

ON CERTAIN SUCCINEID MOLLUSCS FROM THE WESTERN GHATS, BOMBAY PRESIDENCY.

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The material dealt with in this paper was collected by Dr. Sunder Lal Hora at various places on the Western Ghats in the Poona District of Bombay Presidency during the months of August and September, 1924. It includes three species belonging to two genera. Of these one has proved to be new, and the second is the rare and interesting species *Lithotis rupicola* Blanford, while the third is a new form of *Succinea gravelyi* Rao, which has been recorded from Madras. *Lithotis rupicola* was first discovered by Blanford who described it in the year 1863. Since that time up to the present day the species was in obscurity and nothing more was known about its habitat or anatomy than what was described by Blanford and Binney respectively. In March, 1918 the late Dr. Annandale, who investigated the fauna of the hill-streams in the same district, did not find the species. Since that time up to the year 1923 the locality in which Blanford found the species was revisited by members of the Zoological Survey on two or three occasions with the same result. It was, however, reserved for Dr. Hora to rediscover the species in great numbers near the Khandalla waterfall during the rainy season of the year 1924. The specimens he collected are in a very good state of preservation, and have enabled me to study the anatomy of this interesting species in some detail. The knowledge thus gained establishes beyond doubt the position of the genus *Lithotis* as distinct from *Succinea*, not only in respect of the shell but also in that of the soft parts, of which the jaw and the radula were but imperfectly known hitherto.

The species here described as new is of considerable bionomic interest apart from its being distinct in respect of the shell and the soft parts from other species of *Succinea*. Dr. Hora has a separate note immediately following this on the habits of the living animal in a state of hibernation both in its natural habitat and under artificial conditions in the laboratory. That a species of *Succinea* has the habit of aestivating on bark of trees during the rainy season is perhaps a hitherto unknown fact, though rock-inhabiting species such as *S. girnarica*, *S. collina*, *Camptonyx theobaldi* and *L. rupicola* are known to occur in Western India from Kathiawar down to Poona and Mahabaleshwar. But among these the habits of none but *L. rupicola* are known. A knowledge of the habits would be of great use in understanding the factors that govern the life and evolution of these terrestrial forms.

An explanation is perhaps necessary in this connection as regards the applicability of the terms "amphibious" and "terrestrial" to the species of this family. They have been used hitherto in a broad sense and cannot be employed to indicate intermediate conditions of life. It is not suggested that fresh terms would make it easier to appreciate the

inter-relation of the organism and its environments, but it is thought that a clear statement of the exact nature of the surroundings in which a particular species is found will be more useful than short terms which convey but a vague idea.

It is a well known fact that no known species of *Succinea* is truly aquatic in the sense in which members of the family Limnaeidae are. Certain species like *S. indica*, *S. elegantior*, *S. rutilans* and *S. godivariana* seem to be strictly amphibious. They are found sticking to floating vegetation and other objects in pools, lakes and swamps, or at any rate in some area of water which contains rotting vegetation on which they seem to feed as a rule. Some of these have been observed to swim upside down attached to the surface film of water. They, however, never survive immersion in water. In exceptional instances they may be picked up some distance away from water on reeds and other shore plants.

There are species like *Indosuccinea semiserica* and allied forms which are found living on shrubs and trees in the rainy season. They never seem to require large areas of water as a necessary condition for their existence or sustenance. During the drier months they apparently hibernate in concealed positions on the plants on which they live, and with the approach of the rainy season they rouse themselves to activity and feed chiefly on fresh vegetable matter such as leaves and shoots of plants.

There are other species such as *S. gravelyi* and *S. bensoni* which seem to live in moist moss-grown places near small areas of water, but they often wander farther away from their haunts in search of cryptogamic vegetation on which they feed.

Finally there are the true rock-inhabiting species such as *Camptonyx theobaldi*, *S. girnarica*, *S. collina*, *Lithotis rupicola* and *L. tumida* which prefer moist but exposed areas on which sun and rain have free play. They feed on minute cryptogams which cover the rocks during the rainy months. At the approach of summer, when the exposed rocks get rapidly dried up, they seem to retire into crevices, hollows or other sheltered spots, and there withdrawing themselves completely into the shell aestivate during the whole of the dry period.

Thus the members of the family would seem to come under three distinct oecological groups, namely—(1) the truly amphibious, living closely associated with aquatic animals in fairly large areas of water and feeding on decaying vegetation, (2) the pseudo-amphibious, which live close to aquatic areas but in concealed situations feeding on moss and other minute plants, and (3) the strictly terrestrial, which live exposed either on leaves and barks of plants or on rocks and feed exclusively on fresh vegetation such as tender leaves, minute algae, moss or lichens. It is the members of the last-named group that seem to aestivate, as a rule, during the drier months of the year and resume active life when the rains set in.

***Succinea gravelyi* f. *bombayensis*, nov.**

Shells of this form are very similar in outline to the Andamanese form of *S. gravelyi* but are relatively less coarse. The last and penultimate

whorls are tumid and the sides of the shell in dorsal view are obliquely parallel. The suture is well-impressed. This form seems to serve as a connecting link between *S. daucina* and the typical *S. gravelyi*, but as nothing is known about the anatomy or the habits of the former a comparison of the two species would be of little value.

The jaw of this form agrees in several features with that of *S. gravelyi* but has the cutting piece and the basal plate slightly broader.

The radular teeth are very similar to those of the typical species with the difference that the ectocones of the laterals are longer.

The genitalia also agree in every respect with those of *S. gravelyi*.

Type-specimens.—M¹²⁵¹³/₂ Zool. Surv. Ind. (*Ind. Mus.*).

A few living animals were taken by Dr. Hora at Kapurwala, Bombay Presidency, on the surface of wet rocks close to a small waterfall and on grass, etc., growing on them.

***Lithotis rupicola* Blanford.**

1870-76. *Succinea rupicola*, Pfeiffer, *Novitates Conchologicae* (Ser. I), IV, p. 11, pl. 112, figs. 1-4.

1924. *Lithotis rupicola*, Rao, *Rec. Ind. Mus.* XXVI, p. 372.

