FURTHER OBSERVATIONS ON THE AQUATIC GASTROPODS OF THE INLE WATERSHED.

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[Nearly six years ago I published an account of the aquatic molluscs of the Inlé Lake and connected waters. My paper was based on collections made early in 1917 by Dr. F. H. Gravely and myself. The results were so interesting, and cast so much light on general problems of mollusc-ecology and evolution, that I arranged to pay a second visit to the same country in March, 1922. I was accompanied by Dr. Sunder Lal Hora, Assistant Superintendent, Mr. H. Srinivasa Rao, Research Assistant, and Babu D. N. Bagchi, Artist, in the Zoological Survey of India. To these gentlemen, and especially to Dr. Hora, my best thanks are due. Dr. Hora remained in the Southern Shan States after the rest of the party returned and made valuable additional collections. Babu D. N. Bagchi's sketches of living molluscs have proved of great value.

The main object of our expedition was to obtain further information about the remarkable genus *Taia* and especially about its extraordinary variability and plasticity. This investigation was part of one of wider scope on shell-sculpture in the Viviparidae,[1] but the genus will be discussed merely from a taxonomic point of view in this paper. In the course of our work on special lines we obtained much additional information about the molluscs, recent and extinct, of the district, and I was so fortunate as to be accompanied for some time by Mr. F. W. Walker of the Geological Survey of India, to whose assistance I owed much in studying the various deposits of the He-Ho plain and the Hsin Dawng caves.

I have to thank Dr. L. L. Fermor, who was acting as Director, Geological Survey of India, at the time, for permitting Mr. Walker to accompany our party. More frequent co-operation of the kind between the scientific departments of the Government of India seems to me highly desirable. *N.A.*]

No less than 34 species and 10 subspecies of true aquatic molluscs and 2 species of semi-aquatic habits were taken on the two visits to the Inlé watershed. Of these, 7 species and 2 subspecies appear to be extinct and were found in a fossil or subfossil condition. No less than 23 species and 7 subspecies appear to be endemic in the watershed. Of these, 7 species and 2 subspecies were only found subfossil. In this paper we describe 6 species and 3 subspecies as new, several of these were obtained on the former visit but for various reasons were not given names.

The recent specimens collected on the second visit are from all parts of the Inlé watershed except the river which flows out from the south end of the lake. The area they represent extends from Kalaw and Loi-an near the head-waters of the Kalaw River, which enters the lake on the western side, to Taunggyi on the hills above its north-eastern extremity, and from the valley north of the lake to Nanpan close to the point at which the southern river emerges.

The fossil and subfossil specimens are from four different deposits, three of which lie in the He-Ho plain west of the lake, while the third is on the slopes of a little valley to the north-east of Yawnghwe. These four deposits have already been described elsewhere,[2] but the much richer collection made in 1922 renders it possible to discuss the shells

[1] Annandale, *Proc. Roy. Soc. London* XCVI, pp. 60-76 (1924).
[2] Annandale, *Rec. Geol. Surv. Ind.*, L, p. 215 (1919).

found in them more fully than heretofore. Those from the peaty superficial deposit on the He-Ho plain prove on more detailed comparison to be identical with the living molluscs of the valley. The deposit is in places almost incredibly rich in shells of *Taia naticoides* race *intermedia*, and the little streams that traverse it have their beds covered with shells washed out from it in a profusion rarely seen except on the sea-shore.

This is also true of the deeper lacustrine deposit of clay at the east end of the valley just above the gorge. The race of *Taia* represented in it is, however, slightly different though specifically the same. We call it *T naticoides* race *lacustris*. The race *distoma* of *Hydrobioides nassa* is also different from that found living on the plain, and this is probably true of that of *Limnaea shanensis*, which is the typical form of the species, differing in minor characters from the race *superstes* which survives in the Inlé Lake. There are, however, two races or phases of this species in the deposit next to be discussed and their geological relations are not quite clear, though both are distinct from the living form. On the other hand *Acrostoma elongatum* from all deposits is identical with the living form.

The curious bank of calcareous particles at the head of the He-Ho gorge, exactly resembling a sand-bank in appearance, is remarkable for the large number of minute and fragile shells which it contains in a perfect condition. Among those found in it in 1922 were several hitherto not recorded from the Shan States, namely *Ferrissia baconi* (a widely distributed form), *Limnaea laticallosa* (a new species discovered living at Kalaw), *Segmentina taia*, sp. nov., and *Intha capitis* both of which survive in the Inlé valley, a new species of *Camptoceras*, *Succinea godivariana*, a probably amphibious species hitherto recorded only from Peninsular India, *Tricula horae*, sp. nov. and *Hydrobioides diperistoma*, sp. nov., which was formerly confused with *H. turrita*, the type-species of the genus. Both *Limnaea shanensis typica* and another form we call *L. shanensis* f. *hehoensis* occur in this deposit, the shells in which are evidently of mixed origin, some washed out of the superficial peaty deposit of the plain, others from the old lacustrine deposit and yet others of recent origin.

The cave-deposits in the two little limestone caves at Hsin-Dawng were also revisited and the same species found in them, with the addition of imperfect shells evidently representing forms of *Acrostoma elongatum* and the remains of a freshwater crab. The three species of *Taia* already recorded (*viz.*, *T obesa*, *T conica* and *T cylindrica*) were also rediscovered, *T obesa* was much scarcer than the other two. The shells had evidently been washed into the caves mainly through holes in the roof. They occur in one cave in a fan-shaped slope of earth leading down from the former and in the other in the floor just inside the mouth.

Both in living and in comparatively recent fossil freshwater molluscs the Inlé watershed is extraordinarily rich. In spite of its small area it actually contains more species of living aquatic Gastropods than the whole of the plains of Peninsular India between Peshawar and Cape Comorin and between the Indus and the Brahmaputra, and some of the species are very abundant. No less than 27 species and forms are known

to us and it may be doubted whether we have yet, in two short visits, completely exhausted the fauna. In the following list those species and races only known in a fossil or subfossil condition are marked with an asterisk : forms only known from the Inlé watershed by a dagger :–

PULMONATA.

Succinea indica Pfeiffer.
S. godivariana Gude.
* † *Limnaea shanensis* Annandale.
† *L. shanensis* f. *superstes*, nov.
* † *L. shanensis* f. *hehoensis*, nov.
† *L. mimetica* Annandale.
L. luteola f. *siamensis* Sowerby.
† *L. laticallosa*, sp. nov.
L. andersoniana Nevill.
† *L. physcus*, sp. nov.
Indoplanorbis exustus (Deshayes).
Gyraulus euphraticus, Mousson.
G. labiatus (Benson).
† *G. velifer* (Annandale).
† *Intha capitis* Annandale.
Segmentina caenosus (Benson).
† *S. taia*, sp. nov.
* † *Camptoceras*, sp. nov.
Ferrissia baconi (Bourg.).

PROSOBRANCHIA.

* † *Tricula horae*, sp. nov.
* † *Hydrobioides diperistoma*, sp. nov.
H. nassa (Theob.).
H. nassa f. *avarix* Annandale.
† *H. nassa* f. *rivulicola* Annandale.
† *H. nassa* f. *lacustris* Annandale.
† *H. nana* Annandale.
† *Paranerita physcus* (Annandale).
† *Amnicola alticola* Annandale.
Melanoides tuberculatus (Müller).
M. scabra (Müller).
† *Acrostoma elongatum* (Annandale).
† *A. elongatum* f. *planicostata*, nov.
A. variabile (Benson).
† *Vivipara heliciformis* (Frauenfeld).
Lecythoconcha lecythis (Benson).
† *Taia theobaldi* (Kobelt).
† *Taia naticoides* race *intermedia* Annandale.
* † *T. naticoides* race *lacustris* Annandale.
† *T. shanensis* (Kobelt).
* † *T. obesa* Annandale.
† *T. crassicallosa*, sp. nov.
* † *T. conica* Annandale.
* † *T. cylindrica* Annandale.
† *T. elitoralis* Annandale.
† *T. intha* Annandale.
Pachylabra conica var. *compacta* (Reeve).

Genus **Limnaea** (*auctorum*).

The genus is remarkably well represented in the He-Ho plain and the Inlé watershed, for no less than six living species have been found in this area, whereas only three are known from the whole of Peninsular India ; if we exclude the Punjab Salt Range into which certain Palearctic forms intrude. These six species, however, are quite distinct and most of them are not at all closely related the one to the other.

The *Limnaea*-fauna of this district exhibits affinities both with that of Peninsular India and with that of Indo-China. Of the six species one, represented by a Burmese and Siamese race, is conspecific with a common Indian mollusc. This is *L. luteola* f. *siamensis*. The race occurs both in Upper and in Lower Burma and also in Tenasserim. Four species are known only from the district under discussion, *viz.*, *L. physcus* and *L. laticallosa*, both described here for the first time, *L. mimetica*, a true lacustrine form from the lake, and *L. shanensis*, the typical form of which is apparently extinct but is represented in the living fauna by the race *superstes*. Finally, *L. andersoniana* has a range that extends from Western China through the hill country of Burma to Manipur in Assam on the one hand and the Nepal Himalayas and Kashgar in Central Asia on the other. This species is closely allied to the Palearctic *L. truncatula*,

Key to the species of Limnaea *known from the Shan Plateau.*

1. Columellar fold exceptionally broad and coarse, occluding the umbilicus on the ventral surface of the shell. Umbilicus often visible from the dorsal surface.
   - A. Shell not exceeding 16 mm. in length, with 5 whorls, very variable in shape .. *L. andersoniana.*
   - B. Shell over 16 mm. long, with 6 whorls, of a regular narrowly ovate form .. .. *L. laticallosa.*
2. Columellar fold normally developed. Umbilicus never visible on the dorsal surface.
   - A. Spire not depressed, almost or quite as high as broad. Body-whorl much narrower, but not tapering in front .. .. *L. physcus.*
   - B. Spire not depressed at the base, more than twice as broad. Body-whorl much narrower, but not tapering in front.
     - (i) Columellar callus narrow. Spire situated asymmetrically towards the left side of the body-whorl, which is oblique.
       - (*a*) Spire much reduced, blunt at the apex, shell not more than 7 mm. long, colourless, very fragile .. .. *L. mimetica.*
       - (*b*) Spire sharply pointed, short but well developed. Shell at least 9 mm. long, coloured, less fragile .. .. *L. shanensis.*
     - (ii) Columellar callus broad. Spire situated symmetrically on the middle of the body-whorl, which is not at all very oblique. Whole shell of a narrowly oval form .. .. .. *L. luteola f. siamensis.*

Limnaea physcus, sp. nov.

