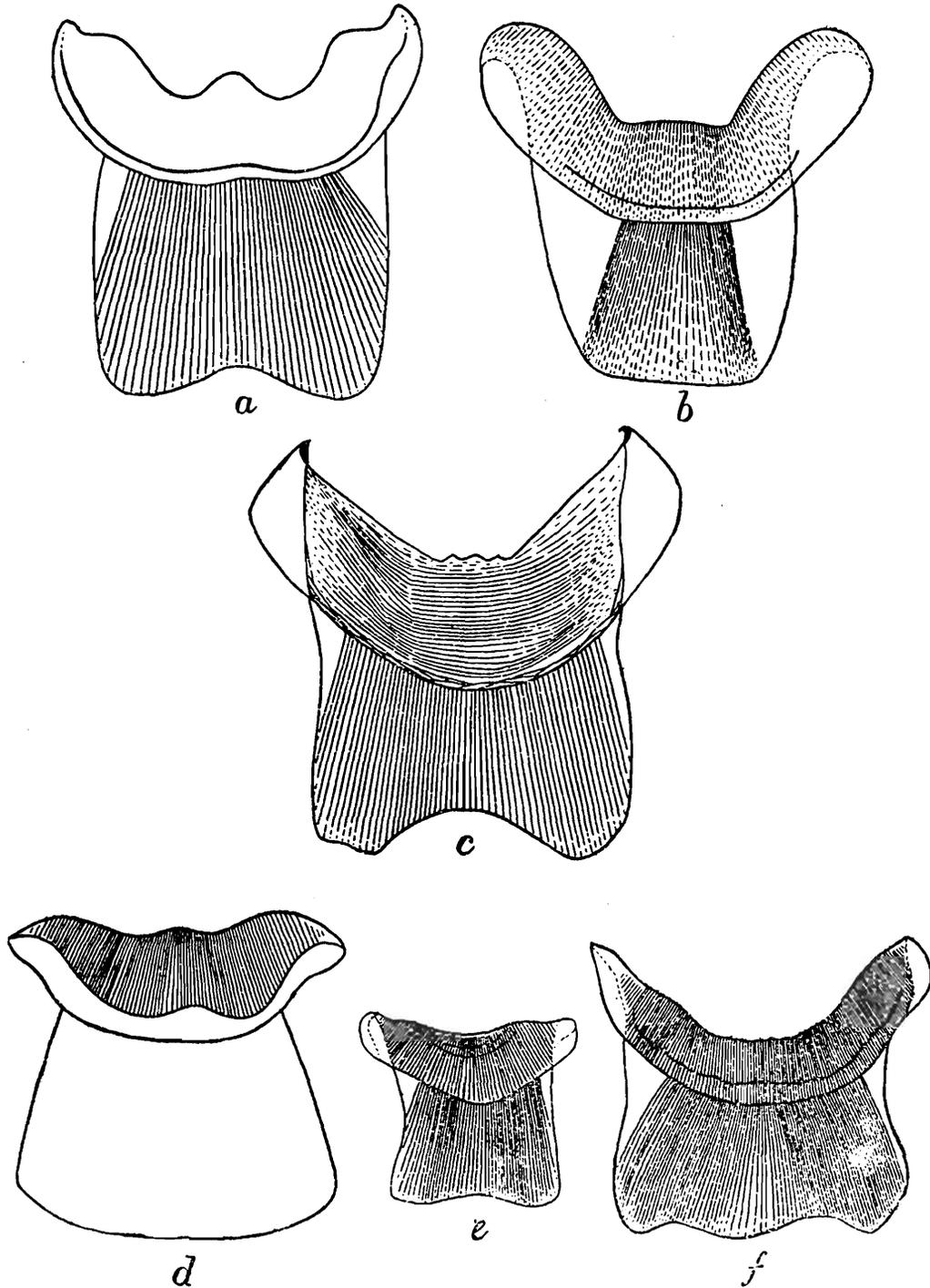


FIG. 6.—Jaws of Succineidae.

- a. *Succinea martensiana* Nevill from Sasstekke, Yarkand.
- b. *Succinea girnarica* Theobald from Girnar Hills, Kathiawar.
- c. *Indosuccinea semiserica* (Gould) from Rangoon.
- d. *Lithotis tumida* Blanford from Singhur, Poona.
- e. *Camptonyx theobaldi* Benson from Girnar Hills, Kathiawar.
- f. *Succinea subgranosa* Pfeiffer from Kumaon.

marginals exceed the height of the basal plate. The marginals have a small tooth on the inner base of the entocone. The approximate radular formula is 16·9·1·9·16.

**Succinea bensoni** Pfeiffer.

1876. *Succinea bensoni*, Hanley and Theobald, *op. cit.*, pl. 67, fig. 9.

1878. *Succinea subgranosa*, Nevill, *op. cit.*, p. 212.

1914. *Succinea bensoni*, Gude, *op. cit.*, p. 456.

This species is represented in our collection by six shells from Bombay collected by Fairbank (from one of which the jaw and radula were extracted) and by a single shell taken by Stoliczka at Kutch.<sup>1</sup> Nevill does not record this species in his Hand-List but has wrongly included the shells with those of *S. subgranosa*. Though the shell of *S. bensoni* has some superficial resemblance to a few short-spined forms of *S. subgranosa* the two species differ in important features. The latter has, as a rule, a thicker shell and a much longer spire, and in the soft parts has the jaw and radula very different from those of *S. bensoni*.

The type-series of *S. bensoni* from Moradabad are still in the collection and are not recorded by Nevill. Our specimens agree with them closely.

A single shell of *S. bensoni* was found mixed up with the shells of *Lithotis tumida* from Poona. As has been pointed out under the account of the latter species, the two species may be confused at first sight, but the real differences are given under the genus *Lithotis*. The columellar fold of this specimen from Poona is much better developed than in individuals from Kutch and Bombay.

The largest shell in the collection has the following measurements in millimeters.

