NOTES ON LAMELLIBRANCHS IN THE INDIAN MUSEUM.

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6. INDIAN SPECIES OF THE GENUS *PISIDIUM.*

(Plates VII, VIII.)

The Indian species of the genus *Pisidium*, as was stated by me elsewhere,[1] are very imperfectly known. The original descriptions of the species are very scanty and inaccurate, while the published figures of the various species owing to their small size are of no value. Owing to a number of types of the Indian species being in the British Museum (Natural History), South Kensington, London, I was not able to deal with this genus till I had examined the types myself. The opportunity came in 1922, when I examined the type-specimens in the British Museum, and I have here to express my sincere thanks to Mr. G. C. Robson, for the facilities given and for getting photographs of the types prepared for me. Owing to pressure of other work the publication of the results has been delayed. I was further hoping to be able to deal with the anatomy of all the Indian species at the same time, but unfortunately it has not been possible to get spirit material of all the species and only in the case of three of the species I am able to add some notes on their anatomy.

I have in the course of my studies on this genus had the advantage of the help of Mr. A. W Stelfox of the Natural History Museum, Dublin, who carefully went over the greater part of the Indian material with me, gave me all facilities for examining his extensive collection of European Pisidia and helped me in elucidating various difficult points. For all this I owe him my hearty thanks.

Dr. A. Weber, Custodian of the mollusc collections in the Munich Museum, was kind enough to send me the type-specimen of his species (*P. zugmayeri*) for examination, and informed me that the bivalve was collected from the Pangkong Lake, Tibet, and not from the Wular Lake in Kashmir, as is stated in his paper.[2]

The first reference to any Indian species of the genus is by Benson, who distributed specimens labelled *Pisidium parvulum* from India. This species is referred to by Prime[3] and Hanley & Theobald[4] but is nothing more than a manuscript name of a species which was neither described nor figured. G. & H. Nevill described the species *P. clarckeanum*

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[1] Prashad, *Rec. Ind. Mus.* XXII, p. 618 (1921).

[2] Weber, *Zool. Jahrb.* (*Syst. Geogr. & Biol.*) XXIX, p. 310 (1910). In the summary at the end of the paper Weber has given the correct locality for the species.

[3] Prime, *Cat. Corbiculidae* p. 17 (1863), also see Prime, *Amer. Journ. Conch.* V, p. 171 (1870).

[4] Hanley & Theobald, *Conch. Ind.* p. 63 (1876).

in 1871[1] from Moisrakha, Bengal. Theobald in 1876[2] described *P. bombayanum*, *P. nevillianum* and *P. atkinsonianum* from various parts of India. Of these *P. bombayanum*, as is shown further on, is synonymous with *P. clarckeanum*. In the same year Theobald in his "Catalogue of Land and Freshwater shells"[3] gave a list of the known Indian species, and included in it a species, *P. stoliczkanum*, from Port Canning, Bengal. This species according to the author is described in "*P. A. S. B.* 1875." No such species was, however, described by the author and the nam emust be considered as a *nomen nudum*. In 1878[4] he described a species from Kashmir under the name *P. hydaspicola*. Preston in his volume[5] in the "Fauna of British India" gave a complete list of all the species, but wrongly included the two Tibetan species *P. stewarti* Preston and *P. zugmayeri* Weber in the list of the Indian species.

Excluding the two Tibetan species mentioned above, we have four species, *P. clarckeanum*, *P. nevillianum*, *P. atkinsonianum* and *P. hydaspicola*. In addition I have found it necessary to describe two new species, one from Paresnath Hill, Bihar, under the name *P. annandalei* and the other from Manasbal Lake, Kashmir, as *P. mitchelli*.

Geographical Distribution:—*P. clarckeanum* G. & H. Nevill is the common species found in various parts of India and Burma in the plains. It is common in tanks, lakes and streams. *P. nevillianum* was found at Rurki, United Provinces, and also appears to be a still-water form. *P. atkinsonianum* is common at altitudes of 5,000-10,000 ft. in the Eastern Himalayas in ponds or small streams. *P. annandalei* was found in a small stream on Paresnath Hill, Bihar, at an altitude of 4,000 ft. *P. hydaspicola* and *P. mitchelli* are both confined to Kashmir, the former occurs in small streams or ponds all over the valley at different altitudes, while the latter was found in Manasbal Lake at an altitude of *ca.* 5,000 ft. above sea-level.

I have followed Mr. B. B. Woodward in the method of describing the species and have to acknowledge here my indebtedness to his valuable work.

The illustrations accompanying this paper were prepared by the artists of the Zoological Survey of India and I have to express my thanks to them for the extreme care they have taken in their preparation.

As has been discussed by Woodward in detail the earlier divisions of the genus into groups on shell-characters as attempted by Clessin,[6] Westerlund,[7] and Dall[8] are not tenable. Odhner[9] has recently, on anatomical grounds, divided the genus *Pisidium* into two subgenera, *Eupisidium* and *Neopisidium*. These two subgenera seem to be well founded, but a great deal of work on the genus still remains to be done.

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[1] G. & H. Nevill, *Journ. As. Soc. Bengal* XL, pt. ii, p. 9, pl. i, figs. 4, 4a-d (1871).
[2] Theobald, *Journ. As. Soc. Bengal* XLV, pt. ii, pp. 188, 189 (1876).
[3] Theobald, *Cat. Land Freshw. Moll.* p. 45 (1876).
[4] Theobald, *Journ. As. Soc. Bengal* XLVII, p. 147 (1878).
[5] Preston, *Faun. Brit. Ind. Freshw. Moll.* pp. 224-228 (1915).
[6] Clessin in Martini & Chemn. *Conch.-Cab.* Cycladeen, pp. 7, 8 (1874).
[7] Westerlund, *Faun. pal. Reg. Binen-Conch.* VII, pp. 18, 19 (1890).
[8] Dall, *Proc. Biol. Soc. Washington*, XVI, pp. 5-8 (1903).
[9] Odhner, *Journ. Conch.* XVI, p. 222 (1921).

Pisidium Pfeiffer.

1913. *Pisidium*, Woodward, *Cat. Brit. Pisidium*, p. 2.
1915. *Pisidium*, Preston, *Faun. Brit. Ind. Freshw. Moll.* p. 224.