1918. *Limnaea ?* prox. *ovalis,* Annandale, *Rec. Ind. Mus. XIV,* p. 111, pl. x, fig. 3.

Two living specimens, one adult and one young, of a species, apparently identical with the fossil or subfossil form cited above, were discovered by Dr. Sunder Lal Hora in a railway reservoir near He-Ho. They are more globose than that form, but otherwise agree with it, so far as can be seen in the imperfect condition of the fossil shells. The species seems to be quite distinct and may be defined as follows :—

Shell small, cordiform, with a very small, sharp spire, delicate, transparent, horn-coloured, decorated with fine longitudinal striae, without spiral sculpture, with an oily lustre. Spire consisting of $2\frac{1}{2}$ short transverse whorls, minutely and obliquely truncate at the apex ; the whorls not at all swollen, with their outlines almost straight but sloping outwards, the second at least three times as long as the apical complete whorl, much narrower than the upper extremity of the body-whorl and situated towards its inner margin ; the suture moderately impressed. The body-whorl relatively very large, oblique, tapering in front to a blunt point, with the outer margin as seen in dorsal view forming a regular curve of less than a semicircle and the inner margin strongly sinuate ; the dorsal surface highly convex. The aperture very large but not expanded, auriculate, pointed and introverted above, narrowly rounded below. The columella twisted and curved ; its callus delicate

but rather broad, completely occluding the umbilicus, meeting the outer lip above. The outer lip curved, very delicate. The ventral surface of the whorl highly convex in its upper half.

Owing to an accident the soft parts of the only adult recent specimen were destroyed. The shell occurs very rarely in the lacustrine deposit of clay on the banks of the He-Ho river and was not found in the sandy mud at the head of the gorge, probably on account of its fragility which would render its transport in the river difficult and improbable.

Measurements (in millimeters) of type-specimen.

Height of shell.	Height of aperture.	Maximum breadth of shell.	Maximum breadth of aperture.
8·4	7·2	6·5	4·2

Type-specimen.—M $\frac{12045}{2}$ Z. S. I. (*Ind. Mus.*).

The species seems to be allied to some of the Palearctic forms of the *peregra* group, but is very distinct from any Indian form hitherto described.

The species is only known at present from the He-Ho plain (alt. 3,800 ft.) in the Southern Shan States.

Limnaea laticallosa, sp. nov.

This is a species resembling the stream form of *L. andersoniana* [1] but with a larger shell, more numerous whorls, a still better developed columellar fold, a distinct flattening of the whorls outside the suture and less numerous radular teeth. It also appears to be related to *L. crosseana* [2] from Cambodia and Tonquin and resembles some specimens of that species more closely than it does the original figure, but has the shell thicker, the columellar fold and callus much better developed, the mouth of the shell more expanded on the outer side, the umbilicus open on the dorsal surface (though occluded on the ventral) and the sculpture much better developed.

The shell is of moderate size, somewhat elongate and rather narrow, sharply acuminate to the naked eye, moderately thin, translucent, of a horny brown colour and sculptured with irregular longitudinal striae interrupted at intervals by spiral decussate lines, with an oily lustre on the surface.

The shape is narrowly ovate with the spire well exserted, comparatively long, placed vertically on the middle of the body-whorl and occupying from about $\frac{1}{3}$ to nearly a $\frac{1}{2}$ of the length of the shell. There are six complete whorls ; they increase gradually and evenly in size. The suture is impressed and a little oblique, especially on the dorsal surface. The upper extremities of the whorls are narrowly and slightly obliquely flattened outside it much as in the shell of *L. truncatula*. The body-whorl is distinctly spiral and the umbilicus or rather a channel leading

[1] Annandale and Prashad, *Rec. Ind. Mus.* XXII, p. 576, pl. viii, figs. 4, 5 (1921).
[2] Mabille and le Mesle, *Journ. Conchyl.* (3) XIV, p. 130, pl. vii, fig. 5 (1866).

to it is visible on the dorsal surface in the form of a pin-hole. The callus and the columellar fold cover a considerable part of the ventral surface of the body-whorl and are coarse, longitudinally striate and lustrous. The columella is strongly twisted and almost vertical. The outer lip is thin and has a somewhat flattened curve. It is not at all introverted above. The aperture as a whole has a distinctly auriculate form and is somewhat dilated outwards below; above it is sharply pointed. The peristome is complete.

Measurements (in millimeters) of type-specimen.

Height of shell.	Height of aperture.	Maximum breadth of shell.	Maximum breadth of aperture.
15·7	9·7	8·4	4·9

The jaw is very characteristic. The maxilla is narrowly biconvex with a transverse ridge in the middle, and the lateral pieces are long and tapering and distinctly fimbriate on the inner surface.

The radula is also very characteristic. The cusps of all the teeth are remarkably long and narrow, especially as regards the mesocone. Some of the laterals are bicuspid, but the first is always tricuspid. The approximate dental formula is 19. 8. 1. 8. 19.

The genitalia offer no very striking peculiarity. In two specimens examined the spermatheca is remarkably large and of subtriangular outline. Its duct is long and somewhat swollen just before entering the sac. In these specimens the penis is very slender and the prostate small and heart-shaped.

The animal (in spirit) is of a leaden grey colour, with the tentacles broadly triangular and the anal funnel exceptionally prominent.

Type-specimen.—M $\frac{12055}{2}$ Z. S. I. (*Ind. Mus.*).

A large series of shells and specimens in spirit was obtained by Dr. Hora from a small reservoir used for horticulture above Kalaw[1] at an altitude of about 4,500 ft. The water was clear, the bottom muddy; there were no water plants.

Limnaea luteola Lamarck.

This is one of the commonest and most widely distributed of the Indian species, but several forms can be distinguished. The common Burmese race, for the study of which abundant material is before us from Tenasserim, Pegu, Upper Burma and the Southern Shan States, is evidently identical with Sowerby's *L. siamensis*. In India and Ceylon at least four forms may be distinguished if sufficient material be examined, but only two of these can be regarded as well established races, namely the *forma typica* (with its phases or varieties *succinea* Deshayes and *impura* Troschel) in India and the subspecies *australis*, nov. in Ceylon and parts of Peninsular India. Specimens from Kulu in the Western Himalayas are quite typical. Nevill recognized the

[1] Kalaw is situated some little distance west of the He-Ho plain on a small stream that ultimately flows into the Inlé Lake after proceeding some miles underground.

Burmese form as a distinct variety but did not give it a name. The five forms may be distinguished as follows :—

I. Length of shell usually more than 20 mm., shell somewhat elongate with the body-whorl subcylindrical and a little compressed—	
A. Shell with pale longitudinal stripes, moderately thin	*forma typica.*
B. Shell pale, without longitudinal stripes, thin	*succinea.*
II. Shell less than 20 mm., in length : body-whorl not subcylindrical.	
A. Shell rather short, ovate	*impura.*
B. Shell more elongate—	
(i) Body-whorl bilaterally asymmetrical in ventral view	*australis.*[1]
(ii) Body-whorl almost bilaterally symmetrical	*siamensis.*

race **siamensis** Sowerby.

1873. *Limnaea siamensis,* Sowerby in Reeve, *con. Icon.* sp. 63, pl. x.
1878. *Limnaeus luteolus* var., Nevill, *Hand List Moll. Ind. Mus.* I, p. 233.

The most characteristic feature of this race is noted in the key. The shell never exceeds 16 mm. in length and is usually about 1½ times as high as broad. It differs greatly in colour and thickness in different localities and types of environment. Specimens from the Royal Lakes in Rangoon are small, with thin, pale lutescent shells ; but Dr. Marshall has sent from the same city a much brighter, rather larger and thicker specimen. Those obtained from a muddy pool used for domestic purposes at He-Ho are thicker and have a solid appearance. The natural colour is dull lutescent, but there is a thin black deposit on the surface and the spire is eroded.

The animal is always rather dark. The tentacles are large and triangular ; the lips normal, the anal funnel is exceptionally well developed. It will be better to defer any description of the anatomy until a comparative account of the soft parts of the different races can be prepared. The radular formula is approximately 16. 7. 1. 7. 16.

This form provides a link (both geographical and structural) with the Malayan *L. javanica.* The shell, however, differs in that the body-whorl is always narrow, with the aperture less dilated, and the spire relatively broader and not so tapering.

Family PLANORBIDAE.

Subfamily *PLANORBINAE.*

1922. *Planorbinae,* Annandale, *Rec. Ind. Mus.,* XXIV, p. 358.

