

favourable, namely a condition either of dryness and cold or of heat and drought, and this they do by withdrawing themselves into their shells and by secreting an epiphragm, or by tightly closing the mouth with the operculum in the case of certain operculate molluscs.

The two phenomena of hibernation and aestivation are outwardly very similar in type but physiologically they must be quite different. Any species that has acquired the one or the other of these habits, in response to changing climatic conditions, must of necessity either be limited in its range of distribution as regards elevation in the hill regions, or must be so plastic as to be able to adapt itself to extremes of climate.

Major Sewell has gone through the manuscript and has made valuable suggestions : for all this my best thanks are due to him.

#### NOTE ON TWO SPECIES OF AESTIVATING GASTROPOD MOLLUSCS FROM THE KANGRA VALLEY.

By H. SRINIVASA RAO.

While touring in the Kangra valley, Western Himalayas, in the months of May and June 1926, Dr. Sunder Lal Hora observed instances of aestivation in two species of molluscs belonging to the families Succineidae and Zonitidae. He was able to study them in the field and record his observations. The present note is based on his observations and those of mine in the laboratory. I have here to thank him sincerely for giving me the opportunity of examining the molluscs and of making use of his field notes.

One of the species is represented by a young individual of *Succinea crassinuclea* Pfeiffer,<sup>1</sup> which is recorded from various places in N. India including the Simla Hills and the Punjab Salt Range. The species was hitherto known only from the shell. I have, in the specimen from Dr. Hora's collection, the soft parts also which are in a good state of preservation. I therefore take this opportunity of adding a brief note on the soft parts before proceeding to describe its habits.

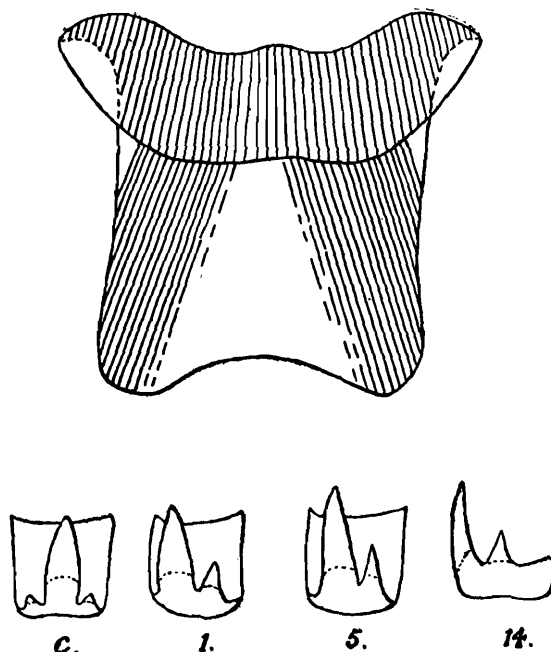
In external features the species does not differ very strikingly from other species of *Succinea*. The jaw is quadratic in form with a saucer-shaped cutting-piece. Its anterior and posterior margins are concave, and the former has in its middle a mound-shaped projection. The arms of the cutting-piece are short and have their extremities broadly conical. The sides of the accessory basal plate are more or less straight, while its posterior margin is cup-shaped in the centre. The jaw is fairly well chitinised in the cutting-piece and on the sides of the basal plate. In the shape of the jaw the species stands distinct, though it is remarkable that the cutting-piece approaches in certain respects those of *Lithotis tumida*<sup>2</sup> and *Lithotis rupicola*,<sup>3</sup> two rupicolous species known to live and hibernate in certain parts of the Western Ghats, Bombay Presidency.

<sup>1</sup> Rao, *Rec. Ind. Mus.* XXVI, p. 387 (1924).

<sup>2</sup> *Id. Ibid.* p. 393, fig. 6d.

<sup>3</sup> Rao, *Rec. Ind. Mus.* XXVII, p. 390, fig. 3 (1925).

This resemblance does not suggest, in my opinion, any natural affinity, but only brings into prominence the fact that two structures functioning similarly in two different species under the same conditions may tend to resemble each other.