Woodward, in the work cited above, has gone into the question of the validity of the name *Pisidium* very fully, and has given full references regarding its synonymy and discussed the various unsuccessful attempts at subgeneric division of the genus by different authors before his time. He has also given an amended description of the genus which I quote below :—

" Shell close, ovoid to orbicular, equivalve, inequilateral, posterior side the shorter, more or less concentrically striate, thin, with olive-horny periostracum, sometimes, especially in young individuals and certain species, sparsely covered with short hairs ; umbones sometimes prominent, sometimes tumidly obtuse, nepionic shell usually smooth ; ligament subexternal ; hinge formula :

R. V. *a. I* : *a. III*	: *c. 3* :	*l*	*p. III* : *p. I*[1]
L. V. : *a. II* :	*c. 2* : *c. 4*		: *p. II* :

A change in this definition is necessitated by the discovery, made independently, by Odhner[2] and Stelfox according to which the shell of *Pisidium* is porous and not hairy and the so-called hairs are fine thread-like prolongations from the pallial epithelium " which penetrate mostly perpendicularly, into the calcareous layer of the shell but not into its cuticle."

Of the six Indian species of the genus *Pisidium* mentioned above, *P. nevillianum*, *P. annandalei* and *P. mitchelli* are only represented by dried shells and I have not been able to examine their soft parts. Of *P. hydaspicola* only a half-dried specimen was available, but this was fortunately sufficient for deciding the exact subgeneric position of the species. The East-Himalayan species *P. atkinsonianum* was represented by a few specimens preserved in spirit, but the material was in rather a poor state of preservation and I have not been able to elucidate the various anatomical features in detail. *P. clarckeanum* is fairly abundant in the Calcutta tanks and I am therefore able to deal with its anatomy fairly fully. I have also examined animals of the species from other parts of India.

As a result of my anatomical studies I find that *P. clarckeanum* belongs to the subgenus *Neopisidium* Odhner. *P. nevillianum* which is closely allied to it also probably belongs to this subgenus. *P. hydaspicola* and *P. atkinsonianum* are both to be referred to *Eupisidium* Odhner, and probably *P. mitchelli* also will have to be placed with them. It is not possible, however, to be certain about *P. annandalei*. As noted further on it is allied to the Tibetan *P. stewarti* Preston, but the animals of both the species are unknown.

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[1] The hinge formula is after Bernard, *Bull. Soc. Geol. France* (3) XXIII-XXV (1895-97). The contractions employed are :—*R. V.* Right Valve ; *L. V.* Left Valve ; *a.* anterior lateral teeth ; *p.* posterior lateral teeth ; *c.* cardinal teeth ; *l.* ligament.

[2] Odhner, *Journ. Conch.* XVI, pp. 219, 220 (1921).

Pisidium clarckeanum G. & H. Nevill.

1871. *Pisidium clarckeanum*, G. & H. Nevill, *Journ. As. Soc. Bengal*, XL, pt. ii, p. 9, pl. i, figs. 4, 4a-d.
1876. *Pisidium Clarkeanum* and *P. Clarkeanum*, Hanley & Theobald, *Conch. Ind.* p. v and p. 63, pl. clv, fig. 10.
1876. *Pisidium Bombayanum*, Theobald, *Journ. As. Soc. Bengal*, XLV, pt. ii, p. 188.
1876. *Pisidium clarckeanum* and *P. Bombayanum*, Theobald, *Cat. Land & Freshw. Moll.* p. 45.
1915. *Pisidium clarckeanum* and *P. bombayanum*, Preston, *Faun. Brit. Ind. Freshw. Moll.* pp. 225, 226, fig. 28, 1-3.
1918. *Pisidium casertanum* (Annandale *nec* Poli), Annandale, *Rec. Ind. Mus.* XIV, p. 142, pl. xix, figs. 13, 14.
1921. *Pisidium clarckeanum* and *P. hydaspicola* (Prashad *nec* Theobald), Prashad, *Rec. Ind. Mus.* XXII, p. 618.

As was pointed out by Theobald in the note under his description of *P. bombayanum* (*loc. cit.*) and as has been noted by me already, the brothers Nevill in their description of *P. clarckeanum* inadvertently described the posterior as the anterior side. In my notes on the species (*loc. cit.*) I was not able to say anything about Theobald's *P. bombayanum* as the type of the species was not available to me in Calcutta. I have since examined the type of *P. bombayanum* in the British Museum, London, and find that it is only a young shell of *P. clarckeanum.*

As the original description of the species is very short the species is redescribed below.

Shell (Pl. VII, figs. 1, 1*a*, 2) of a fair size, moderately thick, very oblique, greatly inflated ; superior margin greatly curved ; superior anterior slope distinct, somewhat curved ; anterior end broadly rounded, situated a little above the middle, inferior margin only slightly curved ; posterior broadly truncate ; umbo situated posteriorly, prominent, swollen, and greatly projecting over the hinge ; surface pale yellow, somewhat shining, with regular closely situated striae on the surface, much closer on the body than on the umbonal region.

Hinge (Pl. VII, fig. 1*a* ; pl. VIII, fig. 1) more than $\frac{3}{4}$ the length of the shell, fairly broad and projecting well inwards, arched, with two distinct flexures in both the valves, better marked in right than in the left.

R. V. *a. I.* a little more than $\frac{1}{3}$ the length of the hinge-line, very strong, somewhat curved and inclined inwards, *base* very strong, swollen ; *apex* on distal side of centre, not very prominent, somewhat rounded, obtuse ; *ridges* rather blunt, distal fairly steep, umbonal curved and descending to a much lower level than the distal.

a. III. about $\frac{1}{3}$ the length of and lying parallel to the distal ridge of *a. I.* ; straight, narrow, erect, linear, without a well marked apex, rather sharp.

c. 3. prominent, sharply flexed and deeply notched underneath the umbo ; *a* short, slightly curved, sharp, higher towards the middle, running downwards and forwards from the umbo across the hinge-plate, and not reaching the margin ; *b* running downwards and backwards from the umbo to beyond the margin of the hinge-plate, swollen at the base and somewhat pyriform.

p. I. about ¼ the length of the hinge-line, narrower than *a. I.*, strong, slightly bent inwards ; *base* thick, shelving into shell-wall ; *apex* near distal end, obtuse ; *ridges* rather rounded, distal short, descending to a lower level than the umbonal.

p. III. about ½ the length of *p. I.*, curved inwards and merging into the umbonal ridge of *p. I.*, without distinct apex, ridge-like, sharp.

