XXV A CATALOGUE OF THE LUCANIDAE IN THE COLLECTION OF THE INDIAN MUSEUM

By F. H. GRAVELY, *M.Sc., Asst. Superintendent, Indian Museum.*

(Plate XXIX.)

The size and variability of the mandibles of male Lucanidae have naturally attracted special attention from the early writers on this family; and the difficulty of correlating the sexes with certainty seems to have led to an undue neglect of the female. Leutner has, it is true, treated females as carefully as males in his monograph of the Odontolabinae; and a number of recently discovered species have been described from specimens of both sexes. But reasons for the traditional association of females with males seem in many species to have been too vague for record; and the most distinctive characteristics of the females of a number of well-known species seem still to remain undescribed.

In the following short account of our collection I have therefore paid special attention to females.[1] The determination of their subfamilies, and sometimes even genera, has been based on tradition, and I am doubtful whether any of my specific determinations are in disagreement with the associations commonly recognized in European museums. But so far as our material permits, reasons for the association have been found and recorded, and attention has been drawn to structural characters by which the females of various species may be recognized.

In one instance the consideration of female characters has led me to suggest a change in generic definitions. The genera concerned are *Hemisodorcus*, *Eurytrachelus* and *Dorcus* of Van Roon's catalogue.[2]

The female of *Hemisodorcus fulvonotatus* was found to differ from that of *H. nepalensis* in having a pair of tubercles on the head instead of a single one; and the female of *Dorcus suturalis*

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[1] Except in the subfamily Odontolabinae, where Leutner has rendered this unnecessary, and in the subfamily Cladognathinae where our material, which is almost entirely Indian, is inadequate for this except in the genus *Cladognathus*. Outside this genus the association of opposite sexes of such species of Cladognathinae as we possess has been based on colour and locality. I have no doubt of the correctness of the determinations made, but have had no opportunity of considering the differentiation of females of species differing in structure but not in colour.

[2] *Coleopterorum Catalogus*, Pt. 8, Lucanidae, Berlin, 1910.

was found to differ from the other species of *Dorcus* in our collection in the opposite direction. Further investigation then showed that the prosternal process of both sexes of the latter species was elevated as in *Hemisodorcus*, not flattened as in *Dorcus*; and that the anterior plates of the head of the male of the former species resembled those of *Eurytrachelus*, not *Hemisodorcus*.

Thomson [1] defines these genera—including as a distinct genus *Platyprosopus*, which Van Roon unites in his catalogue with *Eurytrachelus*—by means of the structure of the mandibles and anterior plates of the head of the male, and the structure of the prosternum. *Hemisodorcus* is said to differ from the other three genera in having elongate mandibles, and this character appears to have been regarded by subsequent authors as being in itself diagnostic of the genus. But it is not correlated with the other so-called generic characters, and a consideration of the female points to the conclusion that it is of less importance than them.

The material in our collection does not enable me to determine whether these other characters are always sharply distinctive, or sometimes grade into one another, but it proves clearly that the extent of their development shows a considerable degree of variation in different species. Thus the posterior end of the prosternal process, though it is always much higher than the mesosternum and more or less abruptly truncate in *Hemisodorcus* and *Eurytrachelus*, and is depressed in the most typical species of *Dorcus* and *Platyprosopus*, is sometimes, in the genus *Dorcus* at least, distinctly convex immediately in front of a narrow depressed posterior margin.

In the table for the determination of these genera given below, I have found it convenient to attach primary importance to the structure of the prosternum, because this applies to both sexes.[2] But when dealing with males only it is often easier to consider first the character of the anterior plates of the head.

These plates, the clypeus and labrum, appear to be more or less fused in most, if not all, Lucanidae; and the plate thus formed—which may be termed the clypeolabrum—is often itself indistinguishably fused with the frons. Among the species before me the outlines of these plates are best seen in *Lucanus cantori*. In the female of this species the clypeus is less coarsely punctured than the frons, and is bounded behind by a tolerably distinct suture: it is very narrow and is keeled in front, overhanging by almost its whole width the larger, still more sparsely punctured, and much more hairy labrum.[3]

In the male the ridge between the clypeus and the labrum is much larger, but the boundary between the clypeus and the

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[1] *Ann. Soc. Ent. France* (4) II, 1862, pp. 421-2.

[2] The genetic relationships of these genera can only be determined by the examination of a representative collection of their species from all parts of the world. I have examined scarcely any but Indian forms.

[3] In the females of most species the labrum is much smaller and the clypeus somewhat larger; consequently the labrum is much obscured.

frons appears only as an exceedingly obscure transverse convexity about one-third of the way from the clypeolabral ridge to the ridge between the anterior angles of the head. That this obscure convexity does really mark the junction of the clypeus and the frons is confirmed by the fact that in *Hexarthrius forsteri*—a species of which the female is unknown to me—it is replaced by a very distinct suture.[1] In *Hexarthrius forsteri* the clypeolabral ridge is replaced by a pair of angular processes, structures which reappear in many species of Lucanidae, and may be supposed when present always to represent this ridge.

The presence of these processes, or of the ridge from which they are derived, distinguishes the genera *Eurytrachelus* and *Platyprosopus* from *Hemisodorcus* and *Dorcus*. But when the whole ridge is present it is often very low, and there seems reason to think that it has sometimes been overlooked, with the result that species of *Eurytrachelus* have been placed in the genus *Dorcus*, and that the differences between the prosterna of these two genera have come to be regarded as of no importance.

The morphological anterior margin of the labrum is, however, densely fringed with hair, and the clypeolabral ridge is hairless. When, therefore, the apparent anterior margin of the clypeolabrum as seen from above is hairy, and no ridge or processes are seen, the specimen will belong to the genus *Hemisodorcus* or *Dorcus*. When, however, it is hairless, a closer examination will show that this margin is really the clypeolabral ridge and that the true anterior margin of the plate is hidden beneath it.

The genera *Hemisodorcus*, *Dorcus*, *Eurytrachelus* and *Platyprosopus* may then be distinguished thus :—

1.	Posterior end of prosternal process abruptly rounded or truncate in both sexes, its horizontal surface raised well above surface of mesosternum	2.
	Posterior end of prosternal process lower in both sexes, either uniformly depressed, or convex in front of a narrow depressed border defined on the inner side by a marginal groove	3.
2.	Clypeolabral ridge absent in male ; female with upper tooth of mandibles very strong and with a median cephalic tubercle	*Hemisodorcus.*
	Clypeolabral ridge present in male (often as a pair of lateral teeth) ; female with upper tooth of mandibles very weak and with a pair of cephalic tubercles ...	*Eurytrachelus.*
3.	Antennae normal in both sexes ; clypeolabral ridge absent in male ; female with a pair of cephalic tubercles	*Dorcus.*
	Seventh joint of antenna (the last before the three bearing pilose lamellae) with a slender polished anterior process as long as the lamella of the succeeding joint and tipped with a cluster of hairs (? in both sexes) ; clypeolabral ridge present in male ; female ? ...	*Platyprosopus.*

[1] This suture is also present in the other species of *Hexarthrius* in our collection ; but in them the clypeus is disproportionally large, the labrum being reduced to a narrow strip along its outer margin.

The above diagnoses are necessarily provisional, being based on Indian species only; but I have found it convenient to adopt them in the following catalogue. Apart from this I have followed the classification, and with one or two exceptions the synonymy, adopted in Van Roon's catalogue (*loc. cit.*, above, p. 407, footnote), where references to literature will be found. As, however, many references are incorrectly given there, the following corrections of the inaccuracies I have noticed will facilitate use.

Lucanus cantori. Hope, *Trans. Ent. Soc. London* IV, 1845-7, p. 73; Hope, *Ann. Mag. Nat. Hist.* XII, 1843, p. 363.

Odontolabis burmeisteri. Hope, *Trans. Ent. Soc. London* III, 1841-3, p. 279, pl. xiii, fig. 3.

Metopodontus maclellandi. Hope, *Ann. Mag. Nat. Hist.* XII, 1843, p. 364; Hope, *Trans. Ent. Soc. London* IV, 1845-7, p. 74.

Metopodontus occipitalis = asteriscus. Add—Westwood, *Cab. Or. Ent.*, pl. x, fig. 4.

Metopodontus wentzel-heckmannae. Locality—N. Nyassaland, not Annam.

Prosopocoelus buddha. Hope, *Trans. Linn. Soc. London* XIX, 1843, p. 107; Parry, *Trans. Ent. Soc. London* (3) II, 1864, pl. xii, fig. 3, ♂

Prosopocoelus bulbosus. Hope, *Trans. Linn. Soc. London* XVIII, 1841, p. 589, pl. xl, fig. 2.

Aegus parallelus. Locality—Khasi Hills, not Prince of Wales Island. The latter locality is recorded for *A. capitatus* (♂) = *A. sinister* (♀), see Westwood, p. 56 of Parry's Catalogue in *Trans. Ent. Soc. London* (3) II, 1864-6.

Nigidius elongatus. Boileau, *Naturaliste* XXIV, 1902, p. 205.

Nigidius vagatus. I have failed to trace this species at all.

Boileau's "Note sur Lucanides conservés dans les collections de l'Université d'Oxford et du British Museum" (*Trans. Ent. Soc. London*, 1913, pp. 213-272, pl. ix) is an important paper published since the catalogue.

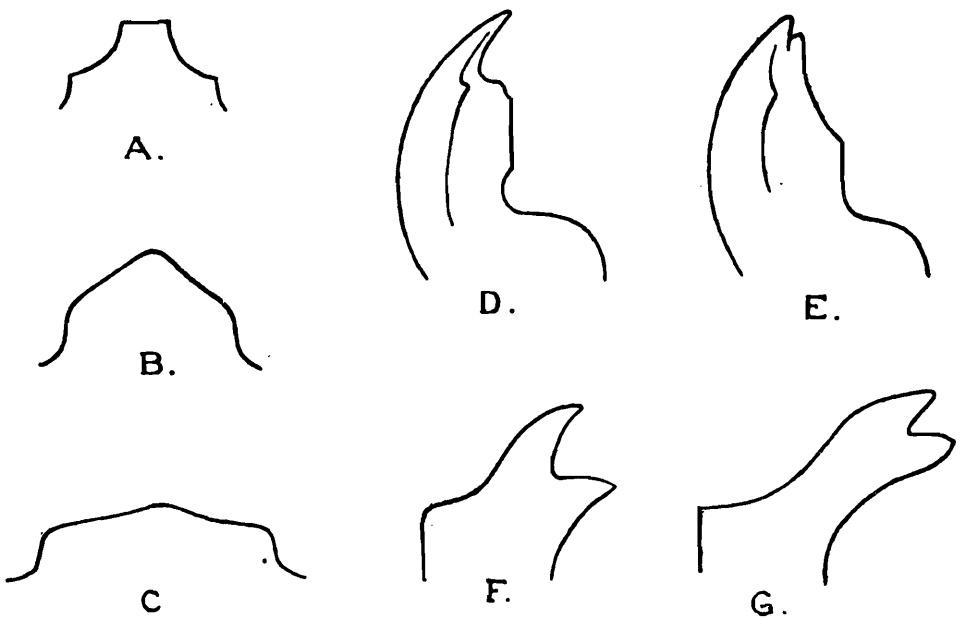
When on leave in Europe in 1913, I took the opportunity of checking my identifications by comparison of a selection of our specimens with those in the British Museum and the Deutsches Entomologisches Museum. My thanks are due to Mr. Arrow and Dr. Horn for the facilities granted me. I have also to thank Mr. Arrow for information with regard to a number of specimens which I had not time to examine fully in London myself, and H. E. Lord Carmichael, Mr. E. E. Green, Mr. R. S. Lister, Mr. E. A. D'Abreu, the Colombo Museum, the Bombay Natural History Society, and the Imperial Agricultural and Forest Research Institutes for the loan of specimens, a number of which have been added to the Indian Museum collection.