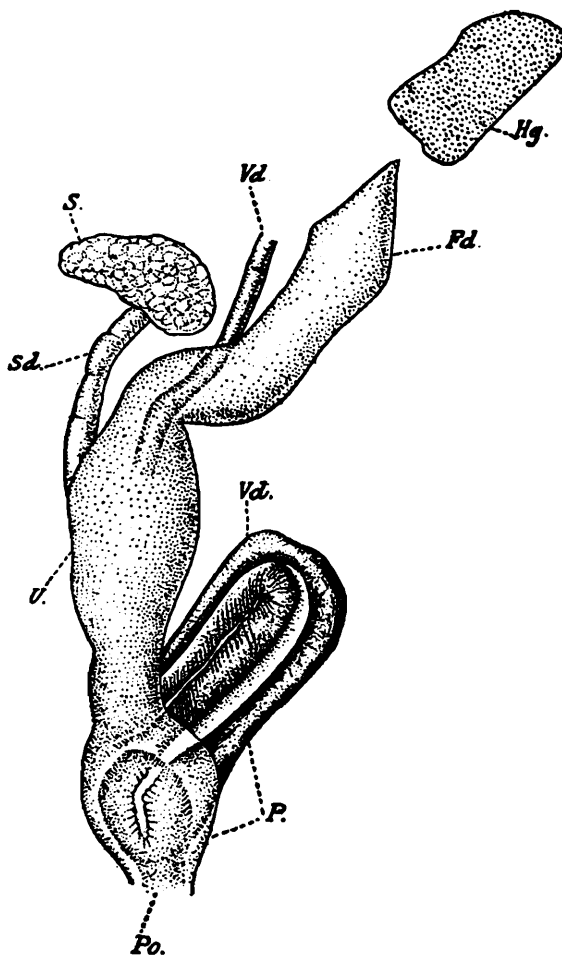
TEXT-FIG. 1.—Jaw and radular teeth of *Succinea crassinuclea*.

The radular teeth in each transverse row of the radula are few in number. The central has the form of a spear-head and has a sharp leaf-like median cusp and two small basal cusps, one on each side. The median cusp is of the same height as the basal plate. The differentiation between the laterals and the marginals is apparently not yet established, and the dental formula may be expressed as 14.1.14. The outermost tooth in each half of a transverse row has, like the laterals, only two cusps which, however, are narrower, the one nearer the central being sickle-shaped. The radular teeth are characteristic of the species. The central, however, differs little from that of *S. crassinuclea* f. *vitrea*.

The genitalia are not well developed, and I have been able to make out only some of the distal parts of the genitalia which are here figured. The spermatheca is roughly oval and lies at right angles to its duct. The uterus is large and barrel-shaped. There is a slight constriction between its distal end and the point where it is joined by the male duct. The vas deferens is doubled back on itself and ends in a bulbous penis.

The specimen under question was picked up by Dr. Hora under a stone on the hill side at Nurpore (Kangra District, Punjab) on the 21st of May 1926. It was probably the driest month in the valley, and, as was to be expected, the mollusc was in a torpid condition. It was found attached to the stone by a sticky membrane. Dr. Hora observed that when removed from its position and transferred to a glass tube, it stuck to the sides of the tube by a sticky secretion which on drying formed a delicate membrane completely closing the mouth of the shell. The animal had retreated into the shell, and all movements had ceased.

Dr. Hora tried the effect of water by placing the aestivating mollusc in a small quantity of it. In a few minutes the animal began to expand



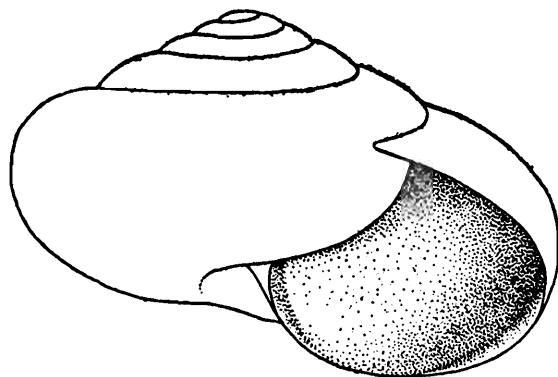
TEXT-FIG. 2.—Genitalia of *Succinea crassinuclea*. Hg., hermaphrodite gland; Fd., oviduct; P., penis; Po., common genital opening; S., spermatheca; Sd., duct of spermatheca; Vd., vas deferens; U., uterus. The proximal part of the vas deferens and the oviduct is incomplete.