L. V. *a. II.* about ½ the length of the hinge-line, narrow, bowed inwards in the umbonal region and outwards in the distal ; *base* thick, merging into the shell-wall ; *apex* on distal side of centre and bent upwards with the distal ridge curved below it, and continued outwards along a short distance ; umbonal ridge fairly high near the apex, then curving sharply inwards to below the umbo.

c. 2. prominent, sharp, somewhat curved, marked off from the hinge-plate by a low depression ; *base* parallel to hinge-plate and continuous with *a. II.*; *apex* rounded and directed inwards.

c. 4. lamelliform, sharp, slanting, parallel to the posterior margin of *c. 2.*

p. II. less than ⅓ the length of the hinge-line, broad, rather thin, bowing outwards ; *base* very strong, shelving into the shell-wall ; *apex* prominent, curving upwards and outwards near the distal end, obtuse, sharp ; *ridges* rather thick, umbonal sloping gradually, distal somewhat curved.

Ligament prominent, thick, of a brownish colour ; ligament pit narrow, about ⅓ the width of the hinge-plate.

Measurements (*in millimetres*).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Length	5·6	5·4	4·7	4·5	3·6	3	3·5	5	5·6	3·7	5·2	4·5	3·4	3·2	3·7	3·5	3·8	4
Altitude	4·7	4·5	4·2	4	3·2	2·6	3·1	4·1	4·7	3	4·4	4·2	3	2·9	3	3	3·2	3·4
Thickness	3·6	3·4	3·0	2·7	2·1	2	2·1	3·2	3·5	2·2	3	3·1	2·1	2	2·2	1·8	2·2	2·4

Specimens 1, 2 type and cotype from Moisrakha ; 3-5 also from Moisrakha ; 6-9 from Calcutta tanks, Bengal ; 10 from Bhagalpur, Bihar ; 11, 12 from Rurki, United Provinces ; 13, 14 from the environment of Bombay ; 15 from He-Hó plain ; 16 from Inlé Lake ; 17, 18 from Maymyo, Burma.

Type-specimen. No. M.$\frac{12531}{2}$ in the collections of the Zoological Survey of India (*Indian Museum*), Calcutta.

Distribution :—This is the most widely distributed of the Indian species of the genus. The type-shells were collected from tanks at Moisrakha on the banks of the Damodar river in Bengal. I have examined specimens from Hazrapur, Calcutta, Chittagong, Bengal ; Bhagalpur, Bihar ; Rurki, United Provinces ; environments of Bombay, Bombay Presidency, and Maymyo, He-Hó plain, Inlé Lake, Burma. It is the common species in Calcutta tanks.

Remarks :—Theobald's *P. bombayanum*, as already stated, is based on young shells of this species. Annandale identified shells from He-Hó plain and the Inlé Lake, Southern Shan States, after comparison with specimens from Lake Biwa, Japan, as *P. casertanum*. I have carefully compared these shells with large numbers of specimens of *P. clarckeanum* and I am of opinion that the Burmese specimens are *P. clarckeanum* and not *P. casertanum*. In my paper cited above, I had identified some shells from streams in Manipur Valley as *P. hydaspicola* Theobald. In the same paper I referred to a young depauperated shell in the collections of the Indian Museum from Bhagalpur, Bihar, to the same species. As a result of more detailed study of all these shells and of the type-shell of Theobald's *P. hydaspicola*, I am now of opinion that they are all *P. clarckeanum*.

In shape and outline *P. clarckeanum* resembles the European *P. subtruncatum* Malm, but the hinge and other characters are more like those of *P. casertanum* (Poli). It is distinguished from the latter by the shape of its shell, its more elongate anterior end, the more prominent umbones, the more strongly developed hinge and differences in the form of the various teeth and sculpture.

The soft parts, however, are quite different, for *P. casertanum* according to a casual reference to this species by Odhner[1] is a *Eupisidium*, while the characters of the soft parts of *P. clarckeanum* are essentially those of a *Neopisidium*.

The soft parts of *P. clarckeanum* as noted above place it in the subgenus *Neopisidium*. These characters are (i) a single gill on each side, (ii) a single siphon, and (iii) the simple organisation of the nephridium. The animal is described in detail below.

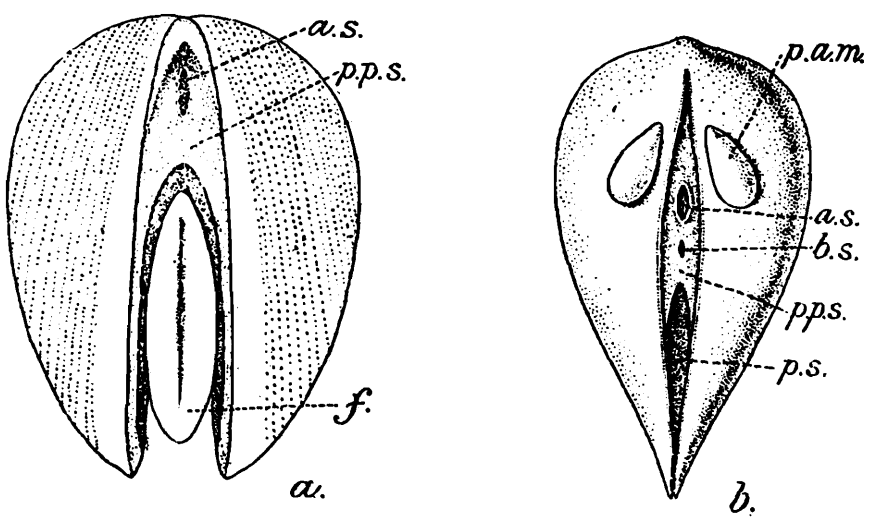

FIG. 1.—Animals of Indian Pisidia seen from the posterior side. In fig. *b*. the shell is removed to show the position of the posterior adductor muscle.
a. *P. clarckeanum* G. & H. Nevill.
b. *P. atkinsonianum* Theobald.
a. *s*. anal slit ; *b*. *s*. branchial slit ; foot ; *p*. *a*. *m*. posterior adductor muscle ; *p*. *p*. *s*. post-padal suture ; *p s*. pedal slit.

Mantle :—The mantle of *P. clarckeanum* resembles that of *P. clessini* and *P. torquatum* described by Odhner. There is a long pedal slit (text-fig. 1*a* and pl. VIII, fig. 2) extending from somewhat below the posterior

[1] Odhner, *Proc. Malacol. Soc. London*, XV, p. 161 (1923).

adductor muscle posteriorly to slightly below the anterior adductor muscle on the anterior side. The post-pedal suture is short, about as high as the posterior adductor muscle, and is about 1½ times the size of the anal slit. There is no separate branchial slit.