Like the Limnaeidae this subfamily is also represented by several species in our recent collection. All but one of these were also taken on the first visit to the Shan States, but the identifications were not all correct. Unlike the Limnaeidae, the Planorbidae offer good generic characters of an anatomical nature, and the seven species can be distributed into four genera which are well defined both on such

[1] *Australis* is the name we propose for *pinguis,* Dohrn, preoccupied.

characters and also conchologically. These four genera are *Indoplanorbis* Annandale and Prashad, *Gyraulus* Agassiz, *Segmentina* Flemming and *Intha* Annandale, the last being a genus recently described from our Shan collection.

Genus **Indoplanorbis** Annandale and Prashad.

1922. *Indoplanorbis,* Annandale, *Rec. Ind. Mus.*, XXIV, p. 360.

Indoplanorbis exustus (Deshayes).

1918. *Planorbis exustus,* Annandale, *Rec. Ind. Mus.*, XIV, p. 111, pl. xi, figs. 1, 1*a*.
1921. *Planorbis* (*Planorbis*) *exustus,* Germain, *Rec. Ind. Mus.*, XXI, p. 26, figs. 1—11 and 13—16.
1923. *Indoplanorbis exustus,*—Rao, *Rec. Ind. Mus.*, XXV, pp. 199—219, text-figs. 1—3*a*, 4—7 and 9—14.

Common in the marginal zone of the Inlé Lake and also on the He-Ho plain. Shells from this district are usually of moderate size and regular form, with fine and regular sculpture and of a chestnut-brown colour.

Genus **Gyraulus** Agassiz.

1922. *Gyraulus,* Annandale, *op. cit.*, p. 361.

Gyraulus convexiusculus (Hutton).

1918. *Planorbis saigonensis* (?), Annandale, *op. cit.*, p. 112, pl. xi, fig. 12.

It is to this species and not to *G. euphraticus* Mousson that shells from the sand-like deposit on the He-Ho gorge belong. A few living specimens were also taken in the marginal zone of the Inlé Lake.

Gyraulus velifer (Annandale).

1918. *Planorbis velifer,* Annandale, *op. cit.*, p. 112, pl. xi, figs. 7—11.

The species is closely allied to *G. convexiusculus* and *G. euphraticus*, but differs from both in its more delicate shell, in the different shape of the mouth of the shell, which is much more expanded, in possessing a thin but distinct callous deposit on both lips and in the very pale colour of its blood.[1] It is by no means confined to the Inlé Lake as was formerly thought, but is also found in ponds and canals in other parts of the valley and subfossil in the sand-like deposit of the He-Ho gorge. The opaque subfossil shells can be recognized by their expanded mouths and by the deposit on their lips, which is particularly distinct in them owing to its polished surface. We figure the living animal from drawings made by Babu D. N. Bagchi in the Southern Shan States. Individuals from the lake are often quite colourless. Sometimes they have a black line running along each tentacle and occasionally the whole of the surface of the body is suffused with black pigment. The shell is

[1] See Annandale, *Rec. Ind. Mus.*, XXIV, p. 358 (1922).

always hyaline and colourless. Specimens from the canal at Yawnghwe are darker and their shell is usually tinted of a pale yellowish colour.

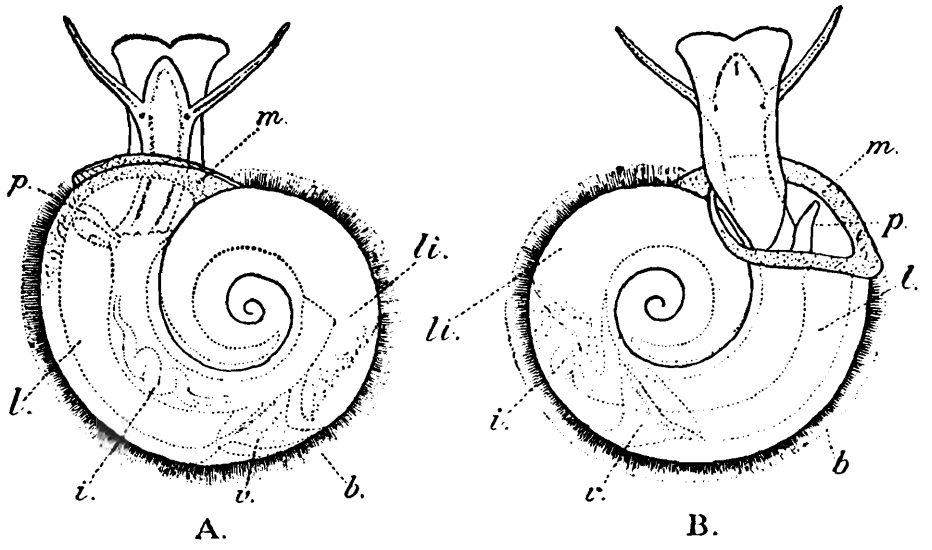

FIG. 1.—*Gyraulus velifer* (Annandale) from Inlé Lake.

A. Dorsal view of living animal in an expanded state.
B. Ventral view of same.

b. bacterial velum; *i.* intestine; *l.* pulmonary chamber; *li.* liver; *m.* edge of mantle; *p.* pseudobranch; *v.* ventricle.

As Annandale has pointed out elsewhere (*op. cit.*, 1922), the blood is slightly pinker in such individuals than in those from the lake.

Gyraulus labiatus (Benson).

1915. *Planorbis (Gyraulus) labiatus*, Preston, *Faun. Brit. Ind.* Freshw. Moll., p. 119, fig. 5.

Several shells from the sand-like deposit at the He-Ho gorge belong to this species. They agree exactly with the figures of Benson's types in the work cited. The whitish ridge on the inner surface of the lip is very well developed in them,[1] but the departure of the last whorl from its axis is less marked than in specimens from Calcutta, Mettupalayam (S. India) and the Central Provinces. The Shan specimens are also smaller.

Genus **Segmentina** Flemming.

1922. *Segmentina*, Annandale, *op. cit.*, p. 362.

The two species Annandale identified in 1918 were, as we now believe, both identified incorrectly. One of them appears to be the true *caenosus* of Benson, the other new.

Segmentina caenosus (Benson).

1876. *Planorbis caenosus*, Hanley and Theobald, *Conch. Ind.*, pl. 39, figs. 7, 8.
1918. *Planorbis calathus*, Annandale (*nec* Benson), *op. cit.*, p. 113.

The specimens examined by Ananndale in 1918 were young. The adult shell, which is not uncommon in the Inlé valley and occurs sub-

[1] The ridge appears to be well formed in adult shells in which the growth of the lip is complete, while it varies in prominence in younger specimens.

fossil at the He-Ho gorge, is much less transparent than that of *S. calathus* and the internal ridges are not so well developed. In some specimens, indeed, they are difficult to detect. The size of the umbilicus is also a good character. The blood is of a much deeper red than it ever is in *Gyraulus velifer*.

Segmentina taia, sp. nov.

1918. *Planorbis caenosus,* Annandale (*nec* Benson), *op. cit.*, p. 113.

The shell is conoidal, flattened below, and concave at the apex above. The last whorl slopes abruptly towards the ventral surface. Four and a half gradually increasing whorls are seen from above. The ventral surface of the shell when seen from below, though flat in appearance, is slightly convex along the middle of the last whorl. The

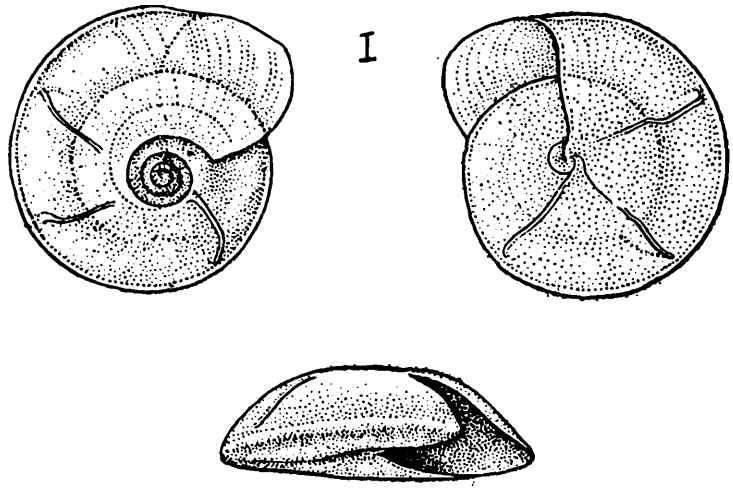

FIG. 2.—Type-specimen of *Segmentina taia,* sp. nov. from Inlé Lake.

umbilicus is minute and occluded and is in the form of a shallow pit. The internal ridges of the shell are visible from below in adult shells, while in young shells they are seen from both surfaces. A faint fourth ridge is often visible on the side nearest to the aperture. In ventral view the aperture has a quadrate appearance while from the sides it is obliquely hastate in outline. The narrow end of the mouth never extends much beyond the level of the opposite extremity of the last whorl. The ventral margin of the peristome is almost straight and joins the strongly arched and convex dorsal margin at its outer extremity. The dorsal margin of the mouth overhangs the ventral considerably in front. The sculpture consists of fine longitudinal oblique striae. The adult shell is of a yellowish brown colour, while young shells are paler.

Measurements of type-specimen in millimeters.

Greatest diameter of shell.	Height of shell.	Greatest height of aperture.	Greatest breadth of aperture.
3·0	1·5	0·7	1·5

Anatomy.[1] The jaw consists of a single narrow chitinuous strip bent in the form of an inverted U and is distinctly segmented. The radula

[1] Rao, *Rec. Ind Mus.*, XXV, pp. 203, 205, 210, 216 and 217 (1923).

is a narrow ribbon with minute teeth. The intestine is long and surrounds the liver more or less completely. The pseudobranch is absent. The genitalia agree with those of *Gyraulus* in general structure and arrangement but differ in the absence of a bulbous swelling to the penis-sheath, and of a penial stylet.

