

MATERIALS FOR A REVISION OF THE RECENT INDIAN LIMNAEIDAE (MOLLUSCA PULMONATA).

*By the late N. ANNANDALE, D.Sc., C.I.E., and H. SRINIVASA RAO,
M.A., Assistant Superintendent, Zoological Survey of India.*

INTRODUCTION.

Our object in writing this paper is to provide a means of identifying the species of *Limnaea* found in the Indian Empire. In preparing it we have had two great advantages. We have had before us by far the largest collection of shells and spirit material of the family ever accumulated from any oriental country, and we have been able to collect specimens and note the peculiarities of their habitat at many places scattered over a very wide area, from the Persian frontier in the west to the Southern Shan States in the east and from the Afghan frontier in the north to the Nilgiri Hills in the south. We have also been able to examine the specimens named by Nevill and other conchologists who have worked in Calcutta.

Limnaea is a very difficult genus to set in order because of the great variation exhibited by many species. This variation is of more than one type. Apart from differences due to age, we may, indeed, note three types:—(1) individual variability, (2) plasticity and (3) racial or local variation. Individual variability may be said to occur when individuals of the same species living together in the same environment differ *inter se* in colour, form or structure. This kind of variability is never completely absent, but it becomes conspicuous only when the individual differences are considerable. By plasticity we mean a physical response to environment on the part of the organism and ultimately in all probability of the race. Strictly speaking this response ought to appear in the lifetime of each individual, and be similar if not identical in all the individuals of any particular environment; but we have little or no experimental evidence so far as Indian species are concerned and we can only suspect that this occurs on the analogy of species observed elsewhere. Racial variation exists when all or most of the individuals of any given locality differ in small but constant characters from those of other localities. This phenomenon is not so common in *Limnaea* as it is in some genera and it is not always possible in the present state of our knowledge to distinguish it from plasticity. It may come about, however, theoretically from one of two causes, either by stabilization of plasticity owing to transmission of characters from one generation to another, in other words by a form of the inheritance of acquired characters¹; or by the appearance and perpetuation of mutations in isolated groups of individuals.

¹ The phrase "inheritance of acquired characters" is commonly applied to two quite distinct phenomena or supposed phenomena:—(1) to the transmission by descent of a sudden traumatic injury or mutilation, and (2) to the transmission of a modification gradually impressed upon an organism by environment from generation to generation. It is in the latter sense that we use the term.

Our position in this matter will be rendered clearer by the citation of actual examples of the three kinds of variation. Individual variability is often well illustrated by the common *L. acuminata* (vide *Rec. Ind. Mus.*, XXII, p. 569, fig. 12 (1921)). The figure cited reproduces the outlines of a group of shells from the same locality. The species is essentially variable in certain conditions and we have no real explanation of the differences between the different shells. As an example of plasticity *L. andersoniana* (pl. viii in the work cited above) provides excellent material. Alike in the Southern Shan States, in the valley of Manipur and probably in other localities, at least two forms of the species are found, one, with a narrow shell, living in running water, the other, with a comparatively broad shell, in still water. It is less easy to find a good case of racial variation in *Limnaea*, but we may refer to the form *siamensis* of *L. luteola*, known from widely separated parts of Burma and Siam, but not from any other country (p. 159, fig. IV, 5 and 6).

The existence of variation renders it necessary to examine large numbers of specimens from many localities. If this be done, another fact becomes evident, that plasticity and individual variability are not always correlated. In a given species we may find one and not the other, both, or neither, that is to say, present in a conspicuous degree.

As Annandale and Prashad have pointed out elsewhere¹ anatomical characters are, on the whole, even less satisfactory in differentiating the Indian species of *Limnaea* than shell-characters. The organs that have been found most useful in this respect are the genitalia, the radula and the jaws. We have examined the radulae of all but two of the species known from the Indian Empire and immediately adjacent districts and the jaws and genitalia of a large proportion. We find only three species, the Palearctic *L. stagnalis* and *L. auricularia* and the Burmese *L. laticalloso* in which precise diagnostic characters of a structural kind are to be found in the genitalia. In several others differences of a less definite kind, such as those in the length of the various ducts, occur, but on the whole the results of our examination of a large amount of material have been disappointing from a taxonomic point of view.

This has also been so with the radulae, the great majority of which, while exhibiting much individual variability and many abnormalities, are very much alike. In only a few species are exact differences to be found.

In a few species the jaws also give sound characters, but only in a few, and species with very different shells have sometimes very similar jaws.

We will, however, discuss the genitalia and the buccal and pharyngeal armature a little further before considering the shell.

JAWS AND RADULAE.

The structure of the jaws and radulae is, with a few exceptions, remarkably uniform in the Indian Limnaeidae, and in many species individual variability is sufficiently great to mask any specific characters that may occur. When this is not the case specific characters may be

¹ *Rec. Ind. Mus.* XXII, p. 567 (1921).

found both in the structure of the upper jaw-piece or "mandible", as it may be conveniently called, and also in the number and shape of the radular teeth. It is rarer to find definite characters in the lateral pieces of the jaw, but in at least one species (*L. laticallosa*) they occur.

Jaw.—The jaw consists, as in species from other countries, of three pieces, the mandible and two lateral appendages. The mandible is lunate, semi-circular or subquadrate in outline. Its free cutting edge may be straight, concave, convex, emarginate or sinuate. Occasionally it is produced in front into a beak-like prominence, but this appears to be an individual rather than a specific character. There is certainly no justification for regarding it as of generic significance, as was suggested by *Bowell*¹. The mandible is of solid structure and composed of horny substance.

The lateral appendages, which hang down one on each side of the mouth firmly attached to the buccal muscles, are band-like or thread-like structures composed of a large number of minute transverse rods, which are as a rule firmly welded together even at the free edge which borders the mouth. In the Burmese *L. laticallosa*, however, the texture is not so firm and the edge has often a fringed or fimbriated appearance owing to the projection of individual rods.

Radula.—The structure of the radula in the Indian species is, apparently, less liable to specific variation than it is among the Limnaeidae of North America², but agrees generally with that of most Palearctic species of which there is any record, except that the number of teeth in a transverse row seems to be generally smaller. This is so even in Indian individuals of species common to Europe and the northern part of India, of which several exist. In Indian Limnaeidae there are rarely as many as thirty teeth on each side of the central. The number of these teeth is a good specific character, but only within wide limits and in some species. The actual size of the teeth is not always correlated with that of the animal and sometimes forms a good diagnostic character.

The teeth exhibit less structural adaptation than might perhaps have been expected. Thus, those of *L. acuminata* and those of *L. luteola* are almost identical, in spite of a distinct difference in the habits of the two species, *L. acuminata* feeding largely on rotting vegetation, particularly on dead leaves of water-lilies, while *L. luteola* feeds almost exclusively on organic matter from mud at the bottom.

The central, in our experience, offers few specific characters, being particularly variable in shape. In all the forms we have examined the cusp consists of a relatively large, more or less triangular process bearing at its tip a minute tooth or spine. This process is never quite symmetrical but bilateral symmetry is approximately reached by some species in which the left side of the cusp is even, while the outline of the right side is sinuate or irregular. In others the irregularity on the right side takes the form of a secondary cusp. There is never any such cusp on the left side, which, however, may be very slightly irregular, indicating a primitive trilobed condition of the tooth. The tooth is always much smaller than any of the laterals, but its relative size is different in different species.

¹ In *Preston, Rec. Ind. Mus.* III, p. 116 (1909).

² *Baker, Chicago Acad. Sci.*, special publication No. 3 (1911).

In all the Indian species but one (*L. hookeri*) the first lateral is normally tricuspid, its free region consisting of a large mesocone in the centre with an entocone on the side nearest the central and an ectocone on the other side. The three cusps may be subequal, but the ectocone is usually much smaller, and the entocone often considerably smaller than the mesocone. The entocone may be reduced to a mere tubercle, but this is exceptional. The teeth immediately following the first lateral usually resemble it, but in one species (the Eurasian *L. stagnalis*) they are normally bicuspid, the entocone having disappeared. In *L. hookeri* the first six laterals are bicuspid, the entocone again being absent.

The radula and jaws of some species thus provide good specific characters, but among the Indian forms we find nothing in these structures that would provide a sound basis for generic or even subgeneric separation. There is, indeed, a very close general similarity, and while in some species there are quite definite and constant features in the details of the dentition, in others there is great individual variability in this respect. Species, moreover, which can be separated on well-defined shell-characters often resemble one another closely in the structure of the buccal and pharyngeal armature.

Among all the species we have examined, only seven stand out as having really characteristic structural features in the radula. They are *L. stagnalis* and *L. brevicauda* from the Kashmir valley, *L. hookeri* and *L. bowelli* from Tibet, *L. lagotis* from the Eastern and other parts of the Himalayas, and *L. laticallosa* and *L. mimetica* from the Shan Plateau. All the others, whether from the Palearctic parts of the Indian Empire, from India proper or from Burma, exhibit a close resemblance *inter se*, and specific differences, as a rule, appear not much greater than individual variability. The only species in which we have found definite structural differences in the radula of individuals from different localities is *L. andersoniana*.

There is considerable individual variability in the number of teeth present in each transverse row and also in the proportionate numbers of laterals and marginals. In the latter character, moreover, it is often difficult to fix a limit between the two series, as the teeth of one change gradually into the type characteristic of the other. There is, nevertheless, a definite specific difference in some cases in both respects, provided that latitude is allowed for variability. *L. mimetica* and *L. horae*, for example, have only about 17 laterals and marginals, while *L. stagnalis* has 28. In *L. laticallosa* there are only about 4 marginals and 23 laterals, while in most species the number of marginals is much greater than that of laterals.

Abnormalities in the outline of the teeth are common. Sometimes they occur in single teeth and sometimes in whole longitudinal series. Laterals not infrequently lack the entocone even in species in which it is normally present, but, though this peculiarity may occur in a whole longitudinal row, it is never, so far as we have seen, perpetuated in whole transverse series. The mesocone may be denticulated or even divided into two or more cusps, but this is not so common. The shape of the central is always somewhat variable, while the marginals exhibit much less regularity and uniformity than do the laterals and are not infrequently monstrous in outline.

GENITALIA.

The genitalia, as in species from other countries, consist of three portions (1) the hermaphrodite gland and its duct, (2) the male organs, including the prostate gland and the penis with their ducts and muscles and (3) the female organs consisting of the albumen glands, the oviduct, and the spermatheca. The hermaphrodite gland and its duct lie embedded in the coils of the liver, while the male and female organs lie on the right side of the pallial cavity between the oesophagus and the rectum. The female organs are superimposed on the male and are conspicuous on opening the pallial cavity. The proximal half of the genitalia, consisting of the hermaphrodite gland, the albumen glands, and the oviduct, is uniform in all the species, whereas the distal half, consisting of the uterus, the spermatheca, the prostate gland, and the penis, is subject to some variation.

The spermatheca is usually an oblong, oval or spherical sac with orange-coloured contents. Its duct commences abruptly as a narrow tube from the lower extremity of the sac and opens into the uterus close to the external opening of the latter. In *L. laticallosa*, however, the commencement of the duct has a characteristic dilatation, absent in other Indian species. The duct usually lies ventrad of the uterus and is nearly as long as the latter except in a few forms.

The prostate gland is a subcylindrical, ovoid, heart-shaped or pyriform body lying just below and a little in front of the large accessory albumen gland. The vas deferens starts from near the distal extremity of the prostate and usually has its commencement dilated. In some Indian species the prostate is bulbous, and in rare instances bilobed. Its size and shape vary in individuals of the same species, apparently according to development. Much stress has been laid on this variation in the grouping of the American species of *Limnaea*, but so far as we can see without justification. So far as the Indian species at any rate are concerned no such grouping is possible. In *L. stagnalis*, *L. brevicauda*, and *L. persica*, which are confined to the north-western part of India, the prostate is a more or less bilobed structure. This character is, however, most marked in the first species, which is widely distributed in the Holarctic zone. In *L. auricularia* the outline of the gland is more ovate than in other species.

The penis is placed in front of the female opening close to the buccal mass on its right side. The vas deferens on leaving the prostate passes through the integument of the head until it reaches the male external opening where it pierces the integument and runs close to the penis. The penis-sac may be divided into a proximal narrow tubular portion, and a distal large cylindrical muscular one. The former, except in *L. stagnalis*, is nearly always as long as or slightly shorter than the latter. It encloses a narrow flagellum-like structure, thin and pointed at its free end, which may conveniently be termed the true penis. The term "epiphallus" has been applied to this structure by some authors, who regard both the proximal and distal portions as the penis proper. In *L. stagnalis* the penis is much shorter than the distal portion and has its free extremity dilated into a glans-like swelling. As in the case of the prostate gland, great importance has been attached to the variations

occurring in the American species in the relative lengths of the penis and the distal portion of the sac. The Indian species, however, do not show constant variations in this respect except between *L. stagnalis* and other species.

The penis and the penis-sac are supplied with retractor and protractor muscles. In all the species discussed here there is a single narrow retractor muscle connected with the commencement of the proximal portion. This is the retractor of the penis. A stout muscle, frequently divided into two or three bundles, is attached to the beginning of the distal muscular portion, and is the retractor of the sac. There are usually four protractor muscles attached to the sides of the distal portion of the sac. They are also divided into bundles, a branch of which may connect them with the retractor of the sac. There is, however, considerable individual variability in the number and arrangement of the muscles.

In view of all these facts we do not find ourselves able to make much use of the genitalia in separating the different Indian species even into groups, much less specifically. *L. stagnalis* stands apart from the others in respect of these organs and minor differences can be noted between a few other species, but in most any specific differences that may exist at one period or another are completely masked, not only by individual variability, but also by differences in structure due to the sexual condition of the individual examined.

Attention has been drawn to the fact that certain species on the north-west frontier of India are functionally protandrous and pair when the male organs are fully developed¹, storing up the spermatozoa for a period until the female organs become ripe. In the course of our investigation of numerous collections from all parts of the Indian Empire we have found much indirect evidence that this condition prevails in most if not in all species. It is rare, for example, to find both the prostate and the spermatheca fully developed in the same individual. Further, we have observed that egg-masses are usually scarce in bodies of water in which the snails are copulating in large numbers, and that, conversely, when egg-masses are abundant pairing does not seem to be at all common. These facts have an important bearing on the taxonomy of the genus, for many of the so-called specific and even generic characters of the genitalia are undoubtedly due to this cause.

THE SHELL.

Although there is in the genus *Limnaea* a certain common facies of the shell hard to define in words, there is also great diversity of outline. The common facies is perhaps best defined mainly by negatives. The shell is never thick and rarely quite opaque; external sculpture of a pronounced kind is rare and never consists of tubercles or spines. The colouration is never conspicuous and rarely diversified; if stripes are present they are never, at any rate in normal shells, spiral and are as a rule produced by differences in translucency rather than colour. Normal shells are always dextral; sinistral abnormalities have been observed, but not among Indian species. The spire varies greatly in proportionate

¹ Annandale and Prashad, *Rec. Ind. Mus.* XVIII, p. 22 (1919).

length but is always more or less tapering and always in, or practically, in the same straight line as the main axis of the shell. The body-whorl may be narrow or almost spherical, but the columella is never transverse to the main axis.

Among the Indian species almost every form of shell found in the genus occurs. *L. acuminata* f. *gracilior*, for example, approaches the extreme of elongation, while *L. brevicauda* is not far from that of rotundity.

The question that naturally arises first in considering the form of the shell, in view of the great variation often displayed within the limits of a single species, is, How far is form of shell correlated with environment? To this question we are not in a position to give a definite answer. Smallness of spire and inflation of the body-whorl are often correlated with a true lacustrine habitat; but the only definite Indian example we can cite is *L. brevicauda* from the lakes of Kashmir. The very narrow, and also very small and fragile *L. mimetica* from the Inlé lake in the Southern Shan States is perhaps a still more typically lacustrine form. It resembles the deep-water *Limnaeae* of the Swiss lakes, but occurs in shallow water, and no deep-water form has been obtained in any Oriental lake. In *L. acuminata* narrow and comparatively broad individuals, apparently of identical habits, occur in the same pond. The only character that the shells of *L. mimetica* and *L. brevicauda* have in common is the reduction of the spire. This feature they share, perhaps by a mere coincidence, with a single individual of *L. acuminata* from the Loktak Lake in Manipur, in which individuals from open water have a slightly more inflated body-whorl than those from the edge of the lake.¹

Where food is scanty, as in pools devoid of aquatic vegetation, the animal, and therefore the shell which covers it, is always small, and the few forms that can live in running water have rather or even very thin shells. Most shells from high altitudes are small, but those of *L. stagnalis* from Kashmir, where they occur at 6,000 feet, are the largest of any Indian *Limnaea*.

Beyond this we cannot go much further. There does seem to be a precise correlation between environment and shell-characters in certain species, for example in *L. andersoniana*, in which we can recognize at least three phases, a broad phase (the *forma typica*) in still water with much vegetation, a narrower phase in running water without vegetation, and a still narrower phase in rapid-running hill-torrents. Indeed, there is even a phase intermediate between the first two living in ponds into which streams run at certain times of the year. But against this we must set off the facts, already mentioned, that the completely lacustrine *L. mimetica*, from a district in which at least the first two phases of *L. andersoniana* are common, is narrow, and that all forms, from the extremely narrow to almost the broadest, of *L. acuminata* can sometimes be found in the same pond. It is not possible at present to formulate any rule, and until it has been feasible to make a complete chemical and physical examination of the environment in which every species and every form

¹ *Rec. Ind. Mus.*, XXII, p. 570 (1921).

of each species normally occurs, our views on shell-variation must be largely speculative. Two things only are clear, that the shell is much more variable in some species than in others and that in some species the variation can be associated with differences in environment, while in others it cannot.

The shell-characters of the living Indian species afford no grounds for recognizing more than one genus among them. Among the fossil forms, those to which the name *Acella* Haldeman has been applied seem at first sight very distinct, with their extremely narrow, elongate shell; but the shell of *L. acuminata* f. *gracilior* provides a transition from the normal type, and among the species described from the Intertrappean beds of the Central Provinces intermediate forms occur, for example *L. subulata*.

Among the living Indian species practically the full range of size that exists in the genus is to be found, from *L. stagnalis*, the shell of which may be over 30 mm. long, to *L. mimetica*, in which it does not exceed 7 mm.

CLASSIFICATION OF THE INDIAN LIMNAEIDAE.

The living Indian Limnaeidae can be separated on both conchological and anatomical characters into four groups, all of which have been described from other parts of the world and regarded by different authorities as having sub-generic or even generic rank. The type-species of all but one are included in the Indian fauna. The characters on which the groups are based are, however, so small and so liable to both individual and specific variation that we do not consider it justifiable to regard the groups even as subgenera. It seems simpler to accept the divisions merely as groups in a single genus *Limnaea* and use the "sub-generic" names that have been applied to them merely as a convenient method of recognizing their relationships. These four groups may be defined as follows:—

I. *Limnaea* s. s.

Shell large, with the spire long and tapering and the body-whorl more or less inflated. *Radula* with most of the laterals bicuspid. *Male intromittent organ* with the proximal part (epiphallus) stout and much shorter than the distal part (penis); prostate bulbous or bilobed.

Type-species : *L. stagnalis* (Linn.).

II. *Radix* Montfort.

Shell of variable size, rarely very small, with the spire acuminate, never very long, often very short and the body-whorl inflated and usually expanded, with the outer lip more or less broadly flattened. *Radula* with the laterals tricuspid. *Male intromittent organ* with the proximal part slender and at least nearly as long as the distal part; prostate sub-cylindrical or pyriform.

Type-species : *L. auricularia* (Linn.).

III. *Galba* Schrank.

Shell never large, comparatively narrow, with the spire long or moderate; the body-whorl never expanded or inflated and the lip not flattened; the columellar fold always exceptionally broad and coarse. *Radula* with the laterals tricuspid, the mesocone being exceptionally long as compared with the base of the tooth, the entocone sometimes reduced. *Genitalia* as in *Radix*.

Type-species : *L. truncatula* (Müll.).

IV. *Pseudosuccinea* Baker.

Shell of variable size, never very large, with its spire extremely variable in length but never scalariform, though always gyrate; body-whorl never greatly expanded. Columellar fold forming a fine lamella, as a rule in close contact with the shell. *Radula* with laterals tricuspid and the mesocone comparatively short. *Genitalia* as in *Radix*.

Type-species : *L. columella* Say (American).

If we include the fossil species found in India, we must recognize another division, perhaps more distinct than any of the four discussed, perhaps worthy indeed of true subgeneric rank. This is *Acella* Halde- man, originally instituted for a living American species but also including, to judge of course by shell-characters alone, a number of forms from the Eocene of Europe and several from the Intertrappean beds (late Cretaceous) of the Central Provinces of India. In *Acella* the shell is extremely narrow and the suture very oblique, so that the whole shell assumes a constricted sub-cylindrical form with the body-whorl much contracted.

Before discussing the species *seriatim* we may say a word about our descriptions. Mere concise technical diagnoses of the shell seem to us of little value in a genus like *Limnaea*, in which only the salient specific characters call for notice. Too great attention to consistency, indeed, tends to obscure rather than elucidate, and we have striven both in our keys and in our descriptions to describe the characters that appeal to us as distinctive rather than to insist on a mathematical precision in the definition of outlines and shapes that are not only variable but also involve the recognition of complex and elusive curves. In one species specific distinction may depend on the structure of the columella, in another on the form of the spire and in yet another on radular characters. It is very rare to find sound diagnostic characters in so many different features, much commoner to be able to select only some one small structural point as the ultimate difference, apart from a peculiarity of facies better shown in a good figure than in any description. In short, it is often more scientific to rely on good figures than on descriptions in words.