Gill :—As has been noted already in *P. clarckeanum* there is only a single gill on each side. This gill of each side, as Odhner has shown, represents the inner gill of other Eulamellibranchs and corresponds to the anterior of the two gills of the members of the subgenus *Eupisidium*. It (Pl. VIII, fig. 3) consists mainly of the outer lamella with a very short reflected lamella only along a limited extent of the gill. The uppermost filament of the gill forms the axis along which the gill is attached to the body as in all Pisidia. The next 10-11 filaments run straight and their ends are not recurved inwards and upwards. Of these the first 4-5 filaments become attached to the body surface. The next filament, as shown in fig. 3, pl. VIII, are recurved upwards and inwards, but the recurved lamella is very narrow being not more than one-third of the total height of the filament. The posterior 10-11 filaments are again nearly straight. Of these the last 4-5 of each side unite behind the foot with those of the opposite side to form the interbranchial septum and the marginal blood vessel runs through it. Inter-filamentor junctions are present between the filaments at equal distances ; I was able to count 10 of them in one preparation.

Nephridium :—The nephridium lies near the posterior adductor muscle and is slightly more complex than that of *P. clessini* described by Odhner. The pericardial branch starts with the ciliated funnel and after

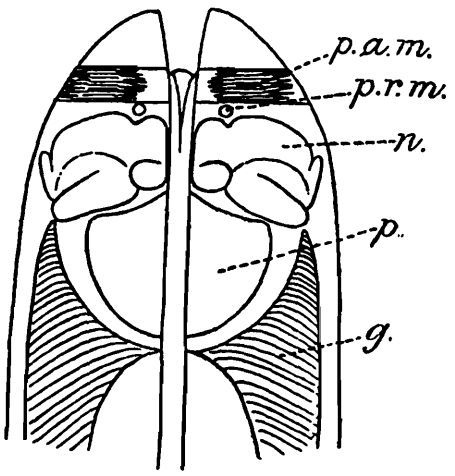

FIG. 2.—Posterior half of the animal of *P. clarckeanum* G. & H. Nevill seen from above. *g.* gill ; *n.* nephridium seen through the mantle ; *p.* pericardial region ; *p. a. m.* posterior adductor muscle ; *p. r. m.* posterior retractor muscle.

a short course backwards turns forwards and upwards. From this place it curves backwards to near the posterior adductor muscle and then curves up to form the big dorsal pouch which curves backwards and downwards and crossing over the pericardial lobe broadens into the terminal pouch to open near the ciliated opening. The dorsal lobe has a distinct fissure.

Stomach :—As is shown in the outline drawing of the anterior part of the alimentary canal (text-fig. 3), the stomach of *P. clarckeanum* resembles that of *P. clessini*. It has no posterior caecum, but the left

anterior caecum is well developed. The duodenum forms a double coil in front of the stomach and the intestine runs over the stomach on the right side.

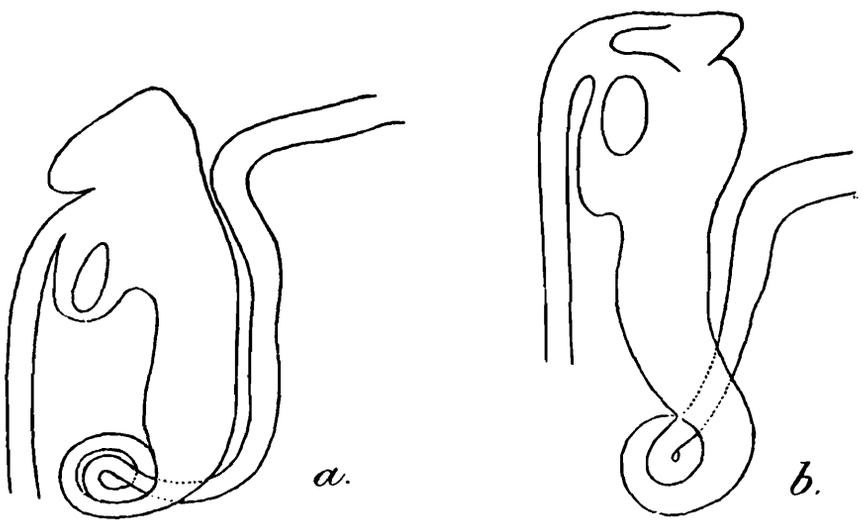

FIG. 3.—Stomach and a part of the alimentary canal of Indian Pisidia.
a. P. clarckeanum G. & H. Nevill.
b. P. atkinsonianum Theobald.

In other particulars the anatomy of this species is similar to that of *P. obtusale* described by Odhner.[1]

Pisidium nevillianum Theobald.

1876. *Pisidium Nevillianum*, Theobald, *Journ. As. Soc. Bengal*, XLV, p. 188.
1876. *Pisidium Nevillianum*, Theobald, *Cat. Land Freshw. Shells*, p. 45.
1915. *Pisidium nevillianum*, Preston, *Faun. Brit. Ind. Freshw. Moll.* p. 227.

Theobald's description of *P. nevillianum* in Latin is very brief and quite insufficient for the recognition of this interesting form. The species has not been figured so far. It was described from a unique type-specimen now in the collection of the Zoological Survey of India (Indian Museum, Calcutta). I give below a detailed description and figure of the type-specimen.

Shell (Pl. VII, figs. 3, 4) large, trigonal, rather tumid, thin and porcellaneous ; striae all over, very distinctly marked, very regular, umbonal region with much stronger and closely placed striae umbones prominent, round, without appendiculae, placed behind the middle towards the posterior end ; dorsal margin sloping regularly and equally on both sides of the umbo, passing gradually into the posterior margin, while there is a more or less well-marked notch between the anterior margin of the umbo and that of the shell ; anterior margin subrostrate, elongately rounded ; posterior margin somewhat convex, broadly rounded ; ventral margin arcuate.

Hinge (Pl. VII, fig. 3*a* ; pl. VIII, fig. 4) nearly $\frac{4}{5}$ of the length of the shell ; much thickened with the inner lateral teeth strongly developed,

[1] Odhner, *Naturw. Unters. Sarekgeb. Schwed.-Lappland* gel. von. Dr. A. Hamberg, IV, pp. 162-165, pl. ii (1908.)

and the inner hinge-plate greatly arched with two distinct flexures in the right valve, flexures less distinct in the left valve.

