

IV MATERIALS FOR A REVISION OF  
THE PHYLACTOLÆMATOUS POLYZOA  
OF INDIA

By N. ANNANDALE, D.Sc., C.M.Z.S., F.A.S.B., Superintendent,  
Indian Museum.

The Phylactolæmata of the Oriental Region have hitherto attracted little attention on the part of zoologists, except a few short papers of my own in the Journal of the Asiatic Society of Bengal and these "Records," the following are the only references (besides a few bare statements as to the existence of *Plumatella* in the East) I can find in literature :—

- 1859. Carter described and figured the statoblast of a "*Lophopus*" (*Lophopodella carteri*) and recorded *Plumatella repens* and *P. stricta* from Bombay (*Ann. Mag. Nat. Hist.* (3), vol. iii, p. 332).
- 1862. Mitchell recorded a species of "*Lophopus*" from Madras (*Quart. Journ. Micr. Sci.* (3), vol. ii, p. 61).
- 1865. Hyatt named the Indian "*Lophopus*" described by Carter as *Pectinatella carteri* (*Comm. Essex Inst.*, vol. iv, p. 203).
- 1887. Kraepelin described *Plumatella philippinensis* (*Deutschen Süßwasser-Bryozoen*, part i, p. 118, footnote).
- 1895. Meissner recorded the discovery of statoblasts of *Lophopodella carteri* in E. Africa ("Moosthiere," p. 6, in *Deutsch-Ost. Africa*, vol. iv).
- 1904. Rousselet placed this species in his new genus *Lophopodella* (*Journ. Quekett Micr. Club*, 1904, p. 51).
- 1906. Kraepelin described *Plumatella javanica* (*Mitth. Naturh. Mus. Hamburg*, vol. xxiii, p. 143).
- 1908. Loppens referred *Plumatella javanica* to *P. emarginata* as a variety (*Ann. Biol. Lacustre*, iii, p. 162).

The following papers by Oka on Japanese forms are also of importance to students of the Indian species of the Phylactolæmata :—

- 1891. "Observations on Freshwater Polyzoa," in *Journ. Coll. Sci. Imp. Univ. Tokyo*, vol. iv.
- 1907. "Zur Kenntnis der Süßwasser-Bryozoenfauna von Japan," in *Annot. Zool. Japon.*, vol. vi.
- 1908. "Ueber eine neue Gattung von Süßwasser-bryozoen," in *Annot. Zool. Japon.*, vol. vi.

As, however, a considerable proportion of the Phylactolæmata of India are identical with or very closely related to northern forms, many of which are practically cosmopolitan, the bulk of the literature regarding them is to be sought in memoirs that refer directly to the fauna of Europe or North America. Fortunately it is possible to regard two separate memoirs as having been unusually complete at the several dates on which they were published. I refer to Allman's *Monograph of the Fresh Water Polyzoa* (1856) and Kraepelin's *Süsswasser-Bryozoen* (1887-1892). It is possible to differ from the conclusions at which either or both of these authors arrived; but the wealth of detail and accuracy of delineation displayed in their works are beyond criticism. Another important memoir is Jullien's "Monographie des Bryozoaires d'eau douce" (*Bull. Soc. zool. France*, vol. x, 1885), which, in spite of the lack of critical instinct and the somewhat splenetic attitude to former writers displayed by its author, contains much valuable information. Braem's "Untersuchungen über die Bryozoen des süßen Wassers" (*Bibliotheca Zoologica*, vol. ii, 1890) deals mainly with anatomy and development but gives good descriptions of the European Phylactolæmata, while Loppens has recently published a concise summary of our present knowledge of the group (*Ann. Biol. Lacustre*, vol. iii, p. 141, 1908).

There are few groups in the animal kingdom on which the views of different authorities as to taxonomy are at greater variance than the Phylactolæmata, and this is the case even as regards the main divisions of the group. The following classification is adopted because it seems to be most convenient:—

## Order PHYLACTOLÆMATA.

### Family I.—PLUMATELLIDÆ.

Ectocyst well developed; base of zoarium never modified to form an organ of progression.

Subfamily A. Zoœcia tubular;  
lophophore circular or oval when  
expanded; statoblasts without  
air-cells

*Fredericellinæ.*

Subfamily B. Zoœcia tubular or  
concealed in a gelatinous syncœ-  
cium; lophophore horse-shoe-  
shaped when expanded; some  
or all of the statoblasts surround-  
ed by a ring of air-cells

*Plumatellinæ.*

### Family II.—CRISTATELLIDÆ.

Ectocyst absent, polypides embedded in a common syncœcium, the base of which is modified to form a creeping "sole"; lophophore horse-shoe-shaped, statoblasts surrounded by a ring of air-cells.

The *Cristatellidæ* consist of a single genus and probably of a single species (*Cristatella mucedo*), which, so far as is at present known, is confined to Europe and North America. Both the *Fredericellinæ* and the *Plumatellinæ* are, however, represented in India. The former subfamily consists of a single genus, in which four species can now be distinguished; while seven genera, five of which have been recorded from India, constitute the *Plumatellinæ*.

Family PLUMATELLIDÆ.

Subfamily **Fredericellinæ**.

Genus FREDERICELLA, Gervais.

*Zoæcia* cylindrical, each arising directly from another. *Zoarium* recumbent or, more usually, with upright branches. *Statoblasts* flat, oval or kidney-shaped, surrounded by a stout chitinous ring. *Polypide* slender and elongate; the tentacles of the lophophore filiform, not very numerous.

Until recently, although several distinct phases or varieties had been described as species, it was only possible to recognize a single form as worthy of specific rank, namely the Holarctic *F. sultana* (Blumenbach). Four species may, however, now be distinguished, although they are all closely allied to one another and might perhaps be regarded rather as local races or subspecies. They are *F. sultana* (Europe, N. America, N. and S. Africa), *F. australiensis*<sup>1</sup> (New South Wales), *F. indica* (Western India) and *F. cunningtoni*<sup>2</sup> (Lake Tanganyika, Central Africa). The following key will serve to distinguish them.—

*Key to the species of Fredericella.*

- A. Ectocyst never heavily encrusted.
- a. Statoblast smooth on both surfaces.
    - a. Lophophore circular *F. sultana.*
    - a' Lophophore oval *F. australiensis*
  - a' Statoblast with minute prominences on the upper surface.
    - Lophophore circular *F. indica.*
- B. Ectocyst heavily encrusted with sand grains.
- Lophophore circular; zoæcium short (statoblast unknown) *F. cunningtoni.*

*Fredericella indica*, Annandale.