Shells of this species are of a dull brown colour, but in the fresh condition the colour is obscured by a deposit of foreign matter which, however, can be removed easily. The inner surface of the shell is generally of a pale or yellowish brown colour often shining on the margins. The sculpture is very rough and consists of well-marked transverse striae and often of ridges. The columellar callus is elongately triangular and tapers from behind forwards with a sharp edge on the side of the peristome. The outer margin of the peristome and the upper part of the callus meet above to form a triangular area which appears to be distinct from the last and the penultimate whorls. The columellar callus is translucent and shining. The largest shell in the collection of Dr. Hora has the following measurements in millimeters.

Height.	Maximum breadth.	Height of aperture.	Maximum breadth of aperture.
10.0	7.0	9.0	6.5

The colour of the animal in spirit is pale blue on the foot and the mantle edge, and smoky black on the whole of the spire. The region of the kidney is yellowish, generally superimposed by a dark shade. The region of the mantle anterior to the kidney is minutely streaked black but often inconspicuous.

The animal is apparently capable of retracting completely within the shell. In the preserved specimens before me no part of the animal is visible beyond the margin of the shell when viewed from above. The mantle is extensive and covers a great portion of the animal. Its edge is broad and thickened and sometimes folded upwards. On the right side, at the point where the pulmonary chamber communicates with the outside by means of a roundish or at times a slit-like aperture, the mantle edge has a special thickening which is, presumably, concerned in the

formation of a groove-like siphon on the inner side of the shell. That part of the mantle which lies in the groove may be raised as a fold or

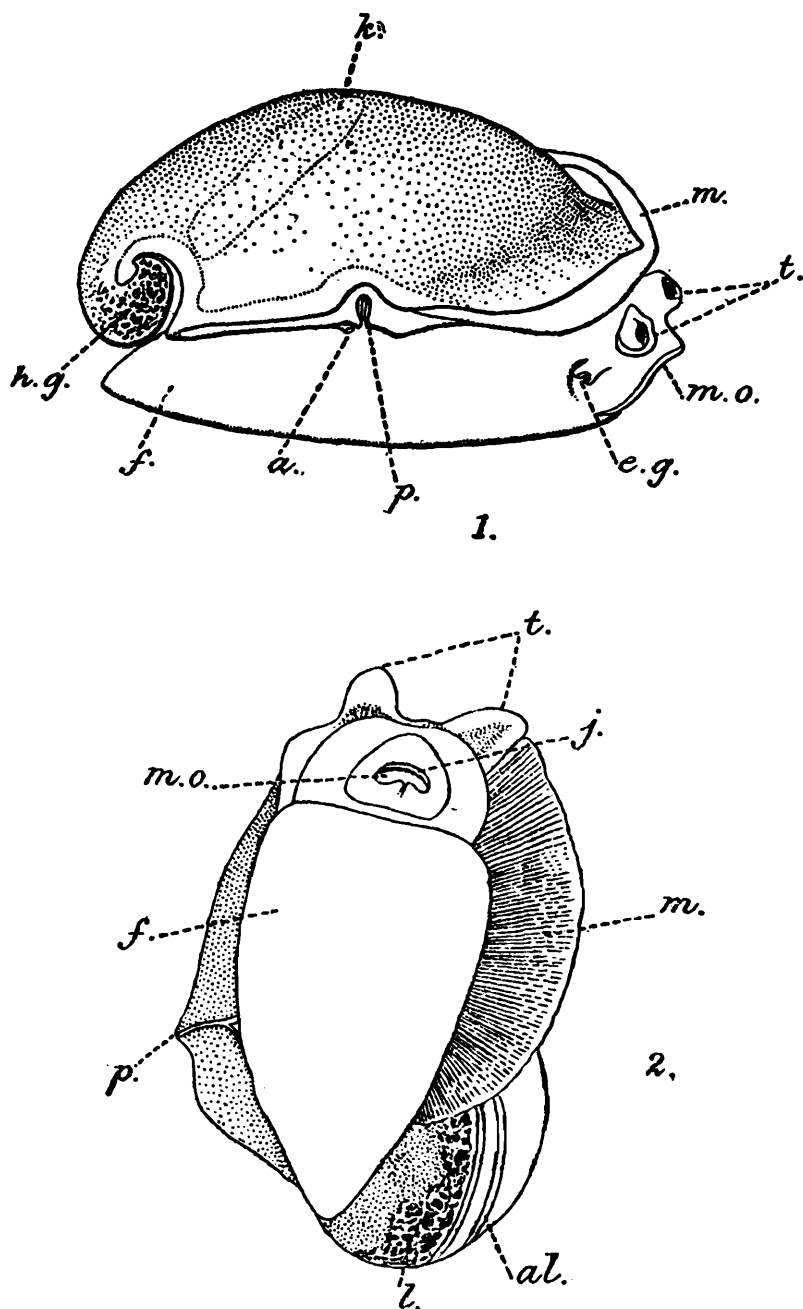


FIG. 1.—*Lithotis rupicola*. Animal removed from shell.

(1) Viewed from the right side. (2) Viewed from below.

a. anus; *al.* intestine; *e. g.* external opening of genitalia; *f.* foot; *h. g.* hermaphrodite gland; *j.* jaw; *k.* kidney; *l.* liver; *m.* edge of mantle; *m. o.* mouth; *p.* pulmonary opening; *t.* tentacles.

convex ridge extending up to the apex of the spire. It must be pointed out that the ridge is not always present on the mantle even in instances where the groove is deep. Close to the pulmonary opening, a little below and behind it, lies the elliptical anal opening. A groove commencing from the pulmonary opening and running underneath it obliquely backwards connects the anal aperture. Often a short groove branches off from the main one a little above the anus and runs straight at right angles to the extreme edge of the mantle. Anteriorly the head bears a pair of stout eye-bearing tentacles the bases of which are pigmented black. They are partially contracted in the preserved specimens before me.

The mouth is an elongated slit bent like the arc of a circle with its convex side anterior. A part of the jaw is often found protruding through the mouth as a strip of chitin, and in exceptional cases a good portion of the jaw may be projecting outside. The genital openings are minute and are placed close together in a shallow depression a little behind the base of the right tentacle. The foot is large and broadly lanceolate or ovate and extends beyond the outline of the visceral hump.

The mouth leads into a short oesophagus which communicates with an enlarged sac which may be termed the crop. The latter contains a mass of filamentous algae and diatoms. It is followed by the stomach, which is a thin-walled transverse sac, but not much differentiated from it. The liver is very compact and is traversed by the coils of the intestine which cut deep grooves on its surface. A short wide duct of the liver opens into the stomach at the commencement of the intestine. There is a single whitish finger-shaped caecum close to the duct of the liver. The intestine forms a double loop above and behind the liver mass and leads to a short rectum on the right side which, emerging from the undersurface of the liver, opens into the anus.