We must express our great indebtedness to the artists of the Zoological Survey of India, who have so ably reproduced the salient features of the shells under our supervision.

Family LIMNAEIDAE.

The family consists of aquatic Pulmonata of the sub-order Basommatophora. It is distinguished from the other families of the sub-order

by the following combination of characters. The shell is thin, normally dextral, spiral, more or less ovate, always less than 50 mm. and almost always more than 5 mm. long. The tentacles are flattened and triangular and the eyes, which are completely sessile, are situated externally at their base. The pulmonary chamber is ample and there is no accessory breathing apparatus or pseudobranch. The blood is colourless. The jaw consists of a stout mandible with an accessory ribbon-shaped appendage hanging down on either side of the mouth. The central tooth of the radula is small and, though often obscurely trilobed, unicuspid. The lateral teeth are tricuspid or bicuspid and the marginals pectinate, without a lateral process. The region of the stomach is divisible into three portions, the anterior oval crop, the middle stomach proper enclosed by the highly muscular bilobed gizzard, and the posterior tapering pylorus from which the intestine commences. There are no pyloric appendages. The kidney is broad and forms the roof of a greater portion of the pulmonary chamber. The male intromittent organ is long and devoid of a flagellum.

Genus **Limnaea** Lamarck.

1911. Sub-family Lymnaeinae, Baker, *Chicago Acad. Sci.*, sp. publ. III, p. 125.

We do not propose to enter into the controversy as to the correct spelling of the name of the genus, whether *Lymnaeus*, *Lymnaea*, *Limnaeus*, *Limnaea* or any other variant.. We merely adopt the best-known form. A full synonymy is given by Baker (*op. cit.*) in his exhaustive account of the North American species. Although we differ from this author not only as to the spelling of the name but also as to the value to be attached to anatomical and other characters, we must express our great indebtedness to his important monograph.

The great majority of the members of the family Limnaeidae fall, in our opinion, into this one genus. The only species, indeed, that we have had an opportunity of examining which we are prepared to separate generically is the Japanese *Omia japonica* (Preston).¹ It differs from *Limnaea* in its neritiform shell, with its almost transverse columella and oblique spire, but has a similar radula and jaw. Unfortunately the anatomy is unknown.

Limnaea (s.s.).

1911. *Lymnaea*, Baker, *Chicago Acad. Sci.*, sp. publ. III, p. 134.

Baker gives an excellent synonymy, which we need not duplicate. No student of the Limnaeidae can afford to be without his book.

Only one Indian species can be assigned to this group. It is *L. stagnalis*, the type-species of the genus, a Palearctic form found in the upper waters of the Indus and in Chitral.

¹ See Annandale and Prasad, *Journ. As. Soc., Bengal* (n. s.) XIV, pp. 460, 461, fig. 2, pl. xii, figs. 4, 4a, 5 (1918).

***Limnaea stagnalis* (Linn.).**

1758. *Helix stagnalis*, Linnaeus, *Syst. Nat.* (Ed. X), I, p. 774.
 1835. *Limnaeus stagnalis*, Rossmässler, *Icon. Land und Süßsw. Moll.* I, p. 95, pl. ii, fig. 49.
 1867. *Limnaeus stagnalis*, Shrenck, *Kais. Akad. Wiss. St. Petersbourg*, II, p. 643.
 1871. *Limnaea stagnalis*, Kobelt, *Malakozool. Blatt.* XVIII, pp. 108-119, pls. ii, iii.
 1877. *Limnaea stagnalis*, Kobelt, *Rossmässler's Icon.* V, pp. 35-37, figs. 1230-1233.
 1884. *Limnaea stagnalis*, Kobelt, *id. (n. f.)*, I, pp. 57, 58, figs. 168-176.
 1911. *Limnaea stagnalis*, Baker, *Chicago Acad. Sci.* (Sp. Publ.), pp. 136-140, pl. xix, figs. 1-3, 4-10; pl. xx, figs. 1-6; pl. xxii, figs. 1-3.
 1915. *Limnaea stagnalis*, Preston, *Faun. Brit. Ind. Freshw.-Moll.*, p. 106.

The literature on this common European and American species is very extensive and we have given only a few of the more important references; a detailed list of its synonymy will be found in Baker's monograph cited above. There has never been any dispute as to the identity of this species, but it has been the cause of a great deal of discussion owing to the very different interpretations which various authors have placed on the limitation of its varieties and forms. Bourguignat¹ described all the different forms and phases as distinct species, and was to some extent followed by Collins² in Belgium as well as by other French malacologists. Kobelt, who undoubtedly had very extensive materials for his studies of the species, tried to reduce to order the confused state of affairs, but did not publish any really critical and exhaustive memoir with a full synonymy. We will content ourselves here with notes on the Indian forms of the species.

We are greatly indebted to Dr. B. Prashad, who has had the opportunity of comparing Indian material with the specimens in a number of European museums, for the following notes:—

“Of the earlier authors Cuvier and Valenciennes³ record the occurrence of *Limnaea stagnalis* in Kashmir from collections made in that area by Jacquemont. Woodward⁴ also recorded a find of the species from the same area without any further details. Von Martens refers to the occurrence of one or other of the forms of *L. stagnalis* in various parts of Central Asia, and in two of his papers⁵ has given useful tables showing the distribution of *L. stagnalis* and other land and freshwater molluscs in these countries. Theobald⁶ also includes *L. stagnalis* in his list of the Kashmir mollusca, and is followed by Godwin-Austen.⁷

“Besides the older collections in the Indian Museum there are large numbers of fresh shells collected by the Zoological Survey party in various parts of Kashmir during the summer of 1921. Various other smaller collections made in the same area and sent to the Indian Museum from time to time are also before me. In this large series of shells I am able to distinguish two distinct forms:—(1) a race described under the new name *kashmiriensis*, and (2) a depauperated form of this new race for

¹ Bourguignat, *Les Spicileges Malacologiques*, pp. 93-103 (Paris, 1862).

² Collins, *Ann. Soc. Malacol. Belgique* VII, pp. 81-94, pl. iv (1872).

³ Cuvier et Valenciennes, *Hist. Nat. des Poissons* XV, p. x (1840).

⁴ Woodward, *Proc. Zool. Soc. London*, pp. 186, 187 (1856), and *Ann. Mag. Nat. Hist.* 2) XIX, pp. 409, 410 (1857).

⁵ Von Martens, *Mem. L'Acad. Imp. Sci. St. Petersbourg* (VII), XXX, pp. 1-66, 5 pls. (1882); Mollusca of Russian Turkestan in *Wiss. Anhang zu Russisch-Central-Asien* von Henry Lansdell, pp. 41-47 (Leipzig, 1885).

⁶ Theobald, *Journ. As. Soc. Bengal*, XLVII, pt. 2, pp. 141-149 (1878).

⁷ Godwin-Austen, *Proc. Mal. Soc. London*, III, pp. 261, 262 (1899).

which I have selected the name *minor* Kobelt, as I am unable to distinguish it by any characters from the European form described under this name.

race **kashmiriensis** Prashad, nov.

“ This race, which I have, after great hesitation, described as new, is closely allied to Kobelt’s var. *palustriformis*¹ from the Euphrates. The variety was found by the Zoological Survey party to be widely distributed in the lakes of Kashmir, for example in the Dal Lake, Wular Lake, Anchar Lake and other smaller lakes ; shells were also found in the streams flowing out of the lakes, but these are not true inhabitants of the streams, being only carried into them with the current. I may also include here a note as to the lake areas. They are fairly large expanses of water sometimes extending over a couple of miles or more ; with the water in most of them not very deep, usually 5-6 feet, somewhat clear but in most cases muddy and foul ; very rich in aquatic plants and the bottom consisting of decayed vegetable debris. Except where the stream is flowing out there is no current in these lakes. The Limnaeas were all found along or near the banks, and the form here described is, from its characters, to be classified as one of Kobelt’s ‘ Sump-formen.’ These forms have a thin, fragile shell, with a wide mouth and the body-whorl in practically all of them is shouldered or ridged.

“ The shell is very large, rather thin and fragile for the size of the species ; of a brownish horny colour and in most of the specimens coated with an algal growth. The surface of the shell is regularly decussated, and has a regular sculpture consisting of fine ridges ; on the penultimate and the body-whorl these longitudinal ridges become rather prominent. The apex is acuminate and somewhat acute ; the spire prominent and occupying two-fifths of the total length in the dorsal view. The suture is deeply impressed and distinctly oblique. There are 6-6½ whorls ; of these the first four are not greatly swollen and increase regularly in size ; the penultimate whorl, however, suddenly grows larger and is moderately swollen. The body-whorl is large, and in dorsal view somewhat ovoidal in outline ; its inner outline is somewhat sinuate below near the anterior angle, but owing to the stumpy appearance of the shell the curving is not quite regular. The outline of the outer lip differs in examples from various areas ; it is either regularly curved with only a trace of a shoulder near the posterior margin, or owing to the presence of a distinct shoulder it becomes distinctly angulate. The mouth is large, but not greatly expanded, over one and a half times as long as broad, somewhat elongate, either ovoidal in shape, or in shells with a marked shoulder it has a straight anterior base and becomes quadrangular. The outer lip is sharp, neither expanded nor retroverted. The peristome is continuous ; the callus broad and thick, extending over the umbilicus, but free along a short distance anteriorly ; the columella shows a distinct and deep fold.

“ *Type-series*.—No. M $\frac{12506}{2}$ in the Zoological Survey of India (*Indian Museum*) from the Wular Lake, Kashmir.”

¹ Kobelt, *Malakozool. Blatt.* XVIII, p. 119, pl. iii, fig. 12 (1871), and *Rossmässler’s Icon.*, V, p. 35, fig. 1237 (1877).

Anatomy.—In general anatomy the Indian variety described above agrees with that of the European material with which we have compared it, and also with the published descriptions and figures (see Stiebel¹, and Baker, *loc. cit.*).

Indian and European specimens differ from all the American forms described by Baker in having the first lateral tooth of the radula constantly tricuspid.² Several teeth in each longitudinal row in the same series, including the second tooth, are, however, always tricuspid. In this respect the species differs from all others described from the Indian Empire except *L. hookeri*, in which the entocone or cusp nearest the centre of the radula is much reduced in the first lateral. In Indian specimens the radular formula is approximately 13.15.1.15.13.

The genitalia agree with published figures of both European and American forms, allowance being made for the fact that our material is preserved in strong alcohol, but individuals of the same batch differ considerably in the shape of the prostate. Our figure represents the genitalia of one in which the gland is very fully developed. The form of the male intromittent organ is different in the glans-like structure of the morphological apex from that of any other Indian species we have examined.

“*Relationship*.—In certain respects this race comes near *palustris formis*, Kobelt (*op. cit.*), but differs in the shell being much larger with a less compact shell-substance, the mouth less expanded, spire much longer and the suture more impressed; while in most of the shells the prominent shouldering of the body-whorl is an outstanding character. I have no doubt as to this race being different from the one referred to as *expansilabris* Hartmann by von Martens (*loc. cit.*, p. 32, pl. iv, fig. 2) from the valley of the Tarim. He also recorded this form later (*Sitzungsber. Ges. Naturfor. Freunde, Berlin*, p. 240, 1887) and Weber³ has recently recorded the same form from ‘*Dscharkentischen Kreis*’ in Central Asia.”

Geographical distribution of the species.—*L. stagnalis* (*s.l.*) is found all over southern and Central Europe and in many northern localities. In the British Isles the range does not extend north of the Lowlands of Scotland, into which some naturalists think it has been introduced artificially. It is, however, common in the small lochs round Edinburgh. The species also occurs in North Africa and in Northern and Central Asia, whence it has made its way down the upper waters of the Indus system into the Kashmir valley, in the lakes of which it is common. It has not been found elsewhere in the Indian Empire⁴ except at high altitudes in Chitral. Local races have been described from North America.

¹ Stiebel, *Limnei Stagnalis Anatomie*, pp. 1-52, pls. i, ii (Gottingen, 1815).

² Cooke's figure in the *Cambridge Natural History* (Vol. III, p. 235) shows the central as large as the laterals, but the tooth figured is probably the first lateral. It differs, however, from our preparations of both European and Indian radulae in having the entocone as large as, instead of considerably smaller than, the ectocone.

³ Weber, *Abh. Konig. Bayer. Akad. Wiss. (Math.-Phys. Klasse)* XXVI, p. 20 (1913).

⁴ Schlesch's record of the occurrence of *L. stagnalis* near Hoti Mardan published in the *Rec. Ind. Mus.* II, p. 108 (1908) needs confirmation. In spite of careful collecting in that area we have failed to find any specimens of this mollusc.

form **minor** Kobelt.

1871. *Limnaea stagnalis* var. *minor*, Kobelt, *Malakozool. Blatt.* XVIII, p. 115, pl. ii, fig. 5.
 1877. *Limnaea stagnalis* var. *minor*, Kobelt, *Rossmässler's Icon.* V, p. 35, fig. 1233.
 1882. *Limnaea stagnalis* var. *minor*, von Martens, *Mem. Acad. Imp. St. Petersbourg*, XXX, p. 33, pl. iv, fig. 1.

“Kobelt's description and figures of the form as also those given by von Martens are enough to recognize this form. I have also examined shells out of Kobelt's and von Marten's series. It is a depauperated or dwarfed form belonging to the category of Kobelt's 'Hungerformen'. In characterizing the surroundings in which such forms occur Kobelt states that the localities are not suited for the animals, usually have a poor food supply and are mostly temporary areas of water with a very low temperature. Kobelt's type-series was obtained from near Lyon, France, and he also had specimens from artificial ponds in the Rhone Valley. Von Martens's specimens were collected near Kashgar.

“The Kashmir specimens, which I assign to this form, are not genetically related to the type-series, but have apparently under similar biological conditions converged to the European and Central Asiatic forms. The Kashmir specimens are a dwarfed form of what has been described above as the race *kashmiriensis*, nov., but the race-characters, as in the case of *Vivipara bengalensis*¹, have become modified or disguised by the peculiar surroundings in which the animals were living.

“The Kashmir shells are usually of a brownish-horny colour, but some of the specimens, owing to a black incrustation on the surface, appear quite dark. The shell-substance is fairly compact, but not very thick. There are usually five whorls, but the apex in most cases is eroded. The spire is elongate, stumpy with the whorls somewhat swollen, the penultimate whorl being markedly so. The body-whorl, which is not very large, is elongate-rounded, somewhat pear-shaped in dorsal view and without any shoulder or keel. The mouth is ovoidal but in some specimens this is not so marked owing to the straight outer lip. The columellar callus is distinctly but deeply arched; its upper margin is straight and it is free in its posterior one-third from the shell. The shell is vertically striate, the striae becoming more marked and like ribs on the body-whorls.

“*Locality*.—Specimens were found in a fair sized 2-3 feet deep pool of water at Srinagar, Kashmir (alt. 5,200 feet). The pool was a temporary area of water full of aquatic weeds like *Potamogeton*, *Hydrilla*, *Nymphaea* and *Spirogyra*. The *Limnaeas* were very abundant in this pool and hundreds of dead shells were lying along the banks.”

Other specimens of this form were obtained by Mr. G. H. Tipper, Geological Survey of India, in Shandur Lake, Shandur pass between Chitral and Gilgit, at an elevation of 12,300 feet.

Radix Montfort.

1911. *Radix*, Baker, *op. cit.*, p. 178.
 1915. *Gulnaria*, Preston, *Faun. Brit. Ind. Freshw. Moll.*, p. 110.

This is another Palearctic group so far as India is concerned. The four species that occur in the Indian Empire are the type-species (*L. auri-*

¹ Annandale, *Rec. Ind. Mus.* XXII, p. 270 (1921).

cularia) and *L. lagotis*, another European species, with *L. persica* and *L. brevicauda*, which are allied respectively to *L. auricularia* and *L. lagotis*. *L. persica*, as its name implies, was originally described from Persia, but also occurs in North-Western India and (exceptionally) in the Deccan. The other three species are found in the Western Himalayas.

***Limnaea persica* Issel.**

1919. *Limnaea persica*, Annandale and Prashad, *Rec. Ind. Mus.*, XVIII, p. 41, pl. v, figs. 3-6.

This species has recently been described in detail, so far as the shell is concerned, in the paper cited. We have extracted the radula and examined the anatomy of specimens from Kumaon. The radular teeth are remarkable, so far as the laterals and inner marginals are concerned, for their great breadth. The first 14 teeth are tricuspid while the other laterals, when not abnormal, as is often the case, have a series of 4 to 6 relatively broad but sharply pointed transverse cusps with two small lateral projections on the outer margin. The marginals are narrow and elongate with only 2 or 3 cusps. The formula is approximately 24. 11. 1. 11. 24, but the differences between laterals and marginals appear so gradually that it is difficult to make a distinction, and it would perhaps be more correct to give the formula as 35.1.35.

The genitalia do not differ greatly from those of other Indian species except that the penis is slender and not quite equal in length to the distal part of the penis-sac. It has, however, no terminal swelling. The prostate in the specimen examined is kidney-shaped. The spermatheca has a fine duct equal in length to that of the uterus.

Geographical distribution.—The species was originally described from Kerman in Southern Persia. It has also been found in the Baluch desert near Nushki, on the North-West Frontier of India near Peshawar, in the Punjab Salt Range, in the Kumaon lakes and in the Kangra Valley in the Himalayas. We have examined several specimens from a large reservoir at Secunderabad near Hyderabad, Deccan. *L. persica*, therefore, appears to be the only Palearctic species of the genus that penetrates into Peninsular India.

The species is probably a lacustrine form. It has been found only in fairly large bodies of still water.

***Limnaea lagotis* (Schrank) Martens.**

1874. *Limnaea lagotis*, Martens in Fedtschenko's *Reise in Turkestan*, *Mollusca*, pl. ii, fig. 22.

1877. *Limnaea lagotis*, Kobelt in Rossmässler, *Icon. Land Süßwass. Moll.* V, p. 37, nos. 1240-41, pl. 128.

L. lagotis is an elusive species in literature, in which the greatest possible confusion reigns between it and *L. auricularia*. The main differences lie, so far as the shell is concerned, in the structure of the spire and of the columellar fold. In *L. auricularia* the suture is impressed and the whorls are fairly convex, but in *L. lagotis* these features are greatly exaggerated, so that the spire assumes a scalariform structure, as though it were disintegrating and about to unwind. In forms of this species in which the spire is very short it has the appearance of being

deeply sunk into the body-whorl and is surrounded by a regular furrow or canal at its base. The differences in the form of the columellar fold are discussed under *L. auricularia*. Otherwise the shells of *L. auricularia* and *L. lagotis* are very much alike. Both are characterised by the fact that, at any rate in the adult, the outer lip is greatly expanded and forms a wide uniform arc, as a rule, practically a semi-circle, with

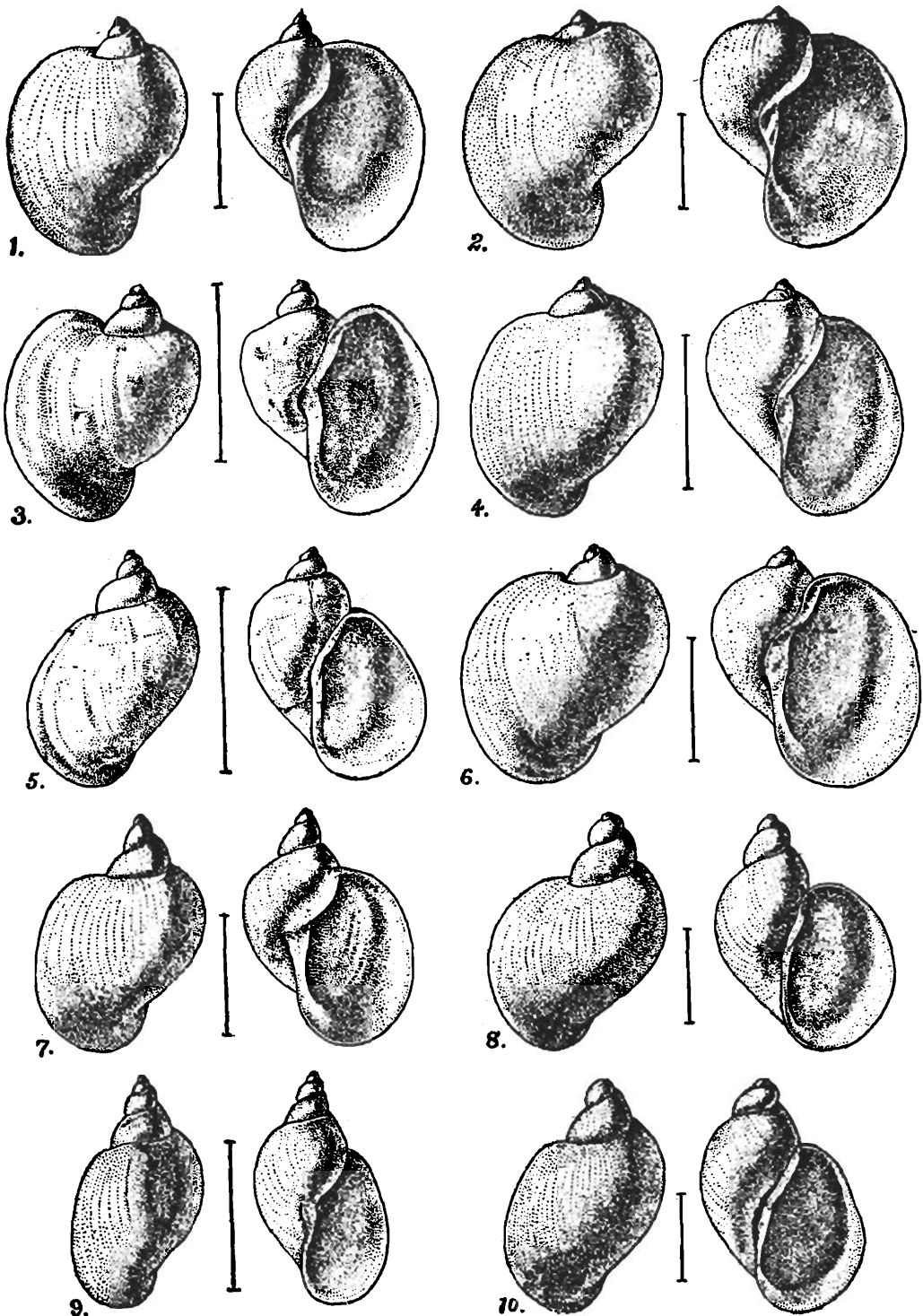


FIG. I.—Shells of Limnaeidae.