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
6·2	4·8	4·0	3·3

The jaw is relatively less strongly chitinised and is longer than broad. The arms of the cutting piece are short with the apices narrow and pointed. The anterior margin is very slightly depressed and may or may not have a median prominence. The posterior side of the cutting piece is rarely emarginate. The basal accessory plate has parallel sides and a depression on each side of its posterior margin.

The radular teeth are relatively few in number, the marginals being fewer than the laterals as in *S. crassinuclea* f. *vitrea*. The central has a well-developed median conical cusp with a lateral tooth at its base on each side. The laterals have much narrower cusps than in the above-named species with the entocones high and well-developed. There are never more than five marginals each having one or two cusps. The radular formula is approximately 4·15·1·15·4.

The jaw and radula are subject to variability to some extent in examples taken from the same locality. In spite of the fact that these structures in *S. bensoni* agree in some respects with those of *S. crassinuclea* f. *vitrea* I regard the two species as distinct. Judging from the

---

<sup>1</sup> I have since been able to collect living individuals of this species on the brick walls of the moat, Fort William, Calcutta, in the month of July 1923, and also from a drain in Sibpore in the same month.

shells alone one would be tempted to treat the present species as no more than a form of *S. crassinuclea* closely allied to the f. *vitrea*.

Living individuals of this species found in Calcutta enabled me to study the genitalia and other organs. The kidney and the pulmonary chamber show no peculiar features. The genitalia, on the other hand, somewhat resemble those of *S. indica*, but have certain distinct features. The albumen and hermaphrodite glands are well developed and the prostate is large and triangular. The uterus and the penis are slightly twisted together. There are three seminal vesicles as in *Succinea graveleyi*, sp. nov. The spermatheca is a globular sac with a long thin duct which opens at the junction of the broad distal portion of the uterus with the narrower convoluted proximal portion. There is a short vas deferens which opens on the top of the stout cylindrical penis which is bulged out at its proximal end, and to which is attached a single retractor muscle. The lumen of the penis has two longitudinal folds which enclose a groove. The terminal portion of the penis may often be protruded through the external opening as shown in the figure.

Living examples of this species are very sluggish in habits and live in crevices between stones and bricks which are overgrown with moss. The colour of the shell with the animal inside harmonises with that of its surroundings. They seem to live on moss growing in the crevices. They hardly contract when disturbed but exude copious mucous from the foot.

### *Succinea ceylanica* Pfeiffer.

1876. *Succinea ceylanica*, Hanley and Theobald, *op. cit.*, p. 64, pl. clviii, fig. 10.  
 1878. *Succinea ceylanica*, Nevill, *op. cit.*, p. 212.  
 1914. *Succinea ceylanica*, Gude, *op. cit.*, p. 457.

I doubt whether this is a distinct species at all. It seems to be closely allied to *S. daucina* Pfr. and might prove to be only the Ceylon form of the latter. But nothing definite can be said about their affinities until the anatomy of both is known.

The single specimen in the collection from Kandy in Ceylon has a thick shell with  $3\frac{1}{2}$  whorls and is relatively narrow. It agrees with the figure of this species in *Conch. Ind.* Though it approaches the typical forms of *S. daucina* in some respects, it differs from the latter in the body-whorl being relatively narrow, in the more deeply impressed suture and in the narrowly elongate aperture, the margin of which is slightly thickened. The colour of the shell is probably variable. It has the following dimensions in millimeters.

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
9.6	6.4	5.4	3.8

### *Succinea daucina* Pfeiffer.

1914. *Succinea daucina*, Gude, *op. cit.*, p. 453.

Several shells from Calcutta and Port Canning in Bengal are represented in the collection. Specimens recorded by Nevill are also intact.

The species is extremely variable in size, form and colour, but when the whole collection is examined at once it is possible to distinguish, at least, two distinct forms, *viz.*, the long-spined and the short-spined. The former are typical and agree with the original description of the