Localities not represented by either sex in the Indian Museum collection are marked with an asterisk (*). The types of *Metopodontus foveatus* subsp. *birmanicus* are now in the British Museum. Those of all other new forms described are in the Indian Museum.

Genus **PSEUDOLUCANUS**, Hope.

Pseudolucanus atratus, Hope.

E. Himalayas : Darjeeling (♂).



TEXT-FIGURE 1.

A. Clypeus of *Lucanus mearsi*, ♀.
B. ,, ,, ,, *lunifer*, ♀
C. ,, ,, ,, *cantori*, ♀
D. Left mandible of *Lucanus mearsi*, ♀
E. ,, ,, ,, ,, *smithi*, ♀
F. Distal end of right anterior tibia of *Lucanus mearsi*, ♀
G. ,, ,, ,, ,, ,, ,, ,, ,, *westermanni*, ♀

Genus **LUCANUS**, Scop.

Lucanus laminifer, Waterhouse.

Assam : Khasi Hills, 1000-3000 ft.(♂).

Lucanus cantori, Hope.

(Text-figure 1C.)

E. Himalayas: Darjeeling District—Darjeeling (♀); Kurseong, 5000 ft. (♂).

Khasi Hills : Shillong (♂).

The longitudinal yellow bands on the femora make the association of males and females of this species easy. In females

the clypeus is transversely linear (text-fig. 1C), and the dorsal tooth of the mandibles is obsolete.

Lucanus lunifer, Hope.

(Text-figure 1B.)

W. Himalayas: Simla (♂); Dehra Dun* (♂); Mussoorie* (♂ ♀); Naini Tal (♂ ♀).

Assam: Khasi Hills (♂).

In the specimen from the Khasi Hills the upper fork of the mandibles is distally enlarged and truncate; in the rest it is normal as in the type specimen (see Boileau, *Trans. Ent. Soc. London*, 1913, p. 218).

The female closely resembles that of the preceding species, but the upper surface of the head is more convex; the clypeus (text-fig. 1B), whose anterior margin is strongly angular instead of almost straight, extends much further forward; and there is a small but distinct tooth on the dorsal surface on the mandibles. The association of this form of female with the male of the present species rests on its uniformly black legs, which separate it from the preceding species, and on its large size and apparent greater abundance in the Western than in the Eastern Himalayas, which separate it from the three following species.

Lucanus mearsi, Hope.

(Text-figures 1A, D and F.)

W Himalayas: Mussoorie (♂ ♀).

E. Himalayas: Darjeeling District—Darjeeling, 7000 ft. (♂ ♀); Kurseong, 5000 ft. (♂ ♀).

To one specimen is attached the label "Bores into dead sap wood of Kharani (*Symplocas* sp.); found at elevation 5000 to 6000 ft. in Sikkim—*G. Rogers*."

Females of this and of the two following species differ from those of the two preceding species in their smaller average size, and in the shape of the clypeus (text-fig. 1A) which, though produced in front as in *L. lunifer*, is always truncate or broadly rounded, instead of strongly angular, in the middle line. Females of the present species may be distinguished from those of the two following by the shape of their anterior tibiae, whose two distal marginal teeth are not specially elongated and are not fused at the base (text-fig. 1F). They are usually of a deep olivaceous colour rather than jet black, and fresh specimens are more or less completely covered with fine golden pile—characters which are shared by the male sex.

Lucanus smithi, Parry.

(Text-figure 1E.)

Van Roon gives *smithi*, Parry, as a synonym of *villosus*, Hope, in his catalogue. Boileau, however, states (*Trans. Ent. Soc. London*

1913, p. 219) that a male of *L. villosus* in the British Museum, possibly the type, closely resembles *L. lunifer* in structure; the measurements given in Gray's brief diagnosis[1] are too large for any specimens of *L. smithi* known to me; the mandibles of *L. villosus* are described by Gray as unidentate, whereas those of *L. smithi* are at least tridentate except in very small specimens; Parry was acquainted with *L. villosus* when he described *L. smithi*.

L. smithi is represented in our collection from the following localities :—

E. Himalayas: Darjeeling District—Darjeeling, 7000 ft., (♂ ♀); Mungphu (♂); Kurseong, 5000 ft. (♂ ♀); Siliguri, in the Terai, a few miles south of the base of the hills (♂ ♀).

The thickening of, and multiplication of teeth on, the mandibles of the male a little beyond the middle is reflected in the great breadth of the mandibles of the female (text-fig. 1E) at about this point, beyond which the inner margin is straight or slightly wavy and blade-like instead of strongly excavate as in *L. mearsi* and *L. westermanni*. The surface is covered with pile as in *L. mearsi*, and the form of the clypeus also resembles that of this species. The anterior tibiae of *L. smithi* resemble those of *L. westermanni* rather than those of *L. mearsi*.

Lucanus westermanni, Hope.

(Text-figure 1G.)

E. Himalayas: Darjeeling District—Darjeeling, 7000 ft.* (♂ ♀); Kurseong, 5000 ft. (♂ ♀).

This species is less densely pilose in both sexes than are fresh specimens of either of the two preceding species. In very small males the mandibles are not forked distally, and the submedian tooth is minute. Small males of the two preceding species show a tendency in the same direction, and it is not impossible that in extreme cases the mandibles of *L. smithi* at least may be indistinguishable from those of the present species—in such cases the length of the pile on the reflexed margins of the elytra would afford a useful guide to identification. Fully hardened specimens of both sexes are jet black in colour, others are reddish. None are in any degree olivaceous.

The mandibles of the female resemble those of *L. mearsi*. The frons is more convex in the middle line in front than in that species. The clypeus differs from that of *L. mearsi* and *L. smithi* in being less abruptly truncate, often broadly rounded, in front. The two distal teeth of the anterior tibiae (text-fig. 1G) are united at the base; their length is about equal to the greatest breadth of the tibia exclusive of its teeth.

A female from Dehra Dun, in the Forest Research Institute collection, resembles *L. westermanni* in general appearance; but its clypeus is like that of *L. mearsi*, and its anterior tibiae are intermediate between those of these two species.

Genus **HEXARTHRIUS**, Hope.

Hexarthrius davisoni, Waterhouse.

Madras Presidency : Cuddapah* (♂) ; Palni Hills (♂ ♀).

Hexarthrius mniszechi, Thomson.

Assam : Sylhet (♂).

Hexarthrius forsteri, Hope.

Assam : Khasi Hills (♂).

Hexarthrius parryi, Hope.

Assam : Khasi Hills—Shillong, 3000-5000 ft.* (♂).
Sibsagar (♂).

The anterior parts of the elytra, though darker than the posterior, are not black in our specimen. They are not sharply marked off from the latter, as in Hope's figure, either in our specimen or in that from Shillong belonging to the Pusa collection.

Genus **NEOLUCANUS**, Thomson.

Neolucanus castanopterus, Hope.

W. Himalayas: Almora—Ramnee.
E. Himalayas: Nepal—Katmandu (♂).
Sikkim—Shamdang, 3000 ft. (♂).
Darjeeling District—Darjeeling, 6000 ft. (♂) ; Mungphu (♂) ; Kurseong, 6000 ft. (♂) ; Singla, 1500 ft.* (♂).
Bengal : Duars—Buxa, near Bhutan frontier (♂).
Assam : Khasi Hills (♂ ♀)—Shillong (♂).
Sibsagar (♂).

Neolucanus marginatus, Waterhouse.

Lower Burma : Amherst District of Tenasserim—Misty Hollow to Sukli, 2100-2500 ft., Dawna Hills (♀).

This specimen closely resembles *N. parryi*, but the anterior femora are scarcely denticulate though they do not look worn. The mentum, too, has only a rudimentary crescent-shaped crest.

Neolucanus lama, Olivier.

E. Himalayas : Darjeeling District—Lebong* (♀) ; Mungphu (♀) ; Kurseong, 5000 ft. (♂ ♀).
Assam : Khasi Hills (♂).

Genus **ODONTOLABIS**, Hope.

Odontolabis siva, Hope.

E. Himalayas: Darjeeling District—Darjeeling, 7000 ft*. (♂ ♀); Mungphu (♂ ♀); Pashok; (♂ ♀); Bhutan (♀).
Bengal: Duars—Buxa (♀).
Assam: Khasi Hills (♂ ♀)—Shillong (♂).
Sibsagar (♂).
Sylhet (♂).

Odontolabis cuvera, Hope.

S. India (♂ ♀); Slopes of Nilgiris (♂); Wynad (♂).
E. Himalayas: Darjeeling District—Darjeeling (♂ ♀); Lebong, 5000 ft.* (♂); Pashok* (♀); Mungphu (♂ ♀).
Assam: Khasi Hills (♂ ♀)—Shillong (♂); Cherrapunji (♂).
Naga Hills (♂).
Lower Burma: ? Rangoon*[1] (♂ ♀); near Sukli, Dawna Hills (Amherst District of Tenasserim), *ca.* 2000 ft. (♀); Tavoy (♀).

This species is evidently rare in South India. There is, however, a large male in the Madras Museum collection of South Indian insects; and in our collection are two intermediate males, one small male, and one female from South India.

The female can easily be distinguished from that of *O. delesserti*, which is much commoner in South India, by its broadly flattened mentum with distinct lateral keels close to the margin.

Odontolabis delesserti, Guerin.

S. India (♂ ♀); Travancore—High Range* (♀); Ponmudi* (♀); Malabar—Wynad (♀); Palni Hills* (♂ ♀); Cuddapah* (♀).

The mentum of the female is broadly concave in the middle and broadly convex laterally.

Odontolabis burmeisteri, Hope.