*Rec. Ind. Mus.*, iii, p. 373, fig. (1909).

To my recent description of this species I need only add that the lophophore is accurately circular when fully extended. The

<sup>1</sup> Goddard, *Proc. Linn. Soc. N. S. Wales*, xxxiv, p. 489, pl. xlvii (1909).

<sup>2</sup> Rousset, *Proc. Zool. Soc. London*, 1907, p. 254, pl. xv, figs. 9, 10.

statoblasts of specimens taken in Travancore were invariably oval, although varying considerably in proportions, but some of the statoblasts of those from the Bombay Presidency were distinctly kidney- or bean-shaped.

In both localities the specimens were taken in November, but in different years. Those from Travancore (1908) were found to be undergoing a process of regeneration owing to the development of statoblasts *in situ*, and only a few polypides were fully developed. Those, however, from Bombay (1909) were in a much more vigorous condition, although even in their case many of the polypides were not fully formed. It seems not improbable that *F. indica* is one of the species that dies down at the beginning of the hot weather, and is regenerated by the sprouting of the statoblasts, either in the old zoëcia or on a new site, at the beginning of the Indian "winter."

### Subfamily Plumatellinæ.

#### Key to the genera of Plumatellinæ

1. Statoblasts without hooked processes.
  - A. Zoëcia cylindrical, not embedded in a gelatinous investment.
    - a. Zoëcia arising directly from one another; no stolon; free statoblast oval *Plumatella*.
    - a' Zoëcia upright, arising singly or in groups from a linear stolon; free statoblasts oval *Stolella*.
  - B. Zoëcia cylindrical, embedded in a structureless gelatinous investment.
 

Zoëcia arising from a ramifying stolon; statoblasts circular *[Stephanella]*
  - C. Polypides embedded in a hyaline syncœcium that conceals the cylindrical form of the zoëcia.
    - c. Polypides upright, their base far removed from that of the zoarium when they are expanded *Lophopus*.
    - c' Polypides recumbent for the greater part of their length at the base of the zoarium *[Australella]*.<sup>1</sup>

<sup>1</sup> *Australella*, gen. nov.—Zoëcia recumbent, aggregated into small linear groups, which are connected with each other by stolon-like lobes and embedded

2. Statoblasts armed (normally) with hooked processes.

A. Processes confined to the extremities of the statoblast; zoaria remaining separate throughout life

*Lophopodella.*

B. Processes entirely surrounding the statoblast; many zoaria embedded in a common gelatinous investment so as to form large compound colonies

*Pectinatella.*

Those genera of which the names are enclosed in square brackets have not been recorded from India, while the occurrence of *Lophopus* in this country is doubtful. *Plumatella* is represented by at least four European species as well as by two peculiar, so far as is known, to the Oriental region. Of the latter, one has only been recorded from a single locality in the Bombay Presidency, while the other was originally described from Java. *Lophopodella* and *Pectinatella* are each represented in the Indian fauna by a single species; that of the former genus occurring also in E. Africa and being specifically identical with a race found in Japan, while that of the latter is only known from India and Burma but has a very close Japanese ally.

#### Genus PLUMATELLA, Lamarck.

*Zoarium* recumbent or partially upright, branching freely, often in two planes. *Zoæcia* cylindrical, arising directly the one from the other, sometimes upright, greatly elongated and agglutinated together; at least the older zoæcia in each zoarium commonly recumbent. *Statoblasts* frequently of two kinds, free and fixed; the latter devoid of air-cells and fastened to the support of the zoarium; the former surrounded by a well-developed ring of air-cells, without processes at the periphery, never more than about 0.6 mm. in length, oval in outline. *Polypide* never with more than about 60 tentacles.

Hardly any two authorities are agreed as to the number of species and varieties that should be recognized in this genus, and it is generally believed that the zoaria exhibit very great individual variation. Observations, however, carried out on a considerable amount of European material as well as a large Indian collection, make me inclined to believe that this is not the case, but rather that a considerable number of forms exist which breed remarkably true even in very diverse conditions. The fact that it is possible to recognize the majority of the well-established European "species" among

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in a structureless gelatinous mass. Statoblasts oval, without hooked processes, intermediate in size between those of *Lophopus* and those of *Plumatella*. Type *Lophopus lendenfeldi*, Ridley, *Journ. Linn. Soc. London, Zool.*, vol. xx, p. 62 (1890).

Indian specimens, as well as several of the varieties, would suggest that the type is preserved with considerable exactness, and this view is confirmed by the fact that several distinct forms are frequently found growing together in conditions so absolutely identical that their zoaria are intertwined.<sup>1</sup>

Two better tests as to the distinctness of "forms" could not, in my opinion, be found; but whether these "forms" should all be recognized as "species" is another question. Personally I think that it would be inconvenient to adopt a course so extreme. I have been forced, therefore, to devise a test for distinguishing "species" from "varieties." The test adopted is as artificial as all such tests must be in the present unsettled state of biological knowledge. I have called those forms (*i.e.*, groups of specimens) "species," the differences between which are so constant and so clear that it is possible to express the more important of them in the form of a key to the genus; while my "varieties" are groups of specimens separated from those comprised in the nearest species by differences that do not appear to be altogether constant or are of a kind that cannot be represented easily in words or numbers. The question of "subspecies" (*i.e.*, local races) hardly arises as regards *Plumatella*, for there is little evidence that such races exist in the genus.

Up to the present time I have been unable, owing to unfavourable climatic conditions, to carry out direct biological experiments as to the effect of environment on the individual zoarium in the Polyzoa, but evidence obtained in the unnatural environment of an aquarium is usually unsatisfactory as regards such points, and I think that the facts stated above will at any rate make my position clear as regards the "species" and "varieties" described below.