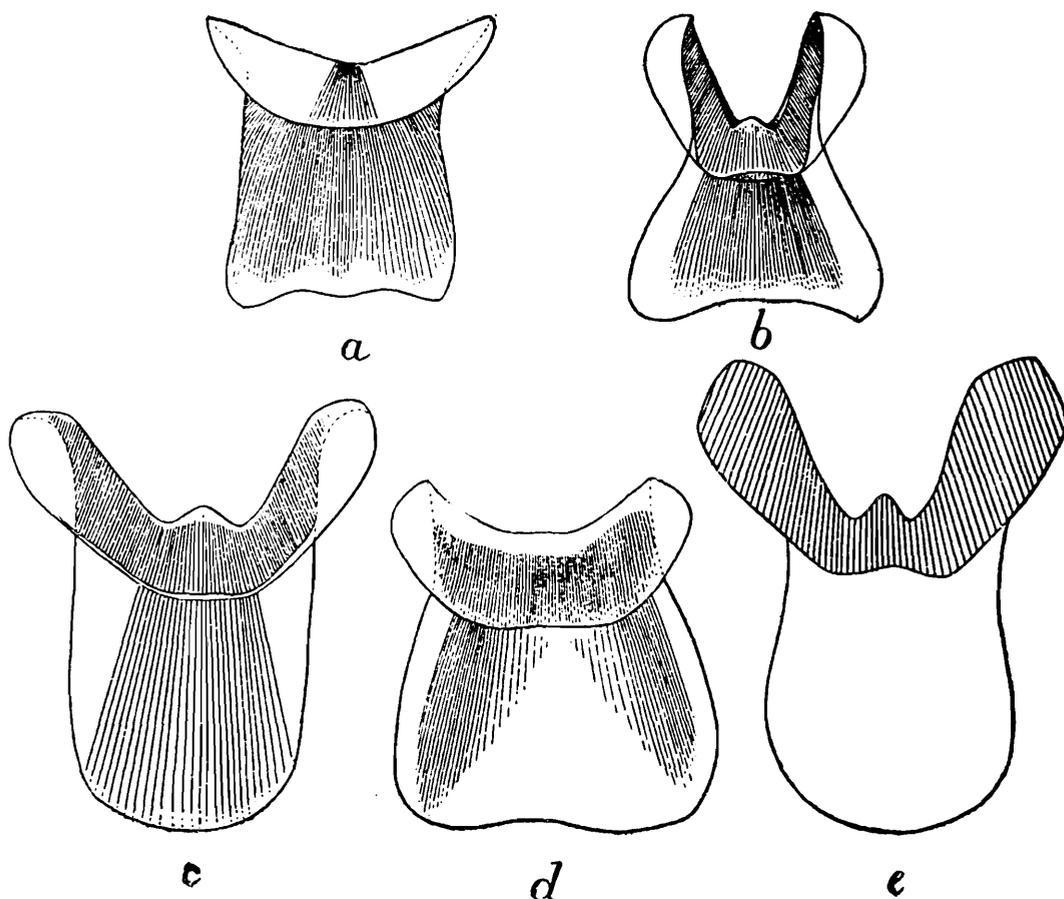


FIG. 7.—Jaws of Succineidae.

- a.* *Succinea bensoni* Pfeiffer from Fort William, Calcutta.  
*b.* *Succinea gravelyi*, sp. nov. from Adyar, Madras.  
*c.* *Succinea stoliczkae*, sp. nov. from Leh, Kashmir.  
*d.* *Succinea crassinuclea* f. *vitrea* Pfeiffer from Port Canning, Bengal.  
*e.* *Succinea stoliczkae*, sp. nov. from 'Karnag.'

species, but not quite with the published figures. They are larger than the type. Gude distinguishes this species from its nearest allies by the inflexion of the outer margin of the peristome. This feature, owing to its variability, seems to me to be an unreliable diagnostic character.

*Measurements in millimeters.*

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
11.5	7.4	6.7	5.2
11.2	8.2	7.5	6.0
10.0	7.0	6.5	4.3
10.0	7.5	6.2	4.8
9.8	6.1	5.9	4.3

The anatomy is unknown. The shells in the collection have been so well cleaned that not a little of the dried animal is left behind to enable one to examine the jaw or the radula.

***Succinea daucina* f. *hraswasikhara*,<sup>1</sup> nov.**

1878. *Succinea daucina* var. (?), Nevill, *op. cit.*, p. 212.

Shells belonging to this form were taken from the same localities as the previous species and found labelled "*S. daucina*, Pfr." In size they are smaller than *S. daucina* and have the spire shorter. They are subject to the same degree of variability in colour and form as the typical *S. daucina*.

The present form is, however, distinct and can be easily distinguished from the typical species by the relatively short spire, by the papillate apical whorl, and by the relatively less tumid penultimate whorl.

Shells intermediate in character between this form and *S. daucina* are also found in the collection, but they are not distinct enough to be regarded as a separate form.

*Measurements in millimeters.*

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
8.0	6.0	5.0	4.0
8.8	6.2	5.9	4.3

*Type-specimen*.—No. M<sup>12396</sup>/<sub>2</sub> Zool. Surv. Ind. (*Ind. Mus.*).

A small broken shell collected by Nevill in Madras is referred to this form.

***Succinea snigdha*,<sup>2</sup> sp. nov.**

The shell is elongate-ovate, conical, moderately thick, shining, and has a pale cream colour. It has fine irregular striae which are conspicuous except on the spire. The spire is high, less than half the total height of the shell, and has  $2\frac{1}{4}$  to  $2\frac{1}{2}$  whorls, but rarely three. The whorls are tumid, the second more than the penultimate which is oblique and about  $\frac{2}{3}$  the height of the spire. The suture is moderately impressed and the apex is minutely papillate. The aperture of the shell is elongate-ovate with the margins relatively thick. The columellar fold is minute or obsolete with a well-defined smooth and shining ridge continuous with the margin of the aperture.

*Measurements in millimeters.*

	Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
Type-specimen	7.8	5.2	3.1	2.7
1	7.5	4.8	4.3	3.3
2	8.7	5.1	4.9	3.4

*Type-specimen*.—No. M<sup>12394</sup>/<sub>2</sub> Zool. Surv. Ind. (*Ind. Mus.*)

*Locality*.—Calcutta.

Several shells of this species were found in a tube with the label "Calcutta" in the box containing *S. daucina*. Nevill does not record them in his Hand-List.

<sup>1</sup> From two Sanskrit words *Hraswa* (=short) and *Sikhara* (=spire).

<sup>2</sup> *Snigdha* in Sanskrit means smooth.

The species is slightly variable in size, thickness and sculpture of the shell, and in the prominence of the columellar ridge. The latter has often the appearance of a minute tubercle in an oblique ventral