S. India: Coorg—Mercara* (♀); Travancore (♀).

The specimen from Travancore agrees in every respect with Leutner's description of this species, except that there is only a narrow band of yellow on the reflexed borders of the elytra. The other specimen belongs to the Pusa collection. It is very much

[1] This record is based on specimens in the collection of the Bombay Natural History Society. The male (a large one) is the only specimen of its sex that I have seen from Burma, and establishes the identity of the form found there with that found in Assam and the Himalayas. The specimens are unlikely, however, to have come originally from Rangoon itself, for the species appears to be confined to hilly country, and is not known to descend below 1500 or 2000 ft.

darker in colour and has no black on the reflexed borders of the elytra.

Odontolabis latipennis, Hope.

Malay Peninsula: Johore (♂).

Odontolabis aeratus, Hope.

Sumatra: Sinkep Island (♂ ♀).

Odontolabis carinatus, Linnaeus.

Ceylon: Central Province—Lindula* (♂); Maskeliya (♂ ♀).
Sabaragamuwa—Bulutota in Ratnapura District (♀).

Genus **HETEROCHTHES**, Westwood.

Heterochthes andamanensis, Westwood.

South Andamans (♂ ♀).

Genus **CLADOGNATHUS**, Burmiester.

Cladognathus arrowi, n. nom.

=*C. confucius*, *auct.*, *nec* Hope.

E. Himalayas: Darjeeling District—Darjeeling, 7000 ft. (♀); Singla, 1500 ft. (♂); Pashok (♂).
Assam: Sibsagar (♂).

The type specimen of *C. confucius*, Hope, is in the British Museum, and has proved to be a small specimen of the following species. A new name is therefore required for the present species in which the mandibles even of the largest males are straight and bear no very strong teeth. I have much pleasure in naming so fine an insect after Mr. G. J Arrow, whose ever-ready help in the naming of Lamellicornia has greatly facilitated my work on the group.

In the female the head is very finely punctured; the anterior angles of the pronotum are scarcely truncate; and the terminal process of the anterior tibia is slender, being formed by the union of two spines only.

Cladognathus giraffa, Fabricius.

W. Himalayas: Dehra Dun (♂ ♀).
E. Himalayas: Darjeeling District—Singla, 1500 ft. (♀); Pashok (♂ ♀).
Bengal: Kaptai, Chittagong Hill tracts (♂ ♀).
Assam: Khasi Hills (♂).
Sibsagar (♂ ♀).
Andamans: Port Blair (♂).

The large tooth and double curve of the mandibles, characteristic of large males of this species, are both lost in intermediate

and small forms; but the forked apex is indicated even in a specimen (in the Dehra Dun collection) in which scarcely a trace of any tooth except the basal remains. The wide separation of the tubercles on either side of the middle of the anterior margin of the head, and the sharp posterior margin of the lower surface of the anterior femora are characters which distinguish small as well as large males of this species from those of the last. Attention may also be called to three other differences, differences which, though slight in themselves, are worthy of note on account of their intensification in the female. They are: the faintly rougher average texture of the anterior parts of the present species; the slightly broader (oblique) truncation of the anterior angles of the pronotum; and the somewhat less slender terminal process of the anterior tibia. The female of the present species differs from that of the preceding species in having the head very coarsely punctured, the anterior angles of the pronotum distinctly (transversely) truncate, and the terminal process of the anterior tibia much stouter and composed of 3-4 teeth.

Genus **METOPODONTUS**, Hope.

Metopodontus foveatus, Hope.

(Text-figure 2.)

The type of this species, which has been re-examined by Boileau, is from Sylhet in Assam; our specimens of the typical form are from Assam and the adjacent Naga Hills. Boileau (*Bull. Soc. Ent. France*, 1911, pp. 63-5, 1 text-fig.) has described as a distinct species *M poultoni* "nombreux specimens des deux sexes, de diverses provenances, mais principalement recus du Boutan (Sakiou, Maria Basti [1])." Our specimens of this form are all from the Eastern Himalayas. A third form is represented by a series of specimens from (?) Rangoon,[2] belonging to the Bombay Natural History Society and to the Agricultural Research Institute, Pusa. The large male of this series (text-fig. 2F) has one large tooth only on each mandible as in *M. foveatus* (text-fig. 2D), not two as in *M poultoni* (text-fig. 2A); but this tooth is basal as in males of *M. foveatus* of moderate size (text-fig. 2E), not median as in large males of that form. These three forms, and possibly *M. cinnamomeus* from the Sunda Islands, should probably be regarded as local races of a single species. It seems doubtful whether any definite distinctions between them exist except in large males.

1. M. FOVEATUS subsp. POULTONI, Boileau.

W. Himalayas: Almora—Kimoli (♀).

E. Himalayas: Darjeeling Dist.—Darjeeling (♂). Kurseong (♂ ♀); Pashok (♂ ♀).

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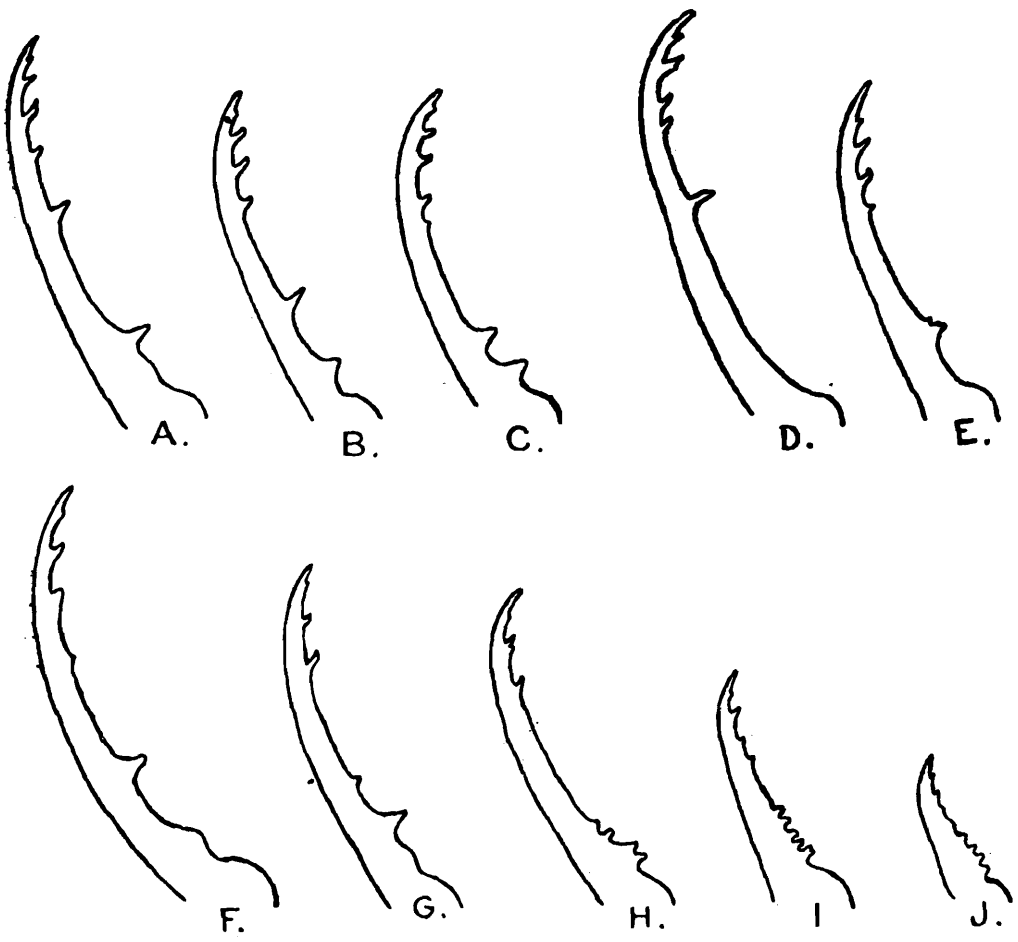
[1] Maria Basti (or Kaggia Monastery) is situated in the part of the Darjeeling District sometimes known as "British Bhutan." Sakiou is doubtless a misprint for Sakion(g), a few miles further west in the same district.

[2] Probably brought with timber from some hilly district.

The only male from Kurseong is a small one and, like all females, is identified on zoogeographical grounds.

2. METOPODONTUS FOVEATUS, Hope, *s. str.*

Assam (♀): Khasi Hills—Cherrapunji (♂).
Naga Hills (♂).



TEXT-FIGURE 2.

A–C. Left mandibles of macrodont males of *Metopodontus foveatus* subsp. *poultoni*, × 2.
D–E. Left mandibles of macrodont males of *Metopodontus foveatus*, s. str., × 2.
F–J. Left mandibles of males of *Metopodontus foveatus* subsp. *birmanicus*, × 2.

3. M. FOVEATUS subsp. BIRMANICUS, n. subsp.

The distinctive characters of this form have already been noticed (see previous page). All the specimens I have seen are somewhat dark in colour, therein resembling the Assamese race rather than the Himalayan.

Upper Burma: Chin Hills—Haka* (♂).
Lower Burma: ? Rangoon[1] (♂ ♀).

[1] See previous page, footnote 2.

Metopodontus maclellandi, Hope.

(Text-figure 3A.)

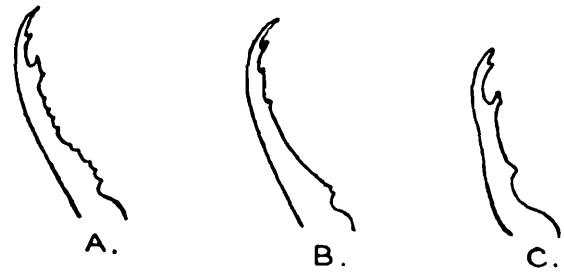
E. Himalayas : Darjeeling Dist.—Darjeeling (♂); Pashok* (♂).
Assam : Sibsagar (♂).

Metapodontus impressus, Waterhouse.

(Text-figure 3B.)

E. Himalayas : Darjeeling District (♀).
Abor Country—Kobo, 400 ft. (♂).

Our only specimens of this species are a macrodont male and a female. The former is very slightly smaller than our macrodont male of the preceding species. The armature of the



TEXT-FIGURE 3.

A. Left mandible of macrodont male of *Metopodontus maclellandi,* × 2.
B. ,, ,, ,, ,, ,, ,, ,, *impressus,* × 2.
C. ,, ,, ,, ,, ,, ,, ,, *biplagiatus,* × 2.

mandibles of these representatives of the two species is of one type, but is much weaker in *M impressus* than in *M maclellandi.* The obscure black median markings of the former species are absent in the latter, and on this character the identification of small males may probably be based. The hind tibiae are hairy on the inner side in both species, but not so strongly as in Westwood's figure of *M. jenkinsi,* nor are they enlarged as in *M. calcaratus* which Boileau believes to be identical with *M jenkinsi.*

Metopodontus suturalis, Olivier.