1. *L. lagotis* f. *striata* (Srinagar).
 2 & 4. *L. auricularia* (Kashmir).
 3 & 5. *L. lagotis* f. *solidissima* (Pankong).
 6. *L. brevicauda* (Kashmir).

7. *L. lagotis* f. *costulata* (Srinagar).
 8 & 10. *L. lagotis* f. *subdisjuncta* (Leh).
 9. *L. lagotis* f. *deflippii* (Kashmir).

the transverse axis at right angles to the main axis of the shell. The margin of the lip is rather broadly flattened. Apparently *L. lagotis*

never attains the same dimensions as those of large specimens of *L. auricularia*.

We have no information as to the radula or genitalia of the typical forms, which has not been found in India. No less than five forms occur in the Western Himalayas.

form **striata** Andreae.

1913. *Limnaea lagotis* var. *striata*, Weber, *Abh. K. Bayer Akad. Wiss (Math.-Phys. Kl.)* XXVI, pt. V, p. 24, pl. i, figs. 10a-h (except e and g).

This form, judged from the figures published by Kobelt and Martens, differs from the European *forma typica* in its more expanded mouth, which extends further up the shell. In specimens from Kashmir the shell is thin, and of a pale horny colour with fine longitudinal striae. There is considerable variation in the shape of the mouth, which is sometimes auriculate and sometimes semi-circular. The columellar fold is broad and well-developed. The largest specimen we have seen from Kashmir has the shell 23 mm. long and 17.5 mm. broad, the mouth being 19 mm. long and 11.5 mm. broad. Most shells are considerably smaller.

The radula has comparatively large teeth but the central is relatively small. This tooth has the main cusp remarkably long and narrow and separated by a very distinct notch from a lateral cusp on the right side. The laterals are tricuspid with all the cusps well-developed, the entocone and ectocone being subequal and the mesocone larger. Those near the centre of the band are broad in proportion to their length but gradually become narrower from within outwards. The inner marginals have five or more large transverse cusps the outermost of which is very large and broad, and also two well-developed lateral teeth on the outer margin. The formula is approximately 29.10.1.10.29.

The genitalia resemble those of *L. brevicauda*, but the duct of the spermatheca is relatively wide.

Geographical distribution.—This form is widely distributed in Kashgar and the neighbouring regions (*vide* Weber). We have examined a large series of specimens, some of which agree well with Weber's figures, from a swamp near Gandarbhal and in road-side ponds between Ichabal and Martand in Kashmir.

The form occurs in areas of still water full of aquatic vegetation.

form **costulata** Martens.

1874. *L. lagotis* var. *costulata*, Martens, *op. cit.*, p. 26, pl. ii, fig. 24.

1878. *L. lagotis* var. *costulata*, Nevill, in Hume's *Sec. Yarkand. Miss. Moll.*, p. 8.

This form differs from the preceding chiefly in its longer spire. The shape of the mouth of the shell is more constant and never so expanded as in some specimens of the form *striata*. The spire is somewhat variable and in some shells is relatively long, especially in dorsal view.

The radula apparently differs from that of the form *striata* in that the laterals are still larger and broader and that the teeth of the marginals are fewer and rather less well-developed.

Geographical distribution.—The form was described (in Russian) from Turkestan. We have examined a large series of specimens from

Leh in Ladak and from the Wurdwara valley (8,500 ft.) in Kashmir, also several recently obtained by Mr. G. H. Tipper of the Geological Survey of India in marshy ground near the village Harchin in Chitral at an elevation of about 9,000 feet. Some of the shells from the last named locality resemble var. *albipicta* of Martens in the work cited (pl. ii, fig. 23).

form **solidissima** Kobelt.

1872. *Limnaea lagotis* var. *solidissima*, Kobelt, *Malak. Blätt.*, XIX, p. 76, pl. ii, figs. 17, 18.

1877. *Limnaea lagotis* var. *solidissima*, *id.*, *op. cit.*, pl. 128, fig. 1242.

1878. *Limnaea lagotis* var. *solidissima*, Nevill, *op. cit.*, p. 7.

This appears to be an abnormal form with a very thick shell but otherwise of extreme variability. It probably lives in water of abnormal

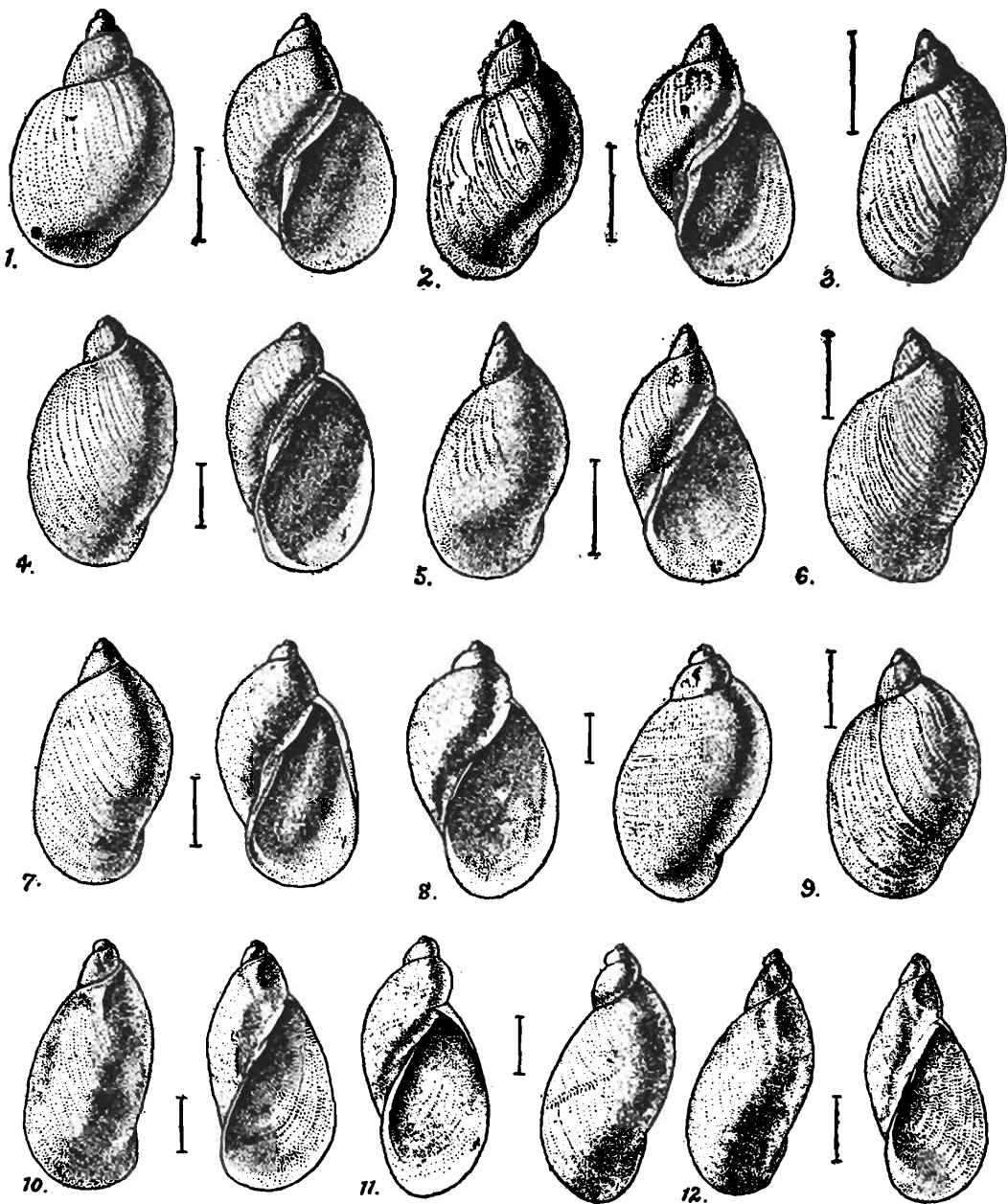


FIG. II.—Shells of Limnaeidae.

1, 2 & 3. *L. shanensis* (He-Ho gorge).

4, 6, 7 & 9. *L. shanensis* (He-Ho).

5. *L. shanensis* f. *superstes* (Inlé Lake).

11. *L. horae* (Assam).

8. *L. horae* f. *laticor* (Assam).

10 & 12. *L. mimetica* (Inlé Lake).

chemical composition. The shell is never very large but is often relatively broad and with a very short spire. The peristome is exceptionally

well-developed, but the columellar fold has never the peculiar shape or porcellaneous consistency of that of *L. obliquata* Martens, which is otherwise closely similar in shell characters. The largest specimen we have examined is 22 mm. long and 14.5 mm. broad, the mouth being 15 mm. long and 10 mm. broad.

We have no information as to the radula or the genitalia.

Geographical distribution.—The form was described from the Himalayas and we have examined a few small specimens from Kashmir as well as the large series from Lake Pankong on the Pamirs recorded by Nevill (*op. cit.*).

form **subdisjuncta** Nevill.

1878. *Limnaea lagotis* var. *subdisjuncta*, Nevill, *op. cit.*, p. 9.

This is a small form with a relatively narrow shell and a rather elongate spire of which the scalariform structure is peculiarly well marked. The base of the spire is considerably narrower than the upper margin of the body-whorl. The shape of the mouth differs somewhat in different specimens, but is never much expanded. The columellar fold is not at all well-developed. The largest specimen we have examined is 11.5 mm. long and 7 mm. broad, with the mouth 8 mm. long and 5 mm. broad. The surface of the shell is covered by a blackish deposit in the type-series.

Possibly this form should be regarded as a distinct species, but some of the shells approach those of the form *striata*. We have not seen either the radula or the genitalia.

Geographical distribution.—The type-series, still in the Indian Museum, is from Leh in Ladak. Weber (*op. cit.*, pl. i, fig. 10g) has figured a specimen from somewhere in Central Asia, but we are doubtful whether this shell really belonged to the form. Its peculiarities seem to have been due to some interference in the growth of the shell and the shape of the mouth differs from that of any specimen in the type-series.

form **bactriana** Hutton.

1850. *Limnaea bactriana*, Hutton, *Journ. As. Soc. Bengal*, XVIII (2), p. 656.

1919. *Limnaea bactriana*, Annandale and Prashad, *Rec. Ind. Mus.*, XVIII, pp. 40, 42, 45, figs. 5-A, 6-E; pl. v, figs. 1, 2; pl. vii, fig. 6.

A comparison with other forms of *L. lagotis* convinces us that this form must be included in the species. The mouth is relatively shorter than in the other Indian forms, approaching that of the *forma typica* in this respect, but the basal whorl of the spire seems to be broader and lower than in European specimens. The form has been fully described by Annandale and Prashad in the paper cited.

The radular teeth are considerably smaller than in the forms *costulata* and *striata* but the central is relatively larger. The whole radula seems to be narrower than in these forms. In a specimen from Mesopotamia the formula is 16. 11. 1. 11. 16.

L. lagotis var. *compressa* Andreae from Central Asia seems, to judge from Weber's figure (*loc. cit.*, fig. 10e), to be very similar, but perhaps the shell is a little narrower.

Geographical distribution.—The range of the species extends from Central Afghanistan to Seistan and S. Iraq.

The form occurs in permanent ponds and pools amongst dense vegetation.

form **defilippii** Issel.

1865. *Limnaea defilippii*, Issel, *Catalog. Moll. Miss. Ital. in Persia*, p. 45, pl. iii, figs. 62, 63.

This form resembles f. *subdisjuncta* in its general shape, but there is usually an extra whorl in the spire and the shell is larger and more fragile and highly polished on the surface. The largest shell we have seen is

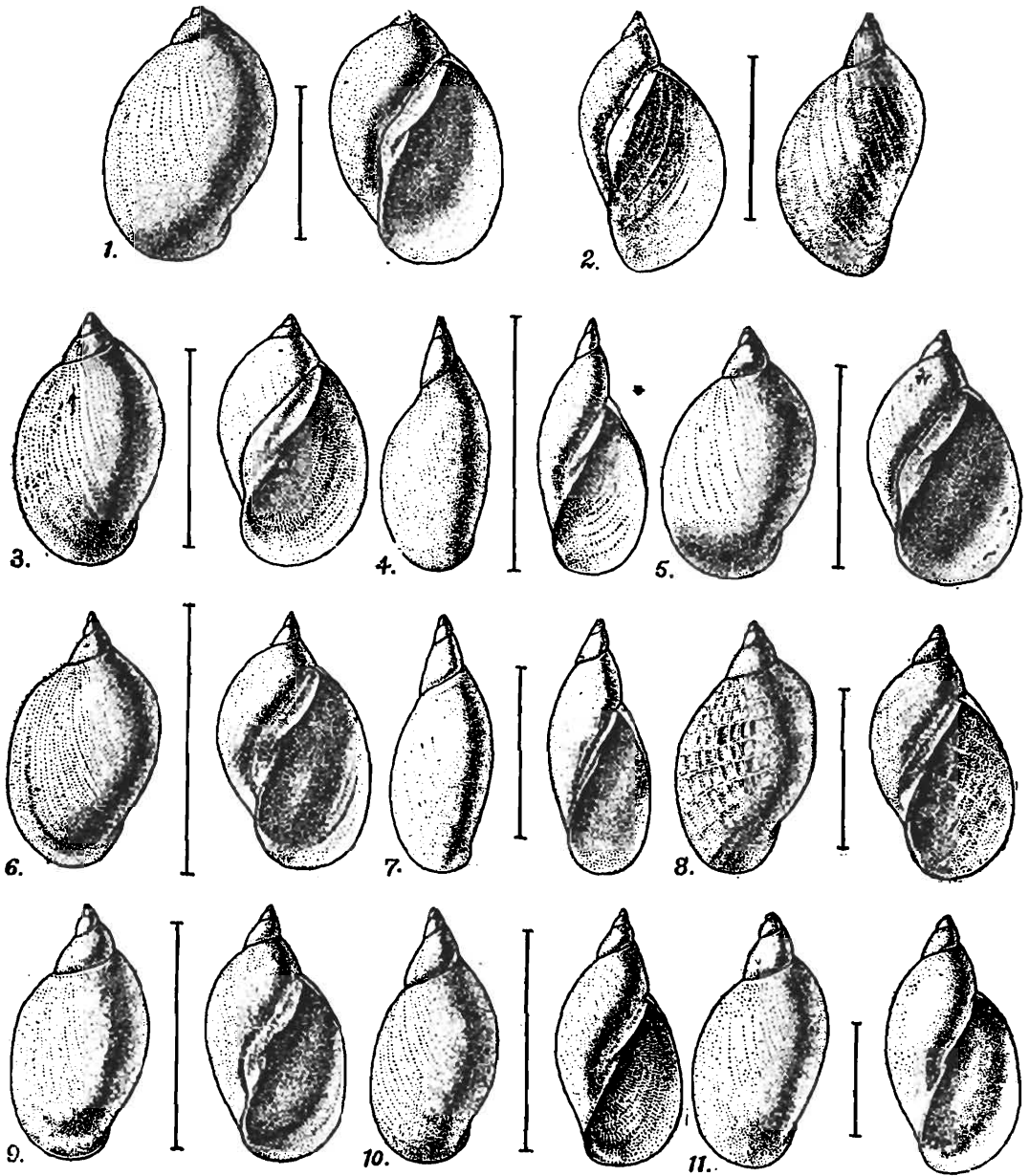


FIG. III.—Shells of Limnaeidae.

- | | |
|--|--|
| 1. <i>L. acuminata</i> f. <i>brevissima</i> (Nagpur). | 6. <i>L. acuminata</i> f. <i>chlamys</i> (Calcutta). |
| 2. <i>L. biacuminata</i> (Hyderabad, Deccan). | 8. <i>L. acuminata</i> f. <i>malleata</i> (Wazirabad). |
| 3 & 5. <i>L. acuminata</i> f. <i>typica</i> (Kulu and Rajputana). | 9. <i>L. acuminata</i> f. <i>patula</i> (Chakradharpur). |
| 4 & 7. <i>L. acuminata</i> f. <i>gracilior</i> (Gungrar and Calcutta). | 10. <i>L. acuminata</i> f. <i>rufescens</i> (Calcutta). |
| | 11. <i>L. acuminata</i> f. <i>hians</i> (Nilgiris). |

17.5 mm. long and 10 mm. broad with the mouth 12 mm. long and 6.5 mm. broad.

Nevill, who regarded f. *defilippii* as distinct, has described a form *sirikulensis* which has a larger, broader and thicker shell than the true *defilippii*. The surface of the shell is dull and malleated.

The radular teeth are intermediate in size between those of f. *bactriana* and those of the other forms we have examined. They seem to be less numerous in each transverse row than in any of these forms. The laterals are relatively short and broad, and the formula in a specimen from Kashmir is 16. 8. 1. 8. 16.

The genitalia are of the usual type. The penis is slender and approximately equal to that of the distal part of the penis-sac. The spermatheca has a long duct, and the two together are approximately equal to the uterus in length.

Geographical distribution.—The form *defilippii* was originally described from Lake Goktscha (5,500 feet). We have examined a large series of specimens from Kukar Nag in Kashmir which agree with Issel's figures and descriptions fairly well.

The form occurs in rice-fields in Kashmir.

***Limnaea brevicauda* Sowerby.**

1873. *Limnaea brevicauda*, Sowerby in Reeve, *op. cit.*, XVIII, sp. 105, pl. xv.

1876. *Limnaea brevicauda*, Hanley and Theobald, *op. cit.*, p. 64, pl. 158, fig. 7.

This is an inflated short-spined lacustrine *Limnaea* which we were at first prepared to regard as an extreme form of *L. lagotis*. It has been confused with *L. auricularia*, from which it differs not only in the structure of the spire but also in that of the jaw, radula and genitalia. The spire has 3 whorls and there is a distinct but narrow canal outside the suture at its base. The body-whorl is always much inflated but the spire never completely sinks into it as in some forms of *L. auricularia*. The columellar fold is much twisted, fairly broad in the region of the umbilicus but disappears below this point. It has not the porcellaneous texture of that of *L. obliquata*. The largest shell we have seen is 19 mm. long and 16.3 mm. broad with the mouth 16 mm. long and 11.5 mm. broad. The shell is rather fragile and has a translucent luteous colour when fresh. The surface is smooth and polished with numerous very fine close-set striae.

The radula is remarkable for the very large size of the teeth, which are also numerous in the transverse series. Some of the laterals are occasionally bicuspid but this is a mere abnormality which is never present in the first lateral. The cusp of the central, which is relatively very small, is almost bilaterally symmetrical. The laterals are relatively long and narrow with elongate sharply pointed mesocones and much shorter ento- and ectocones. These two latter are subequal in the first lateral. The free edge of the inner marginals, which are relatively broader than the laterals, is transverse and has five to six teeth of which the outermost is much the broadest. There are two or three small teeth on the outer margin. The outer marginals are narrow and simple in structure with three terminal teeth. They are much less asymmetrical than in many forms.

The genitalia closely resemble those of *L. lagotis* form *striata* but the spermatheca and its duct appear to be much narrower and the

epiphallus is slightly shorter. These characters, however, may be seasonal.

Geographical distribution.—This is one of the commonest molluscs in the lakes of the Kashmir valley, to which the species is perhaps confined. The type-specimen was stated by Sowerby to come from Australia but the error was demonstrated long ago by Blanford.

The species is found in slow-running streams issuing from springs with a sandy or shingly bottom. In Kashmir the species has been found in large numbers in streams round about Ichabal and in the Chinar-Bagh nullah near Srinagar. Members of the species seem to have a preference to stones and sand and are usually found crawling on them, though aquatic plants are found in abundance in the streams. They apparently feed on minute algae growing on stones and other hard objects.

***Limnaea auricularia* (Linné).**

1805. *Limneus auricularius*, Draparnaud, *Hist. Nat. Moll. France*, p. 49.

1870. *Limnaea auricularia* var. *ventricosa*, Martens, *Malakoz. Blätt.*, p. 152, pl. iii, fig. 8.

1877. *Limnaea auricularia* var. *ventricosa*, Kobelt in Rossmässler's *Icon. Land. Süss. Moll.*, V, p. 40, pl. 129, fig. 1244.