The pulmonary cavity is a closed chamber the roof of which is formed by the mantle and the floor by a thin membrane enveloping the viscera. Its anterior boundary is the head and the posterior the kidney which stretches diagonally as a rectangular block from the left to the right. The mantle is fused in front with the integument of the head, on the sides with that of the foot and at the posterior end with the membrane enclosing the liver, intestines and other structures of that region. A

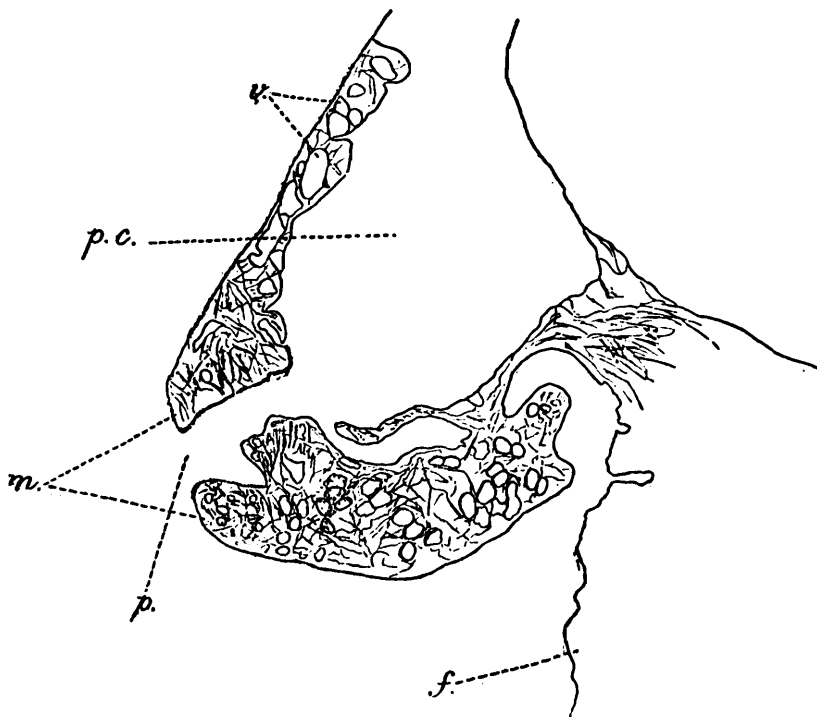


FIG. 2.—*Lithotis rupicola*. Vertical transverse section through the pulmonary opening. *e. m.* edge of mantle; *f.* foot; *p.* pulmonary opening; *p. c.* pulmonary chamber; *v.* vascular vessels of mantle.

flap-like extension of the mantle serves as the connection between the mantle and the body on the sides and in front. The mantle-edge is very

much thickened and seems to contain numerous blood-sinuses. At the point where the pulmonary aperture is placed the mantle-edge, as already mentioned, has a special thickening in the form of a raised ridge which seems to be present from a very early stage of development of the animal, as may be presumed from the fact that the siphonal groove extends from the apex of the spire to the very margin of the aperture in all the specimens that I have examined. The function of the groove must for the present remain obscure as the habits of this species in its natural haunts are still imperfectly known. It may perhaps be suggested that the groove serves to increase the quantity of air in the pulmonary chamber when needed.

The jaw and the radular teeth were first figured by Binney¹ in 1874, long after the species was discovered by Blanford, and since then nothing further was known about these structures. Thanks to Dr. Hora's fairly large collection I am now enabled to say something more about them with confidence. The jaw is distinct from that of the closely allied *L. tumida*. It has an almost square outline with short, blunt, rounded arms to the cutting piece. In some cases the extremities of the arm may be angled posteriorly and rounded anteriorly. A definite median process

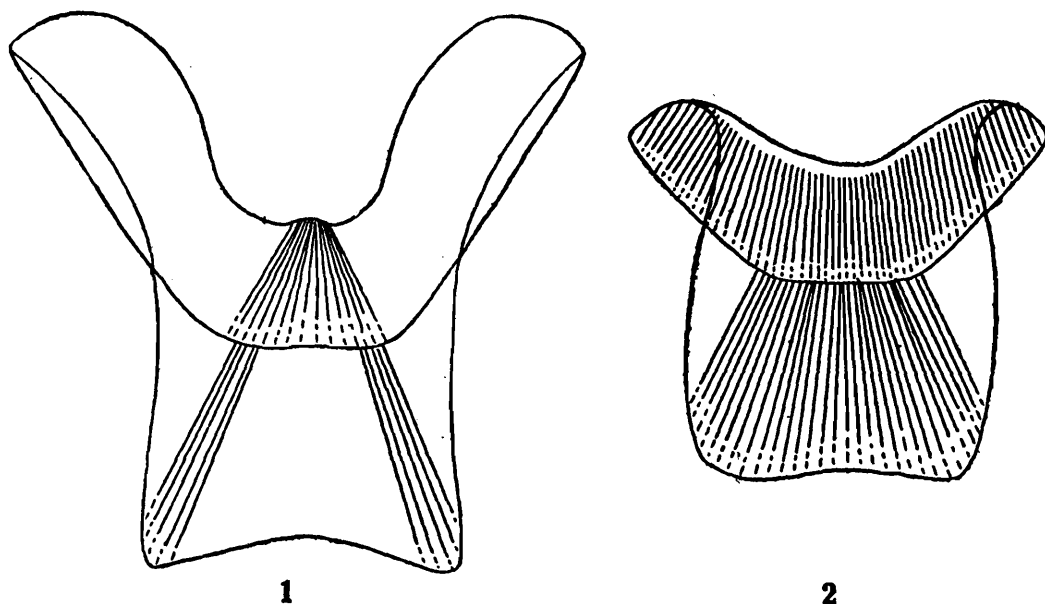


FIG. 3.—Jaws of (1) *Succinea arboricola* and (2) *Lithotis rupicola*.

on the anterior margin of the cutting piece is absent though slight indentations of the margin by injury or wear may be mistaken for the process. I have examined over twenty specimens and I have not found a definite median process in any of them. It occurs, if at all, only as an abnormality. The cup-like depression of the anterior margin is much more marked than in *L. tumida* but never so deeply as in many species of *Succinea*. The striations of the jaw are well marked over the whole surface. The cutting piece is subject to some variability.