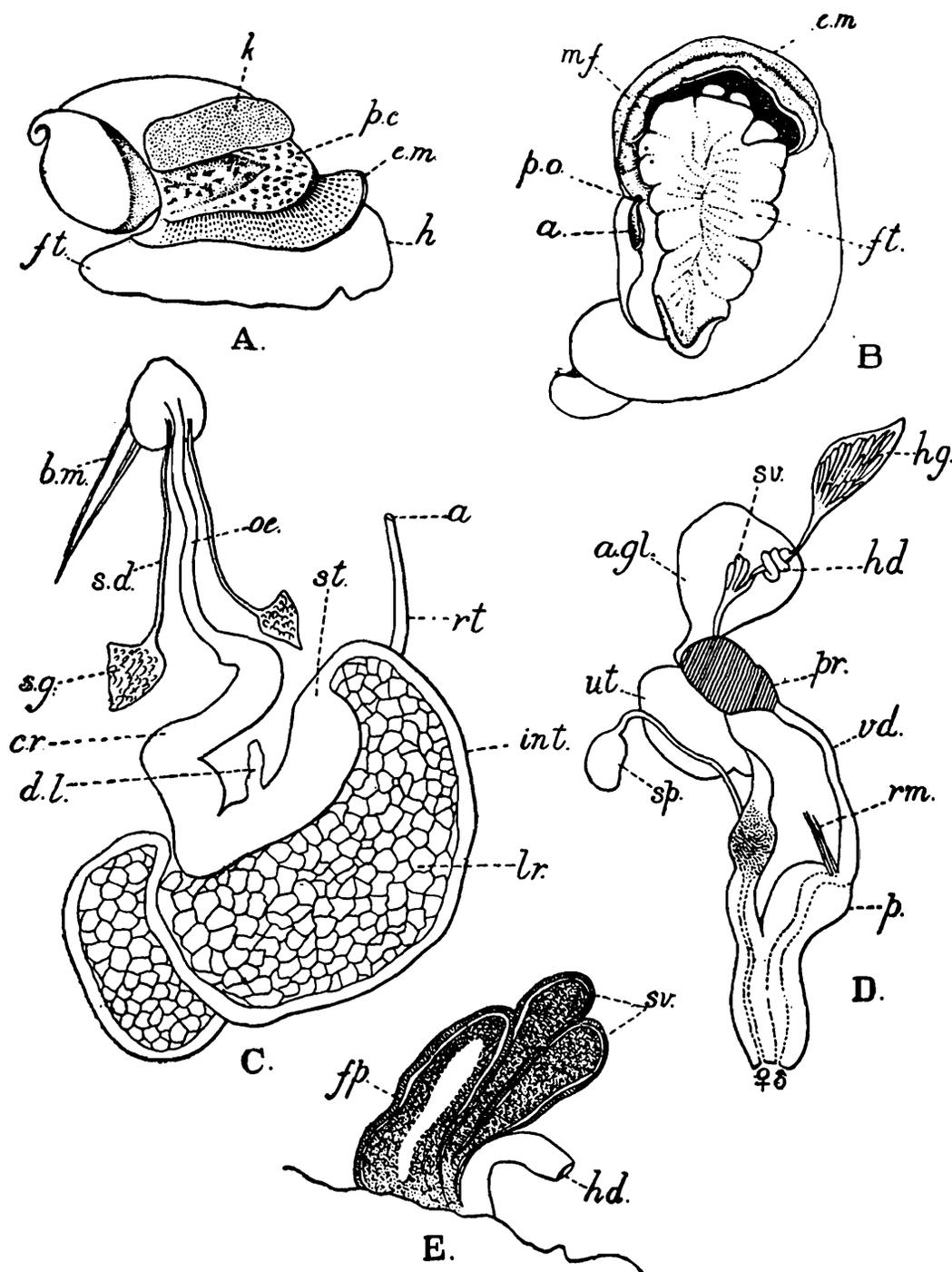


FIG. 8.—External features and anatomy of *Succinea graveli*, sp. nov.

- A. View from the right side of the animal.  
 B. Ventral view of the whole animal.  
 C. Alimentary tract and associated structures.  
 D. Ventral view of the genitalia.  
 E. Enlarged view of the semimal vesicles.

*a.* anus; *a. gl.* albumen gland; *b. m.* buccal muscles; *cr.* crop; *d. l.* duct of liver  
*e. m.* edge of mantle; *fp.* third seminal vesicle representing the modified fecundation pouch; *ft.* foot; *h.* head; *hd.* hermaphrodite duct; *hg.* hermaphrodite gland; *int.* intestine; *k.* kidney with calcareous concretions seen through covering membrane; *lr.* liver; *mf.* fold of mantle; *oe.* oesophagus; *p.* penis; *p. c.* pulmonary chamber; *p. o.* pulmonary opening; *pr.* prostate gland; *rm.* retractor muscle of penis; *rt.* rectum; *s. d.* duct of salivary gland; *s. g.* salivary gland; *sp.* spermatheca; *st.* stomach; *sv.* seminal vesicles; *ut.* uterus; *vd.* vas deferens.

view from the columellar side. The ridge is separated from the body-whorl by an open shallow groove.

Though the present species resembles *S. daucina* in some respects, it differs from it in the smaller size, in the relative thickness of the shell, in being much narrower, in the possession of a relatively long spire for its size, in colour, in the distinct prominence of the columellar ridge and in the polished and shining appearance of the shell.

### *Succinea stoliczkae*, sp. nov.

1878. *Succinea* sp., Nevill, *op. cit.*, p. 214.

The shell is ovate, relatively thick, and has irregular relatively coarse striae. The colour of the shell varies from a pale cream to grey or brown with, sometimes, a characteristic shining appearance. The spire is elongate, obtusely conical, a little less than half the total height of the shell, and has  $2\frac{1}{2}$  to 3 scalariform, quite convex whorls, sculptured with fine oblique striae. The suture is nearly transverse and the body-whorl moderately convex. The aperture is ovate, obliquely flattened above on the columellar side, but regularly rounded below. The outer margin is somewhat arched above. The columellar fold is minute, twisted in the middle, and has a long, oblique, smooth and shining ridge commencing from within the aperture.

#### *Measurements in millimeters.*

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
8.9	5.5	5.6	3.7
8.0	5.5	5.1	3.0
7.5	4.6	4.4	3.1
7.3	4.0	4.2	2.6
7.0	4.0	3.9	2.5

The jaw is very distinct in several features. It is longer than broad and the cutting piece has long and club-shaped arms with a prominent median projection at the bottom of the concavity. The posterior margin of the cutting piece is medially depressed. The basal accessory plate is roughly rectangular with the posterior part broader and rounded.

The radula is a long narrow ribbon with less than 60 teeth in each transverse row. The teeth are relatively small and have sharp elongated cusps. The central has a conical median cusp with a subobsolete lateral tooth at its base. The laterals have, as usual, only two cusps, while the marginals have nearly always 4 cusps including the small tooth at the inner base of the entocone. The approximate radular formula is 16.13.1.13.16.

*Type-series.*—No. M $\frac{12399}{2}$  Zool. Surv. Ind. (*Ind. Mus.*).

Several shells were taken by Stoliczka under stones at "Karnag."