1910. *Limnaea (Gulnaria) auricularia* var. *ventricosa*, Weber, *Zoologisch. Jahrb.*, XXIX, p. 501.

This common European species, which also occurs in Kashmir, is easily distinguished from all the true Indian forms of the genus by its short acuminate spire and very oblique and greatly inflated body-whorl. It is, however, liable to be confused with two related species found with it in Kashmir, namely *L. lagotis* and *L. brevicauda*. From both of these it can be distinguished when the spire is complete by the fact that its suture is linear, whereas in the other two species the suture is so broad that the spire has a scalariform appearance. The spire, however, is often eroded and if this is so, the structure of the columella and its callus provides a sure means of diagnosis. In *L. auricularia* the columella is very strongly twisted and appears as a broad fold which occludes the umbilicus. This fold, however, is not continued down the inner lip to the anterior margin, but disappears a short distance in front of the umbilicus. In the other two species the columella is not so strongly twisted and its fold is continued down the lip, disappearing gradually near the anterior margin. When *L. auricularia* is found together with *L. brevicauda*, as sometimes happens in Kashmir, these differences, once they have been detected, become very clear. The largest shell we have seen is without the spire and is 21 mm. long, 17 mm. broad with the mouth 19 mm. long and 11.5 mm. broad.

Another similar form, so far as the shell is concerned, is the Central Asiatic *L. obliquata*, Martens. In this species, of which we have examined specimens from Issik-Kul, the columellar fold has a very peculiar character. In outline it is not unlike that of *L. auricularia*, but it is greatly thickened and almost tubercular and has a porcellaneous consistency instead of being merely a thin lamella.

The jaw in the Indian specimens of *L. auricularia* we have examined differs considerably from Baker's figure (*op. cit.*, pl. vi, fig. D.), for instead of there being a projection in the middle of the free margin there is a well-defined excavation.

The radular teeth are large and elongated as in *L. brevicauda* but the cusps are comparatively long and stout, and the mesocone is much

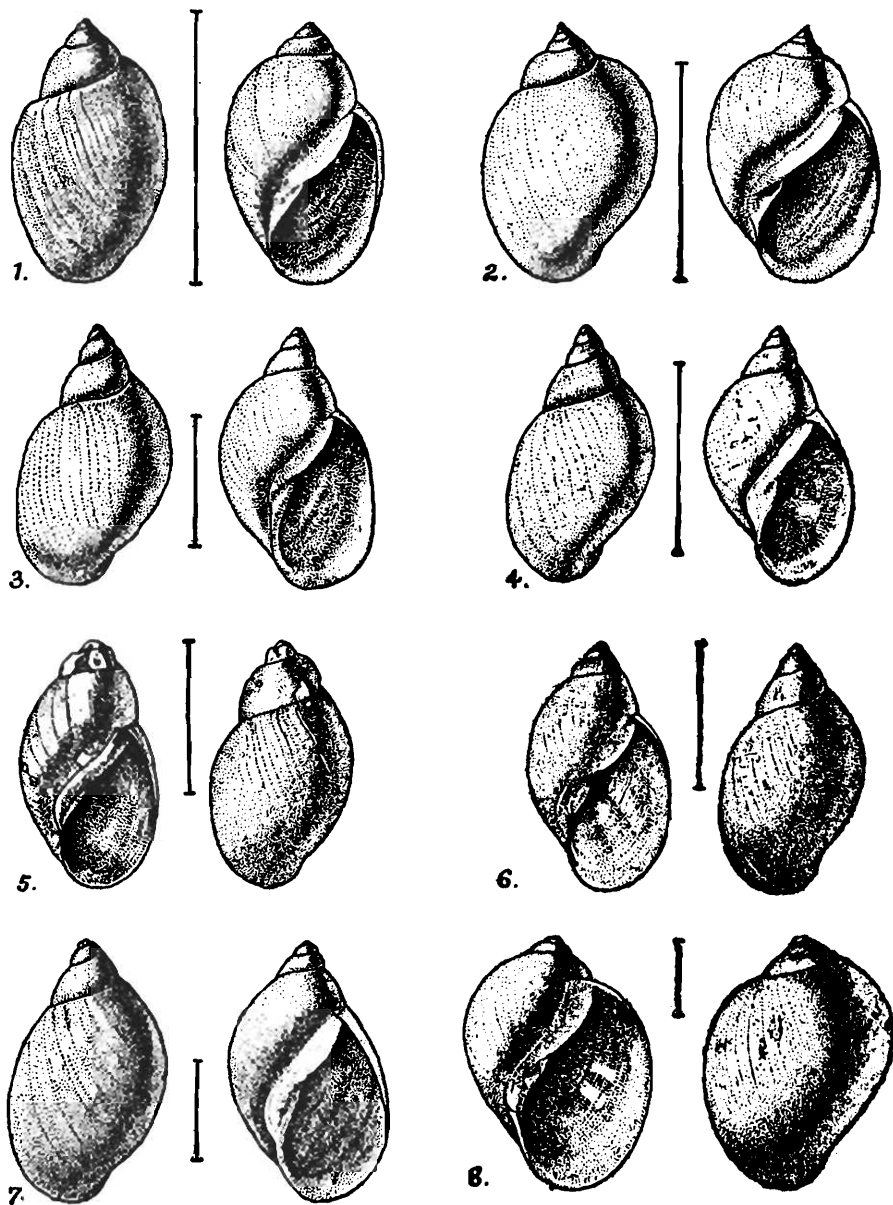


FIG. IV.—Shells of Limnaeidae.

- | | |
|---|--|
| 1. <i>L. luteola</i> f. <i>typica</i> (Bengal). | 5 & 6. <i>L. luteola</i> f. <i>siamensis</i> (Burma) |
| 2. <i>L. luteola</i> f. <i>ovalis</i> (Calcutta). | 7. <i>L. luteola</i> f. <i>impura</i> (Chilka Lake). |
| 3. <i>L. luteola</i> f. <i>australis</i> (Ceylon). | 8. <i>L. physcus</i> (S. Shan States). |
| 4. <i>L. luteola</i> f. <i>succinea</i> (Godavari). | |

larger as compared with the ento- and ectocones and has a more lanceolate appearance. The central is relatively shorter and stouter than in *L. lagotis* f. *striata* and differs from that of *L. brevicauda* in having a small lateral cusp on the right side. The formula is approximately 19.9.1.9.19. Baker's figure (*op. cit.*, pl. vii, fig. C) of the radula of this species was evidently drawn from a specimen in which several of the laterals were abnormal having the entocone more or less completely suppressed. Our preparations agree fairly well with Hazay's figure of European specimens of this species (*Malakoz, Blätt. (N. S.) VII, pl. i, fig. i, 1885*).

In the genitalia the most noteworthy features are that the duct of the spermatheca is even longer than in other Indian forms, considerably exceeding the uterus in length. The prostate is definitely pear-shaped and the vas deferens issues from a depression on its ventral surface considerably above the distal extremity. The distal part of the penis-sac has a more or less well-defined constriction a short distance below its upper extremity. In all these points our preparations agree with Baker's figure (*op. cit.*, pl. x, fig. C).

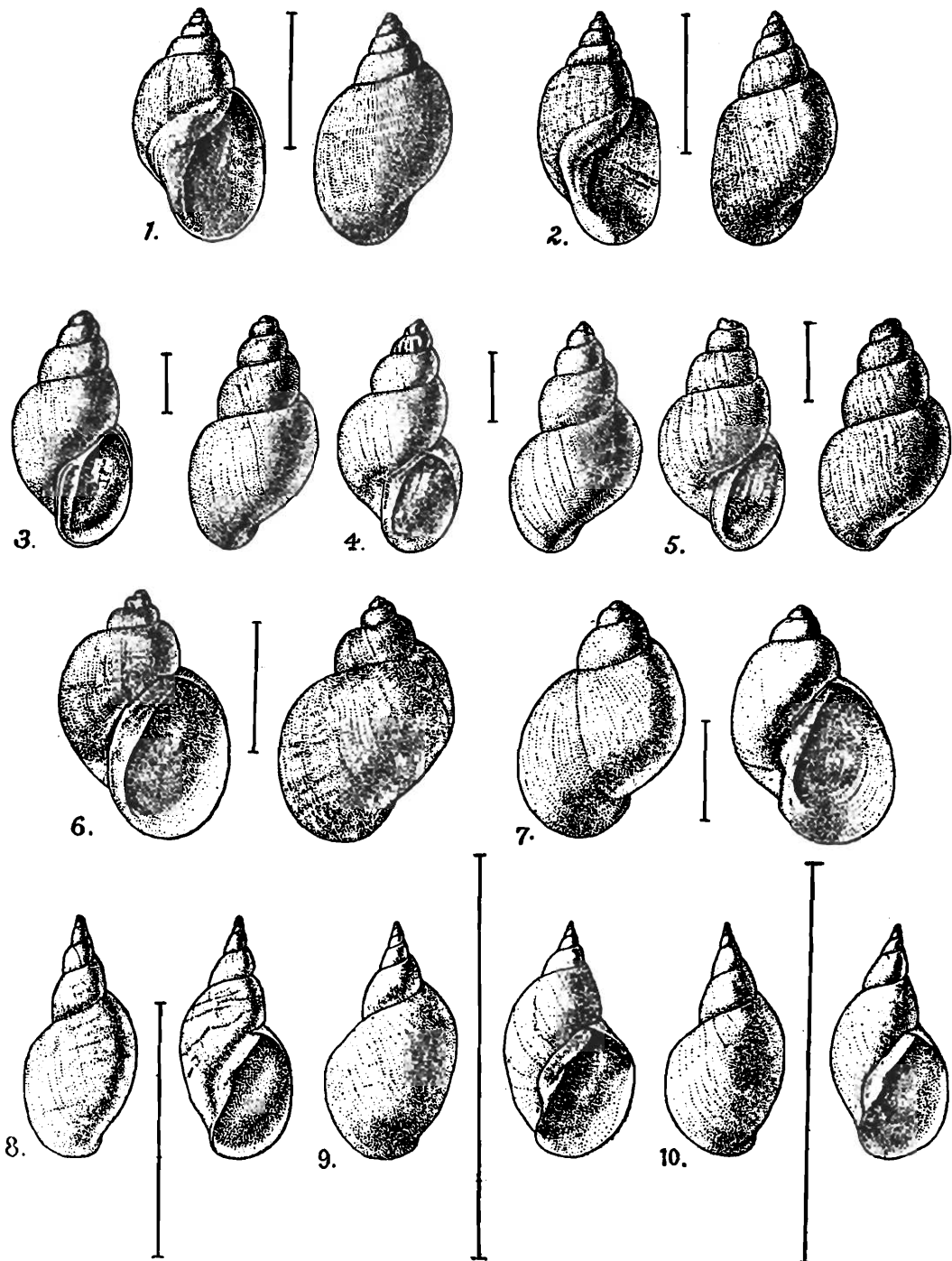


FIG. V.—Shells of Limnaeidae.

1 & 2. *L. laticallosa* (S. Shan States).

3 & 5. *L. truncatula* (Chitral).

4. *L. truncatula* (Kashmir).

6. *L. bowelli* (Tibet).

7. *L. hookeri* (Tibet).

8. *L. stagnalis* f. *minor* (Srinagar).

9 & 10. *L. stagnalis* f. *kashmiriensis* (Srinagar).

Geographical distribution.—The species is distributed over the greater part of the Palearctic region and has been introduced artificially into

green-houses in North America. The only Indian species of which we know are from the valley of Kashmir.

The species is found in the shallower regions of slow streams with thick vegetation and near the shore of lakes overgrown with aquatic plants. In Kashmir it has been found on the shores of the Wular and Dal Lakes, and in large numbers in streams issuing out of these lakes, or in shallow channels between floating islands. Living animals were nearly always found on the leaves of aquatic plants on which apparently they feed.

Shells from Kashmir are referred by Weber to the form *ventricosa* Hartmann, but our specimens do not altogether agree with Kobelt's figures in Rossmässler's *Icon*. We have very little European material for comparison and do not feel justified in referring them to any of the numerous described forms of the species, to which we are strongly convinced they belong.

Galba Schrank.

1911. *Galba* (in part), Baker, *op. cit.*, p. 199.

We use the term *Galba* in a much more restricted sense than Baker (*op. cit.*), confining it to *L. truncatula* and its allies, all of which can be distinguished by the great development of the columellar fold of the shell.

This is probably another Palearctic group that has penetrated into the confines of the Indian Empire from the north and west. The distribution of its species is, however, anomalous and the right to three of the six we include to a place in the Indian fauna is not confirmed. The type-species (*L. truncatula*) has been rightly recorded from Ladak and occurs in Indian territory, also at high altitudes in Chitral, for most previous records are, however, due, in our opinion, to confusion with the closely allied *L. andersoniana*, the range of which extends from Eastern China on the one hand into Upper Burma and the Manipur valley and on the other into Kashgar and the Upper Indus valley. The three species of which the inclusion in our fauna is doubtful are *L. hookeri* and *L. bowelli*, which are only known from the northern watershed of the Himalayas in Tibet and *L. hordeum*, which was originally described from Iraq and has been rediscovered in Seistan and in the Afghan desert near the Perso-Baluch frontier. The sixth species of the group to be considered has been described by us in a paper published recently on the aquatic Gastropods of the Inlé watershed. So far as we know its range is restricted to a small area on the Shan Plateau.

Limnaea truncatula (Müller).

1805. *Limnaeus minutus*, Draparnaud, *Hist. Nat. Moll. France*, p. 53, pl. iii, figs. 5-7; (Tableau. p. 51, 1801).

1862. *Limnaeus truncatulus*, Kuster in *Martini and Chemnitz, Limnaea*, I, abth. 17-B, p. 17, sp. 21, pl. iii, figs. 24-27.

1873. *Limnaea truncatula*, Sowerby in Reeve's *Con. Icon.*, XVIII, sp. 3, pl. i.

1878. *Limnaea truncatula* (in part), Nevill, *Results Sec. Yark. Miss.*, p. 10.

This species seems to run into *L. andersoniana* in a very interesting manner, which we discuss below (p. 166). It is convenient, however, to regard it as distinct for purposes of classification.

A few shells of *L. truncatula* were collected by Stoliczka at Leh in Little Tibet along with a large number of examples of *L. andersoniana*,

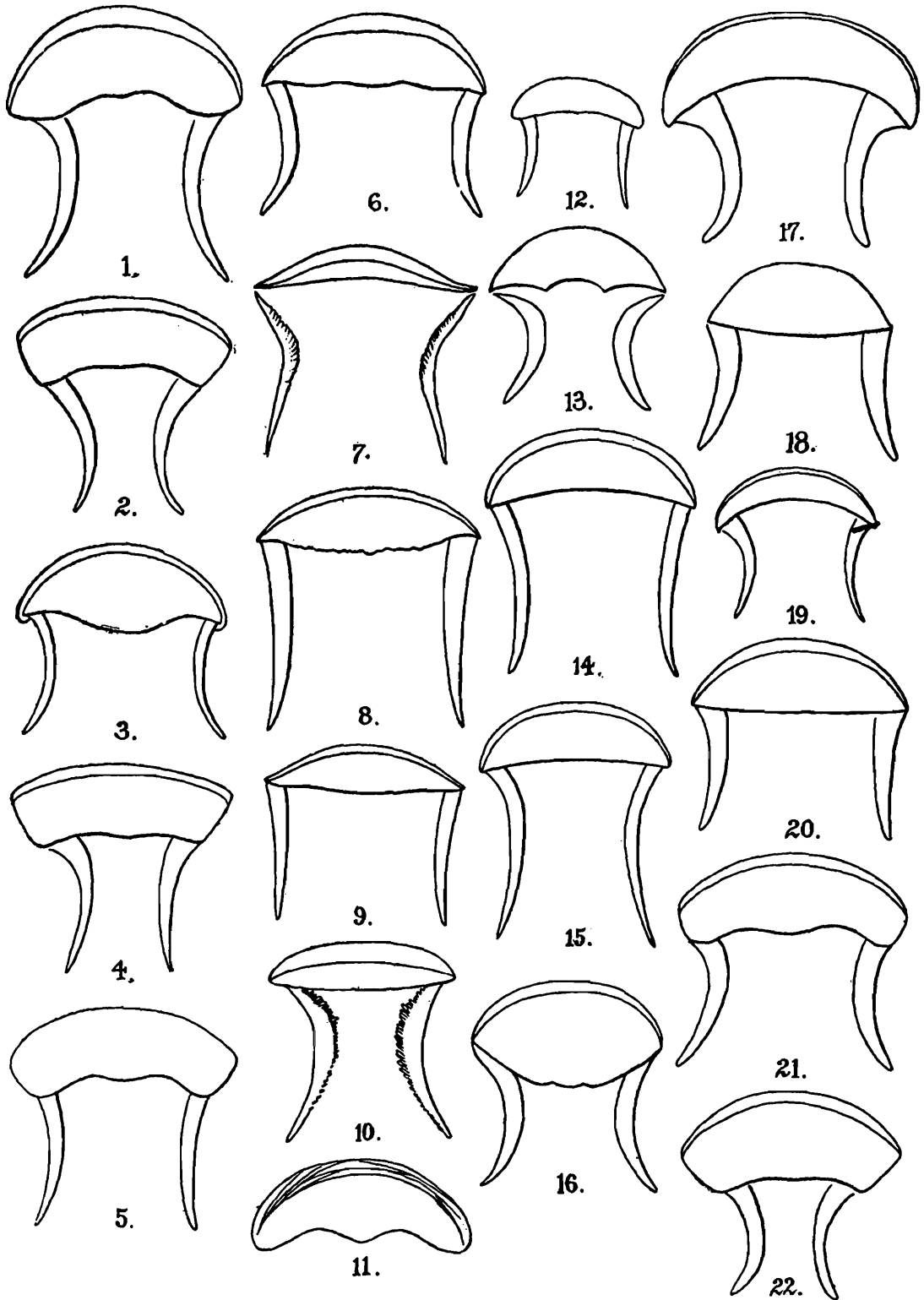


FIG. VI.—Jaws of Limnaeidae.

- | | |
|--|---|
| 1 & 2. <i>L. acuminata</i> f. <i>patula</i> (Manipur and Pachmarhi). | 11. <i>L. bowelli</i> (Tibet) (vertical pieces not figured). |
| 3. <i>L. acuminata</i> f. <i>typica</i> (Manipur). | 12. <i>L. truncatula</i> (France). |
| 4. <i>L. luteola</i> f. <i>siamensis</i> (He-Ho). | 13. <i>L. auricularia</i> (Kashmir). |
| 5. <i>L. luteola</i> f. <i>impura</i> (Barkuda, Chilka Lake). | 14 & 15. <i>L. luteola</i> f. <i>ovalis</i> (Nilgiris and Bangalore). |
| 6. <i>L. andersoniana</i> f. <i>typica</i> (Inlé Lake). | 16 & 22. <i>L. persica</i> (Bhim Tal and Malwa Tal, Kumaon). |
| 7. <i>L. horae</i> (Assam). | 17. <i>L. brevicauda</i> (Srinagar). |
| 8. <i>L. shanensis</i> f. <i>superstes</i> (S. Shan States). | 18. <i>L. biacuminata</i> (Hyderabad, Deccan). |
| 9. <i>L. mimetica</i> (Inlé Lake). | 19. <i>L. peregra</i> (France). |
| 10. <i>L. laticalloso</i> (Kalaw, S. Shan States). | 20. <i>L. iranica</i> (Baluchistan). |
| | 21. <i>L. stagnalis</i> f. <i>kashmiriensis</i> (Kashmir). |

with which he confused them. Nevill recorded in his Hand List shells from Kulu, Kotgarh and Leh under *L. truncatula*, but we find on an examination of the specimens that all except a few from Leh are referable to *L. andersoniana*.

Shells of this species from Leh are more or less typical, but one of them agrees with Martens' figure of *L. truncatula* var. *longula* in Fedtschenko's *Reise in Turkestan* (pl. ii, fig. 26), except that it has the aperture more expanded.

The only other known occurrence of this species within Indian limits is due to Mr. G. H. Tipper of the Geological Survey of India, who recently obtained a few shells from marshy ground near the village Harchin in Chitral at an altitude of 9,000 feet. One of the shells agrees with Martens' figure in the work cited except that the mouth is less expanded. The remaining shells are much smaller and have a relatively small and narrow aperture.

This is a mud-loving form and is practically amphibious in habits.

***Limnaea andersoniana* Nevill.**

1878. *Limnaea truncatula*, Nevill, *op. cit.*, p. 10.

1881. *Limnaea andersoniana*, Nevill, *Journ. As. Soc. Bengal*, L (2), p. 142, pl. v, fig. 9.

1918. *Limnaea andersoniana*, Annandale, *Rec. Ind. Mus.*, XIV, p. 106, pl. x, figs. 1, 2.

1919. *Limnaea truncatula*, Annandale and Prashad, *op. cit.*, p. 50.

1921. *Limnaea andersoniana*, Annandale and Prashad, *Rec. Ind. Mus.*, XXII, p. 574, pl. viii, figs. 1-6.

This species differs from any we have as yet discussed in its extreme plasticity. Individual variability is, as a rule, by no means pronounced however. The main environmental factor in its plasticity is, as a rule, apparently the flow of water, for we can define three well-marked phases, one of which lives in still water, one in ordinary hill-streams and one in rapid-running mountain torrents. We are acquainted also with a fourth phase intermediate between the first two, and in one instance inhabiting a pond into which a stream flows at certain seasons, but the characters of this phase are much less definite. We propose for it the name *intermedia*. The pond form is the *forma typica*, while the stream form has already received a name (*simulans*, Preston). We propose for the torrent form the name *turbinicola*.