The radular teeth are remarkable in this species in their very distinct form and do not seem to approach those of any other species of the family. They have a general resemblance to the teeth of certain species

¹ Binney, *Proc. Acad. Nat. Sci. Philadelphia*, pl. v, figs. 3-6 (1874).

of Testacellidae, but are never so sharp and elongate. The cusps of the central and the laterals are high, blunt at the apex, and are without accessory denticles at their base. The marginals are quadrate in form. The first few of them and sometimes nearly half the number of marginals in one half of a row bear one to three secondary cusps, while the extreme marginals have four to seven cusps. The basal plate of the marginals is produced below into a triangular protruberance. The highest point of the basal plate is, as a rule, shorter than the main cusp in all the teeth of a transverse row. The radular teeth are subject to variability both as regards the occurrence of denticles on the laterals and the number of cusps present on the marginals. Abnormalities occur in rare instances in the laterals and marginals. The approximate dental formula is 34.11.1.11.34.

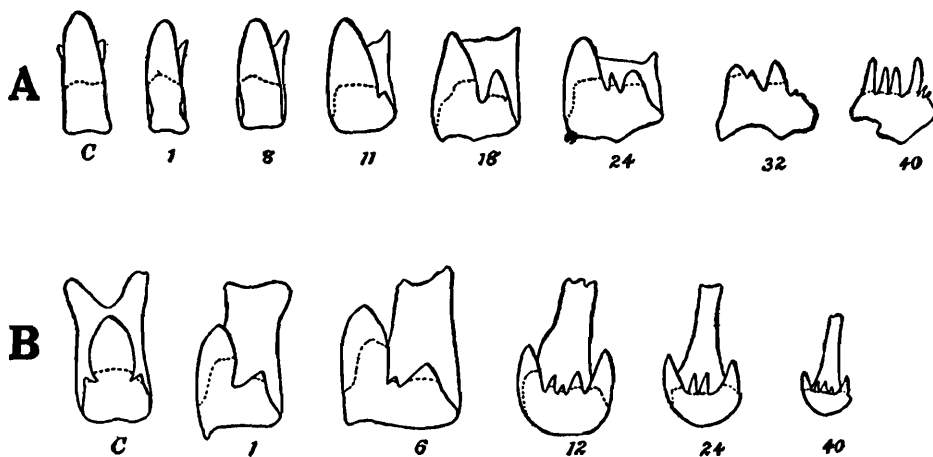


FIG. 4.—Radular teeth of (A) *Lithotis rupicola* and (B) *Succinea arboricola*.

It may be seen that in respect of the jaw and the radular teeth there is no agreement between this species and *L. tumida* or any other species of the family.

A great portion of the genitalia occupies the right half of the anterior part of the animal, and on removing the mantle and the membranous covering of the viscera, the coiled oviduct, the albumen gland, and a portion of the prostate appear conspicuously. The penis and the uterus may also be seen in some cases as two wide tubes placed close to each other. The relation of the various parts of the genitalia to one another can, however, be made out by dissection. The hermaphrodite gland is found in the usual position at the apex of the spire and is a compact mass having the appearance of a bunch of grapes. From a short cleft on its anterior face emerges the hermaphrodite duct which has a wavy course for a short distance at its commencement. It then has a straight course before entering the albumen gland. The latter is large and roughly triangular with a convex dorsal surface. Its ventral side has a large depression in which are lodged the spermatheca, the seminal vesicles and part of the prostate. The hermaphrodite duct divides into two short branches at the level of the base of the albumen gland, one of which enters the latter, while the other after receiving the seminal vesicle enters the prostate gland on its left a little above the base. The prostate is an oval or pear-shaped body placed close to and below the albu-

men gland on its right side. From its anterior face emerges the stout muscular vas deferens which has a short course before it enters the penis.

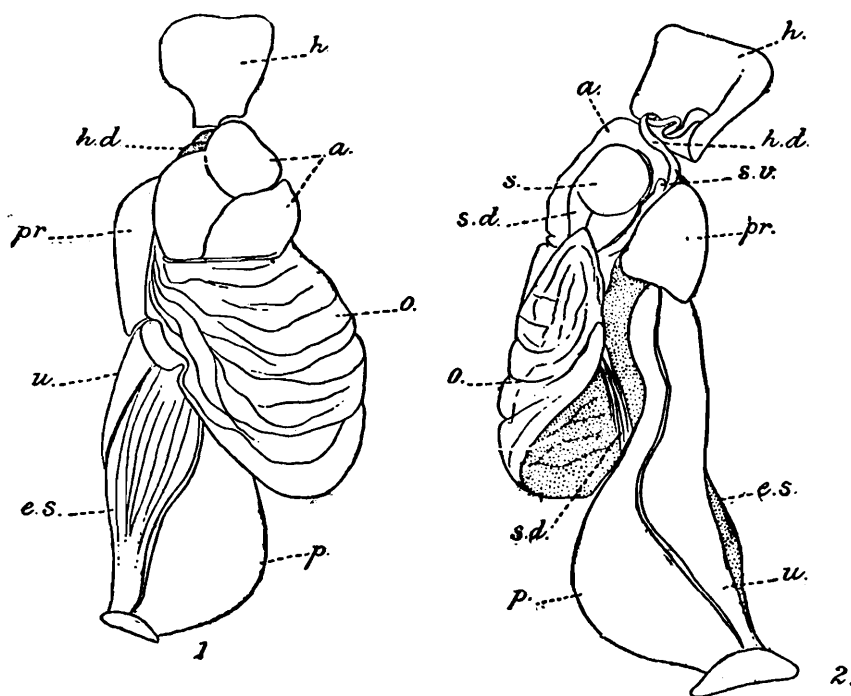


FIG. 5.—*Lithotia rupicola*. Genitalia in situ. (1) Dorsal view. (2) Ventral view. *a.* albumen gland; *e. s.* dilated end of duct of spermatheca; *h.* hermaphrodite gland; *h. d.* hermaphrodite duct; *o.* oviduct; *p.* penis; *pr.* prostate gland; *s.* spermatheca; *s. d.* duct of spermatheca; *s. v.* seminal vesicles; *u.* uterus.