I have been unable to determine the precise position of this locality in the Indian Empire. It is probably the name of a spring in Kashmir. Nevill recorded these specimens in his Hand-List as an undetermined species of *Succinea*:

Shells of this species approach those of *S. snigdha* in some respects, but are distinguished from the latter by the scalariform shell, the

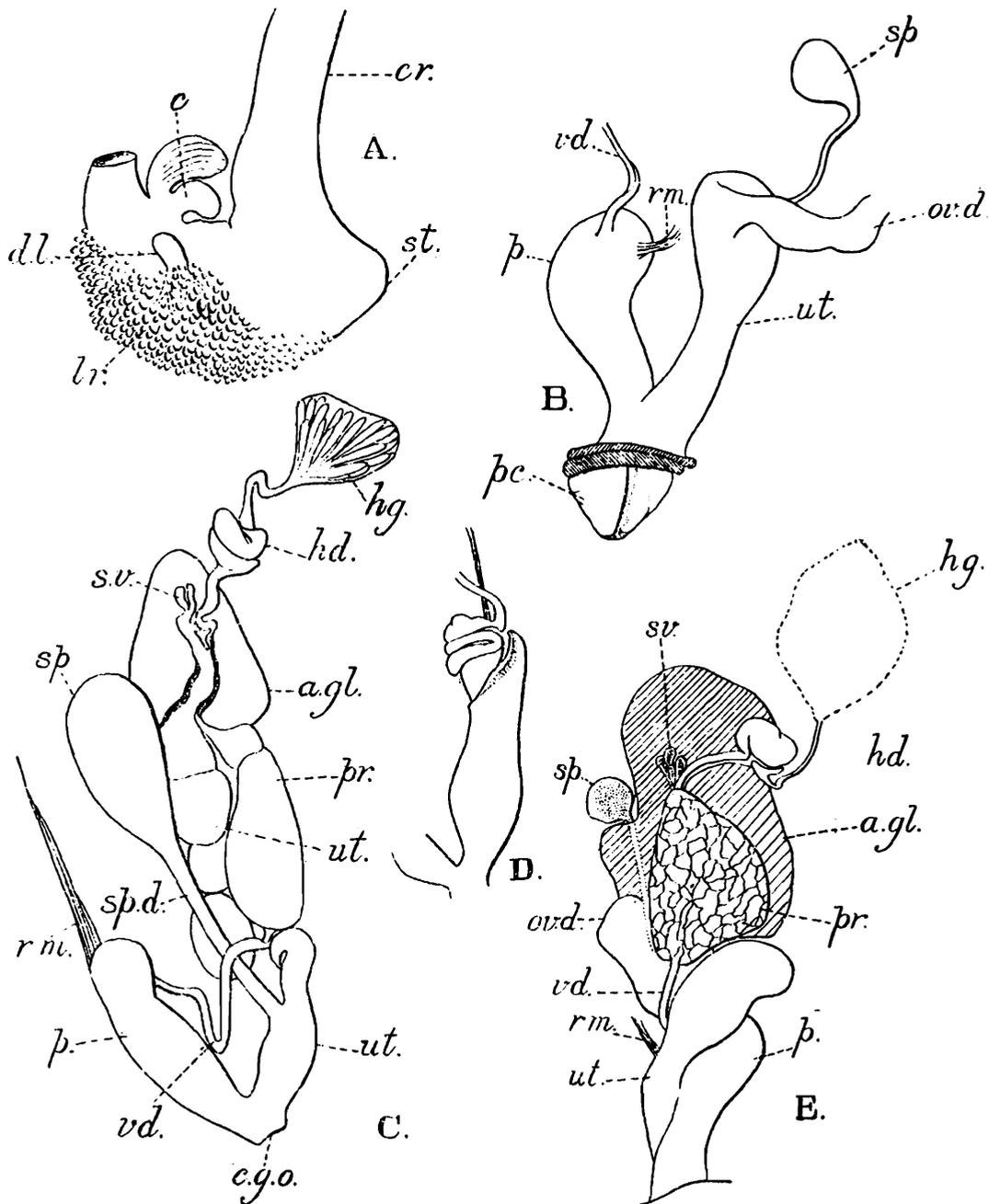


FIG. 9.—Anatomy of Succineidae.

- A. *Indosuccinea semiserica* (Gould). Region of the stomach.  
 B. *Succinea bensoni* Pfeiffer. Terminal portion of the genitalia as seen from the ventral side with the structures dissected out.  
 C. *Succinea indica* Pfeiffer. Ventral view of the genitalia.  
 D. *Succinea indica* Pfeiffer. Penis dissected out from its sac, and showing digitiform process at its proximal end.  
 E. *Succinea bensoni* Pfeiffer. Ventral view of the genitalia (*in situ*).

*a.gl.* albumen gland; *c.* caeca; *c.g.o.* external opening of the male and female ducts; *cr.* crop; *d.l.* duct of liver; *hd.* hermaphrodite duct; *hg.* hermaphrodite gland; *lr.* liver; *ov.d.* oviduct; *p.* penis; *pc.* portion of penis protruding outside with a median groove on it; *pr.* prostate gland; *rm.* retractor muscle of penis; *sp.* spermatheca; *sp.d.* duct of spermatheca; *st.* stomach; *sv.* seminal vesicles; *ut.* uterus; *vd.* vas deferens.

strikingly convex whorls, the coarser sculpture, the dull gray colour, and the nature of the aperture and the columellar ridge.

***Succinea gravelyi*, sp. nov.**

The shell is narrowly ovate, relatively thin, translucent, and more or less regularly finely striated. It is of a reddish-amber colour except on the apex of the spire and on the columellar fold which are often pale in contrast. The spire is short, conical and less than  $\frac{1}{3}$  the total height of shell, and has a blunt apex. It has, as a rule,  $2\frac{1}{4}$  moderately convex whorls, the penultimate oblique and less convex than the last whorl. The suture is not deeply impressed. The aperture is ovate, pointed above and evenly rounded below, and rarely oblique from below the columellar fold. The outer margin of the aperture is very slightly inflexed above. There is often a pearly lustre on the inner surface of the shell. The columellar fold is very thin and minute while its ridge is nearly obsolete.