*Key to the Indian species of Plumatella.*

Group I. (*Repens* group.)

Ectocyst more or less rigid, pigmented or colourless; tip of the zoëcia rounded when the polypide is retracted.

1. All the zoëcia entirely recumbent, having the aperture on the dorsal surface and a strong furrowed keel; ectocyst colourless and transparent; free statoblast elongate
2. The younger zoëcia as a rule forming long free branches, each with the aperture at the tip; a furrowed keel never

*P. javanica.*

<sup>1</sup> In a pond in the Calcutta Zoological Gardens I have found the following forms growing together in this way:—*P. fruticosa* (with the phase *coralloides*), *P. emarginata* (with the phase *benedeni*), the varieties *diffusa* and *dumortieri* of *P. allmani*, *P. javanica* and *P. punctata*.

- present; ectocyst lightly pigmented; statoblasts elongate *P. fruticosa.*
3. Zoëcia and ectocyst as in 2; free statoblasts broadly oval *P. repens.*
4. At any rate the older zoëcia entirely recumbent, sometimes with the aperture on the dorsal surface, with a triangular colourless patch at the tip of the same surface; the ectocyst of the basal part of the zoëcium densely pigmented; free statoblast elongate *P. emarginata.*
5. All or nearly all the zoëcia with their bases recumbent but with their distal part free and turned upwards; the ectocyst of the basal part translucent, roughened on the surface, that of the distal part colourless and smooth, the colourless part frequently passing into the coloured part in the form of a V; free statoblasts very variable in shape *P. allmani.*

Group II. (*Philippinensis* group.)

Ectocyst rigid, deeply pigmented, tip of the zoëcia abruptly truncated when the polypide is retracted.

Zoëcia irregularly but strongly annulated; with a strong furrowed keel on the basal part; free statoblast elongate

*P. bombayensis.*Group III. (*Punctata* group.)

Ectocyst soft and flexible, much swollen; tip of the zoëcia rounded.

Ectocyst colourless; zoëcia without a furrow; statoblasts broadly oval, often asymmetrical in outline

*P. punctata.*a. *Repens* group.*Plumatella repens*, Allman (? Linné).? *Tubipora repens*, Linné, *Syst. Nat.* (Ed. x), 1758.*Plumatella repens*, Allman, *Mon. Fresh Water Polyzoa*, p. 93, pl., v, figs. 1—8 (1856).

- Plumatella polymorpha*, *Kraepelin, Deutsch. Süßwass.-Bryozoen*, pl. iv, fig. 119, pl. v, fig. 122, pl. vii, fig. 139 (1887).  
*Plumatella repens*, *Braem, Bibl. Zool.*, vol. vii, p. 2 (1890).  
 „ „ *Loppens, Ann. Biol. Lacustre*, vol. iii, p. 158  
 (*partim*) (1908).

This species is distinguished rather by negative than by positive characters, and it is perhaps for this reason that I find it difficult at present to regard the form *fungosa* as more than a variety, although the latter appears to exhibit certain peculiarities even at a stage at which it has not assumed its most characteristic features.

*P. repens* may be recognized by the following characters :—

- (1) The great majority of the free statoblasts in any one zoarium are broadly oval in shape, the greatest width being at least  $\frac{5}{7}$  of the length.
- (2) Fixed statoblasts without air-cells are produced.
- (3) The zoœcia, when the polypides are contracted, are always round at the tip. They are never emarginate.
- (4) A *furrowed* keel is never present on the dorsal surface.
- (5) The pigmentation is never dense.
- (6) The zoœcia are slender, and the ectocyst is never very stiff, although it is never soft and contractile as in *P. punctata*, the only species, except *P. fruticosa*, with which *P. repens* is likely to be confused.

The first two of these characters will at once serve to distinguish *P. repens* from *P. fruticosa*, but it must be remembered that elongated statoblasts are occasionally found in the former species, although never in large numbers. The swim-ring of the free statoblasts of *P. repens* is rarely much, if at all, broader at the sides than at the ends.

Var. *fungosa*, Pallas.

*Tubularia fungosa*, *Pallas, Comment. Acad. Sci. Imp. Petropol.*, vol. xii, p. 565, pl. xiv (1768).

*Alcyonella fungosa*, *Allman, op. cit.*, p. 86, pl. iii (1856).

*Plumatella polymorpha var. fungosa*, *Kraepelin, op. cit.*, p. 124, pl. iv, fig. 112, pl. viii, figs. 140—142.

*Plumatella fungosa (partim)*, *Braem, op. cit.*, p. 2, pl. i, fig. 2.

*Plumatella repens var. fungosa*, *Loppens, op. cit.*, p. 161.

The essential characters of this form seem to be (1) that the zoarium branches very profusely when still young and recumbent, and (2) that the ectocyst is surrounded by a gummy secretion. These characters cause crowding together of the zoœcia, which are forced to assume an upright growth and finally, under pressure, a polygonal form in cross-section. Dense masses, often an inch or more in diameter, are thus produced, consisting of upright parallel tubes closely packed together. Specimens from Norfolk, which Dr. F. Harmer has been kind enough to send me, show the earlier stages



of this process, while others from Russia, received from the Geneva Museum, exhibit the actual transition. Dr. Kraepelin has kindly given me some fine German examples named by him *P. polymorpha* var. *fungosa* and including both young and old zoaria, and I have examined others from England and Italy.

Although *P. repens* is here included in the Indian fauna, I am doubtful as to its having been actually found anywhere in the Oriental Region. The form recorded by Carter from the island of Bombay as *P. repens* was, as he himself recognized, the one described by van Beneden under that name and subsequently called *P. stricta* by Allman, who did not regard it as identical with Linné's *Tubipora repens*. The variety *fungosa* has not been recorded from India except by myself, and further experience both of Indian and European specimens proves that what I found was actually an extreme form of the *coralloides* phase of *P. fruticosa*.

*Plumatella fruticosa*, Allman.

*Plumatella stricta*, Allman, *op. cit.*, p. 99, fig. 14.

*Plumatella fruticosa*, *id.*, *ibid.*, p. 102, pl. vi, figs. 3—5.