E. Himalayas: Darjeeling District (♂)—Kalimpong, *ca.* 2500 ft. (♀).
Harmutti, base of Dafla Hills (♂).
Bengal: Duars—Buxa near Bhutan frontier (♂).
Assam : Dunsiri Valley (♂).
Andamans (♂).

Metopodontus occipitalis, Hope.

Lower Burma: Rangoon (♂ ♀).

The median black mark on the pronotum of the male occupies about one-third of the distance between the anterior and posterior margins. In the female it is larger and touches both these margins.

Metopodontus biplagiatus, Westwood.

(Text-figure 3C.)

1. METOPODONTUS BIPLAGIATUS, Westwood, s. *str.*

E. Himalayas: Darjeeling District—Pashok* (♂ ♀).
Assam: Cherrapunji (♂); Sibsagar (♂).
Lower Burma: Tavoy (♂).
Andamans: Port Blair (♂ ♀).

In the Sibsagar specimen the reddish areas of the pronotum are almost as dark as the black ones. One of the males from the Andamans is more highly macrodont than any that appear hitherto to have been described. The form of the mandible of this specimen is shown in text-fig. 3C.

2. M. BIPLAGIATUS subsp. NIGRIPES, Boileau.

Siam: Hills between Thaungyin and Me Ping, *ca.* 1000 ft. (♂).

The markings of this specimen agree exactly with those described by Boileau, but the slight structural characters mentioned are not clearly shown. The pale markings are distinctly yellower than in our specimens of the typical form.

3. M. BIPLAGIATUS subsp. INDICUS, n. subsp.

S. India: Mysore (♂).

We have only one specimen, a small male. The head, thorax, legs and lower surface of abdomen are uniformly black with a faint reddish tinge. The distal tooth on the mandibles is remarkably strong.

Genus **PROSOPOCOELUS**, Hope.

Prosopocoelus approximatus, Parry.

Siam: Raheng (♂) "came into bungalow during the day time."

Prosopocoelus buddha, Hope.

E. Himalayas: Darjeeling District—Singla, 1500 ft. (♂ ♀); Pashok (♂ ♀).

Prosopocoelus oweni, Hope.

Assam: Sibsagar (♂).

Prosopocoelus wimberleyi, Parry.

Andamans (♂ ♀).

In our smallest male (14·3 mm. long) the colour is very near that of *Metopodontus biplagiatus*, though the black markings are less clearly defined. Transitional specimens connect this with the large form. The female resembles *Metopodontus biplagiatus* in colour still more closely.

Prosopocoelus parryi, Boileau.

E. Himalayas: Darjeeling District—Ghumti (♀); Nagri Spur*.

Genus **CYCLOMMATUS,** Parry.

Cyclommatus tarandus, Thunberg.

Malay Peninsula : Johore (♂).

Genus **PRISMOGNATHUS,** Motschulsky.

Prismognathus subnitens, Parry.

E. Himalayas : Darjeeling District—Kurseong (♂ ♀).

The small male (16 mm. long, excluding mandibles) resembles the form described by Parry, but the head is squarer than it appears in his figure. The clypeus is small and strongly bilobed. In the large male (21 mm. long) the head is flatter between the jaws, clypeus very broad and less strongly bilobed. The mandibles are armed with two stout teeth, one just below the tip and one about half way between this and the base ; between these teeth, and between the median tooth and the base, it is armed with about 6-7 smaller teeth.

The female (13·5 mm. long) is slightly darker in colour than the male. The mandibles have an upper, terminal, and lower tooth. The clypeus is undivided ; behind it the anterior border of the head is steep and concave much as in the small male, but there is no angular projection of the canthus. On each side of the head, between and in front of the eyes, there is a rounded ridge followed by a pronounced depression bordering a broad anteromedian convexity—structures which have their counterpart in the male. The whole upper surface is evenly but not very closely punctured, the head more strongly than the pronotum, and the pronotum than the elytra.

Genus **HEMISODORCUS,** Thomson.

Hemisodorcus nepalensis, Hope.

W. Himalayas : Mussoorie (♂ ♀).
Tehri Garhwal—Balcha (♀).
Almora—Binsa* (♂ ♀).

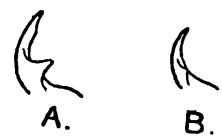
E. Himalayas : Darjeeling District—Darjeeling, 7000 ft. (♂ ♀); Kurseong, 5000-6000 ft. (♂ ♀); Mungphu (♂).

The elytra of the female are scarcely if at all less glossy at the sides than above; the sides (especially the anterior angles) of the pronotum are finely roughened and are as a rule coarsely punctured in addition. The head is finely roughened in front of the tubercle, coarsely roughened on either side of a smooth median band behind it.

Hemisodorcus suturalis, Westwood.

W. Himalayas: ? Kashmir Valley, *ca.* 5000-6000 ft. (♀).
Dehra Dun District—Jaunsar* (♂ ♀).
Tehri Garhwal—Balcha (♂).

This species has hitherto been placed in the genus *Dorcus*, from which it is distinguished by the structure of the prosternum and the characters of the female. The female differs from that of the preceding species in the more uniform sculpturing of the upper surface of the head, in the less prominent canthus, and in the elytra which, like those of the male, are polished only in their anterior inner angles. In the Kashmir specimen the distinction between the dull and polished parts of the elytra is much less



Text-figure 4.
Left mandibles of large and small males of *Dorcus yaksha*, nat. size.

marked than in the others. This specimen may, therefore, belong to a distinct species or local race; or it may be in poor condition.

Genus **DORCUS**, MacLeay.

Dorcus yaksha, n. sp.

(Pl. xxix, fig. 1; text-figure 4.)

E. Himalayas: Darjeeling District—Kurseong, *ca.* 5000 ft. (♂ ♀).
Dafla Hills—Dikrang Valley (♂).

This species resembles *D. vicinus*, Saunders and *D. ratiocinativus*, Westwood, but differs from both in having the large tooth on the mandibles much smaller in proportion to the size of the insect, and situated more basally. It also resembles *D. antaeus*, Hope, but is much smaller, its tooth being proportionally larger than in that species. Females closely resemble those of *D. antaeus*, but are very much smaller.

From Kurseong we have two males, 33 and 29 mm. long respectively, and two females 28 and 22 mm. long respectively. They were all presented to us by Mr. N. B. Jahans, who collected

them when he was at school there. We also have a male collected by Col. Godwin-Austen in the Dikrang Valley ; it is intermediate in size between the two males from Kurseong.

In the largest males there is a rudimentary tooth on the gently tapered distal part of the mandibles as in large specimens of *D. antaeus*, and the proximal tooth is large and conical. In the smallest male there is no trace of the distal tooth, and the proximal tooth is smaller and less acute. The mandibles of the female resemble those of *D. antaeus*. The upper surface of the head is glossy but very finely roughened in the male, and coarsely roughened in the female.

The outer margins of the prominent anterior angles of the prothorax are highly **S**-shaped in the large male, the concavity being situated behind the convexity. In the small male and both the females it is entire In the small but not in the large male the lateral and posterior parts of the marginal groove of the pronotum are broad and coarsely punctured. In the female this puncturing is still more extensive.

The elytra are glossy in both sexes. They are smooth above and coarsely and closely punctured at the sides ; but the punctures are almost obsolete in the large male. In the smaller, and to a less extent in the larger of our two females, the smooth dorsal area is traversed by incomplete longitudinal rows of punctures, arranged after the manner of the striations with which the elytra of *D. hopei* are marked. The posterior margin of the prosternal process is bordered by a groove, in front of which there is a distinct convexity in both sexes. The anterior tibiae are armed with about six teeth, the middle and posterior each with one small tooth.

Dorcus antaeus, Hope.

E. Himalayas: Darjeeling District, 4000 ft. (♂); Darjeeling, 7000 ft. (♂ ♀); Kurseong, 5000-6000 ft. (♂ ♀).

Upper Burma : Southern Shan States—Keng Dung* (♂).

The elytra of females and small males are obscurely punctured at the sides only. The Burmese specimen perhaps represents a distinct local race. It is about 54 mm. long (mandibles excluded), and may conceivably be the large form of *D. laevidorsis*, Fairmaire. It is the property of the Bombay Natural History Society.

Dorcus hopei, Saunders.

W Himalayas : Dehra Dun District—Jaunsar* (♀).

E. Himalayas: Darjeeling District—Darjeeling, 7000 ft. (♂ ♀); Kurseong, 5000-6000 ft. (♂ ♀).

Assam : Khasi Hills (♂).

The elytra of females and small males are coarsely striato-punctate.

Genus **EURYTRACHELUS**, Thomson.

Eurytrachelus fulvonotatus, Parry.

E. Himalayas: Darjeeling District—Darjeeling, 7000 ft. (♂ ♀); Kurseong 5000-6000 ft. (♂ ♀).

This species is distinguished by the structure of its clypeus from the genus *Hemisodorcus* with which it has hitherto been associated.

The extent of the fulvous markings is very variable in both sexes; sometimes only the posterior spots on the pronotum and the posterior streaks on the elytra remain; usually their anterior counterparts are also present and these may fuse with them; the pronotum may be bordered by fulvous markings on all four sides. The female resembles the male in colour.

Eurytrachelus reichei, Hope.

(Pl. xxix, fig. 2.)

E. Himalayas: Darjeeling District—Darjeeling, 6000-7000 ft. (♂ ♀); Kurseong 5000-6000 ft. (♂ ♀); Siliguri, in the Terai a few miles south of the base of the hills (♂).

E. pracellens, Möllenkamp, also from the Himalayas, must be very near if not identical with this species. The thickness of the mandibles of relatively large males, and the width of the pair of teeth on the inner side of each, are very variable.

Females of this species closely resemble those of *E. tityus*. They are, however, distinguished by the sculpture of the posterior ends of the elytra. In females and small males of both species the elytra bear a series of deeply impressed longitudinal punctured grooves with smooth ridges between them, of which ridges the first and third and often the sixth from the suture are the broadest. In the female of *E. reichei* the sixth ridge is of approximately uniform width throughout, and tends to be enlarged at the posterior end where it bends inwards to meet the end of the third ridge (see pl. xxix, fig. 2). In small males of *E. reichei*, it is also of uniform width throughout but the posterior ends of all the ridges are obsolete.

Eurytrachelus submolaris, Hope.

(Pl. xxix, fig. 4.)

W. Himalayas: Murree (♂ ♀); Naini Tal* (♂).

This species is represented in the Dehra Dun collection by a short series of males without any locality record. The largest specimen answers closely to Boileau's account of the type (*Trans. Ent. Soc. London*, 1913, pp. 251-2, pl. ix, fig. 10). There is a similar specimen from Naini Tal in the Pusa collection.

The female is very like that of *E. reichei*, but the striation of the elytra is weaker (see pl. xxix, fig. 4, and Boileau, *Bull. Soc.*

Ent. France, 1904, p. 27—*Dorcus brachycerus* = *Eurytrachelus submolaris*, Boileau, *Trans. Ent. Soc. London*, 1913, p. 251).