The oviduct on leaving the albumen gland is very much coiled in the form of the letter **U** being doubled up as a loop on either side, the whole presenting the appearance of a solid mass of cream-white substance. The distal portion of the oviduct, which has a straight course for a short distance and is distinct from the coiled portion, may be termed the uterus. On a level with the anterior face of the coiled portion of the oviduct the uterus receives the long duct of the spermatheca. The spermatheca is a spherical sac which lies usually hidden from view on the left side of the prostate. Its form seems to be variable in accordance with the volume of its contents. It may have a small dilatation at the commencement of its duct. But at the point where it joins the uterus it has a definite and constant sac-like, muscular enlargement which is about twice as wide as the uterus itself. From the junction of the spermatheca and the uterus a short tube leads to the external genital opening. This short tube may be termed the vagina. The penis is short and bulbous and about just as long as the enlarged sac of the spermathecal duct, and is without a retractor muscle. Though the buccal and columellar muscle strands run very close to the penis no branch of them has been found to reach the penis. There is a club-shaped epiphallus which is apparently capable of expansion and contraction. It is traversed by a wide duct which is often thrown into transverse folds in the upper part of its course. The surface of the epiphallus is usually covered by some foreign particles, apparently minute grains of sand or other material, which seem to stick to it at the time of copulation. The seminal vesicles, the position of which has

already been mentioned, consist of the usual pair of club-shaped sacs with a well developed fecundation pouch. They lie closely pressed to-

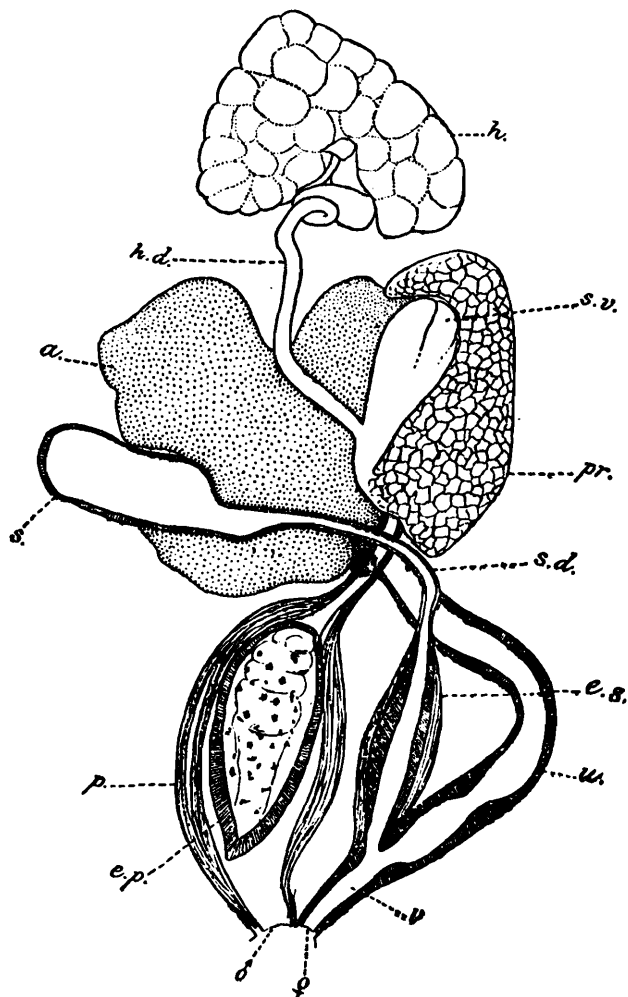


FIG. 6.—*Lithotis rupicola*. Ventral view of genitalia (dissected out). *a.* albumen gland; *e. p.* epiphallus; *e. s.* dilated end of duct of spermatheca; *h.* hermaphrodite gland; *h. d.* hermaphrodite duct; *p.* penis; *pr.* prostate; *s.* spermatheca; *s. d.* duct of spermatheca; *s. v.* seminal vesicles; *u.* uterus; *v.* vagina.

gether and except in good light under a high power of the microscope present the appearance of a single large sac. They and the hermaphrodite gland and duct are usually covered by a thin membrane on which black pigment is displayed in a reticulate pattern.

Self-fertilisation appears to be an occasional phenomenon in this species. In one of the specimens dissected I found the elongated epiphallus curved and extending from the male opening through the vagina up to the junction of the spermatheca and the uterus.

The striking features of the genitalia of this rare species are (1) the remarkably muscular genital ducts having thick walls, (2) the presence of a dilatation at the distal end of the spermathecal duct, (3) the shortness of the vas deferens, and (4) the occurrence of a short, stout penis with a particularly well developed epiphallus but without a trace of the retractor muscle. Of these features the most distinctive are the second and the last.

Compared with the genitalia of other species of the family it seems that *L. rupicola* approaches the terrestrial species *Indosuccinea semiserica*

in the condition of the penis, and in the distinctness of the male and female openings. But it differs from the latter in the prostate gland not being spiral and in the spermatheca not having a separate opening to the outside. The condition of the duct of the spermatheca, however, seems to me to be intermediate between that found in *I. semiserica* and *S. indica*, species occupying the two extremes of biological groups of the family.

With regard to the other structures such as the jaw, radula and mantle there is little that may be considered as common between the present species and all the other species in the family.

Dr. Hora has the following note on the habitat of the species :—

“*Lithotis rupicola* was found in great abundance on the wet rocks at the sides of the waterfall at Khandalla. The rocks were overgrown with algal slime and were kept constantly moist by the spray produced by the waterfall. *Cremnoconchus syhadrensis* was the only other species found with these animals under similar conditions but in much larger numbers. It is rather significant that in spite of a very thorough and careful search not a single specimen of these two species of molluscs was found anywhere between Karjat and Mahabaleshwar except on the rocks at the sides of the Khandalla waterfall. Unlike *Cremnoconchus syhadrensis* the animals of *L. rupicola* lost all vitality when removed from their natural habitat. When examined after a few hours captivity most of them were found dead.”