Living specimens of this species were found in the marginal zone of the western shore of the Inlé Lake and in the canal at Yawnghwe, S. Shan States. Specimens from the latter locality are smaller and paler.

This species is closely allied to *S. calathus* (Benson), from which it can be distinguished by its more pronounced conoidal form, by the gradually increasing size of the whorls, by the sides of the keel forming a small angle (due to extreme flattening), by the straight lower margin of the peristome (which in *S. calathus* is concave), by its greatly arched upper margin, and by the occluded umbilicus.

Type-specimen.—M. $\frac{12461}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

Genus **Intha** Annandale.

1922. *Intha*, Annandale, *op. cit.*, p. 361.

Intha capitis Annandale.

1918. *Planorbis trochoideus*, Annandale (*nec* Benson), *op. cit.*, p. 113.

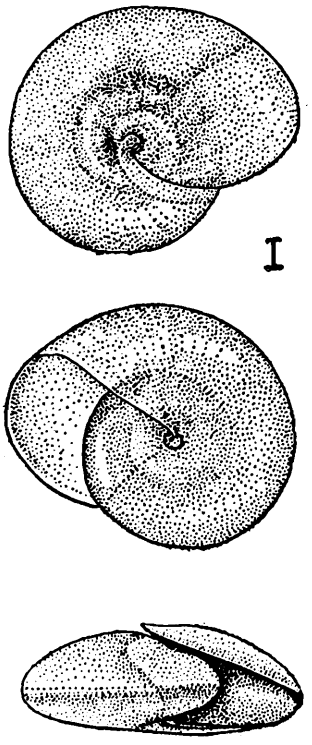

FIG. 3.—Type-specimen of *Intha capitis* Annandale from Inlé Lake.

Living individuals of this species occur commonly in the central and marginal zones of the Inlé Lake, and subfossil shells in the sand-like deposit on the He-Ho gorge.

A further examination of the genitalia of this minute species shows that they do not belong to type I, as stated in the original description of the genus (*op. cit.*, p. 359, 1922), but agree rather with those of *Segmentina*. There are, however, no ear-like processes above the penial sheath. There is no penial stylet. Details are difficult to distinguish on account of the minute size of the structures and the highly contracted state of the material examined.

This species was named after Mr. W. R. Head, Assistant Superintendent, Yawnghwe in 1922 to whom we were greatly indebted for much assistance during our tour in the Yawnghwe State.

Genus **Camptoceras** Benson.

1922. *Camptoceras*, Annandale, *op. cit.*, p. 363.

Camptoceras sp.

Several specimens of a new species allied to *C. terebra* were found in the granular calcareous deposit on the He-Ho gorge. They have been submitted to Dr. Germain for description.

Family ANCYLIDAE.

Genus **Ferrissia** Walker.

In their recent revision of the Indian Ancylidae [1] Annandale and Prashad treated *Ferrissia* as a subgenus of *Ancylus*, and we still believe that they were right in doing so on theoretical grounds; but a practical objection arises owing to the difficulty of deciding what will finally be accepted as the type species of *Ancylus*. We are in full agreement with those who claim that two distinct genera are represented by the two British species of the family (*lacustris* and *fluviatilis*), but which should be regarded as the genotype of *Ancylus* is another matter, which we leave to the experts on nomenclature to discuss. We therefore accept *Ferrissia* as a genus pending final agreement on this point, merely claiming its very close relationship to "*Ancylus*."

Ferrissia baconi (Bourg).

1921. *Ancylus* (*Ferrissia*) *baconi*, Annandale and Prashad, *Rec. Ind. Mus.*, XXII, p. 592.

Several shells were found in the sand-like deposit at the head of the He-Ho gorge. The range of the species is believed to extend from Bengal to Japan.

Family RISSOIDAE.

Genus **Hydrobioides** Nevill.

1884. *Hydrobioides* (subgenus of *Bithynia*), Nevill, *Hand-List Moll. Ind. Mus.*, II, p. 42.
1918. *Hydrobioides*, Annandale, *op. cit.*, p. 117.
1924. *Hydrobioides*, Annandale, *Proc. Malacol. Soc. London*, XVI, p. 28.

As former descriptions of the genus have proved inadequate for its recognition, a more detailed diagnosis is necessary.

The shells of the genus are always rather thick and of a narrowly ovate or turrited form. They are of small or moderate size. The umbilicus is closed or almost so and there is no channel leading downwards from it towards the lip. The lip itself is thickened near the margin, but the actual margin is usually somewhat attenuate, the thickening, which is often visible externally and always well developed internally, is really a kind of varix, but must not be confused with the much more prominent varix that often occurs above it. In addition to being attenuate the lip is more or less expanded outwards in its lower part. The outer thickening forms a ridge inside the shell against which the operculum rests when withdrawn. It is only in growing shells, therefore, that the operculum can be pulled far into the aperture. The col-

[2] Annandale and Prashad, *Rec. Ind. Mus.*, XXII, p. 588 (1921).

umellar callus forms a narrowly flattened and expanded fold which usually occludes the narrow umbilicus.

The operculum is thick and shelly, with a thin outer horny covering. In the very young shell its structure is distinctly paucispiral and the nucleus is situated towards the inner margin near the middle point; but in the adult the spiral figure becomes obsolete and the external sculpture is concentric, while the internal surface is smooth.

The anatomy is very similar to that of *Bithynia.*

Hydrobioides differs from *Amnicola* in the structure of the lip, the operculum (*vide* pl. xiv, *Rec. Ind. Mus.*, XIV, 1918) and of the male organ [1]; from *Digoniostoma*, to which it is closely allied, the chief difference lies in the structure of the mouth of the shell. In the former genus the lip is not so much thickened, the umbilicus is usually more open and is always connected with a channel that runs on the surface of the shell obliquely downwards towards the lip, while the callus is narrow and more ridge-like.

Annandale [2] has recently proposed a division of *Hydrobioides* into two subgenera, *viz.*, *Hydrobioides* s.s. and *Parafossarulus.* The latter, which has its headquarters in China but also occurs in Burma, has no varix on the lip and is sometimes ornamented with spiral shell-sculpture.

Subgenus **Hydrobioides** Nevill.

Hydrobioides diperistoma, sp. nov.

1918. *Hydrobioides turrita*, Annandale (*nec* Blanford), *op. cit.*, p. 117.

The shell is small and thick with the spire conoidal, slightly longer than the inner margin of the body-whorl but much shorter than the outer margin. The body-whorl is markedly sinuate in outline and the anterior lobe as seen in dorsal view is remarkably well developed and distinct. The whorl is sub-carinate with a blunt ridge running round the periphery. This ridge marks the termination of the inner margin of the body-whorl in dorsal view. In ventral view the true spire is half as long as the body-whorl, to the lower part of which the aperture is appended as a kind of projection. The structure of the peristome is highly peculiar, but may be taken to represent that typical of the genus in its highest development. There are indeed two peristomes. The inner of these is comparatively small, ovate and oblique. It is defined by a narrow but prominent ridge which is particularly conspicuous on the internal surface of the outer lip. This peristome, which forms the true mouth of the shell, is situated within another of much larger size, less oblique and of different shape. The

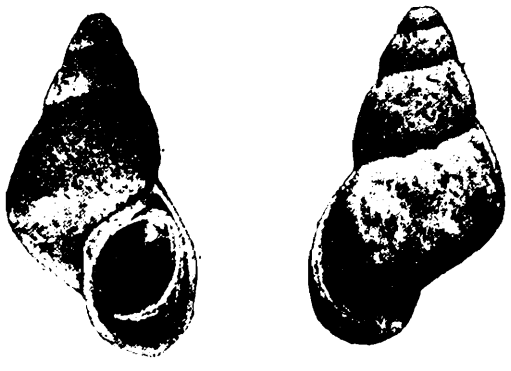

FIG. 4.—Type-specimen of *Hydrobioides diperistoma*, sp. nov.

[1] Annandale and Prashad, *Rec. Ind. Mus.*, XVIII, p. 26, fig. 2 (1919).
[2] Annandale, *Proc. Mal. Soc. London*, XVI, p. 28 (1924).

outer peristome is continued above the inner and is sharply pointed at the apex, leaving a distinct triangular area between the two. The lip is broadly expanded beyond the inner peristome, especially in the anterior region and is somewhat thickened. Its outer margin is a little sinuous but almost parallel to the columellar callus which is quite straight. The callus is rather broad and well developed especially above the rimate umbilicus which is completely closed. Above it meets the outer lip without becoming narrower.

Measurements (in millimeters) of type-specimen.

Height of shell.	Height of aperture.	Maximum breadth of shell.	Maximum breadth of aperture.
5·20	2·35	3·00	1·70

Type-specimen.—M. $\frac{12159}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

The double peristome of this form is much more distinct than in the true *H. turrita* (Blanford), which is figured by Nevill in *Journ. As. Soc. Bengal*, L (2), pl. vi, fig. 15.

The shells were found in large numbers in a subfossil condition in the deposit at the head of the He-Ho gorge. No living specimens were found.

Hydrobioides nassa (Theobald).

1918. *Hydrobioides nassa* (with subspp.) and *H. avarix*, Annandale, *op. cit.*, pp. 118, 120, pl. xiii, figs. 1—7 ; pl. xiv, figs. 3, 4.

Key to the phases of Hydrobioides nassa (Theobald).