The great difficulty we experience in describing *L. andersoniana* is that it approaches in its running-water phases very close to *L. truncatula*, from which the *forma typica* seems to be quite distinct. We will discuss this point at the end of our notes on the species.

The shell is distinguished primarily by the following characters :—

- (1) The possession of a very coarse broad and moderately elongate columellar fold, which completely occludes the narrow umbilicus but stands out over it in such a way that a passage leading to the umbilicus is left open on the dorsal surface of the shell.
- (2) The more or less elongate-ovate shape of the shell.
- (3) Its comparatively small size (height not exceeding 12 mm., and maximum diameter 6 mm.)

- (4) The slight flattening of the upper margin of the whorls outside the suture.
- (5) The very slight obliquity of the suture and its linear structure.
- (6) The fact that the spire is never so long as the body-whorl as seen in dorsal view.

The colour and texture of the shell vary considerably in different localities but it is never very fragile and never dark. The surface is never very highly polished.

The differences in the shell are well shown in the work cited last.

The jaw offers no startling peculiarity. The mandible forms a segment or sector of a circle less than a semicircle and the free border is slightly sinuate. The side-pieces are strongly curved and shorter than in some species.

The radula raises the interesting question, How far is the form of radular teeth to be regarded as of real taxonomic value? It will be simplest to describe the radulae of three different types separately.

The first type is that of specimens of the *forma typica* from the neighbourhood of the Inlé Lake in the Southern Shan States. The formula is approximately 18.10.1.10.18. The teeth are comparatively short and broad. The central is relatively large with a sharp, well-defined cusp on one side of the main cusp. The inner laterals have three well-developed cusps, the ecto- and the entocone being subequal, but the latter is situated on the side of the mesocone much further from the base than the former. The outer laterals or intermediate teeth have four to five cusps in addition to an outer marginal denticulation or pair of denticulations representing the reduced ectocone. The marginals are very similar but grow gradually narrower from within outwards.

The second type is that of specimens of the form *simulans* from streams in the same district. The teeth are perhaps a little more numerous and distinctly larger and longer in proportion to their breadth. The basal denticulations of the outer laterals and the marginals are better developed, but otherwise there is no structural difference.

The third type was found in the radula of a specimen from a series of intermediate shells from the Simla Hill States. Unfortunately we have succeeded in extracting only this one radula. It differs from those of Shan specimens in (a) the obsolete condition of the entocone, which is reduced to a mere projection in all the first lateral and is only a little bigger in the outer members of this series, and (b) in the deeper cleft between the meso- and ectocones of these teeth. The marginals also have a greater tendency to assume monstrous forms. As we shall see later this radula exhibits a close resemblance to that of *L. truncatula*.

The genitalia of *L. andersoniana* are also very like those of *L. truncatula*. The spermathecal duct is a little longer than the uterus and seems to have a permanent curvature just below the spermatheca. The prostate is heart-shaped and the vas deferens issues from it near the pointed distal end. The penis is very slender and distinctly shorter than the distal part of the penis-sac.

Geographical distribution.—*L. andersoniana* is common in the Chinese province of Yunnan, in the Southern Shan States, and in the Manipur valley. It also occurs in the Nepal valley, in the Kangra valley, in

Ladak, and in the Simla Hill-States on the Himalayas, and in Kashgar. It appears thus to be always or almost always an inhabitant of mountain

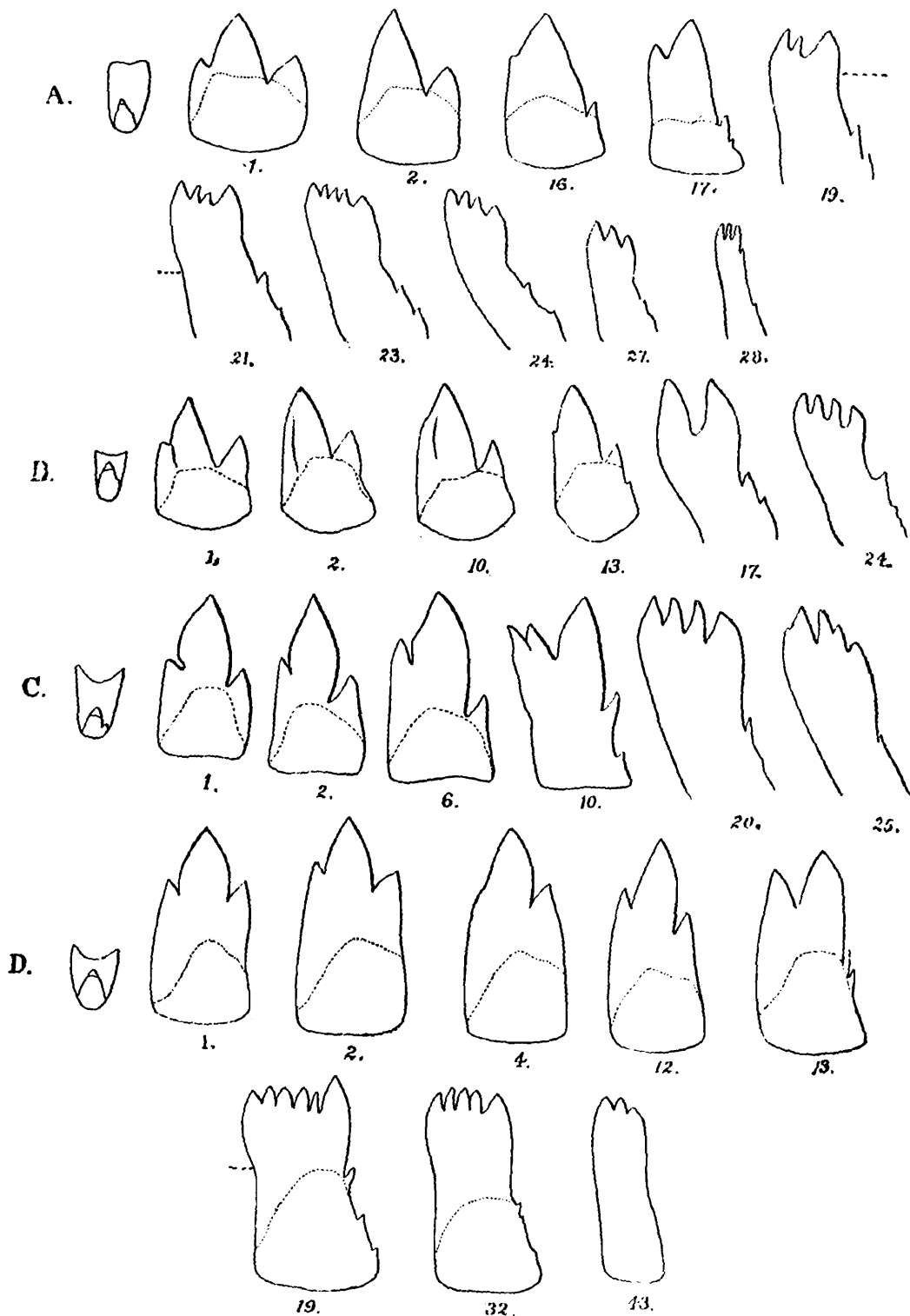


FIG. VII.—Radular teeth of *Limnaeidae*.

- A. *L. stagnalis* f. *kashmiriensis* (Kashmir). C. *L. auricularia* (Kashmir).
 B. *L. stagnalis* f. *minor* (Kashmir). D. *L. brevicauda* (Kashmir).

valleys. The common form in Yunnan is *simulans*, while the specimens we have examined from the Western Himalayas and neighbouring districts belong more or less definitely to the form *intermedia*, which also occurs in Assam near the base of the Naga Hills. The form *turbinicola*

is only known from the hills on the western side of the Manipur valley, but the form *simulans* probably occurs in all Eastern districts in which the *forma typica* is found.

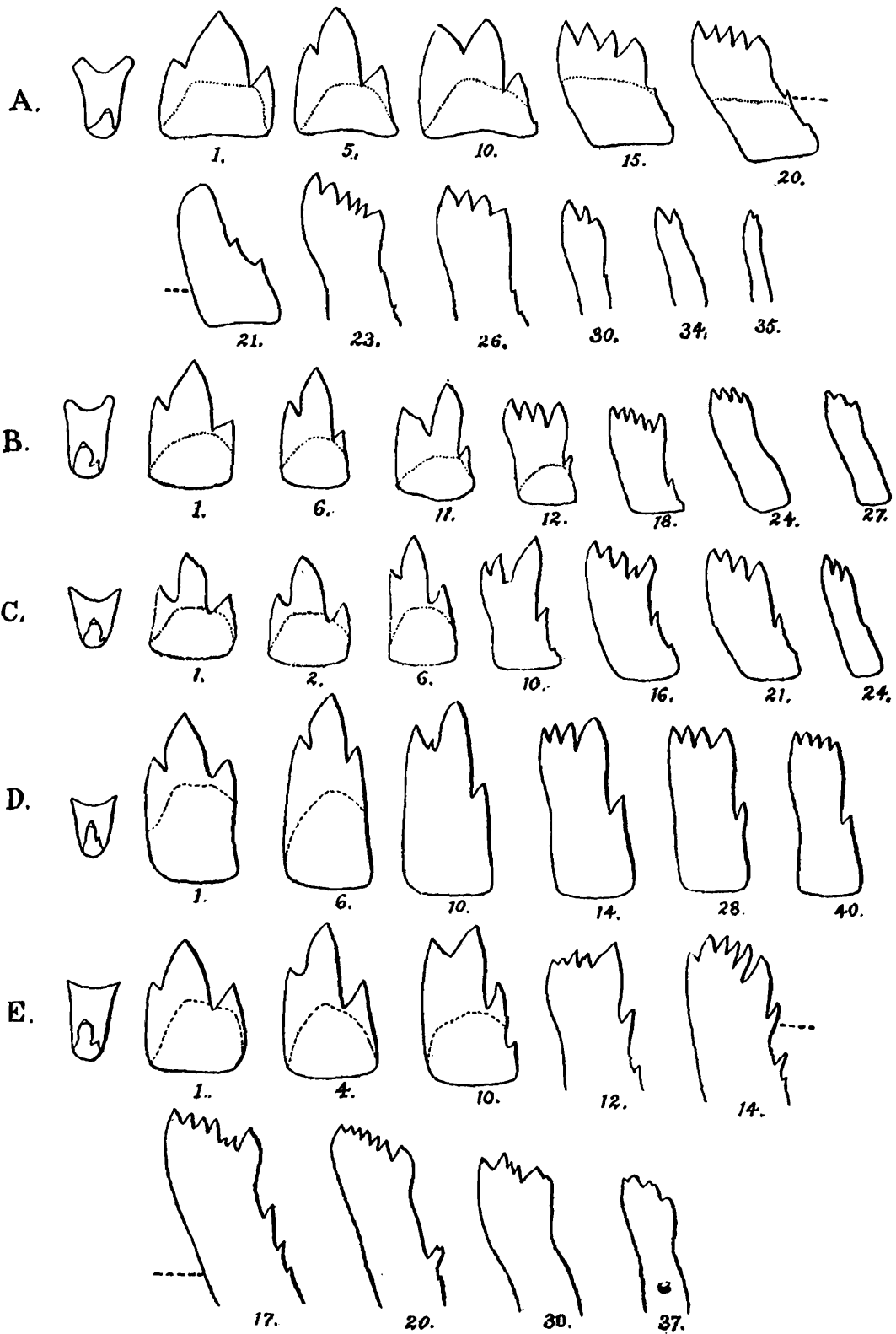


FIG. VIII.—Radular teeth of Limnaeidae.

- A. *L. persica* (Kumaon).
- B. *L. lagotis* f. *bactriana* (Basra).
- C. *L. lagotis* f. *dejilippii* (Kashmir).

- D. *L. lagotis* f. *costulatu* (Kashmir).
- E. *L. lagotis* f. *striata* (Kashmir).

We may now discuss the relationship between *L. andersoniana* and *L. truncatula*. We have seen shells from Chitral on the North-West

Frontier which can be definitely assigned to the latter species, and specimens of *L. andersoniana* from the extreme north-west of India do not approach it any closer than those of the form *simulans* from the Southern Shan States. The two species, however, granted that they are distinct, resemble one another closely in shell structure, particularly in the form and texture of the columellar fold, and in the direction and character of the suture and the adjacent part of the whorls. So far there is nothing to prevent the two species from being regarded as quite distinct though closely allied. This view is also borne out by comparison between the genitalia of the *forma typica* of *L. andersoniana* and those of typical European specimens of *L. truncatula*. An examination of the radula of the different forms concerned, however, renders the problem much more complex. We find that the teeth of the *forma typica*, or at any rate of individuals of this form from the Southern Shan States, do not possess the characteristic features of those of *L. truncatula*. If, however, we examine the radulae of individuals of the form *simulans* from the Southern Shan States we find a distinct approximation to the *truncatula* type, while in individuals of the f. *intermedia* from North-West India the similarity is much greater amounting indeed, if sufficient allowance is made for individual variation, to a practical identity. The explanation may be as follows, but we offer it tentatively.

L. andersoniana has become differentiated from *L. truncatula* on or near the north-west frontier of India, probably in the upper waters of the Indus. Here some factor induced great variability of the shell which, however, became more different from that of *L. truncatula* than did the radula. In the eastern parts of the range of *L. andersoniana* the form *simulans* became more clearly differentiated from the f. *typica*, probably in direct correlation with a greater differentiation of environment in the same localities than was to be found in the mountain valleys near the head-waters of the Indus and the Jumna. The form *simulans* which retained the amphibious habits of *L. truncatula* most distinctly underwent comparatively little change so far as the radula was concerned, whereas the pond-living f. *typica* underwent considerable change in this respect.

Unfortunately we have not been able to examine the radula of individuals of the form *intermedia* from Manipur. It is possible that they are reversions to an ancestral type in a strict sense and that their radula will be found on examination to agree with that of individuals from the north-west, but whether this is so or not can only be proved by an actual examination of specimens.

Limnaea hookeri Reeve.

1850. *Limnaea hookeri*, Reeve, *Proc. Zool. Soc., London*, XVIII, p. 49.
 1873. *Limnaea hookeri*, Sowerby, in Reeve, *Con. Icon.*, XVIII, sp. 74, pl. xi.
 1909. *Limnaea hookeri* (in part), Preston, *Rec. Ind. Mus.*, III, p. 115.
 1915. *Limnaea (Gulnaria) hookeri*, *id.*, *Faun. Brit. Ind., Moll.*, p. 111.

The shell is of moderately small size, not exceeding 12 mm. in height and 8 mm. in maximum diameter. It is of a rather broad ovoid shape, minutely blunted at the apex. In many points it closely resembles

the shell of *L. andersoniana* (p. 163). The following characters are diagnostic :—

- (1) The upper margins of the whorls are rather broadly flattened outside the suture.
- (2) The suture is very oblique, especially just above the body-whorl.
- (3) The columellar callus is very thick and almost porcellaneous.
- (4) The umbilicus, though covered by the fold of the columella in ventral view, is conspicuously present in lateral view.

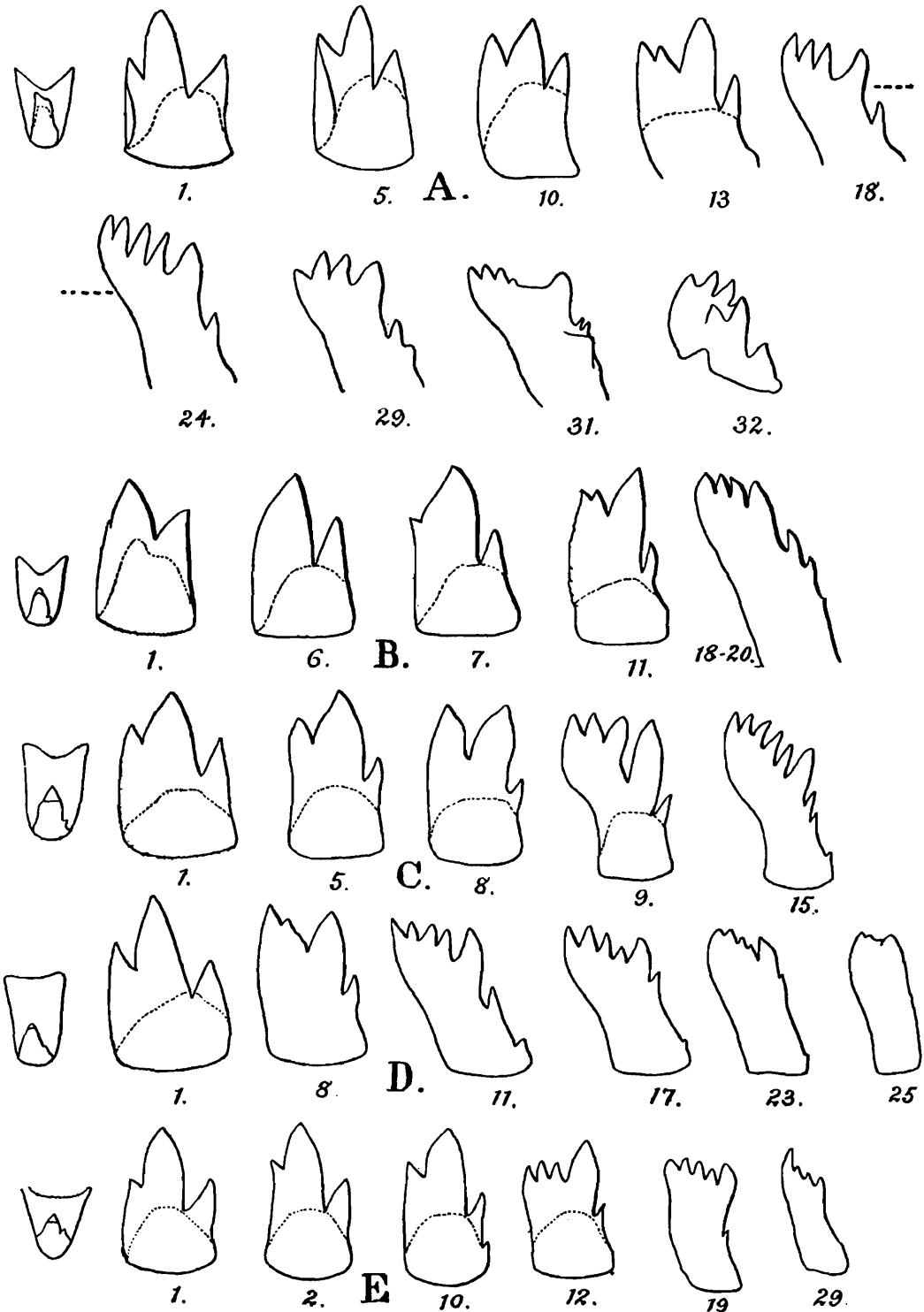


FIG. IX.—Radular teeth of Limnaeidae.

A. *L. bowelli* (Tibet).

B. *L. hookeri* (Tibet).

C. *L. iranica* (Baluchistan).

D. *L. gedrosiana* (Persian Baluchistan).

E. *L. peregra* (France).

In other respects the shell is not unlike that of the widely-distributed Palearctic *L. peregra* in its form *ovata*.

The radula differs from that of all other Indian or Southern Palearctic species (with the exception of some specimens of *L. andersoniana*) so far as they are known, in the fact that the entocone of the first lateral is reduced to a slight projection, the other teeth of the same series being distinctly tricuspid, at any rate for several longitudinal rows. Those of the sixth row in the only specimen examined have lost the entocone, but this is probably abnormal, as the cusp is well developed in subsequent rows. The mesocone of all the laterals is fairly long, sharply pointed and rather narrow. In the intermediate teeth it often assumes a more or less monstrous form and finally becomes broken up into several smaller cusps. The transition from laterals to marginals is gradual. The latter have a transverse series of four or five fairly stout cusps, of which the outermost, representing the mesocone, is the largest, and also one or more comparatively long narrow cusps on the outer margin. We cannot give the dental formula exactly as our radula, extracted from a dried specimen, is incomplete. There are 11 laterals and at least 9 marginals.

Geographical distribution.—It is doubtful whether *L. hookeri* occurs actually within the limits of the Indian Empire. Hooker discovered the original specimens, according to Reeve, “on the Thibetian or north side of Sikkim Himalaya, at 18,000 feet elevation.” Major F. H. Stewart found the species not uncommon in eastern Tibet at altitudes from 13,000 to 14,500 feet.

Habits.—Major Stewart obtained his specimens in a pond which dried up in winter, in a stream from a hot spring and in marshy pools. Spawns was observed in February and March.

***Limnaea bowelli* Preston.**

1909. *Limnaea bowelli*, Preston, *Rec. Ind. Mus.*, III, p. 115.

This species was described from an immature shell or shells only 8.5 mm. high. We recently received a large specimen from Major F. M. Bailey who took it at a height of 16,000 feet in Southern Tibet. This specimen is 15.5 mm. high and 11.0 mm. broad and differs in several particulars from the type, coming very close to some shells of *L. hookeri*, but differing from them in its impressed suture and much wider umbilicus. It is of a fairly dark chestnut colour.

The radula differs greatly from that of *L. hookeri*, the first laterals in particular being tricuspid. Other differences are to be found in the figures. According to Bowell as quoted by Preston ‘the maxilla is also very remarkable with a large blunt beak arising from the centre of the semi-circular piece.’ Our own preparation hardly shows a structure so peculiar, but there is a definite projection on the posterior margin of the jaw, a little more pronounced than in any other species we have examined.