***Succinea arboricola*, sp. nov.**

The shell in this species is more or less regularly ovate with the left anterior margin often slightly converging towards the main axis. The convexity of the left posterior margin of the shell in dorsal view is well marked, and the posterior half of the last whorl is evenly convex. It never consists of more than $2\frac{1}{2}$ whorls the last being nearly five times as large as the spire. The penultimate whorl is quite tumid and has its base about $\frac{1}{3}$ as broad as the last whorl at this point. The suture is oblique and well-defined though not deeply impressed. The shell is fairly thick and tough even in young individuals and has conspicuous parallel oblique striae often interspersed with coarser ones. The sculpture on the penultimate whorl is rather poorly developed. The aperture is oblique and ovate-conical in outline. The extreme margin of the shell in front and on the sides of the aperture is slightly reflected upwards. The columellar callus is very thin and never conspicuous in shells of advanced age. The right margin is continuous with that of the aperture at its apex. The columellar ridge is a narrow translucent strip which narrows down to a line where it meets the left margin of the aperture. The inner surface of the shell near the anterior end has a silky white deposit which is iridescent. The extent to which this deposit is developed varies in different individuals. The colour of the shell varies from a pale yellow to yellowish brown. In life the shells are, as a rule, covered by a greenish deposit of algae or other plant growth. Its rough surface apparently facilitates the growth of microscopic plant life.

The shell as a whole has a general resemblance to that of *I. semi-serica* but is distinguished by its relatively small size, by the quite convex

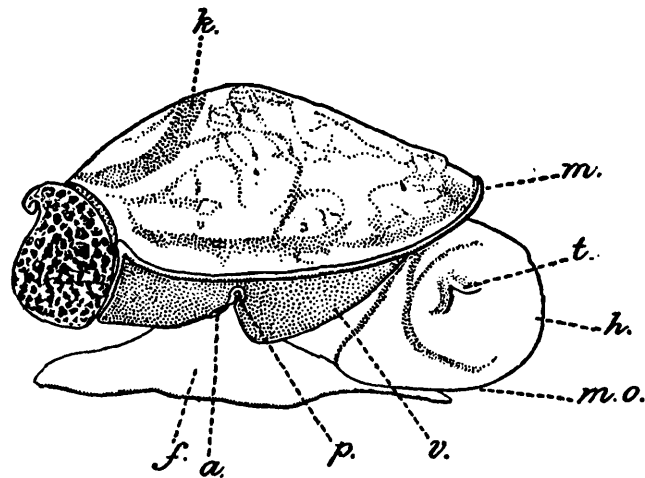


FIG. 7.—*Succinea arboricola*. Animal removed from shell and viewed from the right side. *a.* anus; *f.* foot; *h.* head; *k.* kidney; *m.* edge of mantle; *m. o.* mouth; *p.* pulmonary opening; *v.* *m.* visceral mass; *t.* tentacle.

whorls, by the comparatively thick shell and by the well-defined columellar ridge.

The largest shell in the collection has the following measurements in millimeters :—

Height of shell.	Height of aperture.	Maximum breadth of shell.	Maximum breadth of aperture.
7.3	6.5	4.8	4.0

External features.—As most of the individuals of this species were obtained in a state of hibernation no information is available as to their

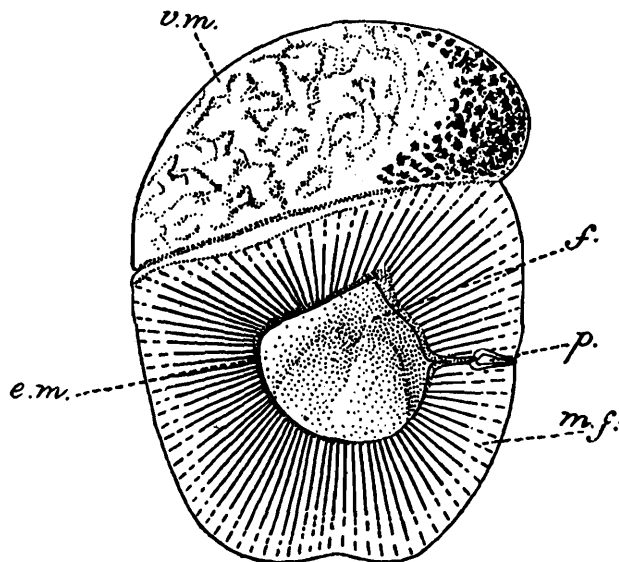


FIG. 8.—*Succinea arboricola*. Ventral view of a contracted animal. *e. m.* edge of mantlefold; *f.* foot seen from below mantle-fold; *m. f.* fold of mantle covering the foot; *p.* pulmonary opening; *v. m.* visceral mass.

external features in active life, but the following description is drawn from hibernating specimens preserved in spirit. The outline of the

animal seems to vary with the extent to which the animal is withdrawn into the shell, but in general it is ovate-conical with the anterior end broad and rounded. The ground colour of the animal is pale yellow, but on the dorsal surface a black pigment is present chiefly on the mantle extending from the anterior margin of the kidney to a little behind the extreme margin of the mantle. Streaks of pigment may also be present on the membrane covering the intestines and other structures behind the kidney. The membrane is so transparent that portions of the liver, the intestine and the genitalia are visible through it. The kidney is a rectangular structure extending obliquely from left to right behind the pulmonary chamber. The edge of the mantle is thickened and has a distinct broad flap which extends horizontally all round on the ventral surface of the animal enclosing a considerable portion of the foot. A small oval area in the centre is left uncovered by the extension of the mantle through which the central part of the foot projects as a convex mass. Near the middle of the mantle flap on the right side lies the minute oval or elliptical opening of the pulmonary chamber. A minute transverse cut extends from the pulmonary opening to the margin of the mantle-flap. On separating the edges of the flap at this point a V-shaped groove with its arms stretching outwards may be seen below. The anus is placed near the posterior arm of the V-shaped groove as a small elliptical aperture.