Eurytrachelus tityus, Hope.

(Pl. xxix, fig. 3.)

W. Himalayas Naini Tal (♂).

E. Himalayas: Darjeeling District—Darjeeling (♂ ♀); Kurseong, 5000-6000 ft. (♂ ♀); Soom, 4000-5000 ft. (♀); Rungneet Tea Estate, 4500-5000 ft.* (♀); Siliguri, in the Terai a few miles south of the base of the hills (♂ ♀).

Assam: Cachar (♀).

In this species the third and sixth ridges of the elytra of females and small males taper away behind, and their union is only faintly indicated (see pl. xxix, fig. 3).

Eurytrachelus travancorica, n. sp.

(Pl. xxix, fig. 5.)

South India: Travancore—High Range, 6000 ft. (♂).

A single male of this species has been presented to us by the Agricultural Research Institute. It is very small (12·3 mm. long), but the dorsal tooth on the punctured and glossy mandibles is so long and slender (pl. xxix, fig. 5) that I think the specimen must be a large one of its kind. Below and slightly proximal to the dorsal tooth is an obsolete ventral tooth as in *Dorcus rugosus*, Boileau, from which the species may be distinguished by its black colour and imperfectly divided eye. The punctured and finely roughened clypeolabrum is keeled above the margin, but the keel is low and is not more pronounced laterally than medially; though perfectly distinct, it is not at all conspicuous. The prosternum, too, is that of a *Eurytrachelus*, not a *Dorcus*[1].

The anterior angles of the head are rounded and slightly prominent; the oblique anterior surface of the head is lightly concave and finely roughened between them; the remainder of the upper surface is glossy, and the whole is strongly punctured. The mentum is very coarsely punctured; it is roughly trapezoidal with strongly rounded anterior angles and very faintly concave anterior margin.

The pronotum is glossy and more coarsely punctured than the head; it is vaguely sulcate in the middle line. The anterior margin is convex in the middle. The anterior angles are acute and very strongly produced forwards by the side of the head. The sides are divergent and lightly convex. The posterior angles are replaced by a lightly concave margin. The posterior margin is faintly convex.

[1] Since the above was written a specimen of Boileau's species has been presented by Mr. H. E. Andrewes. It proves to belong to the genus *Eurytrachelus*, not *Dorcus*. *E. rugosus* and *E. travancorica* are practically identical in structure apart from the slightly shorter canthus of the latter.

The elytra are strongly rugose throughout, with indications of the striae found in small males of *E reichei* and *E. tityus*. The prosternum is coarsely but not very closely punctured in front of the coxae; between them it is more closely and finely punctured, clothed with golden yellow hair, and medially concave; it is closely punctured and almost rectangularly truncate behind. The mesosternum and metasternum are coarsely and closely punctured and clothed with rather long hair. The abdominal sterna are less closely punctured and their hair is very short.

Genus **PLATYPROSOPUS**, Hope.

Platyprosopus titanus, Boisduval.

1. PLATYPROSOPUS TITANUS, Boisd., *s. str.*

Malay Peninsula : Penang (♂).

2. P. TITANUS subsp. WESTERMANNI, Hope.

E. Himalayas : Darjeeling District—Pashok (♂).
Dafla Expedition (♂).
Assam : Khasi Hills—Shillong (♂); Sibsagar (♂).

Genus **GNAPHOLORYX**, Burmeister.

Gnapholoryx velutinus, Thomson.

E. Himalayas : Darjeeling District—Darjeeling, 7000 ft. (♀).
Abor Country—Kobo, 400 ft. (♂).

Genus **AEGUS**, MacLeay.

Aegus adelphus, Thomson.

Malay Peninsula : Johore (♂).

Our specimen agrees in all respects with Deyrolle's figure of a specimen from Borneo (*Ann. Soc. Ent. Belg.* IX, pl. ii, fig. 8).

Aegus capitatus, Westwood.

Malay Peninsula : Johore (♂).

Aegus labilis, Westwood.

E. Himalayas : Dafla Hills—Dikrang Valley (♂); Dafla Expedition (♀).
Abor Country—Upper Rotung, under leaf-stem of plantain (♀).
Upper Burma : Southern Shan States—Reng Dung* (♂ ♀).
Andamans (♂).

The basal tooth is distinctly smaller than the dorsal in the large male (Dikrang Valley). In a smaller form (Andamans) it is smaller and median; in a smaller one still (Dikrang Valley) it is obsolete and very near the base; and in the smallest of all it has

disappeared. The elytra are coarsely punctured marginally, especially in small males.

The clypeus of the female is very broad with concave anterior margin. The sloping anterior part of the head, which is lightly concave, meets the horizontal posterior part at a distinct angle. The pronotum and elytra are coarsely punctured at the sides, more finely above. In the female from Reng Dung, which belongs to the Bombay Natural History Society, the anterior part of the head is less markedly concave than in the Himalayan specimens. The male by which it is accompanied is of the small form in which the dorsal tooth on the mandibles is not developed.

Aegus impressicollis, Parry.

Sumatran Islands : Sinkep (♂).

Aegus chelifer, MacLeay.

Malay Peninsula : Johore (♂).

Aegus roepstorffi, Waterhouse.

Andamans : Port Blair (♂ ♀).
Nicobars (♀).
? Lower Burma : Rangoon (♀).

The clypeus of the female is narrower than in the preceding species. The separation of the anterior and posterior parts of the upper surface of the head is less abrupt. The punctures of the pronotum and elytra are much coarser and tend, even on the innermost ridge of the latter, to fuse together so as to produce a general rugosity of the surface.

Aegus kandiensis, Hope.

Ceylon : Central Province—Kandy (♀) ; Peradeniya (♂ ♀) ; Pundaluoya (♂) ; Talawakelle* (♂).
Sabaragamuwa—Kegalle (♀) ; Yatiyantota (♀).
Uva—Halduinmulla (♂).

The female of this species closely resembles that of the last. It is, however, even more closely punctured, the difference—which is never very great—being clearest on the pronotum.

Genus **NIGIDIUS,** MacLeay.

Nigidius dawnae, n. sp.

(Pl. xxix, fig. 7.)

Lower Burma : Amherst District of Tenasserim—near Misty Hollow and Sukli, towards the top of the western and eastern slopes respectively of the Dawna Hills, 2000-2500 ft. (♂ ♀).

Siam : Meetaw Forest, west of Raheng.

The Burmese specimens of these beetles were found in the interior of two pieces of hard dry wood by the road-side. In one piece—that found on the eastern side of the hills—they were accompanied by larvae.

♂. Short and stout like *N obesus*. Black, 13·0-21·5 mm. long. The long curved dorsal tooth of the mandibles is about as long as the part of the mandible in front of it. Its posterior margin bears a rounded laminar tooth which is sharper in small than in large specimens. The apex of both mandibles is tridentate, but the lowest tooth is rudimentary on the right side The labrum is glossy; its anterior margin is concave and its anterior angles are laterally produced and acute; the clypeus forms a transversely linear convexity above its whole basal width, and is bounded behind by a groove from which a row of erect hairs project in unworn specimens.

The anterior margin of the frons is convex in the middle. The upper surface of the head is flattened as a whole, and slightly undulating; its anterior part is always glossy, but its posterior part may be dull; its punctures are much finer in front than they are behind, where each is broad and flat with a raised ring in the centre. The canthus is abruptly constricted on the outer side about the middle of its length; the posterior part is broader and more convex than the anterior. It is coarsely and very closely punctured. The mentum is closely and very coarsely punctured; it is slightly wider in front than behind and distinctly wider than long; the anterior angles are rounded and the anterior margin is concave.

The pronotum is more than twice as broad as long; it is strongly convex across the middle in front. Its surface is glossy; it is coarsely punctured at the sides, along the anterior and posterior margins and in the median groove which does not nearly reach the anterior margin. The anterior margin is lightly concave on either side of a broad median convexity, the other margins are convex as a whole, but the anterior part of the narrow reflexed border is widened. In large specimens this widening is very abrupt (see pl. xxix, fig. 7).

The grooves of the elytra each contain one row of large shallow punctures, except the last, which contains about three such rows; and there is a row of fine punctures on each side of each of the somewhat narrow ridges between them.

All the sterna are somewhat coarsely punctured; the prosternum is lightly keeled between the coxae and descends gradually to the level of the mesosternum behind them. The metasternum has a median groove.

The basal piece of the genital tube is simple, and does not overlap the median lobe; it is not chitinized in the middle line above. The lateral lobes are very slightly concave on their inner sides. The median lobe is cylindrical and is deeply bifid. The internal sac is laminar, elongate and parallel-sided. It is supported by a pair of strongly chitinized laminae of which one lies on either side of the ductus ejaculatorius in the tissues of the sac.

The tips of these supporting laminae are weak and unite with the chitinous support of the ventral margin and lateral walls of the funnel-shaped aperture of the ductus ejaculatorius. The left lamina, in addition, gives off a broad tongue-like branch just below the tip. This tongue extends slightly beyond the end of the body of the sac. The tongue is unarmed, but a band of fine backwardly directed teeth extends along the ventral distal margin of the body of the sac, and thence obliquely backwards on both sides to the dorsal surface, where the left hand portion of the band ends about opposite the unpaired tongue-like process, the right hand portion being about five times as long.

There is no flagellum.

The internal sac is permanently everted. When the genital tube is retracted this sac does not lie against the median lobe, but in a delicate sheath attached to the outer surface of the internal abdominal segments.

♀ Differs from males only in having somewhat smaller mandibles in proportion to its size, and in the structure of the genitalia.

This species appears to come very near *N. obesus*, Parry, but it is larger and the anterior angles of its pronotum are neither simple nor of the shape shown in Westwood's figure (*Trans. Ent. Soc. London*, 1874, pl. iii, fig. 5).

The anterior margin of the frons, too, is concave on either side of the median convexity, not evenly convex as shown in that figure. There are also slight differences in the shape of the canthus.

Nigidius himalayae, n. sp.

(Pl. xxix, fig. 6.)

E. Himalayas : Darjeeling District—Pashok (♂).

A male of this species was obtained by H.E. Lord Carmichael's collectors in the Darjeeling District. It is 20·0 mm. long, and was the only specimen I had seen when the following description was drawn up. More recently Mr. Lister has sent me specimens from Pashok which vary from 13·7 to 17·7 mm. in length.

In general appearance this species resembles the last, but it is distinctly slenderer. The lowest terminal tooth of the right mandible is absent. The clypeus is longer than and scarcely as wide as in the last species, and is bilobed. The middle part of the frons is less prominent than in that species. The canthus is less deeply cleft, and the posterior part is less prominent. There is a strongly marked depression in the middle line towards the back of the head, as well as a pair of depressions behind the anterior angles.