The genitalia offer no great peculiarities.

Geographical distribution.—The species has not been found within Indian limits but seems to be fairly common in the Gyantse valley in Tibet and the neighbouring districts. Major Bailey’s specimen is from

Tratsang (16,000 feet). The species often occurs in warm springs. It has been found at altitudes between 13,120 and 16,000 feet.

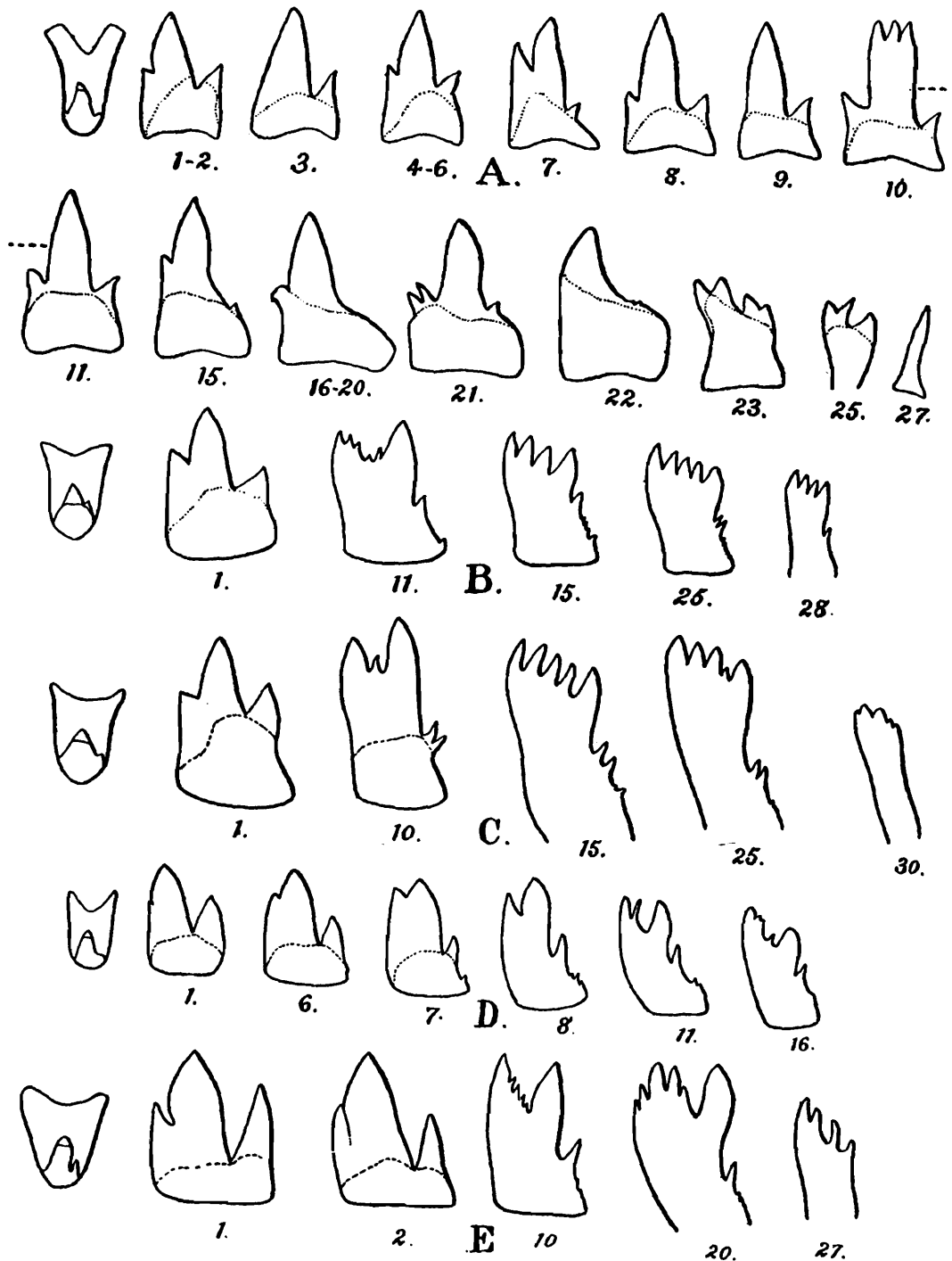


FIG. X.—Radular teeth of Limnaeidae.

- | | |
|--|--|
| A. <i>L. laticallosa</i> (S. Shan States). | D. <i>L. andersoniana</i> f. <i>intermedia</i> (Kot garh). |
| B. <i>L. andersoniana</i> f. <i>typica</i> (S. Shan States). | C. <i>L. truncatula</i> (France). |
| C. <i>L. andersoniana</i> f. <i>simulans</i> (S. Shan States). | |

***Limnaea hordeum* Mousson.**

1874. *Limnaea hordeum*, Mousson, *Journ. Conchyliol.*, XXII, p. 42.

1919. *Limnaea hordeum*, Annandale and Prashad, *op. cit.*, p. 51, pl. vii. fig. 5, and p. 114, pl. xiv, figs. 4, 5.

This curious little species, which is only known from the shell, differs from *L. truncatula* chiefly in its more rounded whorls, more oblique suture, thicker lip, and less well developed columellar fold.

Specimens have been found on the shores of the lower Euphrates, in flood debris in Seistan, and at the edge of Gaud-i-Zirreh, the great salt pan in the Afghan-Baluch desert. All these shells may have been subfossil.

Limnaea laticallosa Annandale and Rao.

1925. *Limnaea laticallosa* Annandale and Rao, *Rec. Ind. Mus.*, XXVII p. 105.

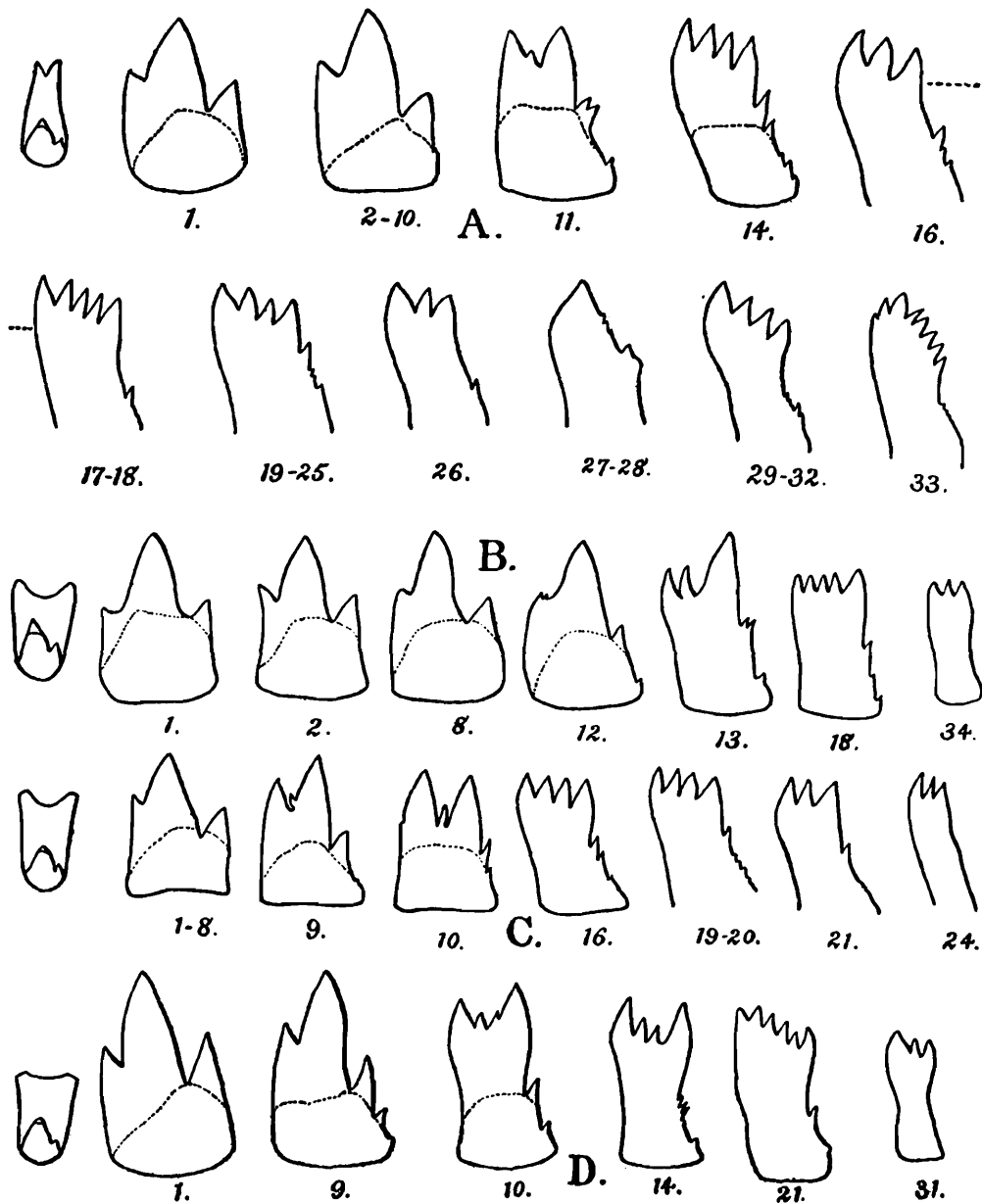


FIG. XI.—Radular teeth of Limnaeidae.

- A. *L. luteola* f. *typica* (Nagpur).
- B. *L. luteola* f. *australis* (Khandalla).
- C. *L. luteola* f. *ovalis* (Nilgiris).
- D. *L. ovalior* (Manipur).

Pseudosuccinea Baker.

1911. *Pseudosuccinea*, Baker, *op. cit.*, p. 162.

The great majority of the true Indian and Burmese species belong to this group, which is also well represented in Europe (by forms of *Limnaea peregra* or very closely allied species), in North America and throughout practically the whole of Asia. In peninsular India *Pseudo-*

succinea was established as early as the late Cretaceous epoch. The form *L. oviformis*, very closely related to the living *L. luteola* was found by Hislop in the Intertrappean beds of the Central Provinces. It is thus possible that the group originated in India, but the Indian species are closely related to the Palearctic *L. peregra* through several forms peculiar to or characteristic of Baluchistan and Eastern Persia. Resemblances are to be found not only in the shell but also in the radulae and genitalia.

Limnaea iranica Annandale and Prashad.

1919. *Limnaea iranica*, Annandale and Prashad; *op. cit.*, p. 43, pl. vii, fig. 1 and p. 42, fig. 6-F.

This species and its ally *L. gedrosiana* form links between the characteristic Indian *L. acuminata* and the European members of the *peregra* group. *L. iranica* has been fully described by Annandale and Prashad. The shell is very like that of smaller forms of *L. acuminata* but the outer margin of the lip is more convex and forms a regular curve.

The jaw differs from that of *L. acuminata* in having a straight instead of a sinuate posterior margin.

The radula is very close to that of European specimens of *L. peregra* but is distinguished by the more oblique and more profusely denticulated cutting margin of the marginals. The denticulation of the inner members of this series is indeed very characteristic and distinguishes the species from *L. acuminata*. In all these forms the cusp of the central is very asymmetrical, the projection on the left having disappeared completely.

Geographical distribution.—We have examined specimens collected by Blanford in Persian Baluchistan and at Magas in Southern Persia.

Limnaea gedrosiana Annandale and Prashad.

1919. *Limnaea gedrosiana*, Annandale and Prashad, *op. cit.*, p. 48, pl. vii, figs. 2-4; p. 42, text figs. 6-A and B, p. 107.

This species has also been recently described by Annandale and Prashad. It is still more closely related to *L. peregra* than *L. iranica*, but the shell is narrower as a whole and has the arc of the lip somewhat flattened above. The spire is also, as a rule, longer and the mouth projects further below the umbilicus.

The radula differs from that of *L. iranica* in having fewer denticulations on the inner marginals. From that of *L. peregra* it only differs in having the teeth somewhat stouter and larger, possibly also the marginal and lateral series are a little shorter. The formula for a specimen from Persian Baluchistan is 18. 7. 1. 7. 18.

Geographical distribution.—This species was originally described from near Kerman in Eastern Persia and has since been found in lakes near Nushki in the Baluch desert. Quite recently Dr. S. L. Hora obtained specimens in the Punjab Salt Range from Namal on the east side of the Indus.

The species is found in pools and backwaters and is active in very cold weather. It feeds on rotten vegetation and on goat-dung. It often lives in rather saline water.

In the Baluch desert this species occurred in apparently perennial pools or lakes. Only empty shells were, however, found in winter.

form **rectilabrum** Annandale and Prashad.

1919. *Limnaea gedrosiana* var. *rectilabrum*, Annandale and Prashad, *op. cit.*, p. 49, pl. vi, figs. 1-6; p. 40, fig. 5-B; p. 42, figs. 6c, 6d.

This form is distinguished from *L. gedrosiana* by the flattening of the outer lip and by its greater variability.

Geographical distribution.—Specimens have been found in the Kushdil Khan reservoir in Baluchistan at an altitude of 5,000 feet, and also in a small pool in the desert south of Nasratabad in Seistan.

This form has been found only in desert pools which are liable to dry up in summer.

Limnaea shanensis Annandale.

1918. *Limnaea shanensis* (phases A to D), Annandale, *op. cit.*, p. 107, pl. x, figs. 5-8; pl. xi, figs. 2, 3.

This species represents on the extreme east of the Indian Empire somewhat the same relationship to *L. acuminata* as *L. iranica* and *L. gedrosiana* on the west to *L. peregra*. It is also closely related to *L. yunnanensis* Nevill from Yunnan, but the shell is distinguished from those of both species by its much narrower columellar fold and less acuminate apex, which is, indeed, minutely mamillate. The shell is extremely plastic but two of the three forms with which we are acquainted are only known in sub-fossil or fossil condition. The shell never exceeds 10.5 mm. in length and 6.5 mm. in breadth and is always thin and fragile.

The radula of the surviving form resembles that of other species in the group but the laterals are distinguished by their quadrate form and relative breadth except in the first lateral. Moreover the mesocone is no longer than the entocone. The dental formula is 20. 8. 1. 8. 20.

The three forms may be defined as follows:—

form **typica** Annandale.

1918. *Limnaea shanensis* (phases A and D), Annandale, *op. cit.*, pp. 107 and 109, pl. x, figs. 5 and 8.

The shell is narrow and has only $3\frac{1}{2}$ whorls. The mouth is somewhat expanded and the lip slightly sinuate in lateral view. The width of the shell and the length of the spire are somewhat variable. It is found sub-fossil in the friable clay of the He-Ho basin.

The form described by Annandale (*op. cit.*, p. 109) as *phase D* appears to be only the young of this form.

This was apparently a lacustrine form.

form **superstes**, nov.

1918. *Limnaea shanensis* (phase C), Annandale, *op. cit.*, p. 108, pl. x, fig. 7.

This is a still narrower form with the apex composed of a complete whorl. It survives in the Inlé valley where it is found in the marginal

zone of the Inlé Lake and in ponds amidst dead and growing vegetation.



FIG. XII.—Radular teeth of Limnaeidae.

- A. *L. acuminata* f. *typica* (Nagpur). D. *L. horae* (Assam).
 B. *L. biacuminata* (Hyderabad, Deccan). E. *L. mimetica* (Inlé Lake).
 C. *L. shanensis* f. *superstes* (Inlé Lake).

form **hehoensis**, nov.

1918. *Limnaea shanensis* (phase B), Annandale, *op. cit.*, p. 108, pl. x, fig. 6.

The chief characteristic of this form is in its reduction of the spire, the apex being composed of less than half a whorl. We have only found it in a curious deposit of calcareous particles at the head of the He-Ho gorge, Southern Shan States, *altitude*, 3,800 feet.

The differences between these three forms are best shown in our figures.

Limnaea physcus Annandale and Rao.

1925. *Limnaea physcus*, Annandale and Rao, *op. cit.*, p. 104.

Limnaea mimetica Annandale.

1918. *Limnaea mimetica*, Annandale, *op. cit.*, p. 109, pl. x, figs. 9, 9a; pl. xi, fig. 4; p. 175, fig. 9.

The shell of this remarkable form is fully described and well-figured by Annandale. It appears to be a dwarfed race of the *acuminata* group

and is closely related to *L. shanensis* though distinguished by well marked characteristics of the jaw, the radula and the genitalia.

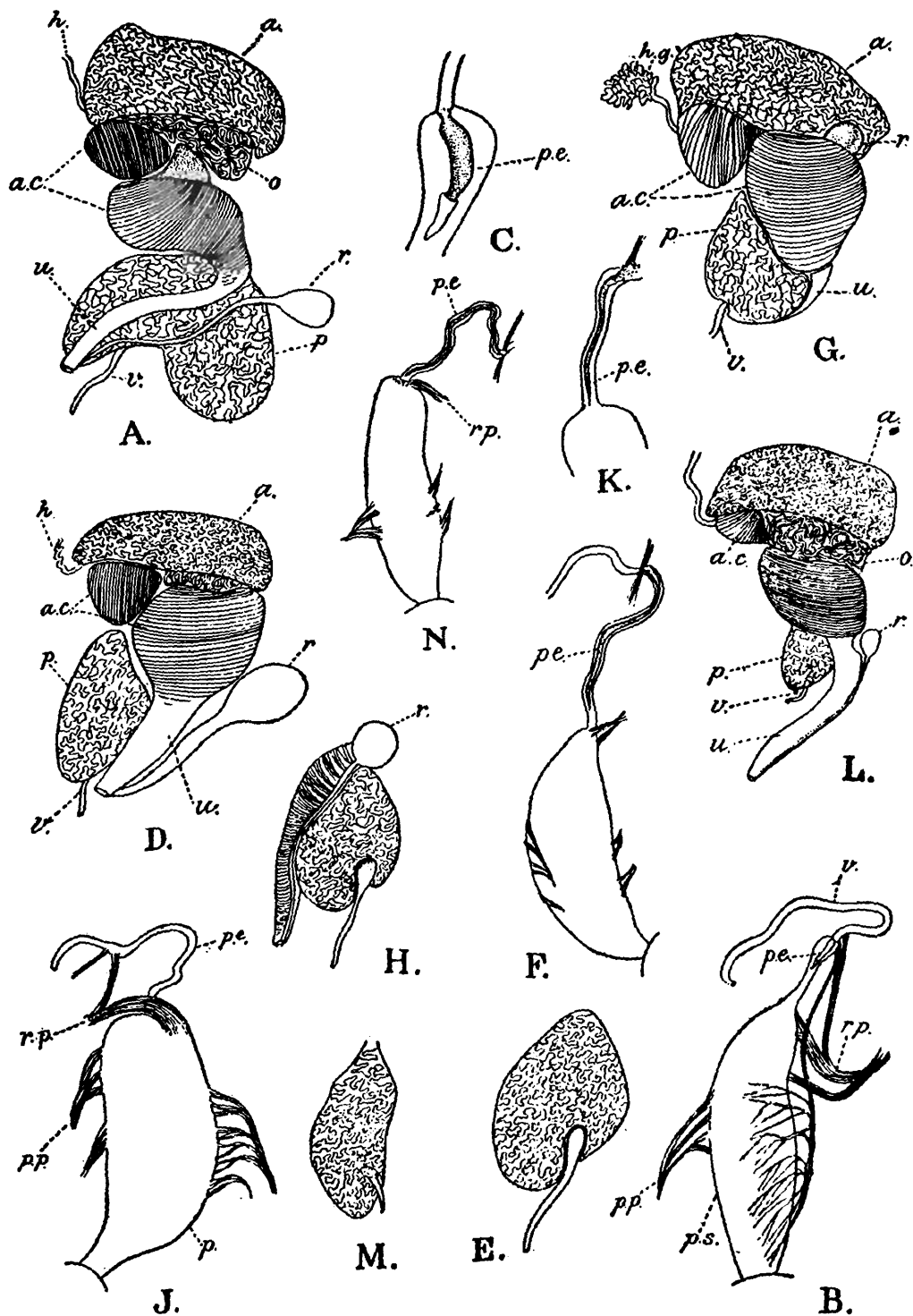


FIG. XIII.—Genitalia of Limnaeidae.

A, B, C. *L. stagnalis* f. *kashmiriensis*.

L, M, N. *L. lagotis* f. *deflippii*.

D, E, F. *L. lagotis* f. *striata*.

E, H, M. Ventral view of prostate gland.

G, H, J, K. *L. brevicauda*.

a. albumen gland; *a. c.* accessory albumen gland; *h. g.* hermaphrodite gland; *h.* hermaphrodite duct; *o.* oviduct; *p.* prostate gland; *p. e.* penis; *p. p.* protractor muscles of penis; *p. s.* penis-sac; *r.* spermatheca; *r. p.* retractor muscles of penis; *u.* uterus; *v.* vas deferens.

A second collection made at the Inlé Lake in March, 1922 proves that the species is a little more variable than is indicated in the original

description. Our figures show the extreme range of variation known to us.

The jaw is remarkable for the great relative breadth and shortness of the mandible and for the straightness of the side pieces. The outer margin of the mandible is arched in a slightly sinuous line while the posterior is also slightly sinuate.

The radula is even very small relatively and has only 35 teeth in a transverse row, the formula being 12. 5. 1. 5. 12. The teeth differ from those of *L. shanensis* not only in their small size but also in being relatively a little narrower. The marginals are also more curved and the cusp of the central is relatively longer and sharper.