Mantle and pulmonary chamber.—The mantle forms a hood over the anterior half of the animal and is fused posteriorly with the membrane covering the structures in that region. Anteriorly and on the sides it is fused with the foot. The chamber enclosed between the mantle above and the membrane below covering the internal organs is the pulmonary

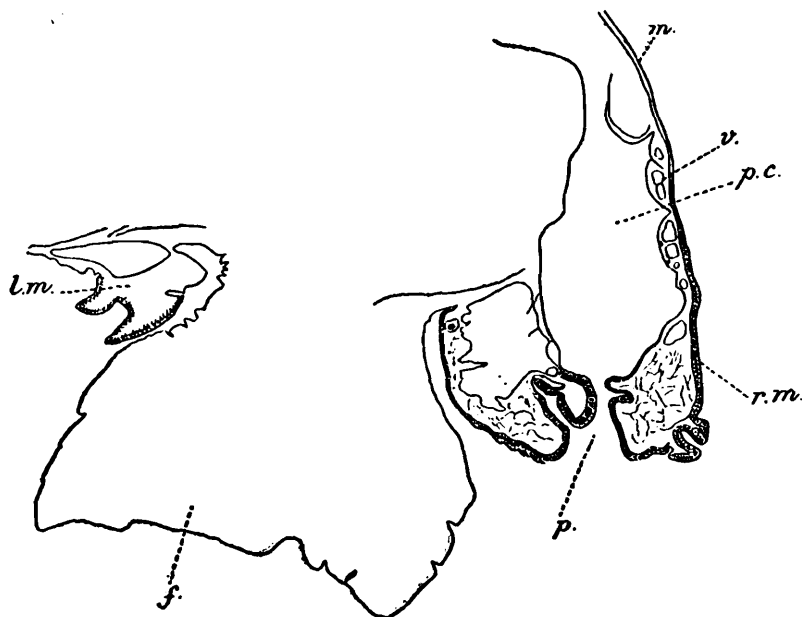


FIG. 9.—*Succinea arboricola*. Vertical transverse section through the region of the pulmonary opening showing relationship of the lobes of the mantle to the aperture.

f. foot; l. m. left mantle-edge; m. mantle; p. pulmonary opening; p. c. pulmonary chamber; r. m. right mantle edge; v. vascular vessels of mantle.

cavity. It communicates with the outside by a single minute opening on the right side of the animal in the position described under external

features. It is thus a closed chamber with only a small opening by which communication with the outside atmosphere is maintained as for instance in the land snails of the genus *Ariophanta*. The mantle is traversed by minute vascular vessels which are thus in close relation with the air of the pulmonary chamber. The edge of the pulmonary aperture, which forms part of the transverse flap of the mantle, is thickened, and when the animals in a state of hibernation are forcibly stimulated to activity by exposure, the aperture opens and closes at intervals for the purpose of carrying on respiration. The extreme edge of the mantle is traversed by a deep groove which is apparently formed by a process of invagination. On the right side the mantle edge is more conspicuously thickened than on the left.

Alimentary system.—The jaw is of strong build with a remarkable development of chitin. A tendency to form oblique chitinous ridges on the cutting piece, as in some land snails, is to be noticed. The accessory basal plate has prominent striae often confined to the two sides. There appears to be considerable variability in the shape of the jaw and no precise description can be usefully attempted. The figure on p. 390 represents the jaw taken from a fairly large individual soaked in cold caustic potash for several hours and cleaned first in water and then in a mixture of glycerine and formaldehyde. Jaws mounted on slides under pressure of the coverslip usually break and do not preserve their natural shape. The figure given has been drawn from a jaw not subjected to any pressure.

In the strong chitination of the jaw though not in actual form the present species approaches *I. semiserica*.

The radular teeth are relatively small and are arranged in regular transverse rows. There are usually about sixty teeth in each half of a transverse row in a full-grown individual. The number of teeth seems to be proportionately less in many young specimens. The central is very little variable and has an ovato-conical cusp with a well-defined denticle at its base on each side. The laterals are very few in number, often not exceeding five, while the marginals may be as many as fifty-five. The laterals very gradually grade into the marginals, and it is at first sight difficult to clearly define the limits of the two sets of teeth. They are somewhat quadrate and never bear more than three cusps, whereas the marginals are distinctly aculeate and have five and six cusps, the ectocones and entocones being relatively large in size. There is, however, considerable variability in this respect. In young individuals (which comprise the whole collection except two which are full-sized adults) the radular teeth exhibit some interesting features. In these, the differentiation between laterals and marginals is rendered more difficult by the presence of additional cusps on the laterals than is the case in the two adult individuals examined. In the first few laterals there usually occur two small cusps between the ento- and ectocones. Their size increases gradually as the outer teeth of the series are reached until they more or less resemble the first few marginals of the adult specimen. These differentiations presumably represent growth change in the radular teeth and have nothing to do with variability of the struc-

tures in this species.¹ A certain amount of variability perhaps occurs as in other species of *Succinea* but with the material before me it is difficult to say anything on the point. The only striking feature of the marginals in this species is the occurrence of long and narrow basal plates, though in this respect it approaches *S. indica* and *I. semiserica* which are relatively large species. The approximate radular formula is 55. 5. 1. 5. 55.

The position of the head in hibernating individuals is remarkable. It is not found in its usual position at the anterior end, but has receded towards the posterior end lying closely adpressed to the liver mass. The cesophagus and stomach are consequently folded up and found close to the head. The contents of the stomach in specimens examined were a pulpy mass in a more or less digested condition and included broken bits of diatoms. The disposition of the alimentary canal is not unlike that of other Succineids.

The situation of the kidney has been pointed out already. Its inner wall is thrown into several lamellate folds which project into its cavity. These folds are lined by spherical or cubical cells each of which contains an oval or spherical calcareous concretion. On the anterior side of the kidney lies a large vascular vessel which traverses its whole length. The heart lies close to the left extremity of the kidney.

Genitalia.—All except two specimens in Dr. Hora's collection are immature and the genital ducts are very poorly developed, though the glands are to be found in their usual positions in a much less compact condition than in the adult. In one of the two adults the genitalia were intact and the following description and the accompanying figure are based on them. The hermaphrodite gland is a roughly triangular structure followed by a much coiled hermaphrodite duct which is usually covered by a thin, dark membrane. The duct leads on to a pair of seminal vesicles which open into it. A thick-walled, compressed tube, much shorter than the vesicles, apparently corresponding to the fecundation pouch of other Succineids, is found closely adpressed to the seminal vesicles. The albumen gland, the prostate gland and part of the oviduct were, however, in a state of disintegration. A well developed bladder-like spermatheca is present on the left of the albumen and prostate glands. The shape of the spermatheca is evidently abnormal as a result of compression by other structures lying close to it. It has a fairly long duct which opens on the oviduct some distance from the external genital opening. The oviduct is wide and expands into an uterus below at the point where it unites with the terminal portion of the male genitalia. The penis is remarkably short and stout, much broader at its proximal end than at the distal. It is muscular and has a well-defined retractor muscle which divides into two separate strands on reaching the proximal end of the penis. There is a short stout vas deferens which connects the prostate glands with the penis. The uterus and the penis are united for a short distance from the external genital opening. Except for the peculiar form of the penis there is nothing in