itself, and breaking open its membranous epiphragm resumed its normal activity. When removed from water and left in a dry place the animal gradually curtailed its movements, withdrew into the shell and secreted an epiphragm. This device of shutting itself up in the shell seems to be common in other species of the family which live under similar conditions. In a former paper on the molluscs of this family I have drawn attention to the fact that the species fall into three natural groups according to their habitat<sup>1</sup>. The present species seems to come under the terrestrial group, the members of which live, in favourable seasons, exposed either on plants or on wet rocks and feed on fresh vegetation. At the approach of dry weather, when the rocks are dry and the plants do not afford enough protection, these molluscs retire for a season from active life by retreating into their shells, and by secreting an epiphragm protect themselves effectively against desiccation due to the excessive heat of the summer sun. The signal for their emergence is given by the first heavy shower which renders their habitat fit for the next period of active life. A curious instance of a Succineid from the Western Ghats hibernat-

<sup>1</sup> Rao, *Rec. Ind. Mus.* XXVII, p. 386 (1925).

ing on tree trunks during the monsoon rains has been recorded by Dr. Hora, and the attention of the members of the Indian Science Congress held in Bombay in 1926 was drawn to it.<sup>1</sup> It may be worth while to draw attention here to the fact that the only other kind of Succineid mollusc collected by Dr. Hora during his recent tour belongs to *Succinea indica* Pfeiffer. This is an amphibious species and was obtained in abundance from the under side of leaves of water-hyacinth plants, covering the surface of a big pond behind the Dak Bungalow at Pathankote. The abundance of individuals of the amphibious species as compared with those of the terrestrial form is noteworthy.

The second species of aestivating mollusc with which the present note deals is *Macrochlamys glauca* Benson of the family Zonitidae. This is also strictly terrestrial in habit and, like most terrestrial Succineids, seeks protection from desiccation during the dry weather by retreating within the shell and closing the aperture by an epiphragm secreted for the purpose by the animal itself. The epiphragm is, however, in this species of a thick shell-like substance unlike the membranous structure of other hibernating molluscs. Dr. Hora has made the following observations in the field book: "When the shell is placed in water the epiphragm is lifted up like an operculum after a long time (2 or 3 hours) and the animal by its movements begins to shake it off. It seems that forming the margin of the operculum and coming in contact with the shell there is a thin area which becomes very soft and dissolves in contact with water, setting free the epiphragm."

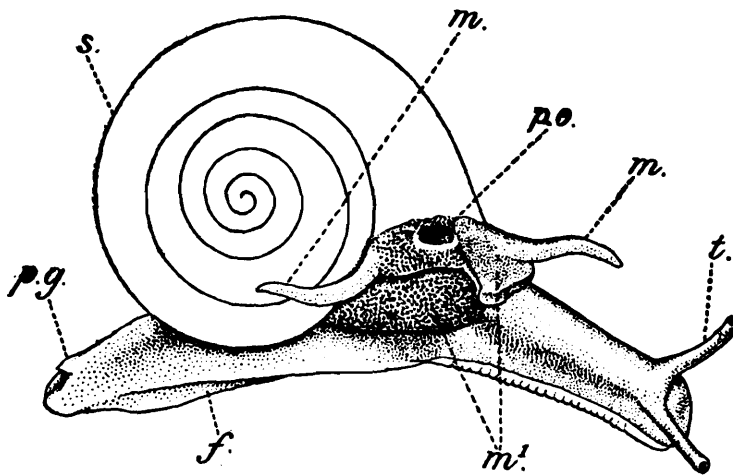


TEXT-FIG. 3.—Shell of *Macrochlamys glauca* showing epiphragm *in situ* in an aestivating individual.

