MOLLUSCS OF THE SIJU CAVE, GARO HILLS, ASSAM.

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Only two species of molluscs were found living in the Siju Cave, one aquatic, the other terrestrial. The aquatic form (*Paludomus blanfordiana*) is evidently a mere visitor: individuals from the cave do not differ from those found in streams outside. It is otherwise, however, with the land-snail, for which we have thought it most convenient to provide a new specific name, viz., *Opeas cavernicola*. This species is very closely allied to the widely-distributed *O. gracile*, empty shells of a race of which were collected in the innermost part of the cave in circumstances which suggest that they had been washed in through some crevice. The eyes of *O. cavernicola* are modified in a very interesting manner.

With the specimens of *O. gracile* a single broken shell of the aquatic species *Melanoides pyramis* (Hutton) was found and another was collected at 350 feet from the entrance.

The following species were found in the immediate vicinity of the cave, but not inside it:—

Acrostoma reevei (Brot),
Cyclophorus affinis Theobald,
Oxytes oxytes (Benson).

Family MELANIIDAE.

Paludomus blanfordiana Nevill.

1876. *Paludomus labiata,* Hanley and Theobald (*nec* Benson), *Conch. Ind.*, pl. cviii, fig. 9.
1881. *Paludomus blanfordiana,* Nevill, *Journ. As. Soc. Bengal*, L, part ii, p.159, pl. v, figs. 3, 3A.

Specimens found in the stream at the entrance to the cave and also for 500 feet in from that point agree well with the figure cited from the *Conchologia Indica* except in being considerably smaller. The species has already been recorded from Pegu and Arrakan in Burma and from Gowhatty (Gauhati) on the Brahmaputra.

Opeas gracile (Hutton).

1906. *Opeas gracile,* Pilsbry in Tryon's *Manual of Conchology* XVIII, p. 125, pl. xviii, figs. 3-6.
1914. *Opeas gracile,* Gude, *Faun. Brit. Ind., Moll.* II, p. 355.

The shell is well described by Pilsbry in the work cited, but exhibits considerable plasticity, and numerous races occur even within the limits of the Indian Empire. Nothing seems to be known of the anatomy, but we hear from Col. Godwin-Austen that he proposes to describe it shortly.

O. gracile has a very wide range in tropical countries and has probably been carried from one to another with potted plants, among which it is often found. In dry weather it buries itself in the earth, emerging only after heavy rain to feed on mosses and algae such as grow on flower-pots, tree-trunks, etc. The eggs, which are spherical and of relatively large size, have stout calcareous shells. *O. gracile* is frequently accompanied and preyed upon by the carnivorous mollusc *Ennea bicolor*, which has some slight resemblance to itself. This has been observed in Ceylon, on the islands of the Chilka Lake, in Calcutta and in the Philippines.

Shells of *Opeas* were found at two spots in the Siju Cave, at 3,600 feet from the entrance and between 450 and 500 feet, at both place on high ground covered with bat-guano and above flood-level. At 3,600 feet from the entrance only a few shells were found and all were empty. They were accompanied by a single dead and broken shell of *Melanoides pyramis* on which remains of the periostracum still existed. These shells we assign to *O. gracile*. At between 450 and 500 feet, however, living snails of the closely allied species described below were abundant on the bat-guano, mostly on the higher ground but a few also lower down near the stream.

About a dozen shells of *O. gracile* were collected at the inner locality. They are very uniform in shape and several of them are considerably larger than any of the form we call *O. cavernicola*. They differ from these in outline as well as size, the whorls being less swollen, the mouth having the outer lip straighter and the body-whorl being more nearly quadrate. We believe that the shells represent a local race of *O. gracile*, perhaps endemic on the Garo Hills. We do not give this race a name because Col. Godwin-Austen informs us that he possesses shells from the Garo Hills and proposes to describe them shortly. The presence among them of an aquatic shell suggests that they may have been washed into the cave in a time of flood through some crevice.

The specimens from the other locality in the cave have much greater interest. We propose to refer to them for the sake of convenience as :—

Opeas cavernicola, sp. nov.