R. V. *a. I.* more than $\frac{1}{3}$ the length of hinge-line, stout, gradually curving inwards; *base* deep, solid, greatly swollen; *apex* further from centre, somewhat rounded, obtuse; *ridges* moderately rounded, umbonal sloping gradually, distal suddenly sloping down and somewhat arched outwards.

a. III. more than half the length of *a. I.*, from which it is separated by a deep notch anteriorly but meeting it on the umbonal side; *apex* not prominent, distal to centre; *ridges* somewhat rounded, umbonal very long and gradually sloping, distal short and steep.

c. 3. arcuate; posterior part corresponding to *b* feebly thickened, very slightly clavate, not reaching the margin of the hinge-plate; anterior part corresponding to *a* very thin, slightly curved and running nearly parallel to the shell-margin.

p. I. shorter than *a. I.*, and much less strongly developed, narrow, slightly curving inwards; *base* moderately swollen; *apex* low, but distinctly marked, very obtuse; *ridges* slightly rounded, umbonal long, gradually sloping to form a very regular curve under the umbo, distal short, gently sloping.

p. III. nearly $\frac{3}{4}$ the length of *p. I.*, narrow, separated by a deep furrow anteriorly, then curving in its apical region towards *p. I.*, and then turning outwards to meet the ligament pit; *apex* near proximal end, recurved over *p. I.*, low, very obtuse; *ridges* only slightly thickened, umbonal short, distal long, gradually curving downwards and outwards, somewhat sinuate.

L. V *a. II.* more than $\frac{1}{3}$ the length of the hinge-line, very stout, strongly deflected inwards; *base* very strongly swollen; *apex* distal to centre, prominent, obtuse, rounded; *ridges* rounded, umbonal more so than distal, umbonal gradually sloping, distal rapidly sloping and somewhat arched.

c. 2. triangular, fairly large, base continued towards *a. II.*, apex obtuse, rather sharp, directed upwards and outwards.

c. 4. sharp, lamellar, slightly curved, nearly $\frac{2}{3}$ the width of the hinge-plate, from the umbo downwards running nearly parallel to the posterior side of *c. 2.*

p. II. slightly shorter than *a. II.*, less stout, more straight but with more distinctly marked outward curvature; *base* deep, strong and thickened; *apex* slightly distal to centre, obtuse, rather rounded, directed distally and recurved outwards; *ridges* rounded, umbonal rather longer than distal, gradually sloping, distal with a short rapid slope, then nearly straight.

Ligament pit comparatively long and deep, nearly straight below, about half the width of the hinge-plate in the middle, narrowing gradually on the two ends.

Measurements (*in millimetres*).

	1	2
Length	4·2	3·6
Height	4	3·3
Thickness	2·3	2·2

1, Type-shell from Rurki, United Provinces; 2, shell without any locality.

Type-specimen. No. $M\frac{12532}{2}$ in the collections of the Zoological Survey of India (*Indian Museum*), Calcutta.

Distribution :—The unique type-shell is from Rurki, United Provinces. The second shell which I assign to the species is without any label as to locality. It was provisionally identified *P. bombayanum* Theobald (=*P. clarckeanum*) by G. Nevill.

Remarks :—*P. nevillianum* Theobald is apparently allied to *P. clarckeanum* Nevill, but differs in the shell being trigonal, the hinge more strongly developed and by the differences in the cardinal and lateral teeth. Some of the young shells of *P. clarckeanum* resemble *P. nevillianum* in form, but the hinge and particularly the teeth *c. 3.*, and *a. I.* are quite different in the two species. It to some extent resembles the European *P. supinum* Schmidt[1] in outline and form of the hinge.

Theobald's reference to this species in his catalogue (*loc. cit.*) is wrongly given as " *P. A. S. B.* 1875 " while his measurements of the type-shell are also wrong.

Pisidium hydaspicola Theobald.

1878. *Pisidium, hydaspicila*, Theobald, *Journ. As. Soc. Bengal*, XLVII, p. 147
1915. *Pisidium hydaspicola*, Preston, *Faun. Brit. Ind. Freshw. Moll.* p. 225, fig. 27.

Theobald gave a very scanty and confused description of this species. Preston who copied the original description inverted the measurements and published the figures of the type-shell as seen from above and of the right valve. I have examined the type-shell in the British Museum and I have before me a fair number of shells from various localities in Kashmir. I give below a detailed description of the species. It may also be noted that the type-shell is not a full-grown specimen and that the species grows to a much larger size.

Shell (Pl. VII, figs. 5-7*a*) of fair size, strong, sub-cordate, ovate, very inequilateral, somewhat tumid; striae very feeble but distinct and running concentrically, more marked in young than in full grown shells; umbones slightly swollen and not very prominent, placed behind the middle nearer the posterior end; dorsal margin sloping regularly, more along the anterior than on the posterior side; anterior margin short, evenly rounded; posterior margin truncate, broadly rounded; ventral margin nearly straight. The young shells are yellowish while full-grown specimens are deep yellow with darker olive bands.

Hinge (Pl. VII, figs 5, 6*a*, 7*a*; pl. VIII, fig. 5) about $\frac{3}{4}$ the length of the shell, rather narrow, but projecting well inwards, greatly arched,

[1] Schmidt, *Zeitschr. Malakozool.* VII, p. 119. See also Woodward, *Cat. Brit. Pisidium*, pp. 100-105, pls. (1913).

more so in the right than in the left valve, with two rather open fluxures in the right valve.

R. V. *a. I.* more than $\frac{1}{3}$ the length of the hinge-line, moderately strong and thick, slightly curved and inclined outwards; *base* very thick, swollen; *apex* nearer the proximal end, obtuse; *ridges* not sharp, both fairly steep, distal more so than the umbonal, umbonal swollen near the base.

a. III. less than $\frac{1}{2}$ the length of *a. I.*, and sloping towards it on its umbonal end, somewhat arched, rather low and thick; *apex* opposite that of *a. I.*; *ridges* sloping unequally, distal short and steep, umbonal long and gradually sloping towards *a. I.*

c. 3. rather feebly developed, greatly flexed, and only slightly notched; *a* shorter than *b*, slightly curved, only little inclined from the umbonal end outwards, thin and sharp, running parallel to the upper margin of the hinge-plate; *b* somewhat triangular at the base and rod-like above, greatly curved inwards and forwards in the middle, not reaching the lower margin of the hinge-plate.

p. I. about $\frac{1}{3}$ the length of the hinge-plate, fairly thickened and not sharp, slightly curved inwards, *base* thick but gradually merging into the shell-wall; *apex* proximal to centre, obtusely rounded; *ridges* rather thick, distal longer than umbonal and reaching a much lower level than the umbonal.

p. III. less than $\frac{1}{2}$ the basal length of *p. I.*, ridge-like, without distinct apex, greatly reflexed outwards; somewhat swollen at the base.