The phenomena of hibernation and aestivation in land molluscs do not seem to have received as much attention as they deserve in the many species possessing these habits. This is not surprising in view of the fact that the earlier students of the mollusca, at any rate those who lived and worked in India before the time of Stoliczka, Blanford, and Godwin-Austen, were merely conchologists, and did not sufficiently realise the importance of studying the anatomy and the habits of the animals inhabiting the shells. It is, however, interesting to note that as early as 1848 H. E. Strickland observed and recorded the hibernating habits

<sup>1</sup>Hora, *Ibid.* pp. 401-403 (1925).

of *Nanina vitrinoides* (Deshayes), which seems to be a *Macrochlamys*,<sup>1</sup> from Ajmere. "Like many of the Helicidae of hot climates," he observed "especially those which are exposed to long intervals of drought, the *Nanina vitrinoides* secretes a calcareous *poma* or deciduous operculum every time that it retires into a state of torpor. The specimens in question had formed two or three successive *pomata*, one within the other, during the process of their desiccation. In hopes of restoring their animation, I placed them upon some wet moss in a warm room. Two of them proved to be past recovery, but the animal of the third was seen through the transparent shell to be gradually enlarging in bulk by the absorption of moisture, and at the end of a week it finally reached the door of its dwelling, threw off the *poma* and began to crawl." His observations go to show that the condition necessary for its revival from the torpid state was only moisture, and that so long as it was kept in a moist condition and was supplied with food, there would be no necessity for aestivation to intervene.



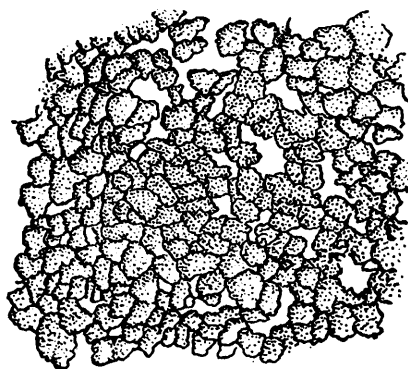
TEXT-FIG. 4.—*Macrochlamys glauca* in an active state. f. foot; m., superior mantle lobes; m<sup>1</sup>, inferior mantle lobes; pg., anal process; po., pulmonary aperture; t. tentacle; s., shell.

The snails of *Macrochlamys glauca* which Dr. Hora brought back from the Kangra valley had their epiphragm intact. A few of these were placed in a dish of water for an hour, at the end of which time all the animals one after another threw off their epiphragm and began to crawl about. Another snail was kept in a tube plugged lightly with cotton wool and the tube half immersed in a bottle of cold water for several hours, but no activity was observed in the animal, and the epiphragm remained in its place. The same snail was then dropped in a dish of cold water and allowed to remain there for a few minutes. It pushed the epiphragm from inside and came out of the shell. This suggests that actual contact with moisture helps the animal to throw off its epiphragm, and that a cool atmosphere alone is not enough to arouse it from its seasonal slumber. But snails thus stimulated did not appear to be capable of continued activity, nor were they inclined to feed on succulent leaves of plants that were supplied to them, for after a few hours of timid crawling they withdrew again into their shells and formed a fresh

<sup>1</sup> Godwin-Austen, *Land and Freshwater Moll. Ind.* Part III, pp. 80-82 (1883).

epiphragm, which was, however, not so thick as the one formed at the commencement of their natural season of aestivation. It was whitish in colour, thin and membranous, and had the same structure as that of the thicker epiphragm, but without the characteristic reddish brown colour of the inner surface of the latter. The same snails were revived again by contact with water, and they remained active for over six hours, after the lapse of which time they again withdrew into the shell closing the aperture of the shell with a still thinner epiphragm. When the process was repeated a third time, a few snails secreted only a portion of the epiphragm, and still fewer retreated as far back into the shell as possible with only traces of a very thin epiphragm at the mouth of the shell. The secretion of an epiphragm is apparently a process of exhaustion for the animal, and seems to decrease progressively when they are alternately allowed to desiccate and revive at short intervals.