The first point to be observed in the shells of this species is that they fall into two very definite series, which at first sight we were prepared to regard as distinct species. The texture and structure of shells of the two series are, however, identical. We can find no difference either in the external anatomy, in the colouration of the animal, in the structure of the eye or in the radula. Pilsbry has pointed out that in many species of the genus *Opeas*, including *O. gracile*, two definite forms occur, one with a longer and narrower shell than the other. Apparently, however, there is as a rule no other difference. In our two series there is the same difference, but in one series the largest shells have two whorls more than the largest shells in the other, in one $8\frac{1}{2}$, in the other $6\frac{1}{2}$. This, of course, is a much greater difference than a mere difference of outline, but, nevertheless, we consider it best to regard the two forms as specifically identical. In *O. gracile* (*fide* Gude) the number of whorls may vary from 9 to 12, while in *O. cavernicola*

itself we find that eggs are occasionally present in shells of elongate form with only 6½ whorls. We believe, therefore, that in the stable conditions prevalent in the cave the two dimorphs of the species are becoming more distinct. Possibly this may ultimately result in the formation of two quite different species, but we do not believe that this has yet occurred. We will call the form with the elongate shell the *forma typica* of *O. cavernicola* and the broader form, var. *vamana*.

Forma typica.—The shell closely resembles that of *O. gracile* as represented by specimens from the valley of the Ganges. The whorls, however, are less swollen, the apex a little blunter, the sutures more impressed and the mouth distinctly U-shaped, not extending backwards along the outer side of the body-whorl. The columella is straight and vertical and its fold well developed. The shell is thinner than that of

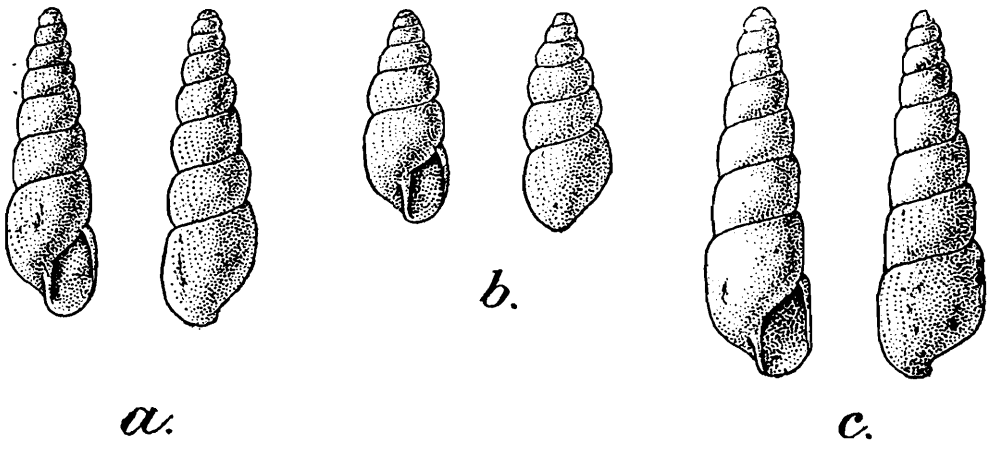

FIG. 1.—Shells of *Opeas* from the Siju Cave.

a. Type-specimen of *O. cavernicola*.
b. Type-specimen of *O. cavernicola* var. *vamana*.
c. Shell of local race of *O. gracile*.

the typical *O. gracile* and perhaps slightly paler. There are 8½ or 9 whorls. The shell differs from that of *O. innocens* Preston [1], an allied form from the Farm Cave near Moulmein, in being longer and much less nearly cylindrical. The mouth also is less ovoid and the columella straighter. We have examined the type of Preston's species.

Type-specimen.—M 12065/2, Zoological Survey of India (*Ind. Mus.*).

var. VAMANA.—The adult shell has only 6½ whorls and is much shorter than that of the *forma typica*. The individual whorls are also shorter and relatively broader and increase in size more rapidly. The apex is blunter. The body-whorl is much more swollen and the mouth is proportionately larger.

Type-specimen.—M 12062/2, Zoological Survey of India (*Ind. Mus.*).

Measurements of six shells of each of the two series are given below in millimetres :—

Forma typica.