The pronotum is less than twice as broad as long. It is bordered in front by a very broad groove. This groove is marked with large shallow punctures, and is crossed in the middle line by a fine keel, which is terminated behind by a transverse keel of similar dimensions to itself. The broadly reflexed anterior parts of the

lateral margins of the pronotum are well developed. The metasternum is not punctured in the middle. The abdominal sterna are also less uniformly punctured than in *N dawnae*.

The basal piece of the genital tube is furnished with an elongate triangular mid-ventral lamella between the lateral lobes. Each of these lobes is strongly concave on the inner side, and is furnished with a large inwardly directed ventral lamina. Together these structures form an imperfect sheath in which the median lobe and the base of the internal sac are hidden. The exposed portion of the latter is ribbon-like with a rounded extremity; the terminal portion, though supported by the chitin accompanying the ductus ejaculatorius, is composed apart from this of a curious cellular material which when dry resembles dried vegetable tissue. The armature is confined to the region immediately preceding this terminal portion. Although the internal sac is permanently evaginated, as in the preceding species, it lies with the remainder of the genital tube inside the internal abdominal segments when at rest.

In other respects this species resembles *H. dawnae*.

Nigidius distinctus, Parry.

Bengal: Duars—Maindabari, Buxa Division (♂ ♀).
Upper Burma: N. Shan States—Hsipaw* (♀).

Mr. Beeson has sent me eight males and four females of what I take to be *Nigidius distinctus* from Maindabari. In both sexes there is some variation in the proportion of length to breadth, and in the puncturing. The specimens agree as well with Fairmaire's description of *N oxyotus* from Tonkin (*Ann. Soc. Ent. Fr.* (6) VIII 1888, pp. 339-340) and Boileau's description of *N birmanicus* from Rangoon (*Trans. Ent. Soc. London*, 1911, pp. 446-449) as they do with Parry's description and figure of *N. distinctus* (*Trans. Ent. Soc. London*, 1873, pp. 341-?, pl. v, fig. 7); and I am unable to distinguish them from the specimen from Hsipaw in the Dehra Dun collection. The Hsipaw specimen is unfortunately a female, and I have been unable to examine the male genitalia of any Burmese or Malaysian specimens. Possibly they might afford distinctive characters as in the two species described above.

Nigidius impressicollis, Boileau.

Assam: Khasi Hills—Maflong, 5900 ft. (♂ ♀).

Adults and larvae of this species were found by Mr. S. W. Kemp in damp and thoroughly soft and rotten wood. The sexes are scarcely distinguishable externally.

Genus **FIGULUS**, MacLeay.

Figulus interruptus, Waterhouse.

Ceylon: Peradeniya.

Figulus scaritiformis, Parry.

Malay Peninsula : Johore.

Genus **CARDANUS**, Westwood.

Cardanus sulcatus, Westwood.

Malay Peninsula : Johore.

EXPLANATION OF PLATE XXIX.

FIG. 1.—*Dorcus yaksha*, n. sp. ♀ × 2.

,, 2.—*Eurytrachelus reichei*, Hope, ♀ × 2.

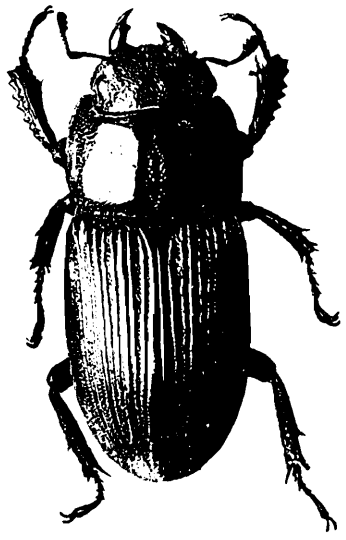
,, 3.— ,, *tityus*, Hope, ♀ × 2.

,, 4.— ,, *submolaris*, Hope, ♀ × 2.

,, 5.— ,, *travancorica*, n. sp. ♂ (type) × 2.

,, 6.—*Nigidius himalayae*, n. sp. ♂ (type) × 2.

,, 7.— ,, *dawnae*, n. sp. ♂ (type) × 2.



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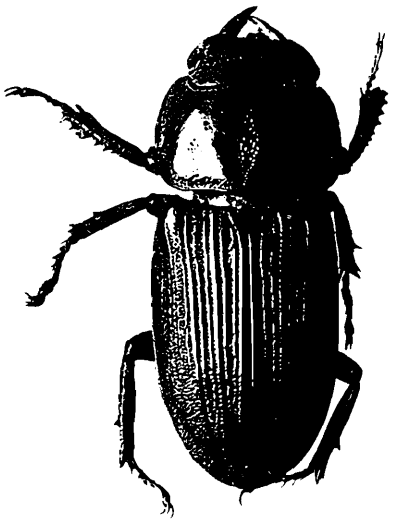

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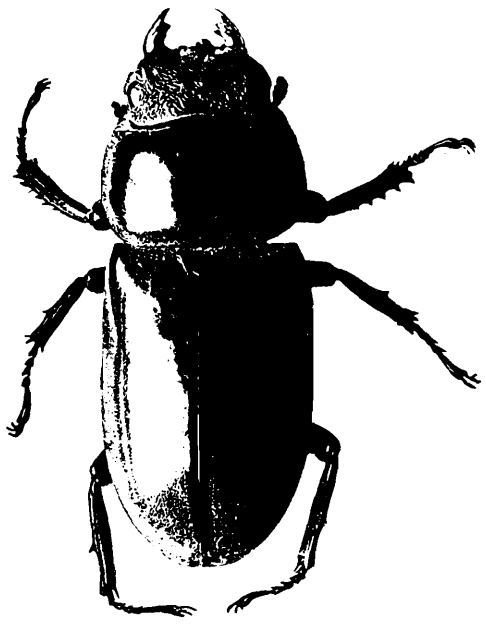

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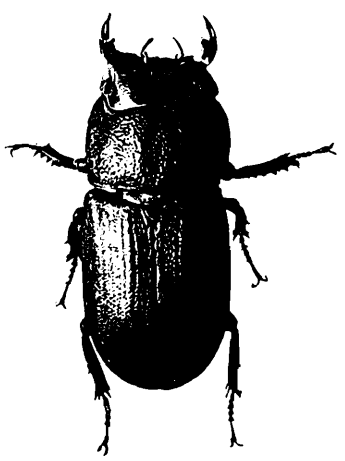

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Bemrose, Collo., Derby.

INDIAN LUCANIDAE.

XXVI A REVISION OF THE ORIENTAL SUBFAMILIES OF TARANTULIDAE (ORDER PEDIPALPI)

By F. H. GRAVELY, *M.Sc., Asst. Superintendent, Indian Museum.*

(Plate XXXI.)

The species of Tarantulidae are rendered exceptionally difficult to separate and define by the insignificance of many of their most distinctive characters, and by the conspicuousness of others whose striking modifications indicate the age of a specimen rather than the species to which it belongs. It is only by the study of long series of specimens that the latter characters can be eliminated and the former recognized with certainty. Kraepelin's "*Revision der Tarantuliden*" (Abh. Ver. Hamburg, xiii [3] 1895, 53 pp., 1 pl.) has straightened out the synonymy of the family, and has gone a long way towards putting the classification into shape. But when this, and the volume of "*Das Tierreich*" by which it was followed, were written, the material available for study appears to have been somewhat scanty. A number of described species which are undoubtedly distinct had therefore provisionally to be united; and a number of species still remain unnamed.

I have now for several years been making special efforts to obtain adequate series of specimens from different parts of the Indian Empire, and whenever possible from beyond. In the present paper I propose to consider the Oriental species in the light of material recently obtained; and it seems best to complete the paper by references to all known members of the two subfamilies dealt with, although those found outside the Oriental Region are not well represented in the material before me.

I am indebted for help in getting material to Dr. Henderson, Mr. E. E. Green, Mr. Kinnear, Mr. T. Bainbrigge Fletcher and especially to Mr. B. H. Buxton who has presented to the Indian Museum a number of new species which he recently collected in the Malay Peninsula.

With the exception of *Stygophrynus moultoni*, of which the type is in the British Museum, the types of all new species described below are in the Indian Museum.

SUBFAMILIES AND GENERAL STRUCTURE.

The Oriental Tarantulidae fall into two very distinct subfamilies, which may be recognized thus:—

Pulvilli present; hand able to bend till it forms a right angle with the tibia, the terminal spines of which are directed sideways; prosomatic sterna small, more or less tuberculiform ... ...*Charontinae*, p. 435.

Pulvilli absent; hand unable to bend at less than an obtuse angle to tibia, the terminal spines of which are directed forwards in adults above base of hand; prosomatic sterna broadly expanded, lightly concave or flat ... ... *Phrynichinae*, p. 447.

The American subfamily Tarantulinae differs from the subfamily Charontinae chiefly in the absence of a pulvillus.

The structure of the arm and hand, though differing in detail in different species, is remarkably uniform in plan in the young of all the species of Tarantulidae whose development is known to me. Considerable changes, however, take place during the growth of individuals belonging to the larger species. This is especially the case with species of the subfamily Phrynichinae, the hand of which is so modified in the adult that each is capable of grasping prey without the aid of the other (see Gravely, 1915, pl. xxiv, fig. 28 of this volume). In this respect the Phrynichinae may be regarded as more highly specialized than the Charontinae, and as the structure of the arm and hand presents greater difficulties than does that of other organs, the Charontinae may conveniently be considered before the Phrynichinae.

In some respects, however, the former are probably more highly specialized than the latter. The jointing of the hind tibiae, for instance, which is often less marked, when it occurs, in young specimens than in old ones, is carried further in the Charontinae than in the Phrynichinae. And it is difficult to think that pulvilli can ever have been present in creatures with the habits of the Phrynichinae, when these are not found in them at the present day. For both Phrynichinae and Charontinae habitually live clinging to the underside of stones or logs of wood; and the latter, which have pulvilli, can cling in this position to polished glass, whereas not even the young of the former, which lack them, can do this.

The fundamental structure of the arms and hands of the Tarantulidae may now be described as it is to be seen, more or less distinctly, in the young probably of all species, and in the adults of many Charontinae. The modifications to which it is subject during the growth of the more highly specialized forms are all in the direction of the specialization of particular spines and the loss of others.

The anterior face of the trochanter is bounded above by a dorsal row of spines, and below by a ventral cluster; while between these is a middle group or longitudinal row.

The anterior face of the femur is flattened, and is bounded by a dorsal and a ventral row of spines. The tibia is similarly flattened in front and armed above and below, the spines of the distal half of the dorsal row always being much the longest.

The hand is armed with two spines above and one below. Occasionally additional spines are also present.

The finger may be armed at the base with 0, 1 or 2 dorsal spines, which remain throughout life. It is always unarmed ventrally.