One of the starved snails was revived by contact with water, and given bits of raw plantain on which it fed. This kept the animal active for about 30 hours, during which it crawled all over the glass tube in which it was kept, with the tentacles, eye-stalks, and mantle lobes well-expanded. Shortly after feeding the snail passed out tiny masses of coiled up thread-like faecal matter, and thereafter showed no inclination to feed again. After the lapse of thirty hours the snail withdrew into the shell closing the mouth of the latter by a freshly-secreted epiphragm which was comparatively thick. After about six hours the animal (on its own initiative and without the stimulus of added water) threw off its epiphragm and commenced crawling, apparently in search of food, which had been removed from the tube. A short while after, the snail retreated into its shell secreting a thin epiphragm. This process was repeated thrice and on the fourth occasion it did not secrete an epiphragm, even of the thinnest kind. Nevertheless the heart was beating, the process of respiration continued in a regular manner, and the surface of the mantle lobes was constantly dimpled by waves of muscular contraction.



TEXT-FIG. 5.—Portion of epiphragm of *Macrochlamys glauca* ( $\times 250$ ).

The epiphragm that is formed at the commencement of the aestivating period fits exactly into the mouth of the shell, is convex on the outer surface, somewhat rough in appearance, and has a white deposit. The inner surface is concave, very minutely granular and somewhat reddish in colour. When viewed by transmitted light the epiphragm presents a cellular appearance.

The process of formation of the epiphragm seems to be as follows, at any rate, under artificial conditions: The animal gradually withdraws itself into the shell, the anterior part being the first to be drawn in. Later on the whole of the foot is withdrawn and the mouth of the shell is completely closed by the lobes of the mantle. The surface of these lobes is always moist and has a pitted appearance, the result of a continual wave of depressions or pits being formed on them from one end to the other. A sticky mucous-like substance is secreted by the activity of the mantle lobes which on drying becomes a thin diaphanous membrane stretching across the mouth of the shell. By further secretion the thin epiphragm becomes thick, opaque, reddish on the inside and white outside. During the process of secreting the epiphragm the animal breathes regularly, as is evidenced by the rhythmical opening and closing of the pulmonary aperture. The heart can also be seen through the shell to be pulsating regularly. When a complete epiphragm has been formed, the heart gradually ceases its pulsation and the pulmonary aperture is completely closed.

The difference in colour between the outer and inner surfaces of the epiphragm is apparently due to the action of the atmosphere on the sticky substance, the outer surface being exposed becomes white, the inner, being excluded from further contact with air and augmented by the deposition of fresh layers of the sticky substance, retains its reddish colour.

ON THE HABITS OF A HIBERNATING SPECIES OF GASTROPOD MOLLUSC FROM PASHOK (EASTERN HIMALAYAS), WITH REMARKS ON CERTAIN OTHER SPECIES.

By SUNDER LAL HORA.

In this note I have to record my observations on the habits of *Glessula* (*Rishetia*) *hastula* Benson, several specimens of which were collected in loose earth at the base of big trees in the jungle at the sides of the main road at Pashok (alt. 2,600 ft.) in the Darjeeling District. I was at Pashok from the 16th to the 21st of December 1926, and most of the observations recorded here were made during that period.

Babu D. N. Bagchi, the artist, who accompanied me on tour, collected an individual of *G. hastula* in a state of torpor on the 16th from underneath a big stone at the side of the P.W.D. Bungalow hill in a more or less shady place. On account of ill health I was keeping in bed on that day and after noticing the peculiar condition of the animal left it in a tube under my pillow. A couple of hours afterwards (about 3 P.M.) it was found that the animal had become active and was crawling about the sides of the tube with the tentacles fully expanded. About an hour afterwards it shut itself up again and did not come out though it was kept immersed in water for a considerable time. The behaviour of the animal showed that the warmth of the day, and especially its position underneath my pillow, had stimulated it to activity and that the fall of temperature in the evening had induced it to retire into its shell again in a state of torpor.