1. Varix on lip of shell poorly developed .. *avarix.*
2. Varix well developed.
   - A. Varix almost confluent with thickened edge of lip, separated merely by a narrow groove *distoma.*
   - B. Varix separated from edge of lip by a flattened area.
     - (i) Edge of lip only slightly thickened; shell comparatively thin .. *rivulicola.*
     - (ii) Edge of lip distinctly thickened; shell thick.
       - (*a*) Flattened area between edge of lip and varix at least $\frac{1}{3}$ as broad as diameter of the shell .. .. *lacustris.*
       - (*b*) Flattened area much narrower .. *typica.*

In specimens of the form *avarix* traces of a varix close to the edge of the lip can be distinguished in a good light and in some it is fairly well developed. We found this form abundant in a warm spring the temperature of which was, at 7 o'clock in the morning, 27° C, while that of the air was 17·6° C.

Shells of the *forma typica* have recently been presented to the Indian Museum by Mr. J. R. le B. Tomlin labelled as *Pachydrobia paradoxa* Crosse and Fisher. They are from the Mekong. The two species resemble one another so far as the shell is concerned, but the operculum, radula and male organ are very different.

Subgenus **Parafossarulus** Annandale.

1924. *Parafossarulus*, Annandale, *op. cit.*, p. 28.

Hydrobioides nana Annandale (*op. cit.*, p. 121, pl. xiv, fig. 3, 1918) belongs to this subgenus. Shells are not uncommon in the deposit above the He-Ho gorge.

In form and colouration the animal differs somewhat from that of *H. nassa*. The foot is very narrow and tapers behind to a fine point. In front it is truncate with the lateral angles evenly rounded and

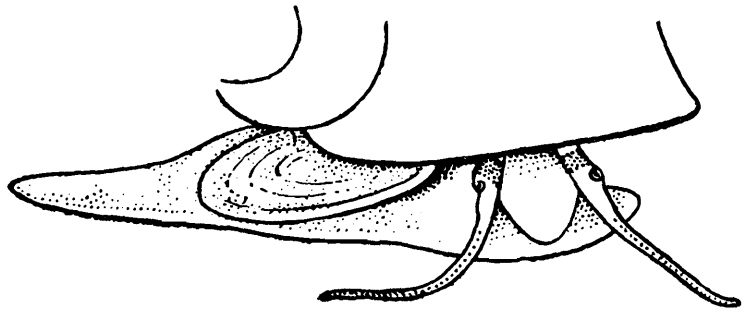

FIG. 5.—Living animal of *Hydrobioides nana* Annandale from Yawnghwe, S. Shan States.

not at all prominent. The snout is short and rather narrow and appears either bilobed or pointed in accordance with the position from which it is seen. The tentacles are very long and narrow and sharply pointed, with the minute eyes situated on them at some distance from their point of origin. The colour of the exposed parts is white or grey with a conspicuous yellow or red blotch behind each eye. The tentacles are spotted with black and the snout is sometimes infuscate.

Genus **Amnicola** Gould and Haldeman.

Subgenus **Alocinma** Annandale and Prashad.

1919. *Alocinma*, Annandale and Prashad, *Rec. Ind. Mus.*, XVIII, p. 23.

Amnicola alticola (Annandale).

1918. *Amnicola alticola*, Annandale, *op. cit.*, p. 122, pl. xiv, figs. 6, 6*a*.
1919. *Amnicola* (*Alocinma*) *alticola*, Annandale and Prashad, *op. cit.*, p. 24, fig. 1-B.

Genus **Paranerita** Annandale.

1920. *Paranerita*, Annandale, *Rec. Ind. Mus.*, XIX, p. 45.
1921. *Paranerita*, Annandale and Prashad, *Rec. Ind. Mus.*, XXII, p. 4.

Paranerita physcus (Annandale).

1918. *Hydrobioides physcus*, Annandale, *op. cit.*, p. 121, pl. xiii, figs. 8, 8*a*, 9; pl. xiv, figs. 5, 5*a*.

Genus **Tricula** Benson.

1921. *Tricula* (in part), Prashad, *Rec. Ind. Mus.*, XXII, p. 67.
1924. *Tricula*, Annandale, *Amer. Journ. Hygiene*, Monographic Series, No. 3, p. 278.

Tricula horae, sp. nov.

Shell narrowly ovate, sub-turrited with $5\frac{1}{2}$ to 6 whorls. Spire occupying in dorsal view a little more than half the total length. Apex blunt, mamillate. Outline of shell regular and very little broken by the suture, which is slightly impressed and transverse, whorls of the

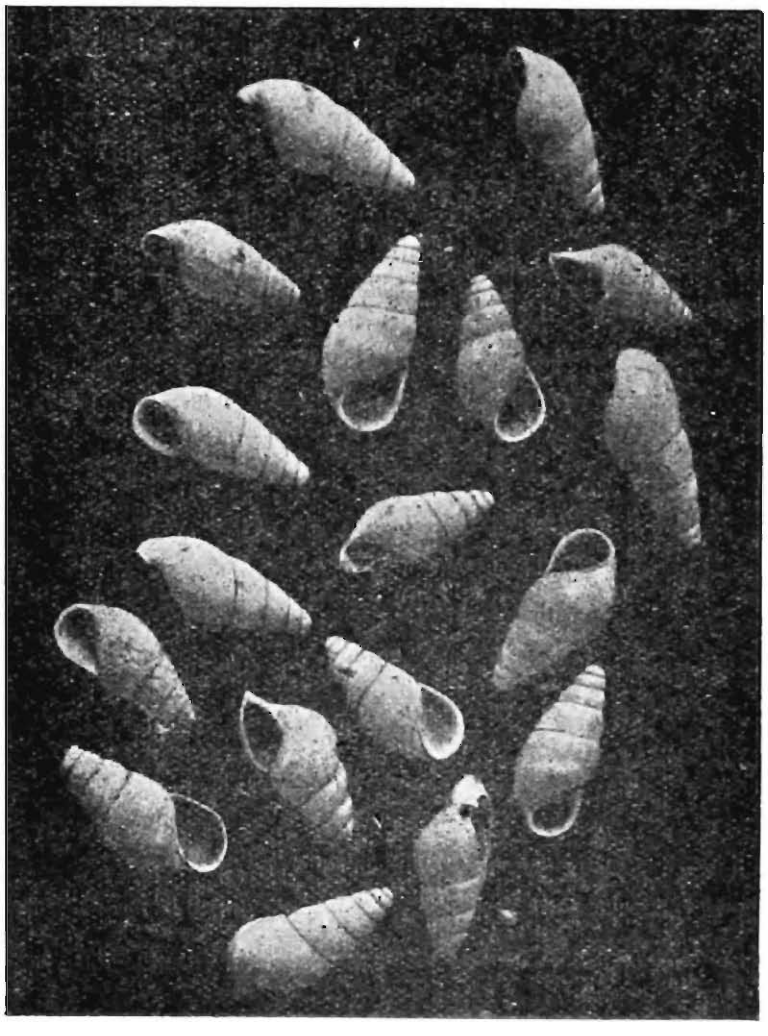

Fig. 6.—Shells of *Tricula horae*, sp. nov.

spire increasing gradually and evenly, the lateral outlines straight and not very oblique. Body-whorl occupying nearly half the length of the shell as seen in dorsal view with the outer margin much longer than the inner, which is evenly rounded. The anterior lobe of the shell in this view not greatly accentuated. On the ventral surface the whorl is slightly convex in its upper part with a slight indication of a peripheral keel, below which it recedes rapidly. The aperture is sub-utriangular and oblique, sharply pointed above and a little expanded below. The outer lip is thin but slightly callous, highly convex downwards and generally having a sinuate outline. The peristome is complete and the callus is well developed in the form of a narrowly flattened ridge continuous at the lip and completely closing the umbilicus. The interior of the mouth is finely polished. The external structure consists of faint longitudinal striae. In a subfossil state the shells have a porcellaneous appearance and sometimes retain faint traces of an olivaceous colour. The operculum has disappeared.

Measurements (in millimeters) of type-specimen.

Height of shell.	Height of aperture.	Maximum breadth of shell.	Maximum breadth of aperture.
2·78	1·05	1·40	0·69

Type-specimen.—M $\frac{1246}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

Shells are common in the deposit at the head of the He-Ho gorge, but we did not find the species alive.

From the shells of *Tricula montana*, the type-species of the genus, those of *Tricula horae* are distinguished by the larger body-whorl and by the structure of the lip.

Family MELANIIDAE.

Genus **Acrostoma** Brot.

1921. *Acrostoma*, Annandale, *Rec. Ind. Mus.*, XXV, p. 509.

Acrostoma elongatum (Annandale).

1918. *Melania baccata* subsp. *elongata*, Annandale, *op. cit.*, p. 115, pl. xii, figs. 3—7.

1922. *Melania persculpta*, Ehrmann, *Sitzungsber. Naturf.-Ges. Leipzig*, IX, p. 18, pl. fig. 8.

Several shells with a thick calcareous deposit were obtained in the stream at Tai-O, Yawnghwe State. The species is commonly found living in swamps on the He-Ho plain. We also obtained several shells from a clay-pit one mile above the He-Ho gorge.

The radular teeth are not unlike those of *Acrostoma variabilis* (Benson), but the large middle cusp of the laterals is much better developed than in the latter species, and the median cusp on the central is somewhat blunt.

Acrostoma elongatum f. **planicostata,** nov.

This form, of which we have a recent specimen form He-Ho and a fossil shell from the Hsin-Dawng Caves, is distinguished by the fact that it has well developed vertical ribs on its whorls and that the two rows of tubercles and the spiral ridges surrounding them are obsolete. Traces of the tubercles can, however, be seen in a good light. The two shells we have examined are small, that from the Hsin-Dawng Cave is incomplete at the apex of the spire, while the living specimen from He-Ho is, unfortunately, broken.