Greatest length of shell	10·5	14·0	11·8	11·8	10·7	10·5
Greatest breadth of body-whorl	3·0	3·5	3·3	3·1	3·0	3·2
Greatest length of aperture	2·7	3·2	3·1	3·1	2·7	2·8
Greatest breadth of aperture	1·5	1·7	1·5	1·4	1·4	1·6

[1] Preston, *Rec. Ind. Mus.* V, p. 33, fig. 2 (1910).

			var. vamana.			
Greatest length of shell	6·8	8·8	7·1	8·8	7·8	8·5
Greatest breadth of body-whorl	2·8	3·3	3·0	3·1	2·9	3·0
Greatest length of aperture	2·4	2·8	2·4	2·8	2·6	2·8
Greatest breadth of aperture	1·3	1·5	1·5	1·6	1·4	1·5

No. 1 in each series of measurements is the type-specimen.

The proportion of the total length of the shell to the maximum diameter, therefore, varies from about $3\frac{1}{3}$ to 4 in the *forma typica* and from $2\frac{2}{5}$ to a little over $2\frac{4}{5}$ in the variety, while the proportion of the total length to that of the mouth varies from $3\frac{4}{5}$ to $4\frac{2}{5}$ in the former and from $2\frac{4}{5}$ to slightly over 3 in the latter.

At the place where the species was found some parts of the cave-floor are considerably higher than others. In examining the collections we find that whereas the *forma typica* predominates in that from the lower spots, the variety does so in that from the higher. In 60 specimens from the former there are 12 of the variety, while in 39 from the latter there are 24.

In the living animal of both forms the foot is long and narrow and narrowly rounded in front with a slight notch in the centre. Its upper surface is rugulose and there is a series of short transverse grooves along each margin. There is a distinct smooth mid-dorsal ridge, which does not quite extend to the extremity, on the region behind the shell. When fully expanded the foot does not much extend behind the upper end of the body-whorl. The eye-stalks are fairly stout and of moderate length. The eyes are situated a short distance from the extremity on the upper surface. There is a short broad snout with a small tubercle on either side, representing the true tentacle. The anterior margin of the snout, which does not extend as far forward as that of the foot, is convex.

Eggs, which occur to the number of 3 or 4 in many individuals captured in February, are spherical, with thick, smooth white calcareous shells, and have a diameter of 1.1 mm. Gude found eggs of a diameter of ·75 mm. in *O. gracile.*

FIG. 2.—Radular teeth of *O. cavernicola.*

The radula is identical with that of *O. gracile* from Calcutta. The formula is approximately 10–13. 11–13. 1. 11–13. 10–13, but the marginals and laterals are not clearly differentiated. It might, therefore, be expressed more accurately as 23.1.23. The transverse rows of teeth are nearly straight. The central is small and more or less distinctly trilobate, the central cusp being relatively long and bluntly pointed. The laterals are tricuspid, the central cusp being very long in those near the centre of the row, where it is lanceolate and sharply pointed. The lateral cusps are small and triangular, projecting at an acute angle from the base of the central cusp. As the teeth proceed outwards the central cusp becomes relatively smaller and actually shorter, while

the lateral cusps become larger, so that in the true marginals the three cusps are equal. The central cusp also becomes blunt at the apex.

The colour of the exposed soft parts of all races of *Opeas gracile* that we have observed, or that have been described by others, is a bright lemon-yellow. In the cave species it is never so bright but varies from a pale lemon-yellow to pure white. We have not been able to correlate differences in depth of colouration with pigmentation or lack of pigmentation of the eye, or with differences in the shape of the shell. The shell itself is very pale in all forms of *O. gracile* and is practically colourless in some forms that live in the open. In *O. cavernicola* it is very pale-straw coloured. The loss of colour, apart from the eyes (which we will discuss immediately), is, therefore, hardly greater than that observed in individuals of certain species of fish captured in the cave.