*Plumatella repens* and *P. stricta*, Carter, *Ann. Mag. Nat. Hist.* (3), vol. iii, p. 332 (1859).

*Plumatella princeps* var. *fruticosa*, Kraepelin, *op. cit.*, p. 120, pl. vii, fig. 148.

*Plumatella fruticosa*, Braem, *op. cit.*, p. 9, pl. i, fig. 15.

*Plumatella repens*, Annandale, *Journ. Asiat. Soc. Bengal*, 1907, p. 83.

This species agrees with *P. repens* in never having the zoœcia emarginate or with a furrowed keel and in having the ectocyst neither deeply pigmented (naturally<sup>1</sup>) nor very stiff. The great majority, if not all of the statoblasts in every zoarium are, however invariably elongate, the length being twice or nearly twice the greatest breadth. The swim-ring, however, is as a rule not much broader at the ends than at the sides. Just as in *P. repens* an occasional statoblast may be found that is elongate, so in *P. fruticosa* an occasional statoblast may be found that is short and broad; but in both species such cases are rare and must be regarded as abnormal; they therefore do not affect the question of the specific distinctness of the two forms. The zoœcia of *P. fruticosa*, although frequently stout, are invariably long, so that the branches are far apart from one another; there is often a simple keel, but with no trace of a furrow, on the dorsal surface of the proximal part of the zoœcium. Young colonies are recumbent but with the tip of each zoœcium upturned, so that the aperture is terminal. In favourable conditions, however, horizontal or dependent branches, often of considerable length, are freely produced. The ectocyst is not sufficiently stiff to give much support to long upright branches, and the branches invariably collapse or droop if the zoarium is removed from the water. The alimentary canal is rather less stout

<sup>1</sup> If attached to dead wood they are apt to become stained.

than in *P. repens*. Among Indian specimens of *P. fruticosa* two varieties can be distinguished:—

Var. A has the branches long and composed of many zoëcia, while the zoëcia themselves have a diameter at the broadest part of nearly half a millimetre. The ectocyst is tinted of a delicate brownish colour.

Var. B (Allman's *Plumatella stricta*), on the other hand, has much more slender zoëcia (greatest diameter about 0.35 mm.), and its branches are sparingly produced and short, consisting of not more than three or four zoëcia each. The ectocyst, except when stained by contact with rotting wood, is practically colourless.

A third form, the *P. coralloides* of Allman, occurs frequently in India but must be regarded merely as a phase directly due to environment. When the zoarium of *P. fruticosa* becomes overgrown by a freshwater sponge, as is frequently the case, the zoëcia are forced by the pressure of its growth to assume an upright direction and often reach a considerable length without branching, in order that their apertures may be on the surface of the sponge. As a rule, however, they are not exactly parallel to one another, and they never assume a polygonal form in cross-section or become agglutinated together. Frequently, moreover, they give rise to branches on the surface of the sponge, even after reaching a considerable length. Zoaria may be found in which the proximal (*i.e.*, the oldest) part is free and has the typical form of *P. fruticosa*, while the younger parts, being embedded in a sponge, have assumed the form of *P. coralloides*.

*P. fruticosa* is a common form in India, especially in Lower Bengal. I have examined specimens of var. A from the island of Bombay, from Igatpuri in the W Ghats, from Lahore in the Punjab (Major J. Stephenson, I.M.S.), and from Calcutta and other places in the Ganges delta. Form B I found growing in abundance in Shasthancottah lake in the plains of Travancore (some of my specimens from that locality being embedded in gelatinous masses formed by a colonial rotifer and having assumed to some extent the *coralloides* characters), and in a jungle stream at the base of the W Ghats in the same State; I also obtained specimens at Igatpuri, and at Kawkareik in Lower Burma. Specimens collected in a pond at Darjiling (alt. 6,900 feet) by Mr. R. Kirkpatrick and now in the British Museum, probably also belong to form B of this species but are in too bad a condition of preservation to make a definite statement possible.

Indian specimens of var. A agree well with a specimen from Germany sent me by Dr. Kraepelin labelled *Plumatella princeps* var. *fruticosa*, while examples of the *coralloides* phase from Calcutta and elsewhere in Bengal closely resemble a specimen of this phase from the neighbourhood of Edinburgh.

In some of the Calcutta tanks *P. fruticosa* grows with great luxuriance. It is only found, so far as my experience goes, during

the cold weather, beginning to flourish in November and dying down again about March. I have not seen resting statoblasts in this species.

*Plumatella emarginata*, Allman.

*Plumatella emarginata*, Allman, *op. cit.*, p. 104, pl. vii, figs. 5—10.

*Alcyonella benedeni*, *id.*, *ibid.*, p. 89, figs. 5—11.

*Plumatella princeps* var. *emarginata* (*partim*), Kraepelin, *op. cit.*, p. 120, pl. iv, fig. 108, pl. v, fig. 123.

*Plumatella emarginata*, Braem, *op. cit.*, p. 9, pl. i, figs. 12, 14.

*Plumatella emarginata* (*partim*), Annandale, *op. cit.*, p. 89.

The main characters of this species, which is remarkably constant, are the following:—

- (1) The zoecia are slender and nearly cylindrical, often quite straight, never dilated at the tip, often (in young or poorly developed colonies) adherent to the support of the zoarium by their whole length. The distal part of each zoecium is never strongly bent upwards when the base is recumbent.
- (2) The aperture is frequently situated on the dorsal surface of the zoecium rather than at the tip.
- (3) The ectocyst is stiff. It is deeply pigmented at the base of each zoecium but colourless at the tip.
- (4) The ectocyst is defected on a triangular area situated at the tip of each zoecium on its dorsal surface,<sup>1</sup> the apex of the triangle, which points away from the aperture, being frequently produced as a furrow running along the middorsal line of the zoecium. The defective area is hyaline, but the furrow is never very deep.
- (5) The statoblast is invariably elongate (not less than 1½ times as long as broad), and (the capsule being small and relatively short) the swim-ring is usually much narrower at the sides than at the extremities.
- (6) In well-developed zoaria part of each zoarium is usually flat and recumbent and part upright, the upright part consisting of branches ramifying in one plane.
- (7) The main axis of the branches forms an angle less than a right angle with that of the zoarium, and is approximately straight.