Subfamily *CHARONTINAE.*

The structure of the second visible abdominal sternum and of the margin of the carapace opposite the lateral eyes, the relative lengths of the two dorsal spines on the hand and of those on the end of the arm, and the jointing of the finger and of the tibia of the fourth leg, appear to be the principal characters that have been used in the definition of genera.

The structure of the posterior margin of the second visible abdominal sternum seems to be very variable, and I am unable to attach any importance to it.

The segmentation of the hind tibiae is often less marked in the young of species in which it occurs, than in adults; it is sometimes variable within the limits of a single well-marked species, and it reaches its highest development in more than one genus, among them the specialized cavernicolous genus *Stygophrynus*. There can, I think, be little doubt that the extent of this segmentation is a mark of the degree of specialization in the species in which it occurs. Probably increased segmentation facilitates in some way the activities of the animal exhibiting it, and may appear independently in different branches of the subfamily. It is also found in the genus *Damon* of the subfamily Phrynichinae.

In species in which the hind tibiae are normally not more than 3-jointed, the tarsi (excluding the metatarsi) appear to be invariably 4-jointed. In most species in which the hind tibiae are 4-jointed the tarsi are 5-jointed. *Sarax javensis* is the only species known to me which appears to have both tibiae and tarsi of the hind legs 4-jointed, and as I have only one specimen before me the tibiae may be abnormal. The structure of the tarsi appears to be constant within the limits of each species, whereas in *Phrynichosarax cochinensis* and *singapurae*, and perhaps therefore in other species also, the structure of the tibiae is variable. Although, therefore, the structure of the hind tibiae is usually much easier to distinguish than is that of the tarsi, it seems best to use the latter rather than the former for the separation of genera.

The structure of the margin of the carapace appears to be of more fundamental importance from a taxonomic point of view than is the structure of the legs. By its means the subfamily may split into two distinct groups. One of these, which may be termed the *Sarax* group, includes only small species whose distribution extends from India through Malaysia as far as the Solomon Islands.

The other, which may be termed the *Charon* group, includes the small species found on the outskirts of and beyond this area from the Seychelles to the Galapagos Islands, together with the large and highly specialized species belonging to the genera *Stygophrynus* and *Charon.*

The *Charon* group is probably older than the *Sarax* group, its range being wider, the hind tibiae being 4-jointed in all except two species (in which they are 3-jointed), and the arms being comparatively long and slender, at least in well developed males, in most if not all species. The carapace of the former group, too, resembles that of all other subfamilies of Tarantulidae, and also, apparently, that of the newly hatched larvae of the only species—*Phrynichosarax cochinensis*—of the *Sarax* group whose larvae I have seen.

The hind tibiae of the *Sarax* group may be 2-jointed (occasionally even entire), and the proportion of the species in which they are 4-jointed appears to be smaller than in the *Charon* group. The arms are almost invariably short and stout even in males.

The relative lengths of the two dorsal spines on the hand, and of those on the end of the arm, may perhaps to some extent be correlated with cavernicolous habits in both groups. So far as I know, however, nothing is known of the habits of the genus *Charon*, one of the two genera of its group in which the spines tend to resemble those of the single exclusively cavernicolous genus *Catageus* of the *Sarax* group. A few species of the latter group belonging to the non-cavernicolous genera have, moreover, been found in caves.

The finger is jointed in all genera except *Charon*.

The genera of Charontinae may now be defined as follows:—

1. Margin of carapace indentated beside lateral eyes ... ... (*Sarax* group) 2.
   Lateral eyes situated further from margin of carapace, which is entire ... (*Charon* group) 4.

2. Longest spine on tibia of the arm the middle one of five well developed dorsal spines in adults, and of three in young; proximal dorsal spine of hand longer than distal ... ... *Catageus*, p. 437.
   Penultimate well developed dorsal spine of tibia of arm the longest in all stages; distal dorsal spine of hand longer than proximal ... 3.

3. Tarsi (exclusive of metatarsi) 4-jointed; hind tibiae 2- to 4-jointed (sometimes entire on one side) but normally 3-jointed (? always) ... *Phrynichosarax*, p. 437.
   Tarsi (exclusive of metatarsi) 5-jointed; hind tibiae 4-jointed ... ... *Sarax*, p. 441.

4. Penultimate dorsal spine of tibia of arm the longest, the one next behind it longer than the one next behind that; distal dorsal spine of hand longer than proximal, not accompanied by additional spines ... ... 5.
   Penultimate dorsal spine of tibia of arm not longer than the one next behind it, often about equal to the one next behind that, sometimes even shorter; long spine on dorsal side of hand usually succeeded by several shorter ones,[1] a short spine often fused to it proximally at base ... ... 6.

[1] Always, so far as is known, except in *Stygophrynus moultoni*, for which a new genus ought perhaps to be established.

5.	Tarsi (exclusive of metatarsi) 4-jointed; hind tibiae 3-jointed	*Charinides*, p. 442.
	Tarsi (exclusive of metatarsi) 5-jointed; hind tibiae 4-jointed	*Charinus*, p. 442.
6.	Finger jointed, three dorsal spines of tibia of arm much longer than any others ...	*Stygophrynus*, p. 443.
	Finger unjointed; two dorsal spines of tibia of arm much longer than any others ...	*Charon*, p. 446.

Genus **CATAGEUS**, Thorell.[1]

Type *Catageus pusillus*, Thorell. No other species of the genus is known, *C. rimosus*, Simon, belonging in reality to the following genus.

Catageus pusillus, Thorell.[2]

(Plate xxxi, fig. 1.)

Catageus pusillus is only known from the Khayon ("Farm") and Dhammathat caves near Moulmein.

The Indian Museum collection includes specimens from both groups of caves They were found under stones, and their habits have already been described.[3]

The *carapace* of our largest specimen is 4·4 mm. across and 3·2 mm. long in the middle line. The *arms* (see fig.) are short and stout in all specimens. The finger is armed dorsally with two minute and slender spinules (see fig.). The *antenniform legs* are very variable in length, their femora being from about two to about three times as long as the carapace is broad. The femora of the first pair of *walking legs* are about 1·3–1·5 times as long as the carapace is broad. The metatarsi of the same pair of legs are about 1·2 or 1·3 times as long as the tarsi, and the first tarsal joints are about 1·4 or 1·5 times as long as the remaining tarsal joints.

Genus **PHRYNICHOSARAX**, n. gen.

Margin of carapace indentated beside lateral eyes; penultimate dorsal spine of tibia of arm longer than all others; distal dorsal spine of hand longer than proximal; hind tibiae normally composed of less than four pieces, tarsi of less than five.

Type *Phrynichosarax cochinensis*, n. sp.

Five species are known to me. They may be distinguished thus:—

1.	Dorsal margin of finger armed with one spine	2.
	Dorsal margin of finger armed with two spines	3.
2.	Spine of finger long; hind tibiae 2- to 3-jointed	*P. cochinensis*, p. 438.
	Spine of finger minute; hind tibiae (? always) 4-jointed	*P. javensis*, p. 439.
3.	Spines on finger large and conspicuous, the distal one about twice as long as the proximal ...	*P. buxtoni*, p. 439.
	Spines on finger small and of more nearly equal size	4.
4.	Spines on finger small but quite distinct ...	*P. singapurae*, p. 440.
	Spines on finger minute and inconspicuous ...	*P. rimosus*, p. 440.

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[1] *Ann. Mus. Civ. Genova*, XXVII, p. 530.
[2] *Ibid.*, pp. 531-8.
[3] *Journ. Asiat. Soc. Bengal* (n. s.), IX, 1914, p. 419.

Phrynichosarax cochinensis, n. sp.

(Plate xxxi, fig. 2.)

This species is common under stones in the evergreen jungles of the lower slopes of the Western Ghats in Cochin, and it is on account of the large number of specimens available for study that I have selected it as the type of the genus. The specimens were found near Kavalai, on the Cochin State Forest Tramway, at altitudes up to about 2500 ft. above sea level; at about 0-300 ft. above sea-level near the same tramway between miles 10 and 14; and at the base of the hills near Trichur. Specimens from the last-named locality differ from the others in that the legs (both kinds) tend to be much longer and slenderer, while the separation of the first and second joints of the hind tibiae is usually obscure or absent. In one specimen, indeed, the right hind tibia is entire.

As type of the species I have selected a female with young still adhering to her back in the preserved state. This specimen is from jungle beside the lower part of the State Forest Tramway.

The *carapace* is 1½ times as wide as it is long in the middle line, or may be a little wider; its maximum width is slightly over 4 mm. It resembles that of *P. buxtoni* (below, p. 439) in general structure, but is finely and evenly granular throughout, and usually *looks* much broader in proportion to its length. The depression in the median groove behind the eyes is less defined, although the groove is well developed. The second radial grooves of the two sides are united across the middle-line, together forming an almost straight line in contact with the anterior part of the fovea.

The *arms* are always short and stout. The proximal dorsal spine on the hand is scarcely as long in proportion to the distal as in *P. buxtoni*. There is only one spine on the finger (see pl. xxxi, fig 2); it is situated close to the base of the dorsal margin, and is about as long as the ventral spine of the hand, which latter spine is situated close to the lower distal angle.

The *legs* are variable in length. The femora of the antenniform legs may be from scarcely 1½ to fully 2½ times as long as the carapace is wide. The femora of the first pair of walking legs may be from a little less than, to nearly 1½ times as long as the carapace is wide. The metatarsi are longer than the tarsi, and the first tarsal joint of each leg is longer than are the rest together —very slightly so in short-legged specimens and much more so in long-legged. The hind tibiae may be more or less distinctly 2- or 3-jointed. In one specimen that of the right side is entire, that of the left side being 2-jointed. The extent of the jointing of the hind tibiae and the slenderness of the legs appears to be correlated with locality as noted above. All the localities from which the species is yet known are situated in one comparatively small area, over the whole of which comparatively uniform conditions

probably prevail. Specimens from any one of these localities appear to exhibit a much smaller range of variation than the species as a whole, their extremes scarcely, indeed, overlapping. The fact that this much variation does, however, occur, and that specimens from other localities in the same neighbourhood may ultimately be proved to show similar ranges of variation which overlap extensively, seems to render it improbable that the Trichur form ought to be recognized as a definite race worthy of a subspecific name.

Phrynichosarax javensis, n. sp.

(Plate xxxi, fig. 3.)

Only one specimen is known to me. It is from Buitenzorg. It differs from *P. cochinensis* only in the minuteness of the spine on the finger (see pl. xxxi, fig. 3) and in the 4-jointed hind tibiae. The 4-jointed tarsi suggest that a larger series would be not unlikely to show that the hind tibiae were normally 3-jointed as in other members of the genus.

The carapace is 3·2 mm. broad by 2·2 mm. long in the middle line. The femora of the antenniform legs are 4·8 mm. long, those of the first walking legs 2·9 mm.