*Measurements in millimeters.*

Type speci- men.	Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
	6.5	5.0	4.7	3.0
1	6.2	4.2	3.8	3.2
2	6.0	4.6	3.7	3.1

*External features.*—The foot of the animal in preserved condition is leaf-shaped, very much wrinkled, broad and rounded in front and tapering gradually behind. The sides of the head and the tentacles are covered by small dark patches of pigment which gradually fade on the sides and posterior extremity of the foot. The edge of the mantle is broad and pigmented, and has a groove near the free margin and a narrow vertically depending fold on its lower surface. The roof of the pulmonary chamber is thin and transparent and covered with sparsely distributed irregular patches of black pigment which fade away on the membranous covering of the spire. The kidney is roughly rectangular, and slightly broader on the right side than on the left. It is yellow in colour and filled with spherical or oval calcareous concretions. The spire has a pale pink colour. The mouth of the animal is a small circular opening, often very much contracted and hidden from view by the folds of the buccal mass and the foot. The anus is an elongated elliptical slit on the right side near the posterior end of the pulmonary chamber and is in communication with the small circular opening of the lung at its anterior end by a short narrow groove as in other species of *Succinea*. The male and female apertures are placed close together on the right side a little below the base of the tentacle.

The jaw is small and delicate and slightly longer than broad. The arms of the cutting piece form a roughly V-shaped structure and are a little broader at their apices than below. The outline of the apex is rounded on the outer side and straight on the inner. The bottom of the V-shaped concavity is raised in the centre into an obtusely conical prominence. The basal accessory plate broadens rapidly from before backwards and has a broad shallow depression on the posterior margin. The striations on the jaw are well marked. In some features the jaw

of this species seems to approach that of *S. indica* but differs from it in having a wedge-shaped basal accessory plate, in the broad depression on the posterior margin, and in its delicate texture.

The radula is a narrow ribbon consisting of relatively few small teeth. The central is short and conical and has at its base on each side a well-developed conical tooth. The basal plate is broad and much higher than the median cusp. The laterals have two cusps with a small one at the base of the inner side of the entocone. The marginals have 4 to 5 elongate narrow cusps of which the entocone is the largest, while the small tooth on the inner side of the entocone is better developed than on the laterals. The dental formula is approximately 13.10.1.10.13. The radula is very distinct in features though some resemblance might be detected to that of *S. rutilans* and some specimens of *S. indica*. It is, in all probability, a chance resemblance rather than any real affinity.

The oesophagus is long and commences from the middle of the dorsal surface of the heart-shaped buccal mass, opening into the crop which is wider. The salivary glands are two in number and roughly triangular in shape, and have thin ducts nearly as long as the oesophagus. The ducts open into the buccal mass one on each side a little behind the commencement of the oesophagus. The crop opens into a wide stomach which together with the former forms a roughly V-shaped structure. The duct from the liver or the hepatic glands opens at the anterior end of the stomach. In the individuals dissected the stomach contained a disintegrated mass of moss or algae and was singularly devoid of hard particles of mud or sand.

The caeca, which are found in other species of *Succinea*, seem to be wanting in *S. gravelyi*. I dissected over a dozen individuals but found no caeca in any of them. If they are present at all they must be extremely delicate and transparent.

The intestine is long and narrow and has a double loop encircling the liver. The rectum traverses the right margin of the posterior half of the pulmonary chamber and opens to the outside close to the opening of the lung.

The kidney is filled with spherical or oval calcareous concretions which seem to obliterate the internal folds as in individuals of *S. indica* from Kashmir taken in July. But individuals of the present species were all collected in January. From the facts available as regards this phenomenon in *I. semiserica*, *S. indica*, and the present species, the real causes of this phenomenon are somewhat obscure though rainfall and a low temperature seem to regulate the deposition of concretions.

The genitalia of *S. gravelyi* are remarkable in certain features. The hermaphrodite gland is elongately triangular and lightly coiled at the apex of the spire. The hermaphrodite duct is relatively short, its terminal portion being spirally coiled and covered by dark pigment. It opens at the base of the seminal vesicles of which there are three. Two of them are sub-equal and thick-walled while the third is slightly shorter than the others, thin-walled and enlarged. The last corresponds to the third vesicle described in *I. semiserica*. I have found spermatozoa in

all of them in transverse sections of the organ. The third sac<sup>1</sup> probably represents the modified fecundation pouch, which, in *S. putris*, is a wide sac into which the seminal vesicles open. The prostate is oval and the vas deferens moderately long and narrow. The latter opens on the proximal extremity of the penis, which is a wide sac in close relation with the vagina. The penis and the vagina are, to a relatively great extent, united along their length, which marks off this species from all others in which the genitalia are known. In cleared preparations of this portion of the genitalia it is evident that the wall of the vagina and the penis are fused together on one side, while their proximal parts are separated. The male and female openings are placed close together in an atrium-like structure. There is a single retractor muscle attached to the proximal end of the penis. The albumen gland is roughly triangular. It is followed by a short and narrow oviduct which leads to an enlarged uterus. The proximal end of the vagina has a bulbous outline and is connected with the uterus by a short wide duct. The spermatheca is oval and has a long fine duct which opens dorsally on the bulbous portion.

*Type-specimen*.—No. M<sup>12378</sup>/<sub>2</sub> Zool. Surv. Ind. (*Ind. Mus.*).

Dr. F. H. Gravely obtained several living individuals on the brick walls of an old well (just above the water-level) at the back of a casuarina plantation on the Elliot's Beach, Adyar, Madras.

This species is very distinct from all others both in the characters of the shell and in the peculiarities of the soft parts. The shell has a general resemblance to that of *S. daucina* f. *hraswasikhara*, but is distinguished from the latter by its relative narrowness and thinness, by the less tumid penultimate and last whorls, by the obsolete columellar ridge, and by the beautiful reddish-amber colour. It might also be confused with that of *S. rutilans*, which, however, can be distinguished by the form and the colour.