In this species the distinction between the dorsal and the ventral surface of the zoecium is often retained, even in the case of entirely free zoecia, more clearly than it is in allied forms, the ventral surface keeping its flattened appearance. The coloration is characteristic. The basal part of the zoecium varies from a fairly pale brown to nearly black in tint, but is always opaque and contrasts with the white tip, which is by no means coterminous with the emargination.

<sup>1</sup> This is what is meant by calling the zoecium emarginate.

Both free and fixed statoblasts are produced in considerable numbers.

In Lower Bengal at any rate, most well-developed zoaria assume, sooner or later, the form described by Allman under the name *Alcyonella benedeni*. This is apparently due to the fact that the growth of the zoarium is vigorous, that proper space for its expansion, in the general absence of large areas of attachment of a suitable kind, cannot be found in a horizontal plane, and that the organism is therefore crowded. Profuse branching takes place and the branches are closely pressed together and forced to assume a vertical direction. The individual zoœcia affected become elongated, although not to the same extent as in *P. repens* var. *fungosa*; they do not lose their power of branching, that is to say, of producing daughter zoœcia; no gummy substance is secreted.<sup>1</sup> The masses formed are, therefore, analogous to those of the *coralloides* phase of *P. fruticosa* rather than to those of *P. repens* var. *fungosa*.

*P. emarginata* is a common species in the East. I have myself found it abundant in Calcutta and the neighbourhood, and also both in Upper and in Lower Burma (Rangoon and Mandalay), in the Malay Peninsula (Jalor in the Patani States) and in Lower Siam (Tale Noi, Lakon Sitamarat). Indian specimens agree with a German one sent me by Dr. Kraepelin as typical of his *Plumatella princeps* var. *emarginata*. The species is usually found in ponds, adhering to solid objects either at the bottom or on the surface, such as stones, logs of wood or large woody seeds; it flourishes in the cold weather, but small feeble colonies, with the majority of the polypides dead, may sometimes be found during the "rains" (July to September).

*Plumatella allmani*, Hancock.

*Plumatella allmani*, Hancock, *Ann. Mag. Nat. Hist.* (2), vol. v, p. 200, pl. v, figs. 3—5 (1850).

*Plumatella diffusa*, Leidy, *Proc. Acad. Nat. Sci. Philadelphia*, vol. v, p. 261 (1851).

*Plumatella diffusa*, *P. allmani*, and *P. dumortieri*, Allman, *op. cit.*, pp. 105, 106, 108, pl. viii, figs. 1—5.

Under the name *Plumatella allmani* I here group several forms that have been practically ignored by recent writers on the Phylactolæmata, except perhaps Jullien, whose synonymy cannot be elucidated without an examination of the specimens on which he worked. These forms, however, seem to me to deserve, together, specific rank, being related to *P. emarginata* but invariably distinguishable from that species. It is possible that they include more than one species, but the different forms here described must be regarded for the present as varieties.

The essential characters in which *P. allmani* differs from *P. emarginata*, the only form with which confusion is likely, are the following :—

<sup>1</sup> Kraepelin's *P. princeps* var. *muscosa* is not identical with "*Alcyonella benedeni*."

- (1) The zoëcia are stout and relatively short ; they are never straight or flat, but invariably have the proximal or basal half horizontal and the distal half bent vertically upwards.
- (2) The basal half in the great majority of the zoëcia is adherent, and the aperture is always terminal.
- (3) Vertical branches are rarely formed and never consist of more than three or four zoëcia.
- (4) The base of each zoëcium is usually tinted, but not very deeply ; it is invariably rough on the external surface, while the distal part is smooth, colourless and hyaline.
- (5) The free statoblast is very variable in shape and is often much broader (relatively) than that of *P. emarginata*.

Although well-developed specimens of this species often look to the naked eye extremely like the *benedeni* phase of *P. emarginata*, examination with a lens invariably reveals the characteristic differences in the coloration of the ectocyst and the growth of the zoarium.

The following varieties may be distinguished .—

Var. A. (*P. allmani*, Hancock.)

The zoëcia in this variety are always more or less distorted and are usually broader at the tip than at the base ; some or all of them are strongly emarginate and have a well-developed furrow. They are never densely pigmented as a whole, but in the older specimens obtained at Bhim Tal in the W. Himalayas there is a band of dark pigment round the middle of each zoëcium. The zoarium is never of great extent. I have found every gradation between this form as figured by Hancock and Allman's *P. elegans*.

Var. B. (*P. dumortieri*, Allman.)

This variety differs little from var. A, but the zoëcia are much more regular in shape. Allman states that the statoblast is like that of *P. repens* but figures it as distinctly elongate.

Var. C. (*P. diffusa*, Leidy.)

The growth of this variety is much more vigorous than that of the other two, and the zoaria frequently cover large areas on logs of wood and stones. The zoëcia are stouter and more strongly curved in outline ; they are often closely pressed together, so that a resemblance to the phase *benedeni* is produced. The base of each zoëcium is usually of a yellowish brown colour, but I refer to the variety with some doubt a fragmentary specimen from Bulandshahr in the United Provinces (*Major H. J. Walton, I.M.S.*) in which it is practically colourless. Even in this specimen the separation of each zoëcium into two distinct regions is quite clear. The variety closely resembles Kraepelin's figures of his *Plumatella polymorpha* var. *cæspitosa*, except that the statoblasts differ in shape (*Deutsch Süßwass.-Bryozoen*, part i, pl. v, figs. 126—128). Resting statoblasts are produced.

Although these three varieties cannot be regarded as local races, seeing that they occur in Europe or North America as well as in India, they are not usually found together. I have only seen var. A in Bhim Tal, a W Himalayan lake several miles in length, and var. B in a tank in Calcutta, in a small lake at Kawkareik in Lower Burma and in a pond at Kurseong (alt. c. 5,000 ft.); but var. C is common all over N. India. Major J Stephenson, I.M.S., has sent me specimens from Lahore, while I owe to Mr. R. Kirkpatrick and Capt. F. H. Stewart, I.M.S., specimens taken on different occasions, in a small pond at Gangtok in native Sikhim (E. Himalayas). I have myself found the variety growing in great abundance in the environs of Calcutta and at Rajshahi on the R. Ganges about 150 miles north of Calcutta. On one occasion I discovered a small colony in the Zoological Gardens at Alipore, growing on a brick side by side with *P. emarginata*.