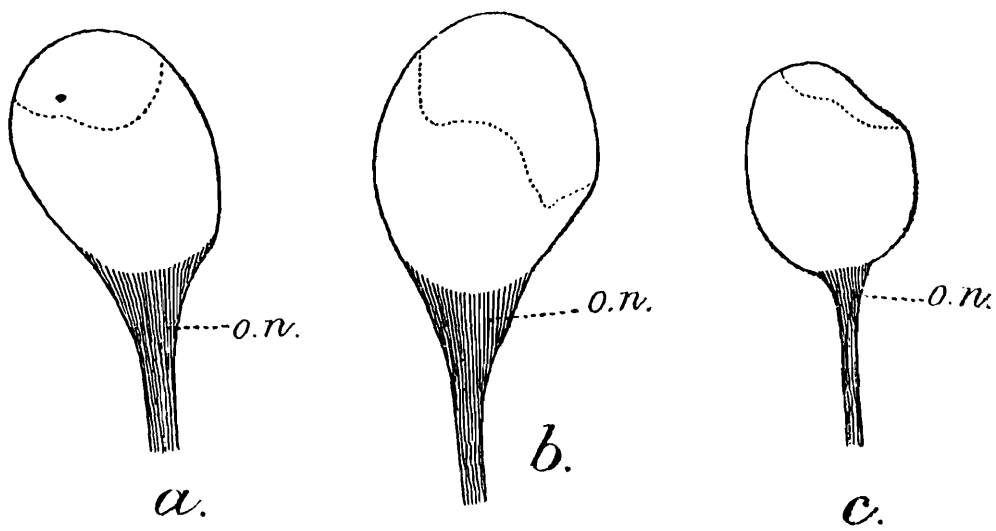

FIG. 3.—Eyes of *Opeas* dissected out of the sheath of the retracted eye-stalk. *a*,*b*. eyes of two individuals of *O. cavernicola* with pigmented retina. *c*, eye of *O. gracile* from Calcutta. All × 300.

The most interesting feature of the cave species is undoubtedly the condition of the eyes. In all the many individuals examined these organs differed from those of any individual of *O. gracile* found living in normal conditions either in Calcutta or on Barkuda Island. In some the eye was completely invisible, although the eye-stalk was always well developed, in others it was black and conspicuous but apparently very small. We examined 100 snails brought alive to Calcutta and found that the eye was invisible in any condition of expansion in 6, while in one it was pigmented on one side but invisible on the other. In the remaining 93 individuals it was of a dense black colour, in which we could detect no variation. There seemed to be a certain variation in size, but it was found impossible to measure so sensitive a structure accurately.

We have cut sections of the eyes of the three forms and dissected out the complete organ in those in which it is pigmented. Our preparations show that the structure of the optic organ of both species is somewhat peculiar. The eye in *O. gracile* is situated some distance behind the tip of the eye-stalk on its upper surface and is elliptical in outline. It is set in the stalk somewhat obliquely, in such a way that the pigmented retina extends over a part of the exposed surface on its inner

margin. The cornea, which is relatively small, is flattened. The condition of the lens seems to be peculiar, for it shows no definite outline in sections, but has the appearance of having been of a semi-liquid consistency. The optic nerve, which enters the eye on its internal surface, is well developed and apparently quite normal. The pigment of the retina, which is contained in the cells in the form of minute but distinct granules, is excessively abundant. We have not been able to eliminate it from our sections, in which it obscures the retinal structure.

In *O. cavernicola* with pigmented eyes the cornea is not so much flattened and appears in life to be distinctly smaller, but the complete optic organ, while varying somewhat in size, is always larger than in *O. gracile*. The pigment is not so dense, and seems to be somewhat deficient in the distal part of the pigment-cells, in which the granules are much more sparsely scattered than in *O. gracile*.

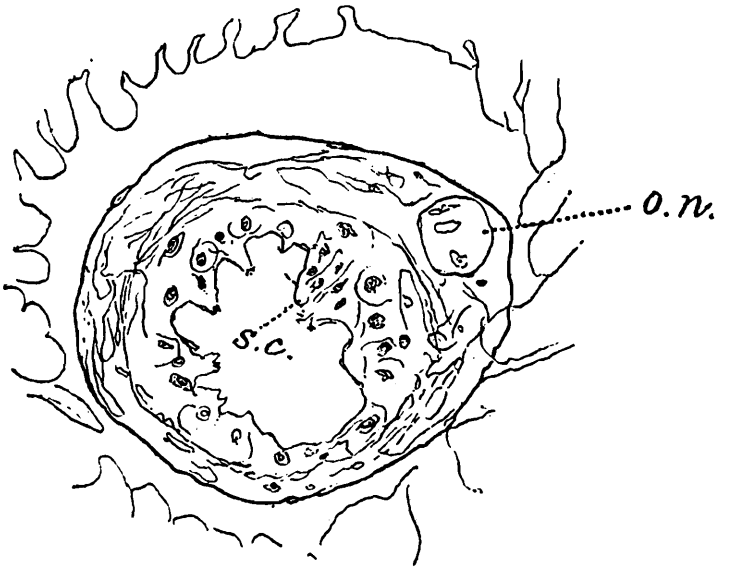

Fig. 4.—Oblique transverse section through eye of *O. cavernicola* with unpigmented retina. *O.n.* = optic nerve. *S.c.* = sense cells of retina.