#### ***Succinea gravelyi* f. *deccanensis*, nov.**

Shells of this form are apt to be mistaken for those of the typical *S. daucina*, but a closer examination of the texture, sculpture and colour of the shells will make the differences clear. They are, however, closely allied to those of *S. gravelyi* in the features mentioned. They are larger in size than the latter and are of a dull amber colour. The penultimate whorl is more convex and the suture more or less well-impressed. The sculpture is coarser, distinctly on the penultimate whorl but minutely on the apical. There are about 2½ whorls in the spire. The largest shell has the following measurements in millimeters.

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
9.5	6.8	5.1	3.8

<sup>1</sup> Jacobi describes, in *S. horticola*, Reinh. a small sac at the base of the vesicles under the name "*Befruchtungstasche*" (vide *Journ. Coll. Sci. Tokyo*, XII, p. 84, pl. vi., figs. 119a and b; 1898-1900), and I presume this corresponds to the greatly developed sac in *S. semiserica* and *S. gravelyi*.

*Type-specimen*.—No. M<sup>12387</sup>/<sub>2</sub> Zool. Surv. Ind. (*Ind. Mus.*).

Five shells of this form were collected by Mr. B. Sundararaj from a walled tank in a mosque, Kurnool town, Madras Presidency.

***Succinea gravelyi* f. *andamanensis*, nov.**

Shells of this form approach those of *S. gravelyi* f. *deccanensis* but have more tumid whorls than in the latter or in *S. gravelyi*. The penultimate and the last whorls are relatively convex and have a very coarse sculpture. The colour of the fresh shells is deeper than in *S. gravelyi*.

The jaw, the radula, and the other soft parts are similar to those of *S. gravelyi*.

The type-specimen has the following measurements in millimeters:—

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
8.3	5.9	6.0	4.0

*Type-specimen*.—M<sup>12424</sup>/<sub>2</sub> Zool. Surv. Ind. (*Ind. Mus.*).

Living specimens of this form were found by Dr. N. Annandale on Mount Harriet (1,100 feet), S. Andamans in December 1923 on damp soil at the base of banana trees in a garden, at some distance from water.

***Succinea rutilans* Blanford.**

1876. *Succinea rutilans*, Hanley and Theobald, *op. cit.*, p. 29, pl. lxxvii, fig. 10.

1914. *Succinea rutilans*, Gude, *op. cit.*, p. 448.

1921. *Succinea rutilans*, Amin-ud-din, *op. cit.* p. 598, figs. 21 (2a, 2b) and 25.

The shells collected by Godwin-Austen in the Khasi Hills and recorded by Nevill are still in our collection. In addition there is a single shell from the Manipur valley which has a light olive-brown colour. It is more elongate than the Khasi Hill specimens and has a higher and more tumid spire.

There are two shells in the collection labelled "*S. taylori*, Pfr. Singapore" which agree closely with the Manipur specimen. They are of a yellowish amber colour. I have little doubt that *S. taylori* is a synonym of *S. rutilans*.

*Measurements in millimeters.*

Locality.				Height of shell.	Height of aperture	Greatest breadth of shell.	Greatest breadth of aperture.
Manipur	...	...	...	9.6	6.5	5.3	3.7
Khasi Hills	...	...	...	9.6	6.1	5.0	3.6
Singapore	...	...	...	9.0	6.4	5.5	4.0

The shells from the Khasi Hills have a remarkably short spire, and are of a pale yellow colour with olivaceous longitudinal streaks on the last whorl.

The jaw of the species is very distinct in features. It has roughly a square outline. The cutting piece is more or less uniform in breadth and has short and blunt arms with flattened apex. Its anterior margin makes a semi-circle and is without indentations. The basal accessory plate has parallel sides and a rounded posterior margin.

The radular teeth are relatively few in number and have characteristic features. The basal plate is nearly always shorter than the highest cusp of individual teeth. The central has an elongated conical cusp without lateral teeth. The laterals are bicuspid with the ectocone much shorter than the entocone. The marginals have three to five cusps of which the entocone is the largest. There is a large conical tooth on the inner side of the base of the entocone, which may be rarely absent on one or two of the longitudinal rows of marginals.

The genitalia are of the usual type in amphibious species and exhibit no distinctive features.

The species is, presumably, widely distributed in Assam, Burma and the Malay Peninsula. In the present state of our knowledge of the species of *Succinea* as a whole no definite statement as regards their distribution can be made.

### ***Succinea godivariana* Gude.**

1914. *Succinea godivariana*, Gude, *op. cit.*, p. 449, fig. 140.

A single shell, collected by me from a sand-like deposit on the sides of the He-ho Gorge, S. Shan States in March 1922, is referable to this species. It agrees very closely with the figures of this species in the "Fauna" volume, but has half a whorl more. The shell is amber-coloured.

#### *Measurements in millimeters.*

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
3·4	2·5	3·0	1·8

The type-series were collected by Beddome on Gorge Hill, "Godivari" (apparently misspelt for Godavari in the Madras Presidency).

The distribution of this small species is interesting in that it has been found in two such remote places as "Godivari" in India and He-ho in Burma. The species being the smallest in size is much more likely to escape the attention of collectors than the larger species, which are themselves so little known owing to their cryptic habits.

### ***Succinea godivariana* f. *vangiya*,<sup>1</sup> nov.**

Two shells from Port Canning in Bengal are here regarded as a distinct form of the foregoing species. They were found in our collection with only the locality label. Nevill did not record them in his Hand-List. They had a muddy deposit on the outer surface of the shell which was curiously raised into minute spine-like processes. These latter gave them the appearance of a marine or estuarine species (like

<sup>1</sup> *Vangiya* is the adjective form of *Vanga* in Sanskrit for Bengal.

that of a spiny *Neritina*). On washing the shells in water the muddy deposit disappeared and their true affinity was discovered. One of them had a tough epiphragm on removing which the dried animal was found in the shell. It was soaked in cold caustic potash for a few hours and the animal removed for the extraction of the jaw and the radula. The former structure was, unfortunately, not to be seen.