*Plumatella javanica*, Kraepelin.

*Plumatella javanica*, Kraepelin, *Mitth. Nat. Mus. Hamburg*, vol. xxiii, p. 143, figs. 1—3 (1906).

*Plumatella emarginata* var. *javanica*, Loppens, *op. cit.*, p. 163.

This is a much more constant species than the last, related to *P. emarginata* but distinguished by characters that vary little. These characters are the following :—

- (1) The zoëcia are entirely and invariably recumbent, so that the aperture is always on the dorsal surface. They are very long and narrow and produce daughter zoëcia sparingly, so that linear series without lateral branches are sometimes formed. The emargination and furrow are strongly developed.
- (2) There is never any trace of pigment in the ectocyst, which is markedly transparent and delicate; the external surface is smooth.
- (3) The capsule of the statoblast, which is elongate, is large as compared with the swim-ring.

Dr. Kraepelin has very kindly sent me one of the types of this species, and I have found other specimens among Prof. Max Weber's collection of sponges from Java. *P. javanica* is common in Calcutta, and I obtained specimens in a canal near Srayikad in Travancore. In a freshwater sponge collected by Prof. Max Weber in Natal there are the remains of a zoarium that may belong to this species.

b. *Philippinensis* group.

The type of this group is Kraepelin's *Plumatella philippinensis* from the Philippines, and the only other species definitely known to belong to it except *P. bombayensis* is Rousset's *P. tanganyikæ* from Central Africa. The group would therefore appear to be essentially a tropical one.

*Plumatella bombayensis*, Annandale.

*P. bombayensis*, Annandale, *Rec. Ind. Mus.*, vol. ii, p. 169, figs. 1, 2.

*Zoarium*. The whole colony is recumbent but branches freely and at short intervals in a vertical plane, so that the zoœcia become crowded together and the branches sometimes overlap one another. The zoarium often covers a considerable area, but growth seems to be mainly in two directions.

*Zoœcia*. The walls of the zoœcia are thick, stiff and densely pigmented; the external surface, although not very smooth, is always clean; a flat membrane, which is apparently an extension of the ectocyst, frequently extends between different zoœcia and branches. The two most noteworthy characters of the zoœcia are (1) their truncated appearance when the polypide is retracted, and (2) the conspicuous, although often irregular external annulation of their walls. The tip of each zoœcium, owing to the fact that the tentacular sheath is soft and sharply separated from the stiffened wall of the tube, terminates abruptly and is not rounded off gradually as is the case in most species of the genus; sometimes it expands into a trumpet-like mouth. The annulation of the external surface is due to numerous thickened areas of the ectocyst that take the form of slender rings surrounding the zoœcium; they are most conspicuous on its distal half. On the dorsal surface of the base of each zoœcium there is a conspicuous furrowed keel, which, however, does not extend to the distal end; the latter is oval in cross-section. The zoœcia are short and broad; their base is always recumbent, and, when the zoarium is attached to a stone, often seems to be actually embedded in the stone; the distal part turns upwards and is free, so that the aperture is terminal; the zoœcia of the older parts of the zoarium exhibit the specific characters much more clearly than those at the growing points.

*Polypide*. The lophophore bears 20 to 30 tentacles, which are long and slender; the velum at their base extends up each tentacle in the form of a sharply pointed projection, but these projections do not extend for more than one-fifth of the length of the tentacles. Both the velum and the tentacular sheath bear numerous minute tubercles on the external surface. The base of the stomach is rounded, and the whole of the alimentary canal has a stout appearance.

*Statoblasts*. Both fixed and free statoblasts are produced, but not in very large numbers. The latter are broadly oval and are surrounded by a stout chitinous ring, which often possesses irregular membranous projections; the surface is smooth. The free statoblasts are small and moderately elongate, the maximum breadth as a rule measuring about  $\frac{2}{3}$  of the length; the ring of air-cells is not very much broader at the ends than at the sides; the dorsal surface of the central capsule is profusely tuberculate. The outline of the whole structure is somewhat irregular.

This species is perhaps no more than a variety or a local race of the African *P. tanganyikæ* and is closely related to *P. philippinensis*; from the former it differs mainly in its darker and more strongly

annulated ectocyst, while it may be at once separated from *P. philippinensis* by the fact that the latter's zoëcia are smooth and polished and show no trace of annulation.

*Habitat.* As yet only known from Igatpuri Lake, which is situated in the Western Ghats about 60 miles N. E. of the island of Bombay at an altitude of about 2,000 feet.

*Habits.* I found this species common in the lake in November, 1907 and 1909. The largest zoaria were growing on the lower surface of stones, but a few were found attached to the stems and leaves of water-plants. The latter, however, did not appear to be in a very flourishing condition and were all small; their pigmentation was not so dense as that of the colonies on the stones. Probably *P. bombayensis* is a species that flourishes during the "rains," for even the most vigorous colonies appeared, in November, to be dying; there were patches among them in which the polypides had disappeared from the zoaria, and sometimes the zoaria had decayed, leaving the fixed statoblasts to mark their former position.

### c. *Punctata* group.

This group comprises Jullien's genus *Hyalinella* (1893) and probably consists of a single species.

#### *Plumatella punctata*, Hancock.

*Plumatella punctata*, Hancock, *Ann. Mag. Nat. Hist.* (2), vol. v, p. 200, pl. v, figs. 6, 7, and pl. iii, fig. 1.

*Plumatella punctata*, Allman, *op. cit.*, p. 100.

„ „, Kraepelin, *Deutsch. Süßwass.-Bryozoen.*, p. 126, pl. iv, figs. 115, 116, pl. v, figs. 124, 125, pl. vii, figs. 153, 154.