L. V *a. II.* little more than $\frac{1}{3}$ the length of the hinge-line, thick and greatly reflexed inwards, rather broad; *base* greatly swollen but gradually shelving into the hinge-plate; *apex* obtusely pointed; *ridges* rather thickened, not sharp, umbonal ridge shorter than distal which, after a sharp slope, gradually merges into the hinge plate.

c. 2. not very prominent, apex obtuse, sharp, pointing downwards, only slightly thickened, basal part running parallel to hinge-plate and continuous with *a. II.*

c. 4. lamelliform, sharp, very thin, running at an angle to the distal end of *c. 2.*, nearer it in the umbonal region but reaching further outwards in the distal.

p. II. shorter than *a. II.*, rather broad and somewhat reflexed inwards; *base* greatly swollen in the middle, slightly curved and gradually shelving on the two sides into the hinge-plate; *apex* proximal to centre, obtuse; *ridges* not very thick and rather sharply sloping from the apex.

Ligament pit comparatively long and deep, extending to about the middle of the hinge-plate and from anterior to the centre of the umbo to the end of *p. III.* in the right valve, and umbonal ridge of *p. II.* in the left value.

Measurements (*in millimetres*).

	1	2	3	4	5	6	7	8	9	10
Length	4·2	4·6	4·4	4	2·5	2·5	3·6	3	3	3·2
Height	3·5	3·8	3·4	3·1	2	2	3·1	2·5	2·4	2·7
Thickness	2·3	2·5	2·2	2·1	1·2	1·1	2·1	1·5	1·3	1·6

1 Type shell from Shupion ; 2 from Mousterman ; 3 from Olus Valley ; 4, 5 from Islamabad ; 6 from Pandrenthan tank ; 7—10 from Eishmukam, Kashmir Valley.

Type-specimen in the British Museum (Natural History), South Kensington, London.

Distribution :—Theobald's unique type was found in the stream near Shupion, Kashmir. I have, as noted already, examined a fair number of specimens from Mousterman, Olus Valley, Wean, Islamabad, Pandrenthan tanks and Eishmukam and Manasbal Lake. All the localities are in the Kashmir Valley. I have also seen a fossil shell from Kuardo, Kashmir, Quarternary, recent Mall, collected by the late Col. H. H. Godwin-Austen. This specimen is in the Indian Museum. A photograph of the hinge of the type-shell is reproduced on pl. VII, fig. 5.

Remarks :—*P. hydaspicola* belongs to the same groups as the European *P. casertanum* (Poli). It differs from its Indian ally *P. clarckeanum* in that the shell is smaller, less tumid, sculpture not so marked, umbones much less prominent and the hinge less strongly developed. The hinge teeth are also differently disposed.

Animal (Pl. VIII, fig. 6) :—As noted in the introductory remarks, I had only a half-dry and badly preserved specimen of this species from Islamabad, Kashmir, in spirit, and I am not able therefore to deal with the anatomy of the species in detail. There is no doubt, however, that the species belongs to the sub-genus *Eupisidium* Odhner.

Mantle :—The pedal slit is large and extends to shortly in front of the anterior outline of the posterior adductor muscle. The post-pedal suture is broad and nearly as high as the posterior adductor muscle. There is a short branchial slit about $\frac{1}{2}$—$\frac{2}{3}$ the size of the anal slit, the two apertures being separated by an area slightly larger than the anal slit. The anal slit is not more than $\frac{2}{3}$ the size of the post-pedal suture and has thickened margins.

Gill :—There are two gills on each side. The posterior gill, which, as has been demonstrated by Odhner, corresponds to the outer of the gills of each side of other Eulamellibranchia, is very much reduced and is represented only by the reflected lamella. In *P. hydaspicola* it is about half as long as the anterior gill and barely reaches its ventral margin. It consists of 13-14 filaments. The anterior gill which corresponds to the inner gill consists of 30-31 filaments. Each filament consists of a well developed outer lamella which extends to about half the width of the outer lamella. Along its lower $\frac{1}{2}$—$\frac{2}{3}$ the reflected lamella is fused with the direct outer lamella. The reflected lamellae of the last 10-11 filaments are fused behind the foot with the reflected lamellae of the gill of the opposite side. It was not possible to determine the numbers of the lamellae which are attached to the body anteriorly.

I was not able to study in detail the structure of the nephridium, the stomach and the pericardium owing to the poor condition of the material.

Pisidium atkinsonianum Theobald.

1876. *Pisidium atkinsonianum*, Theobald, *Journ. As. Soc. Bengal*, XLV, pt. II, p. 189.
1876. *Pisidium atkinsonianum*, Theobald, *Cat. Land Freshw. Shells*, p. 45.
1915. *Pisidium atkinsonianum*, Preston, *Faun. Brit. Ind. Freshw. Moll.* p. 226, fig. 29.

The description of the species by Theobald is very inadequate and Preston's figures of the type do not help in the recognition of the species. Indeed it was this which led Annandale[1] to consider this species as "merely a dwarfed form" of what he considered to be *P. casertanum* (see *antea* p. 410). It is, however, quite a distinct species and is nearly allied to *P. hydaspicola*.

The species may be redescribed as follows:—

Shell (Pl. VII, figs. 8-10*a*) of medium size, rather thin in the half-grown type-shells but growing thicker with age; orbiculate-ovate; not much swollen; feebly striate in young, but with the striae much more irregular and better marked in full grown specimens; umbones only slightly tumid, not prominent, placed behind the middle with very minute striae, dorsal margin sloping slightly with a well-marked shoulder on the posterior slope; anterior margin subtruncate, broadly arched; posterior margin short, rounded; ventral margin only slightly curved; young shells are yellowish in colour but full-grown specimens become dirty olive.

Hinge (Pl. VII, figs. 8, 9*a*, 10*a*; pl. VIII, fig. 7) about $\frac{2}{3}$ the length of the shell, rather narrow, but projecting well inwards, strong, slightly arcuate with two marked flexures in the right valve.