The latter is paler in colour than most specimens of the species and has a well-marked spiral band of a dark brown colour running round the whorls.

We have a fossil specimen with two rows of tubercles from the Hsin-Dawng Cave.

We have been able to extract the radula from the specimen obtained at He-Ho. The radular teeth do not differ from those of *Acrostoma elongatum* f. *typica*.

The species is so variable in details of sculpture (although less so in its general character than many others) that it seems unnecessary to regard *Acrostoma elongatum* f. *persculpta* Ehrmann as distinct.

The range of the species extends from the head-waters of the Kalaw stream at Loi-an through the He-Ho plain down to its entrance into the Inlé Lake on its western shore.

Melanoides tuberculatus (Müller).

1918. *Melania tuberculata*, Annandale, *op. cit.*, p. 114 and pp. 155—156, pl. xii, figs. 1, 2.

Eight large shells of this species were obtained in a clay-pit one mile above the He-Ho gorge along with shells of *Acrostoma elongatum*. They are of the same size as the specimens obtained in our previous visit in a ridge of recent tufa on the He-Ho plain, and agree with the Shan species figured as *Melania pyramis* var. *adspersa* by Hanley and Theobald [1] except that the mouth is relatively small and not expanded.

Melania terebra Benson.

1918. *Melania terebra*, Annandale, *op. cit.*, p. 115, pl. xii, fig. 9.

We obtained no individuals of this species unless an incomplete smooth shell from the Hsin-Dawng Cave deposit, that we took along with *A. elongatum*, represents it.

Family VIVIPARIDAE.

Genus **Vivipara** Montfort.

The only specimen of this genus we have from the S. Shan States is a shell of *V. heliciformis* [2] Frauenfeld collected by Dr. S. L. Hora at Kalaw near the head-waters of the stream which enters the Inlé Lake on the west side. This shell and the single specimen of *Lecythoconcha lecythis* collected in the Inlé Lake on the first visit are the only Viviparidae other than *Taia* we have seen from the Inlé system.

Genus **Taia** Annandale.

1918. *Taia*, Annandale, *op. cit.*, pp. 123, 160.
1924. *Taia*, Annandale, *Proc. Roy. Soc. London*, B, XCVI, p. 60.

One of the main objects of our visit to the Shan States in 1922 was to obtain further information about this interesting genus, and a large additional collection of shells and preserved material was made.

The characteristic anatomical features of the genus are:—(*a*) the head of the animal is relatively larger than in *Vivipara* and has the eyes almost completely sessile; (*b*) the edge of the mantle is more muscular, though there is no greatly enlarged sphincter, and the margin is frequently produced into broad, highly contractile lobes correlated

[1] Hanley and Theobald, *Conchologia Indica* p. 45, pl. cx, fig. 4 (1876).
[2] Kobelt perpetuates the erroneous belief that this is an African species in his monograph on "Paludina" in the *Conch. Cab.* (1909), p. 172. Cf. Hanley and Theobald, *Conch. Ind.*, p. 33 (1876).

with the shell-sculpture[1] ; there is also a broad lobe corresponding to the thickened columellar callus ; (*c*) the marginal teeth of the radula are relatively narrow ; (*d*) the inner wall of the stomach is thrown into transverse folds which are frequently chitinized : (*e*) the central ner-

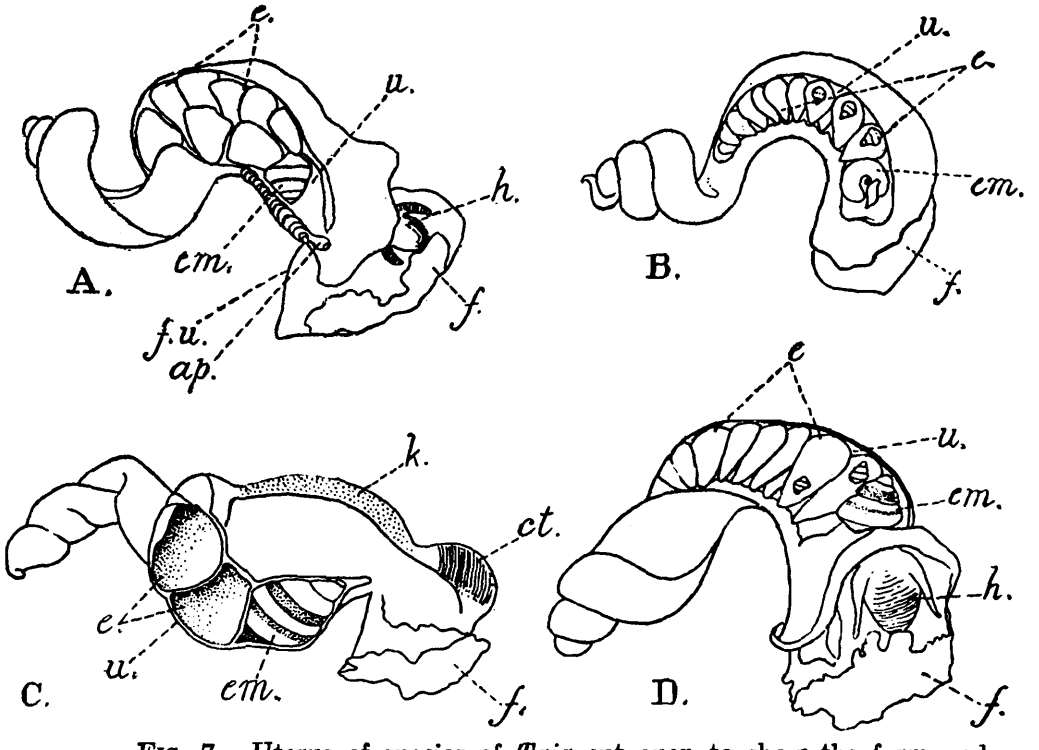

FIG. 7.—Uterus of species of *Taia* cut open to show the form and disposition of embryos and ova.

A. *T. crassicallosa.* C. *T. intha.*
B. *T. shanensis.* D. *T. naticoides* f. *intermedia.*

ap. anal papilla ; *ct.* ctenidium ; *e.* ova ; *em.* embryos ; *f.* foot ; *f.u.* folds of uterus (the arrow should reach the folded area behind the anal papilla *ap.*) ; *h.* head ; *k.* kidney ; *u.* uterus.

vous system is relatively very large, with broad ganglia and greatly thickened commissures : (*f*) the uterus contains only a small number of embryos, which are more fully developed at birth than in *Vivipara ;* (*g*) the gill-filaments are high and narrow with a short base of attachment.

The question of the relative fertility of the different species has been considered by Annandale (*Proc. Roy. Soc. London*, XCVI, p. 70, 1924) in reference to their evolution. An interesting point in this connection is the proportionate numbers of the sexes, for we have to consider the number of developed embryos and not merely that of unfertilized ova. In *T naticoides* f. *intermedia* only four males were found among 25 individuals ; in *T crassicallosa* there were 4 males to 6 females ; in *T intha* 22 males to 27 females ; in *T shanensis* 18 males to 14 females ; in *T elitoralis* 10 males to 4 females. The numbers of individuals are small, but it would appear that while in the two species which live in streams or in paludine conditions the number of females predominates over that of males, the opposite is the condition in lacustrine and

[1] Annandale, *Proc. Roy. Soc. London*, XCVI, p. 67, fig. 5 (1924).

even paludine forms. There is thus further evidence for the reduction of fertility in the latter.

The examination of much further material renders it necessary to combine several of the forms hitherto regarded as distinct species, but on the other hand reveals the existence of yet another new species in the Inlé valley. We have thus the following living forms in the Inlé watershed :—

Taia naticoides race *intermedia* Annandale
Taia theobaldi (Kobelt)
Taia crassicallosa, sp. nov.
Taia shanensis (Kobelt).
Taia elitoralis Annandale.
Taia intha Annandale.

With the exception of *T theobaldi*, which we have not examined anatomically, these five forms are distinguished by apparently constant characters in the soft parts as well as the shells.

Four fossil or subfossil species also occur in the same area, namely :

Taia naticoides race *lacustris*, Annandale
Taia obesa, Annandale
Taia conica, Annandale.
Taia cylindrica, Annandale.

The first of these is known to us from the lacustrine deposit above the He-Ho gorge, while the other three were found in two small limestone caves at Hsin-Dawng, a few miles from the town of Yawnghwe.

We have recently received from Mr. F. W Walker of the Geological Survey of India a number of shells of the species described by one of us as *Taia incisa* [1] and later made the type of the subgenus or genus *Temnotaia*.[2] In some of Mr. Walker's specimens the operculum remains. It proves that the species is really a Melaniid and not a Viviparid. *Temnotaia*, therefore, if it is to be retained, is no more than a section of *Paludomus* and a new name must be found for the smooth and thick-shelled forms of *Taia*. The name *Lissotaia* is here proposed. The species are *fulva* (Reeve), *concolor* (Nevill) and *bhamoensis* (Nevill). It is perhaps best, until their anatomy is known, to regard them as representing merely a subgenus of *Taia*.

Taia naticoides (Theobald).

As Annandale pointed out in his original description of the Inlé species of the genus, the form that occurs commonly in swamps and backwaters in the Inlé valley is specifically identical with Theobald's species, but shells from the valley are not precisely identical with those from the Upper Salween, whence *T naticoides* was originally described. Further, they differ slightly on an average from those from the He-Ho plain on the same watershed but 800 feet higher. Living specimens from the latter locality were thought to differ from subfossil shells from the superficial peaty deposits on the same plain, and these subfossil shells

[1] Annandale, *Rec. Ind. Mus.*, XIV, p. 213 (1918).