The most striking character of this species is the nature of the synœcium. Although the zoëcia retain their tubular nature to a very considerable extent, the ectocyst is so soft and as a rule so much inflated that this character of the zoëcia is masked, and frequently the zoarium appears to represent an almost uniform flat area rather than a branching structure. The movements of the polypides, moreover, affect the ectocyst directly, and it is drawn together by the contraction of the muscles in a way that does not occur in other species of the genus. There is therefore no difficulty in recognizing living specimens; but preserved ones are often apt to be confused with *P. repens*. The statoblasts are, however, often even broader than is the case in that species, and even in badly shrunken specimens the ectocyst is always thicker. The zoëcia are colourless or nearly so, either hyaline or translucent.

In Europe Kraepelin has recognized two seasonal forms as varieties under the names *prostrata* and *densa*, the former being found in summer, the latter in autumn. In var. *prostrata* the zoëcia are elongated and entirely hyaline, with the external surface nearly smooth, whereas in var. *densa* they are much stouter



and more closely crowded together, and have the ectocyst distinctly clouded and the external surface tuberculate. Var. *densa* has also bigger and broader statoblasts than var. *prostrata*. In the Indian race the degree of transparency of the ectocyst is somewhat variable, but the surface is, in all the specimens I have seen, slightly tuberculate and the method of growth resembles that of var. *densa*. There appears to be a difference as regards the number of tentacles, for while European specimens are said to have from 40 to 60, specimens from Calcutta have from 30 to 40. The statoblasts of Indian specimens resemble those of var. *densa* in being broad, but are rather smaller; they are frequently somewhat asymmetrical in outline. Fixed statoblasts have not been found.

I have, as yet, only found *P. punctata* in the neighbourhood of Calcutta, where it is common in ponds in which a slight infiltration of brackish water may be suspected. It flourishes during the "rains" and the cold weather, but I can detect no difference between specimens taken in July and others taken in January.

#### Genus STOLELLA, Annandale (1909).

This genus is closely allied to *Plumatella* and especially to the *punctata* group, from which it is probably derived. The young zoarium closely resembles that of *P. punctata*, and it is only after several zoëcia have been produced that the characteristic mode of growth becomes apparent, long processes being given out from the base of certain zoëcia so as to take the form of a stolon, and all the zoëcia assuming an upright position.

#### *Stolella indica*, Annandale.

*Stolella indica*, Annandale, *Rec. Ind. Mus.*, vol. iii, p. 279 (1909).

This species is often found growing in close proximity to *Plumatella punctata*, from which even young zoaria may be readily distinguished by their strong emargination and furrow. The upright position of the older zoëcia and the false stolon that separates the little groups of zoëcia in well-developed colonies are, of course, clear diagnostic characters. I have never seen a zoarium with lateral or vertical branches. The free statoblasts are variable in length; they are usually elongate as a whole, but the capsule is nearly as broad as long and the swim-ring is exceedingly narrow on both faces at the sides. The fixed statoblasts, which are produced in considerable numbers, are very variable in proportions. The chitinous ring surrounding them is stout and is surrounded in its turn by a narrow membranous ring indistinctly ornamented with a reticulate pattern. The surface of the capsule is smooth. The tentacles possess a short and feebly festooned velum at the base.

*S. indica* is common in the neighbourhood of Calcutta during the "rains" and has been taken by Major Walton at Bulandshahr in the United Provinces.

Genus *LOPHOPUS*, Dumortier.

The *punctata* group of *Plumatella* is to some extent intermediate between *Lophopus* and the typical species of its own genus, but in *Lophopus* the tubular character of the zoëcia is still further masked by the development of the synœcium, which takes the form of a gelatinous vertical sack. The polypides are invested in this sack in an upright position, as is most clearly seen when they are fully expanded. Their lowest point is separated by some little distance from the base of the zoëcium, except when the whole organism is very strongly contracted. The free statoblasts resemble those of *Plumatella* but are much larger; fixed statoblasts are not formed.

Only two species of *Lophopus* can be recognized, namely *L. crystallinus* (Pallas) and *L. jheringi*, Meissner. The former occurs in Europe and North America and has the statoblasts of an oval shape with the extremities much produced; the latter has only been found in Brazil and has the statoblasts irregularly polygonal or almost circular.

It is doubtful whether any species that really belongs to *Lophopus* occurs in India, for the species found by Carter in Bombay must be placed in the genus *Lophopodella*, while there is no information available regarding a form said to occur in Madras.

Genus *LOPHOPEDELLA*, Rousselet (1904).

There has been much confusion between this genus and *Lophopus*, but a recent examination of living specimens, which I was able to keep under observation for some weeks, shows me that I was wrong in regarding the two as identical. Rousselet's genus may be distinguished by the following characters:—

- (1) The polypides are arranged in the synœcium in such a way that they radiate from a common centre. When fully expanded they do not stand upright but recline with their main axis at a tangent to the base of the synœcium, from which they are not far separated.
- (2) The statoblasts normally bear at either end a series of delicate chitinous processes each provided with several pairs of minute hooks.

From *Pectinatella* the genus is distinguished, (1) by the fact that different zoaria do not become embedded in a common jelly, and (2) by the structure and position of the chitinous processes of the statoblasts.

Three species of *Lophopodella* may be distinguished.

- |  |                                   |
|--|-----------------------------------|
| I. Extremities of the statoblast produced                | <i>L. capensis</i> . <sup>1</sup> |
| II. Extremities of the statoblast convex or sub-truncate | <i>L. carteri</i> .               |
| III. Extremities of the statoblast concave               | <i>L. thomasi</i> .               |

<sup>1</sup> Miss I. B. J. Sollas, "A new freshwater Polyzoon from S. Africa," *Ann. Mag. Nat. Hist.* (8), vol. ii, p. 264 (1908).

All three species occur in Africa, but *L. carteri* was discovered in Bombay and is represented in Japan by what appears to be a local race.

*Lophopodella carteri* (Hyatt).

*Lophopus* sp., Carter, *Ann. Mag. Nat. Hist.* (3), vol. iii, p. 335, pl. viii, figs. 8—15 (1859).