R. V *a. I.* more than $\frac{1}{3}$ the length of the hinge line, stout, curving inwards; *base* very thick and strong; *apex* distal to centre, prominent, distally directed, somewhat rounded, obtuse; *ridges* rounded, distal descending steeply, umbonal sloping gradually and to a lower level than the distal.

a. III. more than $\frac{1}{2}$ the length of *a. I.*, narrow, opposed to shell margin and running parallel to it; *apex* distal to centre, broadly rounded; *ridges* rather sharp, distal very short and descending quite steeply, umbonal very long and sloping very gradually.

c. 3. distinctly curved, prominent, lying close to but not reaching the margin of the hinge-plate; part corresponding to *b* swollen, knob-like, *a* sharp, lamelliform.

p. I. about $\frac{1}{3}$ the length of the hinge-line; stout, only slightly curving inwards; *base* strong but not much swollen; *apex* slightly distal to centre, rather sharp, obtuse; *ridges* rounded, both umbonal and distal subequal and descending about equally.

p. III. about $\frac{2}{3}$ the length of *p. I.*, stout, greatly curving outwards towards the shell margin; *apex* distal to the centre, slightly pointed, obtuse; *ridges* rounded except for proximal half of distal which is somewhat sharp, curved and folded outwards, umbonal sloping regularly to about the posterior extent of the ligament pit.

[1] Annandale, *Rec. Ind. Mus.* XIV, p. 142 (1918).

L. V. *a. II.* about $\frac{3}{8}$ the length of hinge-line, fairly strong, stout, nearly straight; *base* very stout, swollen; *apex* subcentral, prominent, acuminate, directed inwards and upwards; *ridges* only slightly rounded, sloping about equally.

c. 2. prominent, somewhat triangular with a deep depression at its base; *apex* directed upwards.

c. 4. sharp, lamelliform, anterior portion above *c. 2.*, posterior part curving down to below the middle of the hinge-plate.

p. II. somewhat smaller than *a. II.*, fairly strong, stout, slightly curved; *base* strong but not much swollen; *apex* proximal to centre, pointing inwards and downwards, acuminate; *ridges* rather sharp, distal somewhat curved, proximal straight, sloping gradually.

Ligament pit about $\frac{2}{3}$ the length of the umbo; deep, nearly reaching below the middle of the hinge-plate, ventral margin straight.

Measurements (*in millimetres*).

	1	2	3	4	5	6
Length	3·4	4·7	4·4	4	4·2	4·3
Height	2·8	3·9	3·6	3·3	3·2	3·5
Thickness	1·8	2·5	2·5	2·2	2·1	2·2

1 from Sureil, Darjeeling District; 2—4 from Sonada, Darjeeling District; 5, 6 Gangtok, Sikkim.

Type-specimen in the British Museum (Natural History), South Kensington, London.

Distribution:—Theobald's type-shells were collected at Tonglu, Sikkim, at an altitude of 10,000 ft. I have examined these shells and compared others from various localities in the Darjeeling district at altitudes between 5,000 and 10,000 ft., and can find no differences between them.

Remarks:—The species is allied to *P. hydaspicola* Theobald, but is distinguished by the form of the shell, the much less prominent umbones and the different arrangement of its hinge-teeth.

The soft parts of this species (Pl. VIII, fig. 8) show that like *P. hydaspicola* it is to be referred to Odhner's subgenus *Eupisidium*. The main characters are (i) the two pairs of gills, (ii) separate branchial and anal slits in addition to the pedal aperture, and (iii) the nephridial structure. Unfortunately the specimens of this speices were not very well preserved and it was not found possible to investigate the structure of the nephridium in detail.

Mantle (text-fig. 1*b*):—The pedal aperture is large and extends anteriorly to below the anterior adductor muscle and posteriorly to a short distance in front of the posterior adductor muscle. The post-pedal suture is short, being only about half the height of the posterior adductor muscle. The branchial slit is narrow and is only a little more than the post-pedal suture. Its edges are not greatly thickened and it is separated from the anal slit by an area slightly shorter than the post-pedal suture. The anal slit is surrounded by thick muscles and is about twice as high

as the branchial slit. The margin of the mantle is thickened uniformly and shows the radiating muscles.

Gills (Pl. VIII, fig. 9) :—There are two gills on each side. The posterior gill, as in the case of *P. hydaspicola*, is greatly reduced and consists of 18 filaments. It is very narrow but is more extensive than in the case of *P. hydaspicola*. The filaments are not recurved and are greatly reduced in the lower region.

The anterior gill consists of the well developed direct lamella and a reflected lamella which, as shown in the figure, reaches different levels in different parts of the gill. The margin of the lamella is attached to the body along about half of its length, while behind the foot lamellae of the gills of the two sides are united to form the interbranchial septum. In some of the gravid specimens the developing embryos were contained in this part of the gills, which, as in other species, serves as the brood pouch. The reflected lamella is fused with the outer lamella along more than half of its extent, while the marginal blood vessel runs along its margin.

Nephridium :—The nephridium of *P. atkinsonianum*, so far as I have been able to elucidate its structure, resembles that of *P. personatum* described by Odhner.[1] The pericardial tube is more extensive and coiled while the dorsal lobe is large with a deep fissure.

Stomach (text-fig. 3*b*) :—The structure of the stomach is similar to that of *P. personatum* described by Odhner (*loc. cit.*). There is a distinct posterior caecum in addition to a left caecum of the stomach. The duodenum is coiled in front of the stomach and runs backwards to the intestine on the right side of the stomach.

Pisidium mitchelli, sp. nov.

Shell (Pl. VII, figs. 11, 11*a*) large, subtrigonal, very tumid, rather thin, fragile, with well-marked, thick closely set striae all over ; umbones prominent, placed behind the middle towards the posterior end ; dorsal margin sloping regularly, more along the posterior than on the anterior slope ; anterior margin broadly rounded ; posterior margin sub-truncate, rounded ; ventral margin greatly arched ; shell of deep-horn colour, shining.

Hinge (Pl. VII, fig. 11*a* ; pl. VIII. fig. 10) more than $\frac{2}{3}$ the length of the shell, fairly wide, projecting and with the teeth recurved upwards, arched with two distinct flexures in the right valve.

R. V. *a. I.* more than $\frac{1}{3}$ the length of the hinge-line, strong, curving inwards ; *base* strong and swollen ; *apex* subcentral, obtusely acuminate ; *ridges* slightly rounded, fairly steep, sloping about equally.

a. III. nearly $\frac{3}{4}$ the length of *a. I.*, strong, opposed to the shell margin ; *apex* not prominent, subcentral, rounded, obtuse ; *ridges* somewhat rounded, sloping equally.

c. 3. arcuate, thin, lamelliform, with the portion corresponding to *b* only slightly swollen, portion corresponding to *a* running parallel to the shell margin.