¹ Annandale, *Rec. Ind. Mus.* XXVI, pp. 549-551, fig. 11 (1924); Sewell, *ibid.*, XXVI, pp. 542-544.

the genitalia which distinguishes the species from other Succineids in which the genitalia are known. Besides it would be premature to

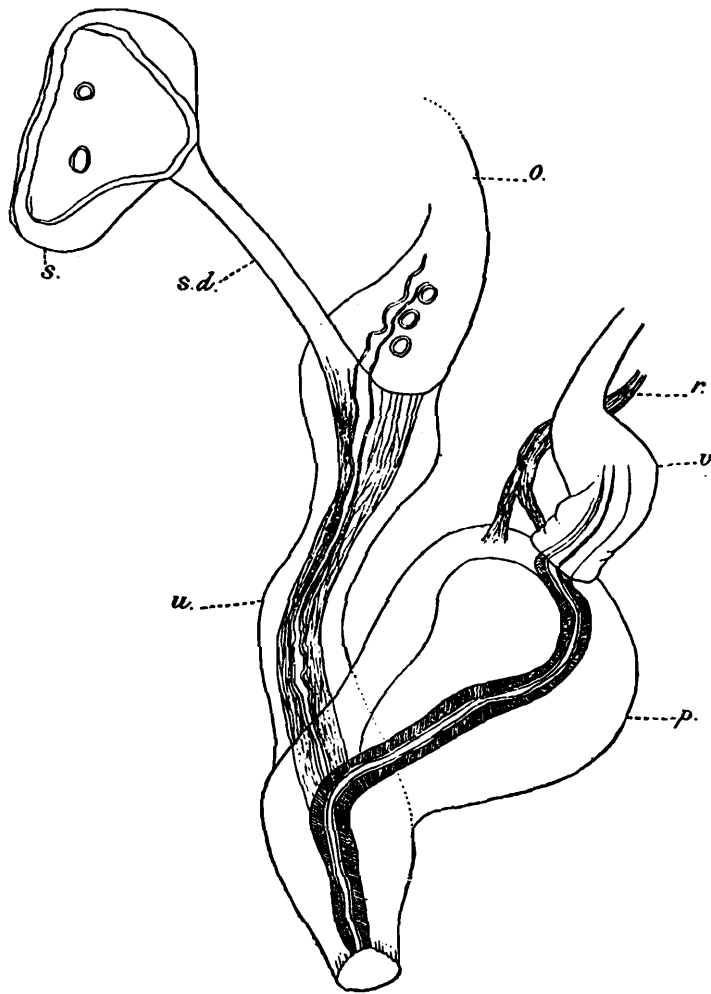


FIG. 10.—*Succinea arboricola*. Dorsal view of terminal portion of genitalia. *o.* oviduct; *p.* penis; *r.* retractor muscle of penis; *s.* spermatheca; *s. d.* duct of spermatheca; *u.* uterus; *v.* vas deferens.

institute comparisons until the genitalia are more definitely known from an examination of several adult individuals of the species.

In the only other adult specimen in the collection a curious abnormality of the genitalia was observed. A pair of long cylindrical thin-walled tubes tapering gradually towards their distal extremity was found in the position occupied by the genitalia in the normal specimen. Their external openings were narrow and placed close together. A little way from the external opening of one tube an elongated sac with a narrow neck joined it, while in the other a fan-shaped structure with finger-like processes. The free extremity of the tubes had reddish-brown spots arranged more or less in a concentric manner, while a little below was found a regularly interrupted broad band of the same colour round the tube. How the genitalia came to be modified in the manner described is difficult to say, but it is clear from the position of the structures in the animal in which no trace of the genitalia was found, that they represent the latter and have undergone modification as a result, apparently, of parasitisation by some organism.

Type-specimen.—M $\frac{2514}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

Dr. Hora¹ found several young individuals and two adults in a state of hibernation on the bark of mango trees in the compound of the Hamil-

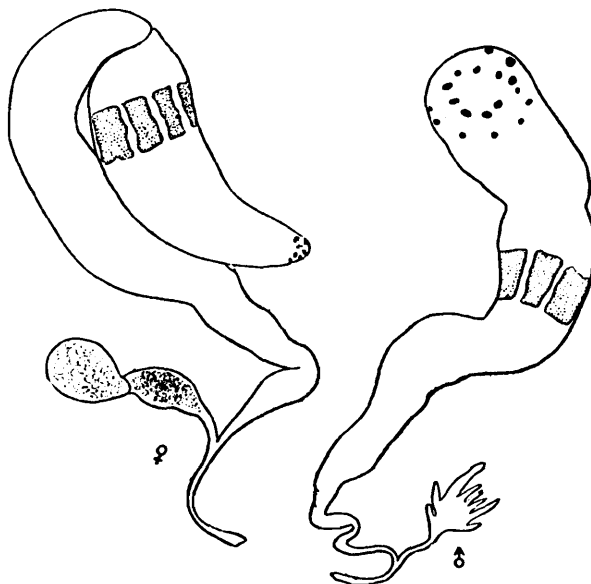


FIG. 11.—*Succinea arboricola*. Abnormal genitalia.

ton Hotel at Lonavla, Bombay Presidency, and two active young specimens on moss at base of trees on the way to Khandalla.

Several examples of young *S. arboricola* have since been found in a collection of *I. semiserica* f. *khandalla* made by Mr. R. Hodgart in the same place where Dr. Hora got his two active specimens.

Several specimens of *Pupisoma evezardi* Blanford were found living in close association with them on the bark of mango trees. This species was first recorded by Colonel Evezard at Karkalla, near Khandalla.

There seems to be little doubt that the species is strictly terrestrial in habit. The species, while being distinct in its shell, mantle and penis, has some points of resemblance to other terrestrial and amphibious species. Although the jaw and the radular teeth agree in some respects with those of *I. semiserica*, the genitalia are very different in the two species. In respect of the genitalia, however, the species approaches *S. bensoni*, *S. indica* and *S. gravelyi*, especially in the relative positions of the uterus, penis and spermatheca.

¹ A detailed account of the habits of the species is given by Dr. Hora in the paper following this.