? *Lophopus* sp., Mitchell, *Quart. Journ. Micros. Sci.* (3), vol. ii, p. 61 (1862).

*Pectinatella carteri*, Hyatt, *Comm. Essex Inst.*, vol. iv, p. 203 (1865).

*Lophopodella carteri*, Rousselet, *Journ. Quek. Micr. Club*, 1904, p. 47, pl. iii, figs. 6, 7.

*Lophopus lendenfeldi*, Annandale (nec Ridley), *Journ. Asiat. Soc. Bengal*, 1907, p. 92, pl. ii, figs. 1—4.

*Lophopus lendenfeldi* var. *himalayanus*, *id.*, *Rec. Ind. Mus.*, vol. i, p. 143, figs. 1, 2.

*Lophopus carteri*, *id.*, *ibid.*, vol. ii, p. 171, fig. 3.

The characteristic features of the zoarium of this species are obscure unless it be examined either in a healthy living condition or preserved with the polypides fully expanded. The general form of each zoarium as viewed from above is circular or oval, with more or less distinct lobate projections, which become more conspicuous when the animals are strongly contracted. The centre of the structure, owing to the arrangement of the polypides, appears to be practically empty when the polypides are expanded, so that the whole has a ring-like appearance. Viewed from the side it resembles a low mound. The gelatinous parts are colourless, but the stomach has a greenish tinge. The tentacles are long and slender but much shorter than those of *Austrellella lendenfeldi*; they usually number about ninety. The shape and proportions of the statoblast vary considerably, but the extremities are never concave. The number of chitinous processes is not constant, and their degree of development varies even in specimens from the same locality.

The form described by me as *Lophopus himalayanus* is distinguished by the small number of its tentacles and the absence or abortive condition of the processes on the statoblast. This form, however, must be regarded merely as an abnormality in which the polypides are stunted and the statoblasts retain immature characters. I have recently received typical specimens of *L. carteri* from Bhim Tal, in which the abnormal form was originally discovered.

*Pectinatella davenporti*, Oka, of which Dr. Oka has been kind enough to send me specimens, is certainly, as Loppens indicated,<sup>1</sup> a form of *L. carteri*, the range of which, therefore, extends from E. Africa to Japan. In India, however, the occurrence of the species is sporadic. It was originally found in Bombay and is common in Igatpuri Lake; possibly it occurs at Madras. It is usually found either on the lower surface of stones or among gelatinous green algæ on the stems of plants.

<sup>1</sup> "Les Bryozoaires d'eau douce," *Ann. Biol. Lacustre*, vol. iii, p. 166 (Decr. 1908).

## Genus PECTINATELLA, Leidy.

The structure of the individual zoarium of this genus agrees closely with that found in *Lophopodella*, but in fully mature colonies a large number of zoaria secrete a common investment or basal membrane of a gelatinous nature, so that compound colonies, often of gigantic size, are produced. The statoblast is entirely surrounded by chitinous processes, each of which bears at its extremity a pair or a small bunch of hooks.

Three species of *Pectinatella* can be distinguished, *P. magnifica* from N. America and the continent of Europe, *P. gelatinosa* from Japan, and *P. burmanica* from Bengal and Lower Burma. They may be distinguished as follows:—

- |      |   |                       |
|------|---|-----------------------|
| I.   | Statoblast circular, surrounded by processes which are much longer than the hooks at their tips               | <i>P. magnifica.</i>  |
| II.  | Statoblast somewhat irregular in shape but nearly circular; the processes not or barely longer than the hooks | <i>P. burmanica.</i>  |
| III. | Statoblast subquadrate; processes as in II  | <i>P. gelatinosa.</i> |

*Pectinatella burmanica*, Annandale.

*Pectinatella burmanica*, Annandale, *Rec. Ind. Mus.*, vol. ii, p. 174 (1908).

*Zoaria* circular or oval, sometimes constricted in the middle owing to approaching division, of large size, embedded in large numbers in a greenish jelly of considerable thickness, the compound colonies often measuring a yard or more in length and several inches in diameter.

*Polypides* large, the free part measuring when fully protruded about 5 mm. Tentacles numbering about 90, slender, moderately long, tuberculate; the velum at their base narrow, never strongly festooned.

*Statoblast* almost circular but invariably a little irregular in outline, measuring about 1.75 mm. in diameter, provided with a complete ring of very short chitinous projections each of which bears a pair of hooks at the tip. The hooks normally bend backwards in a wide arc and nearly touch the edge of the statoblast; sometimes they are distorted or abortive.

Young zoaria resemble those of *Lophopodella carteri* both in general structure and in histology but may be distinguished, even before the secretion of the common jelly, by the large size of the polypides and the green colour of the synœcium.

I described *P. burmanica* from a statoblast found in March in a lake at Kawkareik in Lower Burma, but later in the year (October) discovered mature colonies growing in great abundance in the Sur Lake near Puri in Orissa. They grew on the stems of rushes, which they completely encased. Both larvæ and statoblasts were being given out in large numbers.

In concluding these notes I have to thank the many colleagues who have assisted me with specimens and information. For Indian examples of the Phylactolæmata I am indebted to Major H. J. Walton, Major J. Stephenson and Capt. F. H. Stewart of the Indian Medical Service, and to Mr. R. Kirkpatrick, to whom I must also express my thanks for assistance as regards exchanges with the British Museum. The named European specimens sent me by Dr. Kraepelin and Dr. W. Michaelsen from Hamburg have proved exceedingly useful, while I cannot express my admiration too strongly as regards the exquisite preparations given me by Mr. C. Rousselet. I owe to Dr. F. Harmer's generosity some valuable specimens and am indebted to Prof. Max Weber, Dr. Oka, Mr. T. Evans and the authorities of the Geneva Museum for others. Last but not least the Trustees of the Indian Museum are entitled to my gratitude for the liberality with which they have allowed me to travel in India and Burma.

This paper is merely a preliminary attempt to classify the Indian representatives of a very difficult group. It will, I hope, be followed by the publication of a more ambitious work. I need, therefore, hardly say that criticism will be most valuable, especially on the part of those who have a practical acquaintance with the Phylactolæmata of Europe and N. America.