[1] Odhner, *Proc. Malacol. Soc. London* XV, pp. 160, 161 (1923).

p. I. more than ½ the length of and about as broad as *a. I.*, strong, curving upwards ; *apex* distal to centre, slightly rounded, obtuse ; *ridges* somewhat rounded, umbonal sloping regularly, distal shorter than umbonal and sloping steeply.

p. III. slightly shorter than *p. I.*, narrow, strong, slightly curved, opposed to the shell margin ; *apex* subcentral, obtusely pointed ; *ridges* sharp, distal sloping a little more than umbonal.

L. V. *a. II.* more than ⅓ the length of the hinge-line, stout, strongly curving upwards and outwards ; *base* strong, swollen ; *apex* distal to centre, acute, pointed, sharp ; *ridges* sharp, umbonal sloping suddenly and then curving regularly, distal descending rapidly for a very short distance and then regularly.

c. 2. rather short, ridge-like, in continuation of the umbonal ridge of *a. II.*, running parallel to and near the hinge-plate margin.

c. 4. longer than *c. 2.*, lamelliform, slightly arcuate, curving over anterior margin of *c. 2*, and running diagonally to near the margin of the hinge-plate.

p. II. about ¾ the size of *p. I.*, broad, strong, curved, inclined upwards and outwards ; *base* strong, swollen ; *apex* subcentral, pointed, obtuse ; *ridges* sharp, umbonal descending gradually along a somewhat arched course, distal sloping very suddenly and then running nearly straight.

Ligament pit more than half the length of the umbo and arising from in front of its centre, reaching to about the middle of the hinge-plate and ending in front of the umbo.

Measurements (*in millimitres*).

	1	2	3	4
Length	3·8	3·8	3·6	3·8
Height	3·6	3·6	3·3	3·5
Thickness	3·1	3	2·5	3

All specimens from Manasbal Lake ; No. 1 is the type-shell.

Type-specimen. No. M $\frac{12533}{2}$ in the collections of the Zoological Survey of India (*Indian Museum*), Calcutta.

Distribution :—About a dozen complete shells of the species were collected by Mr. F. J. Mitchell of Srinagar, Kashmir, out of the stomach of a trout caught in the Manasbal Lake at an altitude of *ca.* 5,000 ft.

Remarks:—The species resembles the European *P. lilljeborgii* Clessin[1] but differs in the form of the shell and the different type of hinge. It is closely allied to *P. hydaspicola* Theobald.

Pisidium annandalei, sp. nov.

Shell (Pl. VII, figs. 12, 12*a*) small, subtrigonal, thin, porcellaneous, slightly tumid ; concentrically striate, with close-set regular lines running

[1] Clessin, *Malakol. Blatt.* (N. F.) VIII, p. 119 (1886). See also Woodward, *Cat. Brit. Pisidium*, pp. 111-116 (1913).

all over the surface, striae less marked on the umbonal region; umbones not prominent, only slightly projecting, subcentral; dorsal superior margin short, slightly arched with well marked shoulders on both anterior and posterior slopes; anterior margin regularly and narrowly curved; posterior margin broadly arched, subtruncate; ventral margin curved, shell of a shining horny colour.

Hinge (Pl. VII, fig. 12*a*; pl. VIII, fig. 11) more than $\frac{3}{4}$ the length of the shell, fairly broad, projecting inwards, very strong, very arched with two distinct flexures in both the valves.

R. V *a. I.* about $\frac{1}{2}$ the length of the hinge-line, broad, strong, slightly curving inwards and upwards; *base* strong, swollen; *apex* distal to centre, prominent, acuminate, obtuse; *ridges* somewhat rounded, distal arched, umbonal straight, descending gradually.

a. III. less than $\frac{1}{2}$ the length of *a. I.*, running parallel to the shell wall, nearly straight; *apex* not well marked, proximal to centre, very obtuse; *ridges* sharp, umbonal very short.

c. 3. very prominent, greatly projecting inwards, slightly curved, the rounded end *b* knob-like, nearly reaching the margin of the hinge-plate; upper part corresponding to *a* nearly straight, sharp.

p. I. about $\frac{1}{2}$ the length of the hinge-line, broad, strong, only slightly narrower than *a. I.*, *base* strong, swollen; *apex* distal to centre, obtuse, somewhat rounded; *ridges* slightly rounded, sloping unequally, umbonal somewhat arched, distal short and descending suddenly.

p. III. more than $\frac{1}{3}$ the length of *p. I.*, running parallel to shell wall, narrow, evenly developed; *apex* distal to centre, obtuse, acuminate; *ridges* sharp, descending unequally, umbonal long, distal very short.

L. V *a. II.* more than $\frac{1}{3}$ the length of the hinge-line, broad, nearly straight; *base* very strong and swollen; *apex* proximal to centre, not very prominent, very obtuse, somewhat rounded, greatly curved inwards and upwards; *ridges* sharp, sloping very steeply and about equally.

c. 2. prominent, obtusely triangular; *apex* directed upwards and outwards towards the umbo; base continuous with umbonal ridge of *a. II.*

c. 4. thin, arc-like, sharp, prominent, arising from near the shell-margin and curving over the posterior margin of *c. 2.* to near the margin of the hinge-plate.

p. II. smaller than *a. II.*, broad, strong, nearly straight; *base* strong, swollen; *apex* subcentral, prominent, directed upwards and somewhat onwards, obtuse, pointed; *ridges* sharp, umbonal descending regularly, distal descending sharply at first and then running nearly straight.

Ligament pit placed very far back, starting from near the posterior end of the umbo and running to opposite the apex of *p. II.* in the left valve.

There is a very deep depression in the hinge-plate behind and above the *c. 3.*, in the same situation in which it is found in *P. stewarti* Preston.[1]

Dimensions.—The type-specimen measures 2·6 × 2·2 × 1·4 mm., while the single right valve measures 2 × 1·7 mm.

Type-specimen. No. M $\frac{7033-7034}{1}$ in the collections of the Zoological Survey of India (*Indian Museum*), Calcutta.

Locality :—One complete shell and a right valve were collected by the late Dr. Annandale from Pareshnath Hill, Bihar, at an altitude of 4,000 ft.

Remarks :—The species is closely allied to *P. stewarti*, but is distinguished by the different facies and the different type of hinge.

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[1] Preston, *Rec. Ind. Mus.* III, p. 116, fig. 3 (1909). See also Preston, *Faun. Brit. Ind. Freshw. Moll.* p. 227 (1915).