In the optic nerve there is no structural difference between these two species, but curiously enough, the nerve is distinctly stouter in the cave-form than in the other, thus corresponding to the size of the optic organ. In both species it is spread out at the base of the retina, forming a definite cup of nervous tissue. In the cave-species this cup is distinctly better developed than in the other.

Individuals of cave species with unpigmented eyes provide greater facilities for the study of retinal structure than those with pigmented eyes. Although the eye is invisible in the living snail, it is in most respects just as well developed as in the other phase. In only two points can we detect a definite difference, namely, in the complete absence of pigmented cells from the retina and in the apparent absence of a lens. As to the latter point we cannot be quite sure. Our sections,

owing to climatic difficulties, have not been altogether satisfactory and it is quite possible that the lens may have dropped out. This, however, does not seem probable in view of the condition of the lens as seen in pigmented eyes.

The sense-cells of the retina are well developed and, although our sections are not as thin as we would have liked, they show the minute hair-like processes of the distal extremities of the cells and also the radiculae at their base quite clearly.

The optic nerve is in the same condition as in the cave form with pigmented eyes.

An important point observed in the living individuals of the three forms, namely, *O. gracile* from Calcutta, *O. cavernicola* with pigmented eyes and *O. cavernicola* with invisible eyes, was that we could detect no difference in the movements of their eye-stalks, or in the sensitiveness of these structures. In all three the eye-stalk was retracted as soon as any object was brought within a few centimetres, and this was done, so far as could be judged, with equal rapidity in pigmented and in unpigmented eyes.

These facts suggest interesting conclusions. Firstly, it is evident that even in individuals which have lost the optic pigment altogether, and probably also the lens, the eye is just as much an organ of sense as it is in normal individuals. Much has been written on the sense of sight in molluscs and we need not here add any further to the literature on the subject. We may, however, point out that it is quite possible that the eye-stalks have always sensory functions other than optic.

The second conclusion to be drawn is that the eye is becoming modified in *Opeas cavernicola* along two different lines of evolution. In one direction it is becoming reduced as an optic organ, but actually increasing in size, as an organ of sense ; in the other it is losing its optic function by an actual disappearance of definite structures. In the former the evolution is both indefinite and liable to variation ; in the latter it is as a rule definite and where variation occurs it affects, so far as we know, not both members of a pair of organs but one of the two of a pair of organs. We saw no specimen in which the retinal pigment was present only to an extent sufficient to give an appearance of a dull or greyish eye. In every eye examined the pigment was either abundant or absent, and in our sections we can detect no trace of the pigment-cells, which have apparently disappeared completely, though in individuals with pigmented eyes they are sufficiently large to obscure the sense-cells.

The phenomena that have occurred in this snail are, therefore, not altogether analogous to those observed in the other animals with reduced eyes from the cave, namely, the prawn *Palaemon cavernicola* and the wood-lice *Philoscia dobakholi* and *Cubaris cavernosus*. Dr. Kemp has not been able to find any variation in the size of the eyes of the former, although they are always very small, nor has he found any individual in which retinal pigment had been lost. The general colouration of the prawn, moreover, seems to have been more uniformly affected than that of the snail. As to the wood-lice, the eyes of *P. dobakholi*, though

always pigmented, are very small and apparently exhibit marked variation in size, while the colour of the animal is very pale. In *C. cavernosus*, on the other hand, the eyes though small are not quite so much reduced and the animal is deeply pigmented.

We have assumed in this argument that *Opeas cavernicola* is descended from individuals of a race of *O. gracile* with normal eyes. This assumption seems to be justified not only by the close similarity of the two forms but also by the general distribution of *O. gracile*, its occurrence in other situations in the Garo Hills and the fact that it exhibits a marked tendency towards the evolution of distinct races. Possibly the ancestors of the cave-form may have entered the cave not from the main entrance but from some crevice in the interior. This is suggested to us by the presence at the inner end of the cave of dead shells of a race of *O. gracile*, associated with a worn but recent shell of *Melanoides*, an aquatic genus not found living in the cave.