[2] Annandale, *Rec. Geol. Surv. Ind.*, L, p. 231 (1919) and *Rec. Ind. Mus.*, XXII, p. 293 (1921).

were separated into two species. The differences between living Inlé and He-Ho individuals are, however, so slight that it does not seem advisable to recognize them by the use of different names, while the living He-Ho form is found to grade absolutely into the common sub-fossil form originally called *intermedia*, of which the form *analoga* proves to be a mere monstrosity or aberration. We think it best, therefore, to combine all the living and fossil forms of this species from the two connected valleys under the name :

race **intermedia** Annandale.

1918. *Taia naticoides* (in part), *T. intermedia* and *T. analoga*, Annandale, *op. cit.*, pp. 126, 128, 132, pl. xv, figs. 6, 7, 12, 13, 16, 17 ; pl. xvi, figs. 3-6, 7-9 ; pl. xvii, figs. 3, 4 ; pl. xviii, figs. 1-3.

The shell of this race is rather more elongate and frequently much larger than that of the *forma typica* from the Upper Salween. It is, moreover, never wholly devoid of coarse spiral ridges, though they vary greatly in development.

The stomach of this form has a distinct chitinous lining and a pair of parallel chitinous ridges of a pinkish colour are usually to be found a little below the junction of the stomach and oesophagus. They are not always to be detected, however, and it is possible that they are worn out or cast off and replaced periodically.

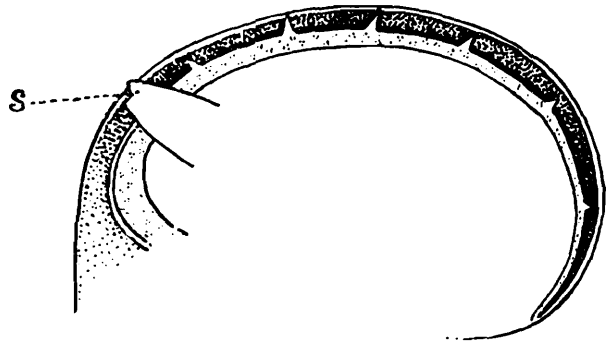

FIG. 8.—Mantle edge of young specimen of *Taia naticoides* f. *intermedia* as seen from below. *S.* siphon.

The gill-filaments are very narrow ; their base is somewhat produced backwards.

The auricle of the heart is a lobed structure, larger than the spongy, thick-walled ventricle.

The uterus as a rule contains several embryos with well-developed shells, but two of these are usually larger and better developed than the others. About nine polygonal, compressed eggs are also present ; altogether there may be as many as thirty eggs and embryos. The embryonic shells are always banded.

Of 25 individuals examined at the Inlé Lake only 4 were males.

race **lacustris** Annandale.

1918. *Taia lacustris*, Annandale, *op. cit.*, p. 131, pl. xv fi 10 (*not* 11) ; pl. xvii, fig. 1 ; pl. xviii, figs. 7, 8 (*not* 9).

The shell of this fossil form only differs from that of the race *intermedia* in being a little longer, narrower and less conical. It never

reaches a large size and is fairly constant in shape and sculpture. It occurs only in the clay banks of the He-Ho river above its gorge.

Taia shanensis (Kobelt).

1918. *Taia shanensis*, Annandale, *op. cit.*, pl. xv, figs. 14, 15; pl. xvi, fig. 10; pl. xviii, figs. 4, 6.

This species appears to be somewhat modified structurally in correlation with its environment, especially in three systems, namely the shell, the respiratory system and the alimentary system, the environmental peculiarities being the very foul water in which it lives and the existence of an abundant supply of an alga containing hard calcareous particles on which it feeds. The shell is relatively thin and brittle. The chitinous lining of the stomach is particularly well-developed and the ridges and folds into which it is thrown unusually prominent, while the radular teeth are stronger than in other species. In the other direction, the gill-filaments are relatively broad, while the supra-intestinal fold of the mantle running close to and parallel to the ctenidium is strongly developed and perhaps acts as an accessory organ of respiration.

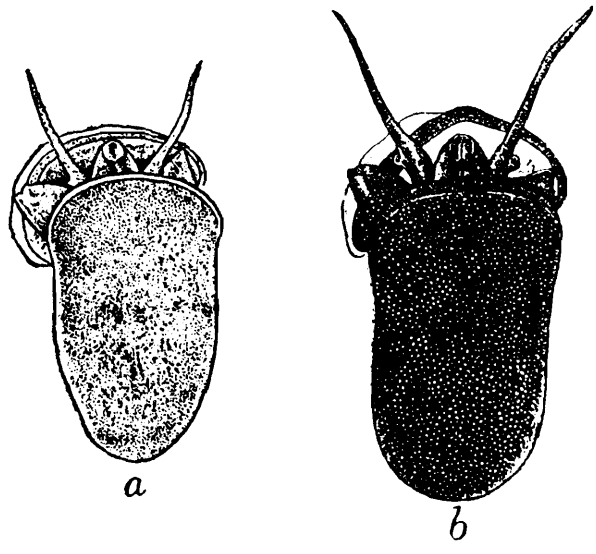

FIG. 9.—*a*. Ventral view of living animal of *Taia shanensis*.
b. Ventral view of living animal of *Taia intha*.

The colour of the exposed parts of the living animal, including the edge of the mantle, is nearly black with the usual yellow specks.

Other anatomical peculiarities noted are that both the auricle and the ventricle of the heart are globular and that the testis is of a peculiar shape, being elongate and curved with its anterior extremity extending to the base of the right tentacle. The ejaculatory duct has a tortuous course in the tentacle.

There are usually three to five embryos with distinct shells in the uterus, one or two being further advanced than the others. About eighteen undeveloped eggs are also present as a rule. The embryonic shells are not banded.

Taia theobaldi (Kobelt).

1918. *Taia theobaldi*, Annandale, *op. cit.*, p. 126, pl. xv, fig. 18; pl. xvi, fig. 1; pl. xviii, figs. 15–17.

The spire of the shell is shorter than in any from of *T naticoides* and the body-whorl is usually more swollen, but the most distinctive feature is in the callus, which in young shells is often ridge-like and even when

fully developed has a sharp outer edge, which leaves a chink leading to the umbilicus open.[1]

Taia elitoralis Annandale.

1918. *Taia elitoralis*, Annandale, *op. cit.*, p. 134, pl. xv, figs. 4, 5 ; pl. xvii, figs. 5, 6 ; pl. xviii, figs. 13, 14. *Taia intha*, pl. xv, fig. 3.

Much additional material of this species, which was scantily represented in the former collection, was obtained and it becomes evident that the distinction between it and *T intha* was not quite correctly set forth. The shells from towards the edge of the lake referred to *T intha* really belong, as is proved by an anatomical examination, to *T elitoralis*. This fact, while it still further limits the apparent variability of *T intha*, which was always regarded as a peculiarly stable form, renders that of *T elitoralis* somewhat wider. The figures cited, however, should render the matter clear.

In anatomy *T. elitoralis* stands somewhat apart from the other two species from the Inlé Lake. It differs from *T shanensis* both in the structure of the stomach and in that of the respiratory system. The folds of the inner wall of the stomach are much less developed and there are no chitinous ridges, while the heart is better developed and the base of the gill-filaments relatively broader.

The large size of the heart may be correlated with the fact that the auricle is often filled with ova, apparently of an Echinostome trematode. No adult or larval parasites were found, probably because the time of year (March) at which the specimens were examined was unfavourable.

The number of embryos present in the uterus with shells is sometimes larger than in *T shanensis*, but in specimens dissected at the Inlé Lake it was found that there were as a rule three such embryos, of which two were larger than the third. There are also about eight undeveloped spherical eggs, which are remarkable for their extraordinarily tough and fairly thick outer layer, which has a glistening surface. Inside this layer there is a mass of yolk with a cavity at one end in which the embryo is apparently developed. The eggs are attached to the wall of the uterus as in *Vivipara*.

Of 31 individuals examined at the lake 22 were males.

Taia intha Annandale.

1918. *Taia intha*, Annandale, *op. cit.*, p. 135, pl. xv, figs. 1, 2 ; pl. xvii, fig. 7 ; pl. xviii, figs. 10–12.

This is much the most constant species known to us as well as a species with the most highly developed shell-sculpture. Its anatomy resembles that of *T shanensis* but the following differences have been observed. The testis has as a rule a sharp bend at its posterior end.

[1] Examination of a few specimens of this species from the N. Shan States recently sent by the Director of Public Health, Burma, has enabled me to add a short note on the anatomy. The mantle-edge has a wavy margin in some but has no definite processes. The stomach is relatively small in size and has a few raised folds on the internal wall. The gill-filaments resemble those of *T. raticoides* f. *intermedia* but are shorter and broader with their extremities rounded. Of seven specimens examined only two were females of which one was immature. The uterus was large and contained three embryos of which the anterior was the largest, and eight much compressed eggs. The embryos were faintly banded. Several very minute spiral ridges were present on the shell, the central ones being more prominent on the last whorl. (H. S. R.)

The structure of the rectum appears to be peculiar. The inner wall is provided with transverse folds and a median ventral double ridge running longitudinally.

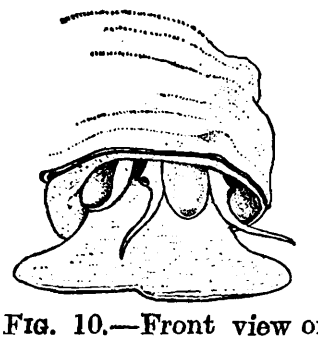

Fig. 10.—Front view of living animal of *Taia intha.*

The gill-filament is broad at the base but tapers to a fine and almost thread-like extremity.

The colour of the exposed parts of the living animal is pale olivaceous with yellow specks which appear to be universal in the family.