The radular teeth are large for the size of the animal, and few in number. The basal plate of individual teeth is always shorter than the highest cusp. The central has a long conical and apically blunt median cusp and two well-developed lateral cusps. The laterals have two cusps of which the entocone is larger. The marginals have 3 to 4 cusps one of which is the inner lateral denticle at the base of the entocone. The cusps are elongate, narrow and more or less sharp. The approximate dental formula is 8. 7. 1. 7. 8.

The largest shell has the following measurements in millimeters :—

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
3.6	3.0	2.5	2.0

*Type-specimen*.—No. M<sup>12392</sup>/<sub>2</sub> Zool. Surv. Ind. (*Ind. Mus.*).

The shells are whitish in colour and are narrower and much less convex than those of *S. godivariana*. The sculpture is also much coarser. The margin of the aperture below the columellar fold is inflexed.

The present form seems to give a clue to the true distribution of *S. godivariana*, which, from its known *provenance* alone, is likely to be regarded as a species having a discontinuous distribution.

### ***Succinea limnaeiformis*, sp. nov.**

The shell is narrow, elongate-ovate, fairly thick with fine, close-set regular longitudinal striae. It has a pale yellowish-brown colour. The spire is very short and about  $\frac{1}{5}$  the total height of the shell with only two whorls. The penultimate is oblique and moderately convex with very minute longitudinal striae. The body-whorl is not at all tumid but is somewhat convex in a dorsal view. The apical whorl is minutely papillate. The aperture is somewhat oblique, elongate-ovate, apically acute, and has a moderately thick margin. The columellar fold is thin, elongate, broad above and narrowed below and is continuous with the lower margin of the aperture. There is a distinct shining columellar ridge a little above the middle of the columellar margin. The outer margin is evenly convex. There is an elongate open groove below the columellar fold comparable to an umbilicus.

#### *Measurements in millimeters.*

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
6.5	5.5	3.5	3.2

*Type-specimen*.—No. M<sup>12374</sup>/<sub>2</sub> Zool. Surv. Ind. (*Ind. Mus.*).

Dr. Sunder Lal Hora obtained two living shells from the edge of the White-crow tank near Yawngwe, S. Shan States, Burma.

This species is very distinct from any of the Indian or Burmese ones, and is remarkably like a *Limnaea* in general appearance, but the nature of the columellar fold and the ridge and that of the spire is enough to put it at once as a *Succinea*.

#### ADDENDUM.

Since this paper went to press I have had the opportunity of examining a small collection of freshwater Gastropods made by Dr. Sunder Lal Hora near Amingaon in Assam, in which were found two specimens of *Succinea godivariana*. Fortunately the animals were in a good state of preservation and the jaw and the radula could be extracted.

The shells are of about the same dimensions as the Shan specimen with the spire very similar. The colour is somewhat paler.

The jaw is very minute and rather feebly chitinised, but its outline

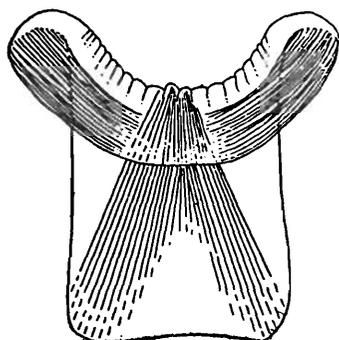


FIG. 10.—Jaw of *Succinea godivariana* Gude from Assam.

and texture are well marked. The cutting piece is trough-shaped, and has short arms, with their apices broad and rounded. The anterior margin of the cutting piece is fragmented and has a characteristic appearance, while the remaining portion is transversely striated except for a triangular space in the middle. The basal accessory plate has parallel sides and a slightly depressed posterior margin.

The radular teeth are very similar to those of *S. godivariana* f. *vangiya* both in the number and form of the teeth in a transverse row.

The genitalia could not be made out owing to the delicate nature of the animal.

Specimens were apparently found in close association with *Limnaea*s attached to dead twigs and leaves in Thumarkur nullah, 3 miles from Sorupeta on the Amingaon side.

The occurrence of this species in the S. Shan States, in Assam and Bengal, and in the Madras presidency far from its being an instance of local or discontinuous distribution would lend, in my opinion, ample proof of its wider distribution than we as yet know. The minuteness of the species is the only deterrent to our knowledge of its distribution but a careful collector to whom the minuteness of a species is no serious obstacle is bound to throw more light on this question.

#### *Indosuccinea semiserica* f. *khandalla*, nov.

Shells of this form are indistinguishable from those of f. *sthulasiras*. They are thin and brittle, and of a yellowish amber colour. They do not exceed 12 mm. in height. The sculpture and the thickening of the upper part of the body-whorl are variable but the latter is relatively prominent.

The jaw resembles that of f. *sthulasiras*, but has two chitinous thickenings running diagonally on the basal accessory plate from below the middle of the cutting piece towards the outer lower corners of the former.

The striations on the remaining portions of the jaw is a little more conspicuous than in f. *sthulasiras*.

The radular teeth are very similar to those of *I. semiserica* and its closely allied form.

In the genitalia the duct of the spermatheca has no separate external opening but joins the oviduct some distance above the female aperture. The vas deferens is short and the penis relatively long. There are two seminal vesicles, sometimes unequal in length but without the sac corresponding to the fecundation pouch. It probably varies in prominence according as it is full of spermatozoa or relatively empty.

These differences in the anatomy of the animal seem, in my opinion, sufficient to warrant the recognition of this form as distinct from either *I. semiserica* or the allied f. *sthulasiras*.

*Type-specimens*.—No. M.  $\frac{12564}{2}$  Zool. Surv. Ind. (*Ind. Mus.*).

Several living specimens of this form were taken by Mr. R. Hodgart on shrubs growing in moist ground near Khandalla, Bombay Presidency in July 1924.