The species is only found amongst dense growing vegetation, particularly *Najas minor*, in very clear water in the Inlé Lake.

Limnaea horae, sp. nov.

This species is closely related to *L. mimetica* but the shell differs (1) in having the spire better developed and broader, with an extra half whorl at the apex, (2) in the complete absence of a columellar callus, (3) in the nature of the sculpture, in which minutely decussated longitudinal striae, set close together and very numerous, are a conspicuous feature. Some shells, moreover, are distinctly pigmented and of a pale horny colour.

The jaw resembles that of *L. mimetica* in the shortness and breadth of the mandible (a character which is even more accentuated in the new species) and also in the slenderness of the side pieces. They are, however, geniculate inwards instead of being straight, and slightly fimbriated on their inner margin.

The radula is perhaps even less well developed than in *L. mimetica*, the dental formula being the same. The teeth differ in being shorter and broader. The cusp of the central is also considerably smaller.

The genitalia are very similar in the two species, but the duct of the spermatheca is much longer than that of *L. mimetica*.

Type-specimen.-M $\frac{12481}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

We are indebted to Dr. Sunder Lal Hora for the following note on the habitat of the species:—

“Living specimens were found in the backwater of the Thumarkur nullah close to the railway bridge about three miles from Sorupeta on the Amingaon side, Assam. They were found on rotten twigs of trees which were floating in water or partly embedded in mud at the bottom. There was no vegetation except long grass near the shore. The water was quite clear and the bottom muddy.”

form **latior**, nov.

The shell of this form, which is closely allied to the typical *L. horae* differs in its thicker shell, broader body-whorl, shorter spire, and in the fact that it possesses slight traces of a columellar callus.

Dr. Hora obtained two specimens from near Amingaon in Assam and has furnished us with the following note on their habitat:—

“Living specimens were found attached to weeds in Jaulah Lake situated at a short distance from Amingaon. The lake is flooded every

year by the Brahmaputra. It is almost choked to the surface with water-weeds, and approaches to it from all sides are through marshy land covered with long elephant-grass. In most respects it is like the Loktak Lake in Manipur."

***Limnaea acuminata* Lamarck.**

We have already referred to the extreme variability of this species in certain circumstances and the question has been discussed by Annandale and Prashad elsewhere (*Rec. Ind. Mus.*, XXII, p. 568, 1921). Before attempting to differentiate the species from others or to separate its various forms we must say a little more on this point. In certain places there is extreme variability and a series of shells can be selected that includes representatives of the greater number of the forms here recognized. In other places, however, the species is much more stable and its shell-characters are, comparatively speaking, constant. We do not know why this is so. So far as our experience goes, the variability seems to be rather an inherent character of certain strains or family groups in the species than to be directly due to the effect of environment. Nevill probably had the same idea, for he gave the manuscript name "var. *variabilis*" to a large series of shells from Moradabad which exhibited this character in a superlative degree.

Apart from variability in the strict sense of the term true plasticity also apparently occurs. In certain places all the shells are very small. These places are either situated at rather high altitudes or else afford an environment in which succulent aquatic vegetation is scanty. Dwarfing is probably due, therefore, either to too cold a temperature or to scanty food supply, and may thus be regarded as a manifestation of the phenomenon of plasticity. One other character also occurs to be definitely correlated with environment, *viz.*, extreme thinness and pale colouration of shell, with which is associated a distinct malleation of the surface. Shells with these characters occur as a rule in running water amongst green filamentous algae.

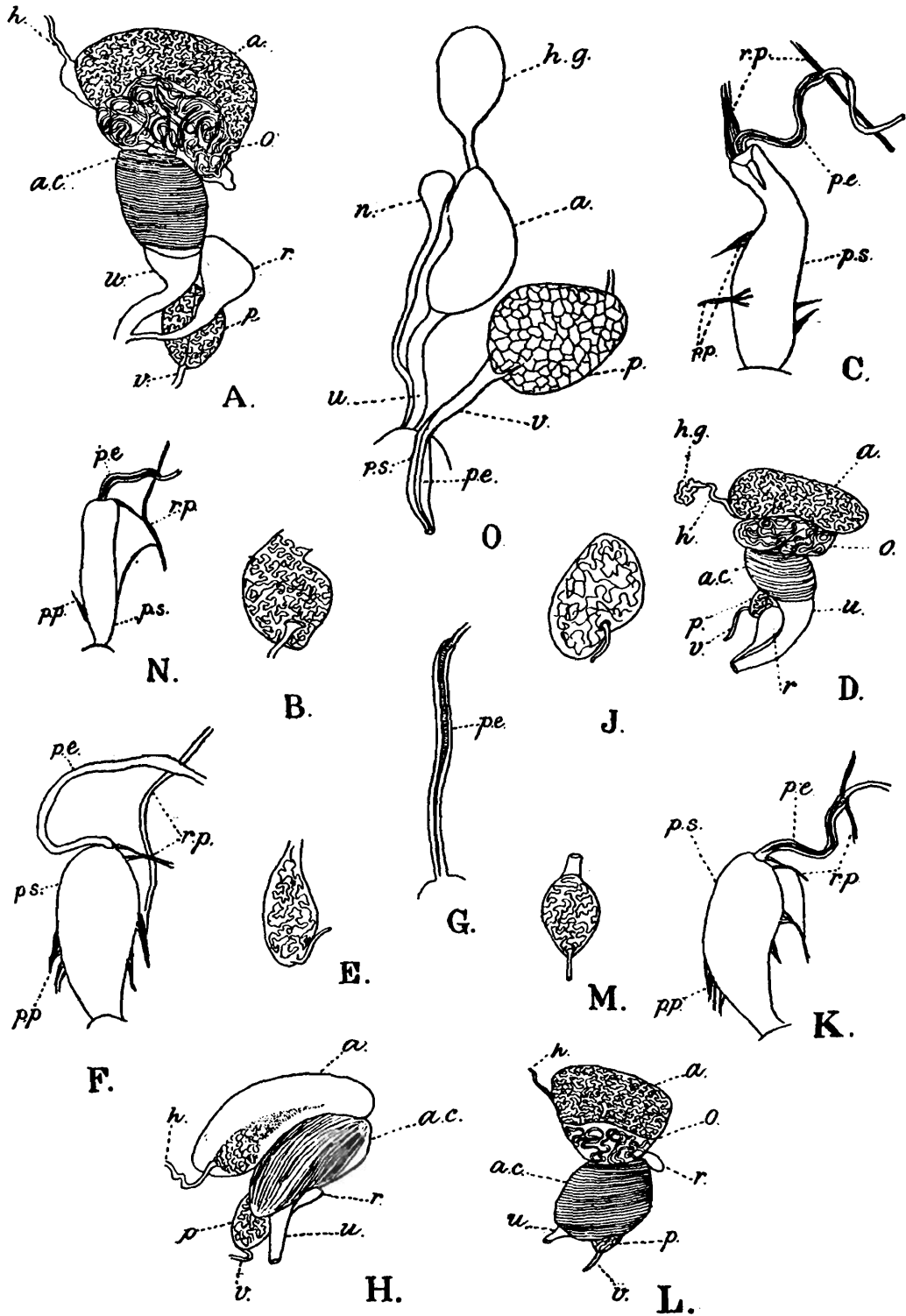
These are the only characters, however, that we can claim definitely as due to plasticity, though we may suspect that others are also present, and for the causation of the majority of our "forms" we can make no constructive suggestion. We must, therefore, leave them as mere forms, including under the term both extreme examples of variability (*e.g.*, f. *gracilior*) and authenticated examples of plasticity, as, for example, the mountain phase *hians*.

Geographical factors seem to have little, if any, significance in this species, but it is always rare in districts in which the differences between the dry and the wet seasons are extreme, probably because it lives, as a rule, in perennial pools and feeds mainly on succulent vegetation.

Although as a matter of convenience we treat these forms as distinct, we must make it quite clear that all of them grade into other forms and that we have found many shells which we cannot assign definitely to any one form rather than another.

The ultimate characters whereby the shell of *L. acuminata* can be distinguished from those of allied species are of a very subtle kind. We must rule out colour, size, thickness and even sculpture completely, as

all of these are liable to extreme variation, and even outlines must be considered with the greatest caution, as can be understood from a glance



XIV.—Genitalia of Limnaeidae.

- A, B, C. *L. laticallosa*.
- D, E, F, G. *L. peregra*.
- H, J, K. *L. persica*.
- L, M, N. *L. truncatula*.

- O. *L. horae*.
- B, E, J, M. ventral view of prostate gland. Lettering as in Fig. XIII.

at fig. III on p. 156. Practically all that remains, as a sure foundation for specific diagnosis, is the nature of the spiral course of the shell, the form of the outer lip and a number of negative characters which differentiates the species from certain others but not from its nearest allies. We may deal with the last first. The whorls are never tumid, and their upper

extremity is never flattened or truncate. The suture is never anything but linear. The body-whorl is never greatly inflated and the spire is rarely very short. The apex is never blunt. The sculpture is never very prominent, but the shell is never quite smooth. The mouth of the shell is never very oblique and always relatively high and narrow. So far as positive characters are concerned, the outer lip differs from that of the nearest ally of the species (*L. yunnanensis*) in that it is very little

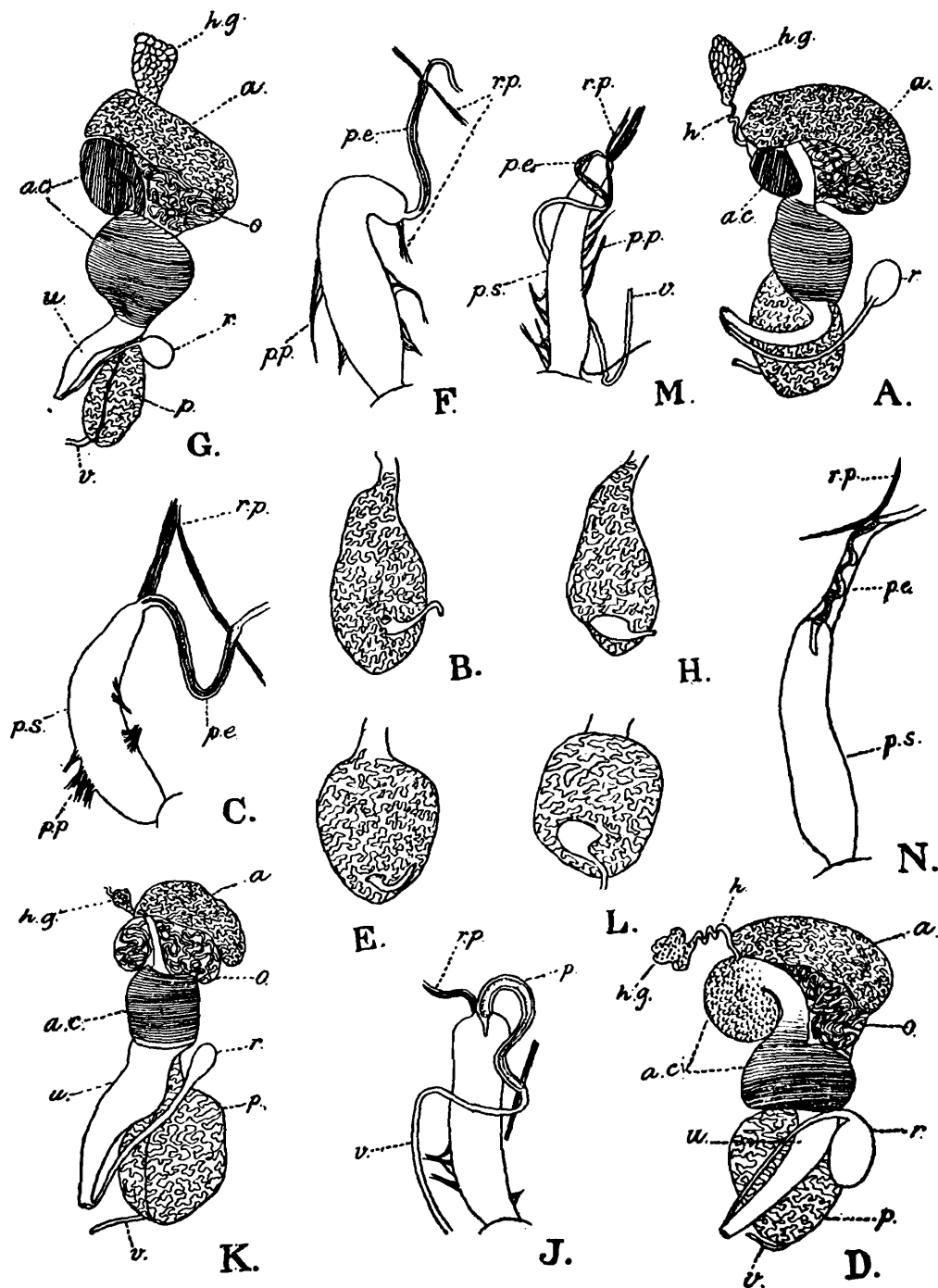


FIG. XV.—Genitalia of Limnaeidae.

A, B, C. *L. auricularia*.

D, E, F. *L. andersoniana* f. *typica*.

G, H, J. *L. acuminata* f. *typica*.

K, L, M, N. *L. luteola* f. *ovalis*.

B, E, H, L. Ventral view of prostate gland. Lettering as in Fig. XIII.

convex as a whole in lateral view in a ventrad direction. The lower part, however, may project a little in this direction. From other allied

forms the structure of the spire differs considerably. The suture is very oblique and roughly gyrate and the whorls are, as it were, very lightly wound together. The slope towards the apex is therefore gradual and even and the spire passes into the body-whorl gradually and without an abrupt step. The length of suture, moreover, seen in dorsal view just above the body-whorl is always considerably longer than the diameter of the base of the spire taken with the callipers at right angles to the main axis of the shell. In the great majority of shells there is a perceptible change in the direction of the suture, which turns upwards slightly on the outer part of its final gyration. The direct length of the spire is usually greater than the direct basal diameter.

The jaws and radulae closely resemble those of the European *L. peregra*, but the mandible is stouter and the teeth a little shorter and broader in proportion. The mandible is stout and as a rule almost semi-circular. Occasionally, however, it is sub-quadrate, the lateral extremities being obliquely truncate. The posterior margin is sinuate or nearly straight. The lateral pieces are short, tapering, slender and strongly curved.

The radular formula is variable, but there are usually about 20 marginals. The teeth are short and stout. The central is relatively large and its cusp is markedly asymmetrical. The laterals are normally tricuspid, with the mesocone large and with slightly sinuate and distinctly lanceolate outline. The entocone is situated considerably in front of the ectocone, which is rather small. All but the outer marginals have the free margin transverse with a large outer tooth and one or two outer denticulations near the base.

We have not found any constant difference in the jaws and radulae of the different species.

The genitalia conform to the type of the group. The penis-sheath seems to be longer and narrower than in *L. peregra* and the penis probably shorter. The duct of the spermatheca is also longer.

The range of this species is somewhat restricted by the fact that it always lives in bodies of water which are permanent throughout the year and contain abundant vegetation. It rarely leaves the water, but is occasionally found on the upper surface of water-lilies and similar plants. It feeds chiefly on soft vegetation and is particularly fond of the decaying leaves of *Limnanthemum* and water-lilies. On occasion it is cannibalistic and in captivity will feed on soaked bread.

form **typica** Lamarck.

1837. *Limnaeus amygdalum*, Troschel in Wiegmann's *Archiv. für. Naturg.*, III p. 168.
 1841. *Lymnea acuminata*, Delessert, *Recueil coquilles decrite par Lamarck*, pl. 30, figs. 6-A and B.
 1873. *Limnaea acuminata*, Sowerby in Reeve's *Con. Icon.*, sp. 66, pl. x.
 1876. *Limnaea acuminata*, Hanley and Theobald, *op. cit.*, p. 30, pl. lxxix, figs. 8, 9.
 1878. *Limnaeus acuminata*, Nevill, *op. cit.*, p. 233.
 1881. *Limnaea acuminata* var. *amygdalum*, Martens, *Conch. Mittheil.*, I, p. 76, pl. xiv, figs. 7, 8.
 1921. *Limnaea acuminata*, Annandale and Prashad, *op. cit.*, p. 568, fig. 12a and b.

In this form the shell is always fairly large and has a regularly ovate outline. The spire is short and broad. The colour of the shell is variable

and the sculpture consists of fine curved vertical lines without spiral lines or ridges or with sculpture of the kind very feebly developed.

We have examined specimens from the Punjab, United Provinces, Central Provinces, Chota Nagpur, Bengal and Assam.

form **patula** Troschel.

1837. *Limnaeus patulus*, Troschel, *op. cit.*, p. 167.

1881. *Limnaea acuminata* var. *patula*, Martens, *op. cit.*, p. 75, pl. xiv, figs. 1, 2.

1919. *Limnaea acuminata*, Annandale and Prashad, *Rec. Ind. Mus.*, XVI, p. 140, pl. v, fig. i.

This is a considerably narrower form of equal or greater size with a relatively much larger spire. The mouth of the shell is less expanded especially towards the anterior extremity.

We have examined specimens from Peshawar, the Kangra Valley, Rawalpindi, the Salt Range in the Punjab, Chota Nagpur, the Nepal valley in the Himalayas, Mysore, Hyderabad (Deccan), the Kurnool district of Madras, and Manipur in Assam.

form **chlamys** Benson.

1836. *Limnaea chlamys*, Benson, *Journ. As Soc. Bengal*, V, p. 744.

1876. *Limnaea chlamys*, Hanley and Theobald, *op. cit.*, p. 30, pl. 69, figs. 5, 6.

1919. *Limnaea chlamys*, Annandale and Prashad, *Rec. Ind. Mus.*, XVI, pp. 142, 143, fig. 4; pl. v, fig. 3.

This form is intermediate between f. *typica* and f. *patula*. The spire is, however, narrower than in either and the columella a little more twisted.

We have examined specimens from the Gurdaspur district of the Punjab, from Moradabad in the United Provinces, from the Dehing river in the extreme east of the Himalayas, and from Manipur in Assam.

form **rufescens** Gray.

1820. *Limnea rufescens*, Gray in Sowerby's *Genera of Shells*, I, *Limnea*, fig. 2.

1873. *Limnaea patula*, Sowerby in Reeve, *op. cit.*, pl. 2, sp. 10.

1876. *Limnaea rufescens*, Hanley and Theobald, *op. cit.*, p. 30, pl. 69, figs. 1-4.

This is a still narrower form than any other with which we have dealt and has a larger spire. The mouth of the shell is also relatively shorter and less expanded. The colour of the shell is not always redder than that of other forms.

We have examined specimens from Peshawar and Sind, Ghazipur in the United Provinces, Chota Nagpur, Bengal, Burma, the Andaman Islands, Colair Lake in the Kistna district of Madras and Secunderabad.

form **gracilior** Martens.

1873. *Limnaea rufescens*, Sowerby in Reeve, *op. cit.*, pl. 3, sp. 14.

1876. *Limnaea rufescens* var., Hanley and Theobald, *op. cit.*, p. 30, pl. 70, fig. 1.

1881. *Limnaea acuminata* var. *gracilior*, Martens, *op. cit.*, p. 77.

1921. *Limnaea acuminata*, Annandale and Prashad, *op. cit.*, p. 569, figs. 12g, h.

The extreme limit of narrowness of the shell in *L. acuminata* relative to size is reached in the form *gracilior*. The spire is relatively long and narrower than that of f. *rufescens*. The mouth of the shell is,

as a rule, still less expanded than that of the latter form. The sculpture is often inconspicuous, and the surface of the shell has a smooth appearance. The colour of the shell varies from a dull grey or cream to a light pink.

We have examined specimens from Calcutta and Raneeunge in Bengal, from the districts of Singbhum and Manbhum in Bihar and Orissa, the Ganjam district of Madras, Ghazipur and Moradabad in the United Provinces, and from Moulmein, Mandalay and the Northern Shan States in Burma.

form **hians** Sowerby.

1873. *Limnaea hians*, Sowerby in Reeve, *op. cit.*, sp. 57, pl. ix.

1886. *Limnaeus hians*, Clessin, Martini and Chemnitz's *Conch. Cab. Limnaecea* I, p. 392, pl. lv, fig. 9.

1915. *Limnaea (Gulnaria) hians*, Preston, *op. cit.*, p. 113.

This is the smallest of forms known to us in the species. It appears to be a curious dwarfed phase adapted to life in lakes and pools at high altitudes. In general form the shell approaches that of f. *patula*, but the mouth of the shell is, as a rule, never expanded. The spire is relatively high and narrow. The texture of the shell is somewhat variable, but the sculpture usually consists of very fine lines which become obsolete in some shells. A fine muddy deposit is often found on the outer surface of the shell while its inner surface is polished and sometimes tinted black or brown.

We have examined specimens from the Kangra Valley, Sialkot, in the Punjab, Bhim Tal in Kumaon, Dheri Jaba in the Salt range, Buldana in Berar, Secunderabad and in the lakes of the Nilgiri district in South India.

form **malleata**, nov.

As its name signifies the peculiarity of this form is in the texture of the shell, particularly in the region of the body-whorl. In shape the shell of this form approaches that of *patula* and is usually of small size. The body-whorl, except the outer lip, is marked by well-defined malleations in which the entire thickness of the shell takes part.

We have examined specimens from Peshawar, Wazirabad and Madhopur in the Punjab, and Manipur in Assam.

form **brevissima**, nov.