The fertility of the species is much reduced. There is often only a single very large embryo in the uterus; this occurred in six females examined consecutively at the Inlé Lake. A second and even a third smaller embryo is sometimes present. Undeveloped eggs are often absent and the single embryo present is often so large that it fills practically the whole cavity. It is thus not improbable that other ova are suppressed by its growth. The embryonic shell is banded.

Taia crassicallosa, sp. nov.

This species stands in much the same relation to *Taia naticoides* (Theobald) as *Taia intermedia* Annandale (here recognized as a form of *T. naticoides*), so far at any rate as the external features of the shell are concerned; but differs from both in the relatively short, broad spire, which never exceeds the height of the last whorl, and especially in the extremely broad, very prominent and greatly thickened columellar callus. The last is smooth and polished, but less so than in *T naticoides.* The base of the aperture is slightly more oblique than that of *T naticoides* f. *intermedia.*

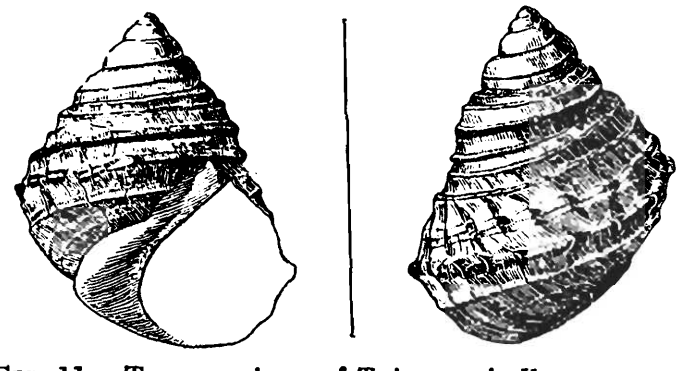

Fig. 11.—Type-specimen of *Taia crassicallosa*, sp. nov. from S. Shan States.

Some of the smaller shells of the species seem to approach *T obesa* Annandale in general form, but the great breadth and thickness of the columellar callus and its smooth and polished surface are sufficient to separate the species.

Fig. 12.—Operculum of *Taia crassicallosa.*

The degree of variability in the sculpture and ornamentation of the shell is much the same as in *T naticoides* f. *intermedia*, but the tendency to form tubercular ridges on the whorls is less marked. Squamous projections are rarely formed in a regular series on the last whorl.

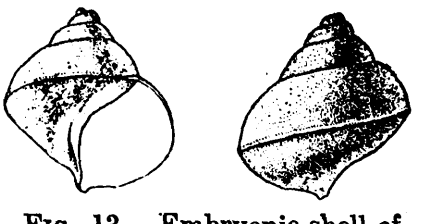

Fig. 13.—Embryonic shell of *Taia crassicallosa.*

Measurements of type-specimen in millimeters.

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
31·5	20·0	26·0	13·0

In actual bulk this species is the largest of all living species of *Taia*.

Anatomically the species is well differentiated : it seems to be intermediate in some features between *T. naticoides* f. *intermedia* and *T. elitoralis*. The gastric cavity is, however, devoid of folds and chitinous ridges. The gill-lamella is relatively long but narrow at the base, and is intermediate in form between those of the two species mentioned. The kidney is, curiously, different in the two sexes, at any rate in the specimens examined. In the male it is triangular with an elliptical renal aperture at its posterior end, whereas in the female it is oval with the renal aperture in the middle of the ventral surface. With only a few specimens before us, however, we are unable to judge whether this difference is merely an individual variation or due to sex. The uterus is transversely folded in such a way that its external surface has the appearance of a series of lamellae. The roof alone is involved in this folding process, while the floor has a thick, wavy longitudinal fold. There are only two full grown embryos (without bands on the shell) and six eggs with undeveloped embryos in them.

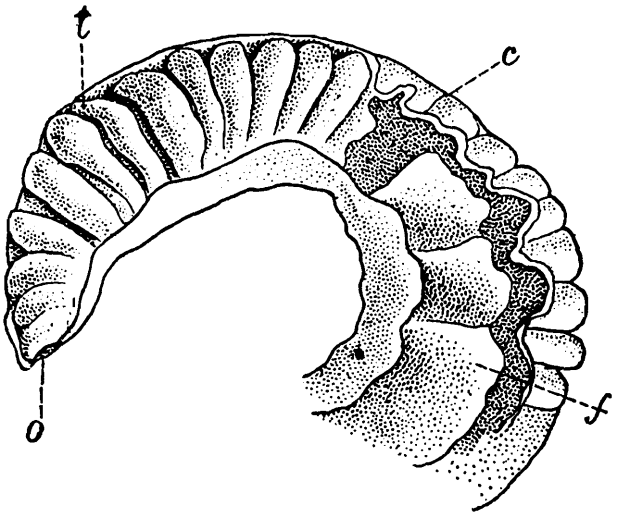

FIG. 14.—Uterus of *Taia crassicallosa* with its posterior half cut open.

o. external opening of uterus ; *t*. transverse folds of the dorsal wall of uterus ; *c*. cavity of uterus ; *f*. longitudinal fold in the floor of the uterine cavity.

Anatomically the characteristic feature of this species is the peculiar structure of the uterus.

Type-specimen.—M. $\frac{12462}{2}$ Zool. Surv. Ind. (*Ind. Mus.*)

Living and dead shells were taken by us on the edge of the Yawnghwe river near Tai-O, Yawnghwe State, S. Shan States in March, 1922. Well-preserved specimens of the species were also brought back by Dr. S. L. Hora who visited the stream in April of the same year.

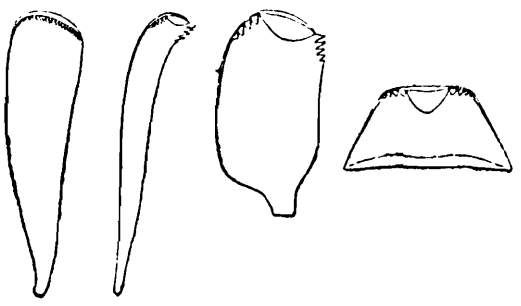

FIG. 15.—Radular teeth of *Taia crassicallosa*.

Several of the dead shells were covered by a thick calcareous deposit[1] which completely obscured their form and sculpture. Some

[1] We have to thank Mr. K. C. Biswas for examining the deposit. *Cf.*—Paul Ehrmann " Land-und Susswasserschnecken aus den Südl Schan-Staaten " in *Sitzungsber. Naturf. Ges.* IX, pp. 24–25, pl. i, fig. 9 (Leipzig, 1922).

of the bivalves obtained in the same locality had a similar deposit on them, which, however, is due to a deposit of diatoms.

Taia obesa Annandale.

1918. *Taia obesa,* Annandale, *op. cit.,* p. 128, pl. xv, fig. 19; pl. xvi, fig. 2.

Two fully grown shells, larger than the type-specimen, and several young shells were obtained in the Hsin-Dawng caves. Of the former, one is broken at the lip and has its spire relatively long, its total height being 46·2 mm. The other is complete and relatively broad. It has the following measurements in millimeters :—

Height of shell.	Height of aperture.	Greatest breadth of shell.	Greatest breadth of aperture.
41·5	22·5	34·0	17·0

The tubercles on the spiral ridges of the shells are relatively feebly developed, especially in young individuals.

Taia cylindrica Annandale.

1918. *Taia cylindrica,* Annandale, *op. cit.,* p. 130, pl. xv, fig. 9, pl. xvii, fig. 2.

A large number of shells, some of them broader and higher than the type-specimen, was collected in the Hsin-Dawng caves on a mud slope leading from a hole in the roof of one of the caves to the interior, but many of them are incomplete. In one of the shells we found an exceptionally large embryo, but, unfortunately, in a bad condition.

Taia conica Annandale.

1918. *Taia conica,* Annandale, *op. cit.,* p. 133, pl. xv, fig. 8; pl. xvii, fig. 8.

This is much the most abundant of the fossil species found in the Hsin-Dawng valley. Our recent collection includes several shells smaller than any in the type-series.

Family AMPULLARIDAE.

Genus **Pachylabra** Swainson.

1920. *Pachylabra,* Annandale, *Journ. Nat. Hist. Soc. Siam,* p. 4, pls. i and ii.

Pachylabra conica var. **compacta** (Reeve)

1918. *Ampullaria winkleyi,* Annandale, *op. cit.,* p. 138, pl. xii, fig. 10.
1921. *Pachylabra conica* var. *contracta,* Annandale, *Journ. Fed. Malay St. Mus.,* X, p. 193.

We have consulted Dr. Baini Prashad, who has recently examined the type-specimens of *Pachylabra* in various European museums, as to our specimen. He is convinced of the identity of all from the Southern

Shan States [1] and regards them as falling within the limits of the form *compacta*. As a result of Dr. Prashad's investigations considerable changes become necessary in the nomenclature of the Indian species of the genus.[2]

The variety is widely distributed in Burma and occurs also in the Malay Peninsula. We obtained specimens at Loi-an near Kalaw as well as in the Inlé valley.

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[1] I take this opportunity to invite attention to an unfortunate printer's error in my paper on Malay apple-snails. A whole paragraph has been omitted after the first paragraph on p. 195, *Journ. Fed. Malay St. Mus.*, X, including the name *Pachylabra conica* var. *compacta* in black type. The second and third paragraphs, as they stand, refer not to *P. stoliczkana*, but to this form. There are several other misprints in the paper, of which I did not see a proof, but I think the others explain themselves. (*N. A.*)

[2] Prashad, *Journ. Asiat. Soc. Bengal* (N. S.), XVIII, pp. 585–591 (1923).