This form is closely related to the typical *L. acuminata* but differs in the spire being still further reduced with less than three whorls in the spire. This feature is apparently an abnormality.

We have examined specimens from Nagpur.

Limnaea biacuminata, sp. nov.

The shell of this species resembles that of *L. acuminata* f. *hians* in some respects, but is easily distinguished by its being strongly spindle-shaped, the anterior margin of the shell being pointed as well as the apex of the spire. The shell thus tapers towards both extremities. Its bilateral asymmetry is very great, the middle region of the outer

lip projecting considerably in a wide arc. Apart from the convexity thus produced the shell is narrow and elongate. The mouth is very large, ovate, almost symmetrical bilaterally, and in ventral view projects forwards much beyond the body-whorl. The columella is slightly twisted and has a broad fold, which extends forwards only to a point a little more than half way along the major axis of the mouth. It is joined to the upper lip above by a well developed callus. The umbilicus is completely occluded. The shell is thin and fragile. The sculpture consists of fairly strong curved longitudinal striae which are situated rather far apart and have a regular symmetrical character. The colour is very pale luteous.

The jaw and radula closely resemble those of *L. acuminata*, but the posterior margin of the mandible is nearly straight, only slightly convex and not at all sinuate.

Type-specimen.—M- $\frac{12466}{2}$ Zool. Surv. Ind. (*Ind. Mus.*).

We have examined specimens from the Hosainsagar tank between Secunderabad and Hyderabad and from Naini Tal, Kumaon.

The species seems to be a lacustrine form. We keep it specifically distinct from *L. acuminata* with some doubt, but the shape of the mouth of the shell seems to be both constant and characteristic.

***Limnaea luteola* Lamarck.**

1925. *Limnaea luteola*, Annandale and Rao, *op. cit.*, p. 106

The characters by which the shell of *L. luteola* is distinguished from those of related species are rather less elusive than in *L. acuminata*, but the chief feature in the shell which distinguishes it from that of *L. acuminata* lies in the structure of the spire and the form of the body-whorl. The negative characters in specific diagnosis enumerated under *L. acuminata* are applicable to *L. luteola* also.

The spire, is, as a rule, about one-third as high as the shell and consists of 4 or 5 gradually increasing transverse whorls which are never very convex. The suture which is always more or less transverse, and the length of which is never less than the height of the spire, affords the chief character of distinction between the two species. The mouth of the shell is usually narrow, ovate, evenly rounded anteriorly, and gradually narrowing towards its posterior extremity. The outer lip is never so expanded or so convex in outline as that of *L. acuminata*. The columellar callus is thin and broad, while its twist is short and less conspicuous. The texture and sculpture of the shell are variable in the different forms of the species.

The jaw and radula have the same characters as those of *L. acuminata*, the former being a little more variable than the latter.

In the genitalia the prostate differs from that of *L. acuminata* in being more or less regularly quadrate in outline.

This species is much less particular in its choice of a habitat than *L. acuminata* and is frequently found in bodies of water which dry up periodically. When this occurs it buries itself in the mud. It seems to obtain the greater part, if not the whole, of its nourishment from vegetable matter in mud and they may often be seen even in hot sunshine

outside the water, as a rule, on the mud. It is noteworthy that there should be so little difference between the radula and jaw of species so different in habits as *L. luteola* and *L. acuminata*.

form **typica** Lamarck.

1841. *Lymnaea luteola*, Delessert, *op. cit.*, pl. 30, figs. 5, A and B.

1881. *Limnaea tigrina*, Martens, *op. cit.*, p. 85, pl. xv, fig. 5.

In this form the shell is of fairly large to very large size. The body-whorl has a somewhat compressed form and the outer lip, the edge of which is often introverted above, is nearly straight for the greater part of its length. The spire is broad and short. It tapers gradually, and its suture is more oblique than in some forms. The shell is, as a rule, rather thick and almost smooth. Pale vertical stripes are sometimes present.

This form has a much wider distribution in the Indian Empire than the typical *L. acuminata*. We have examined specimens from Rawalpindi, Srinagar in Kashmir, the Punjab Salt Range, Kulu, Delhi, Naini Tal, Mussoorie, Pharping in Nepal, from Calcutta, Rajmahal, and Raneeunge in Bengal, from Manipur in Assam, from Ranchi and Manbhoom in the province of Bihar and Orissa, from Rangoon and the Andaman Islands, from Kallikote (Ganjam District), Kurnool, Secunderabad, Golconda, Madras, Travancore, Mysore, Kallar (Nilgiri District) in South India, from Salsette in Goa, and from Nagpur, Itarsi and Pachmarhi in the Central Provinces.

form **ovalis** Gray.

1820. *Limnea ovalis*, Gray in Sowerby, *op. cit.*, *Limnea*, fig. 4.

1876. *Limnaea ovalis*, Hanley and Theobald, *op. cit.*, p. 30, pl. lxx, figs. 2, 3.

1881. *Limnaea nucleus*, Martens, *op. cit.*, p. 82, pl. xv, figs. 8, 9.

Although the extreme form is very different from the forma *typica* the two intergrade to such an extent that it is often difficult to decide in individual shells to which they should be assigned. The form *ovalis* is always large and stout with the body-whorl typically much more inflated than in the *forma typica* and with the outer lip curved. The spire is smaller and more acuminate and tapers more abruptly. The suture is much more transverse.

We have examined specimens from the Kangra Valley, from Almora and Bareilly in the United Provinces, from Purneah in Bihar and Orissa, from Calcutta, Barrackpore, Rajshahi and Raneeunge in Bengal, from Manipur in Assam, from the Southern Shan States and the Andamans, from Rambha, Madras, Nellore, Pondicherry and Mysore in South India, and from Kamptee in the Central Provinces.

form **australis**, nov.

1876. *Limnaea pinguis*, Hanley and Theobald, *op. cit.*, p. 30, pl. lxx, figs. 7-10.

1915. *Limnaea (Gulnaria) pinguis*, Preston, *op. cit.*, p. 113.

This is a small form resembling the f. *typica* but with much narrower and a more elongate spire, with the suture more impressed and more sinuous and without any compression of the body-whorl. The shell is also thinner and, as a rule, more polished.

We have examined specimens from Rasalpole, Dharamsala, Ferozepore in the north-west of India, from Roorkee, Mirzapore and Moradabad in the United Provinces, from Puri, Ranchi, Chakradharpur and Chandbally in Bihar and Orissa, from Calcutta, Garia, and Chittagong in Bengal, from Gauhati in Assam, from Rambha, Kaligiri (Nellore District), Madras, Hosainsagar and Golconda (Hyderabad State), Trichinopoly, Travancore, Bangalore, Coimbatore and the Nilgiri district in South India, from Satara and Karachi in Bombay, from Nagpur and Buldana in the Central Provinces, and from Ceylon.

form **impura** Troschel.

1881. *Limnaea succinea* var. *impura*, Martens, *op. cit.*, p. 86, pl. xv, figs. 6, 7.

1919. *Limnaea acuminata* var. *nana*, Annandale and Prashad, *Rec. Ind. Mus.*, XVI, pp. 141-142, fig. 3, pl. iv, fig. 1; pl. v, fig. 2.

This is a still smaller form with rather narrower body-whorl, pyriform mouth and a thicker shell. The surface of the shell is feebly smooth and rather rough. It is usually covered with a black deposit. The colour is always pale.

We have examined specimens from Naukuchia in Kumaon, Dimapore in Assam, Kallikote, Rambha, and Barkuda in the Ganjam district, from Secunderabad, from the Malabar district, from Khandalla in Bombay, and from Rangoon.

form **succinea** Deshayes.

1834. *Limnaea succinea*, Deshayes, *Voy. dans. Ind. Belanger. Zool.*, p. 418, pl. ii, figs. 13, 14.

1862. *Limnaeus succineus*, Küster, *op. cit.*, p. 29, pl. v., figs. 18, 19.

1919. *Limnaea pinguis*, Annandale and Prashad, *op. cit.*, p. 144, fig. 5, pl. v, fig. 4.

This is a rather large very narrow form with a large tapering spire and a comparatively small mouth. The outer lip is arched. The shell is pale and thin. Its most characteristic feature is its sculpture, which includes very fine spiral striae as well as interrupted longitudinal striae. These give it a silky lustre which, doubtless, suggested its name.

We have examined specimens from Kashmir and Benares in Upper India, and from Hosainsagar, Bolarum (Hyderabad State), Godaveri, Kurnool, the Nilgiris and the Palni hills in South India.

form **siamensis** Sowerby.

1873. *Limnaea siamensis*, Sowerby in Reeve, *op. cit.*, p. 63, pl. x.

1915. *Limnaea (Gulnaria) siamensis*, Preston, *op. cit.*, p. 113.

1925. *Limnaea luteola* race *siamensis*, Annandale and Rao, *op. cit.*, p. 107.

This form seems to be almost in the nature of a local race representing the eastern type of the species. The shell is never large. It is easily distinguished by its narrow, ovate, almost symmetrical outline and by its relatively long auriculate mouth. The suture is not so impressed as in most forms of the species and the spire is relatively small. The texture of the shell varies considerably. In some localities it is very thin with the columellar callus poorly developed.

We have examined specimens from He-Ho, and the Inlé Lake in the Southern Shan States, and from Rangoon.

Limnaea ovalior Annandale and Prashad.

1921. *Limnaea ovalior*, Annandale and Prashad, *op. cit.*, pp. 572, 573, fig. 13, A, pl. vii, figs. 4-6.

The shell of this species, in spite of its resemblance to that of *L. luteola* f. *ovalis* in form, is easily distinguished from the latter by the size and form of the spire, by the structure of the columellar callus, and by the sculpture and colour.

The very regular and symmetrically ovate shape of the shell, the relatively short, blunt spire with its base nearly as broad as the upper part of the body-whorl, its height being only $\frac{1}{4}$ of that of the shell, the absence of angulation in the whorls of the spire, the broad and coarse columellar callus which extends very little below the body-whorl in ventral view, the peculiar sculpture and opaqueness of the shell are the chief distinguishing features of the species.

The jaw and radula are not unlike those of *L. luteola* f. *ovalis*.

In the genitalia the duct of the spermatheca in specimens examined is much shorter than that of the form *ovalis*.

The species is apparently confined to parts of Assam. We have examined specimens from Dimapore and the Manipur Valley.

The members of the species lead an almost amphibious existence in and on damp mud at the edge of small pools which are devoid of true aquatic vegetation, or in very foul water of jungle-pools. They appear to feed on mud and decaying vegetable matter.

Key to the living species of Limnaea known from the Indian Empire and its immediate frontiers.

1. Shell very small and delicate (less than 10 mm. high), narrow with the apex blunt.
 - A. Spire with 2 whorls; columellar callus present *L. mimetica.*
 - B. Spire with $2\frac{1}{2}$ whorls; columellar callus absent *L. horae.*
2. Shell never so delicate and usually more than 10 mm. high.
 - A. Spire scalariform or at least canalized at the base. Columellar fold not narrowed immediately below the umbilicus.
 - I. Spire at least moderately exerted, body-whorl not greatly expanded. *L. lagotis.*
 - II. Spire extremely short; body-whorl greatly inflated. *L. brevicauda.*
 - B. Spire never scalariform (except as an abnormality) or canalized at the base. Columellar fold varying in structure.
 - I. Spire with 5 complete whorls.
 - (a) Shell less than 20 mm. high, with the body-whorl not expanding outwards and the columellar callus exceptionally broad and coarse; the spire moderate. *L. laticallosa.*
 - (b) Shell usually much more than 20 mm. high, with the body-whorl expanding outwards and the columellar callus well but not exceptionally well developed; the spire exceptionally long and slender. *L. stagnalis.*

- II. Spire with not more than 4 complete whorls.
- (a) Shell with the columellar callus exceptionally well developed.
- (i) Whorls of spire increasing gradually in size; the basal whorl of the spire not twice as broad as the one above it.
- α. Body-whorl much longer than spire in dorsal view *L. andersoniana*.
- β. Body-whorl and spire subequal in dorsal view *L. iruncatula*.
- (ii) Basal whorl of spire more than twice as broad as the whorl above it.
- α. Suture impressed; umbilicus broadly rimate *L. bowelli*.
- β. Suture not impressed; umbilicus narrowly rimate *L. hookeri*.
- (b) Columellar callus not exceptionally well developed.
- (i) Spire very short, at least 3 times as broad at the base as high.
- α. Spire passing evenly into the body-whorl; shell almost bilaterally symmetrical in dorsal view *L. ovalior*.
- β. Spire very much narrower than upper margin of body-whorl, shell very asymmetrical bilaterally.
- A. Columellar fold narrowed abruptly below umbilicus *L. auricularia*.
- B. Columellar fold poorly developed, not narrowed below umbilicus *L. physcus*.
- (ii) Spire longer, much less than 3 times as broad at base as high.
- α. Shell small (less than 15 mm. high), with the mouth not at all dilated; (upper margins of whorls convex) *L. hordeum*.
- β. Shell more than 15 mm. high with the mouth more or less dilated.
- A. Length of suture seen in dorsal view at base of spire considerably greater than height of spire.
1. Height of mouth of shell at least $\frac{3}{4}$ of the total height *L. persica*.
2. Height of mouth of shell less than $\frac{3}{4}$ of the total height *L. shanensis*.
- B. Length of suture at base of spire not or hardly longer than height of spire.
1. Diameter of base of spire measured at right angles to main axis of shell considerably less than height of spire.
- (a) Anterior margin of mouth of shell broadly rounded or subtruncate *L. acuminata*.
- (b) Anterior margin of mouth of shell pointed *L. biacuminata*.
2. Diameter of base of spire not or hardly less than height of spire.
- (a) Outer lip of shell slightly dilated *L. luteola*.
- (b) Outer lip more dilated, at any rate below.
- I. Arc of lip quite regular; apex of shell sharply pointed *L. iranica*.
- II. Arc of lip irregular; apex bluntly pointed *L. gedrosiana*.

Table of measurements in millimeters.

Name of Species.	1				2				3			
	Height of shell.	Height of aperture.	Maximum breadth of shell.	Maximum breadth of aperture.	Height of shell.	Height of aperture.	Maximum breadth of shell.	Maximum breadth of aperture.	Height of shell.	Height of aperture.	Maximum breadth of shell.	Maximum breadth of aperture.
<i>Limnaea stagnalis</i>	47.7	27.0	23.7	15.3	45.1	26.9	24.3	14.8	40.2	25.5	24.5	18.0
<i>L. stagnalis</i> form <i>kashmiriensis</i>	54.0	28.0	28.0	19.4	52.0	33.0	27.0	19.0	48.0	28.0	25.0	17.0
<i>L.</i> „ f. <i>minor</i>	34.0	21.0	18.2	12.0	32.0	18.5	16.2	10.4	30.0	17.0	16.0	11.2
<i>L. persica</i>	13.3	11.1	10.0	7.0	14.4	12.4	11.0	8.9	8.8	7.2	6.3	4.5
<i>L. lagotis</i> f. <i>striata</i>	17.0	13.9	13.8	9.1	19.2	16.7	14.8	9.7	13.0	10.0	9.8	7.1
<i>L.</i> „ f. <i>costulata</i>	17.5	12.8	11.7	8.0	14.5	10.7	10.2	6.3	10.5	7.4	7.1	4.5
<i>L.</i> „ f. <i>solidissima</i>	22.0	18.1	17.2	10.0	21.4	15.1	14.4	8.3	19.2	13.9	12.5	8.1
<i>L.</i> „ f. <i>subdisjuncta</i>	12.7	8.6	8.5	5.0	12.2	8.5	8.2	5.5	10.5	6.2	6.7	4.0
<i>L.</i> „ f. <i>bactriana</i>	17.7	12.2	11.7	7.0	10.0	6.8	6.7	4.1	7.5	5.1	4.5	2.5
<i>L.</i> „ f. <i>defilippii</i>	17.8	11.5	10.4	5.9	17.3	12.5	10.5	6.8	14.8	10.5	9.3	6.0
<i>L. brevicauda</i>	17.8	14.9	14.8	10.0	14.8	12.5	12.4	8.5	15.1	11.7	11.9	7.7
<i>L. auricularia</i>	17.9	14.7	14.0	8.5	23.5	19.3	17.5	11.2	10.5	9.4	8.7	5.5
<i>L. truncatula</i>	8.8	4.2	5.0	2.0	10.6	5.4	5.6	2.5	7.8	3.4	4.4	2.0
<i>L. andersoniana</i> f. <i>typica</i>	7.5	5.2	4.6	2.7	7.0	4.6	4.3	2.4	6.3	4.2	3.9	2.3
<i>L.</i> „ f. <i>simulans</i>	9.0	5.5	5.7	3.2	11.2	6.7	6.7	3.7	9.8	6.0	6.2	3.4
<i>L.</i> „ f. <i>turbinicola</i>	11.5	7.5	6.3	3.5	..	..	..	..	..	..	..	..
<i>L.</i> „ f. <i>intermedia</i>	6.8	4.4	4.3	2.0	7.3	4.5	4.3	2.5	5.4	3.2	3.8	2.2
<i>L. hookeri</i>	8.9	6.5	5.5	3.6	8.4	6.3	5.6	3.7	11.4	7.8	7.6	4.5
<i>L. bowelli</i>	8.8	5.7	5.7	3.3	15.3	10.1	10.9	6.2	12.7	7.9	8.6	5.0
<i>L. hordeum</i>	6.1	3.7	3.4	2.0	4.8	2.6	2.4	1.4	3.6	2.1	1.9	1.0
<i>L. laticallosa</i>	15.7	9.7	8.4	4.9	15.2	10.1	8.8	5.3	15.0	9.2	8.0	4.7
<i>L. iranica</i>	18.4	14.2	11.4	8.0	15.4	11.9	9.5	6.5	14.2	10.7	8.3	5.5
<i>L. gedrosiana</i>	11.5	9.0	7.1	5.0	9.3	7.1	6.0	4.2	8.4	6.4	4.8	3.3
<i>L.</i> „ f. <i>rectilabrum</i>	10.8	7.4	6.4	3.8	15.4	11.7	10.8	7.5	14.8	10.8	9.0	6.5

<i>L. shanensis</i>	11.1	7.9	7.6	5.3	9.9	6.9	6.2	4.0	9.4	6.5	5.0	3.5
" <i>f. superstes</i>	10.1	7.5	5.4	4.2	7.6	5.1	4.2	2.8	..	..	..	..
<i>L. " f. hehoensis</i>	7.3	5.4	4.6	2.9	6.6	5.3	3.9	3.0	6.1	5.0	3.7	2.8
<i>L. physcus</i>	8.4	7.2	6.5	4.2	9.1	8.0	6.0	3.7	..	..	..	..
<i>L. mimetica</i>	7.0	5.1	3.5	2.8	5.6	4.5	2.9	2.3	4.9	3.7	2.5	2.0
<i>L. horae</i>	6.0	4.3	3.0	2.4	5.4	3.6	2.9	2.0	..	..	..	..
<i>L. " f. latior</i>	4.9	3.7	3.0	2.0	..	..	..	..	..	..	..	..
<i>L. acuminata f. typica</i>	38.2	29.9	22.4	14.7	25.6	20.5	16.6	11.0	18.6	15.5	13.0	9.2
<i>L. " f. patula</i>	31.8	24.0	17.9	12.5	28.7	20.9	15.5	10.3	22.7	17.0	12.9	9.0
<i>L. " f. chlamys</i>	32.6	28.5	20.9	16.0	26.4	20.7	16.4	12.5	17.8	13.3	11.6	8.5
<i>L. " f. rufescens</i>	38.7	29.2	19.7	14.0	37.1	27.1	18.0	13.8	24.9	17.3	11.2	7.5
<i>L. " f. gracilior</i>	28.4	18.8	12.0	9.5	26.5	17.6	11.5	8.0	24.5	16.8	9.6	7.2
<i>L. " f. hians</i>	13.3	9.6	7.4	5.0	11.7	8.1	6.3	4.2	11.3	8.0	5.5	3.7
<i>L. " f. malleata</i>	17.4	13.0	9.4	6.8	19.4	15.0	11.0	8.2	18.3	13.7	11.3	8.0
<i>L. " f. brevissima</i>	16.9	14.2	11.1	8.2	17.0	13.8	11.0	7.5	..	..	..	..
<i>L. biacuminata</i>	18.2	14.2	10.1	7.6	15.0	11.0	7.8	5.7	13.9	10.6	7.3	5.5
<i>L. luteola f. typica</i>	28.5	20.3	16.8	10.3	24.4	16.1	13.0	9.2	18.1	13.8	11.3	6.8
<i>L. " f. ovalis</i>	20.0	15.2	13.6	8.0	18.7	12.7	11.6	6.5	12.8	9.4	8.6	5.0
<i>L. " f. australis</i>	20.0	13.0	11.9	7.0	12.0	9.0	7.7	5.0	11.2	7.7	7.0	4.4
<i>L. " f. impura</i>	19.3	13.5	10.9	7.3	14.8	11.0	10.2	6.5	8.8	6.1	5.3	3.5
<i>L. " f. succinea</i>	21.3	13.8	11.0	7.0	19.9	15.4	12.8	8.4	16.3	11.6	9.5	6.4
<i>L. " f. siamensis</i>	16.4	11.0	9.5	6.1	15.1	11.1	9.7	6.5	10.5	7.7	6.6	4.5
<i>L. ovalior</i>	17.9	13.9	12.4	7.8	17.6	12.5	11.8	7.0	13.9	10.8	9.7	6.0