Phrynichosarax buxtoni, n. sp.

(Plate xxxi, fig. 4.)

Two specimens (one immature) were collected by Mr. B. H. Buxton in Kubang Tiga cave, Perlis, Malay Peninsula.

The *carapace* is heart-shaped. In the mature specimen (♀) it is 4·1 mm. broad by 3·3 mm. long in the middle line. Behind the lateral eyes it is bordered by a broad horizontal ledge. The fovea is deeply impressed, continuous with a pair of large lateral grooves directed slightly backwards, and with a short median groove behind it. In an anterior median groove, about two-thirds of the way from the fovea to the eye, is a hollow somewhat smaller than the fovea, with which, and with two pairs of lateral depressions together enclosing a rectangle, it forms an almost regular hexagon. The anterior sides of this hexagon are, however, a little longer than the posterior, and these than the lateral. A radial groove extends outwards and a little forwards from each member of the two pairs of lateral depressions, and between the posterior of these grooves and the lateral grooves connected with the fovea is a pair of short grooves extending from the margin about half way to the fovea. A single line of tubercles runs from the fovea outwards and backwards towards the margin between the last-mentioned grooves and those immediately behind them. The rest of the surface is ornamented with less definite bands and patches of tubercles.

The *arms* are short and stout. The proximal dorsal spine of the hand is little more than half as long as the distal; there is a somewhat shorter spine on the ventral margin. Even the ventral of the spines of the hand is, however, longer than either of the two

spines with which the finger is armed. Both the spines on the finger are dorsal, and the proximal is less than half the size of the distal, being about equal in length to the distance from its base to the base of the finger or of the distal spine (pl. xxxi, fig. 4).

The femora of the antenniform *legs* are 8·6 mm. long in the adult specimen, those of the first walking legs being 5·5 mm. The anterior metatarsi are 2·6 mm. long, the anterior tarsi 2·0 mm. The tarsi are 4-jointed, the first joint distinctly longer in all legs than the other three together. The posterior tibiae are 3-jointed in both specimens.

Phrynichosarax singapurae (Gravely).[1]

(Plate xxxi, fig. 5.)

In view of what has been pointed out above with reference to *P. cochinensis*, it is very doubtful whether the proportions of the legs have any great taxonomic importance; and it was on these that my preliminary separation of the present form as a subspecies of *Sarax sarawakensis* was based. A more detailed examination has shown, however, that the armature of the hand and finger of the Singapore form differs markedly from that of the Sarawak form, and that the tarsi have one joint less.

Only one out of our series of eleven specimens from Singapore shows any trace of a fourth joint in the hind tibiae, though this joint is well developed in two specimens recently collected by Mr. B. H. Buxton in Lankawi (? main island) off the west coast of the Malay Peninsula. One of the Lankawi specimens has slenderer arms than any other specimen belonging to the *Sarax* group known to me.

This species is closely related to the next, from which it only differs in the larger size of the spines on the hand (compare figs. 5 and 6, pl. xxxi).

Phrynichosarax rimosus (Simon).[2]

(Plate xxxi, fig. 6.)

The Superintendent of the Cambridge University Zoological Museum has been good enough to send me the type specimen of this species for examination. It is an ovigerous female, and was found by a member of the "Skeat" expedition to the Malay Peninsula at Kuala Aring in Kelantan. The species is represented in our collection by two specimens (one probably, the other certainly, immature) collected by Mr. B. H. Buxton in Lankawi (? small island not far from main island) off the west coast of the Malay Peninsula.

The *carapace* resembles that of *P. buxtoni* rather than that of *P. cochinensis*, but the depression in the anterior part of the

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[1] *Sarax sarawakensis* subsp. *singaporae*, Gravely, *Rec. Ind. Mus.*, VI, pp. 36-38.

[2] *Proc. Zool. Soc. London*, 1901, p. 77.

median groove is not distinct. The hand also resembles that of *P. buxtoni*. The finger is armed above with two spines situated as in *P. buxtoni*, but quite minute, each being about half as long as the shorter of the two found in that species (see pl. xxxi, fig. 6). In this character *P. rimosus* resembles species of the following genus.

Genus **SARAX**, Simon.[1]

Type *S. brachydactylus*, Simon.

In "*Das Tierreich*" Kraepelin recognized two species in this genus, *S. brachydactylus*, Simon, and *S. sarawakensis* (Thorell). A number of species have undoubtedly, however, been grouped together by various authors under the latter name, including some belonging to the genus *Phrynichosarax*.

S. brachydactylus is not known to me. The remaining species may be distinguished thus:—

Proximal spine of hand slightly more than half as long as distal ... ... *S. willeyi*, p. 441.
Proximal spine of hand scarcely half as long as distal ... ... *S. sarawakensis*, p. 441

Sarax brachydactylus, Simon.[2]

Simon records this species from Luzon in the Philippines, where it was found in the caves of Antipolo (Province Morong), San-Mateo (Province Manila) and Colapnitam (Province Camarines-Sur).

Sarax willeyi, n. sp.[2]

(Plate xxxi, fig. 7.)

Two specimens preserved in the Indian Museum were collected by Dr. Willey in New Britain. The only character by which they appear to be distinguished from *S. sarawakensis* has been noted in the above key (see also pl. xxxi, figs. 7 and 8). In both *S. willeyi* and *S. sarawakensis* the spines on the finger are extremely small. In this respect these species closely resemble *Phrynichosarax rimosus*, which *S. willeyi* also resembles in all other characters except the structure of the legs by which the genera *Sarax* and *Phrynichosarax* are separated.

A specimen from Narcondam Island in our collection, and one from Table Island (Andamans) in the British Museum collection, must belong to this species or to one not yet described ; but the spines on the finger are imperfect in both.

Sarax sarawakensis (Thorell).[3]

(Plate xxxi, fig. 8.)

This species was described by Thorell from Sarawak. Mr. Moulton has sent me from the Sarawak Museum two specimens

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[1] *Ann. Soc. Ent. France*, LXI, 1892, p. 43.
[2] *Ibid.*, pp. 43-44.
[3] *Charon sarawakensis*, Thorell, *Ann. Mus. Civ. Genova*, XXVI, 1888, pp. 354-358.

found on Klingkang summit, between Sarawak and Dutch Borneo. They differ from all other species of *Sarax* and *Phrynichosarax* known to me in the markedly greater difference in size between the two spines on the dorsal margin of the hand (see pl. xxxi, fig. 8). The spines on the finger are minute as in the preceding species.

The larger specimen is somewhat larger than the type, the carapace being 4·5 mm. in width.

Genus **CHARINIDES**, Gravely.[1]

Type *Charinides bengalensis*, Gravely.

The genus *Charinides* bears to *Charinus* the same relation as does the genus *Phrynichosarax* to *Sarax*. Both *Charinides* and *Charinus* resemble the preceding genera in general structure, and in the size to which specimens grow. They differ only in the structure of the ocular part of the carapace and in this they resemble the following genera, from the much larger adults especially of which they differ markedly in the structure of the arm and hand.

Only one species of *Charinides* is known.

Charinides bengalensis, Gravely.[1]

This species is only known from Calcutta and its immediate neighbourhood, where it is quite common under bricks in shady places where desiccation is not too severe.

The proximal spine on the dorsal margin both of the *hand* and of the *finger* is about half as long as the distal. These spines are long and slender on the finger as well as on the hand (see pl. xxiv, fig. 29 of this volume). They closely resemble those of *Phrynichosarax buxtoni* (pl. xxxi, fig. 4).

Genus **CHARINUS**, Simon.[2]

Type *C. australianus* (Koch).

The genus *Charinus* is represented in the Indian Museum collection by two specimens of *C. seychellarum*, Kraepelin.

Kraepelin distinguishes three species in "*Das Tierreich*":—*C. australianus* (Koch)[3] from Viti and Samoa, *C. neocaledonicus*, Simon,[4] from New Caledonia, and *C. seychellarum*, Kraepelin,[5] from the Seychelles. *C. insularis*, Banks,[6] has since been described from the Galapagos Islands.

This genus and the preceding include all the most primitive species of the group to which they belong, and it is noteworthy that they are only found north, east and west of the country inhabited by the following genera, genera of which the adults are much larger and have more highly specialized arms and hands.

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[1] *Rec. Ind. Mus.*, VI, pp. 35-36, fig. 2B.
[2] *Ann. Soc. Ent. France*, LXI, 1892, pp. 43 and 48.
[3] *Phrynus australianus*, Koch., *Ver. Ges. Wien*, XVII, p. 231.
[4] *Abh. Ver. Hamburg*, XIII, p. 47.
[5] *Mitt. Mus. Hamburg*, XV, p. 41.
[6] *Proc. Washington Ac.*, IV, p. 67, pl. ii, fig. 8.

Genus **STYGOPHRYNUS**, Kraepelin.[1]

Type *S. cavernicola* (Thorell).

In this genus, as in all of the foregoing of which I have sufficient knowledge to speak with certainty, particular spines on the second appendages have proved to provide admirable characters for specific diagnoses, while others are absolutely worthless for this purpose. The granulation of the surface of these appendages, and of the carapace, is also important in this connection.

The following species may be recognized:—

1. Armature of hand consisting of two long dorsal spines and one ventral one only ... ... *S. moultoni*, p. 443.
   Hand armed above and below with one long spine succeeded by a series of short spines which increase in length distally ... ... 2.
2[2]. Adults pale in colour[2], rather small and very lightly built, with long slender arms; occular lobes of carapace finely and evenly granular, without tubercles ... ... *S. cavernicola*, p. 444.
   Adults somewhat or much darker in colour, larger and more heavily built with much stouter arms, occular lobes of carapace more coarsely and less evenly granular, usually marked with a number of scattered tubercles 3.
3. Distal of three long spines on dorsal margin of tibia of arm with a spine of nearly half its own length on either side of it ... ... *S. longispina*, p. 445.
   Spines on either side of distal of three long spines on dorsal margin of tibia of arm quite short in adults, the proximal one short in young specimens also ... ... 4.
4. Adults somewhat pale[2] in colour, not very strongly granular ... ... *S. berkeleyi*, p. 445.
   Adults very dark and strongly granular ... *S. cerberus*, p. 446.

Stygophrynus moultoni, n. sp.

(Plate xxxi, fig. 9.)

Mr. Moulton has sent me a single much broken specimen of this species. It was found on Klingkang summit, between Sarawak and Dutch Borneo. It is somewhat small, but appears to be mature or very nearly so. It is a male and is very distinct from all other species of the genus.

The *carapace* is 7·4 mm. broad by 5·7 mm. long in the middle line. It is somewhat pale in colour, finely granular and without tubercles, like that of *S. cavernicola*.

The *arms* (pl. xxxi, fig. 9) are somewhat slender, but are much shorter than in adult males of that species, the femur being no longer than the carapace is broad. The armature of the femur resembles that of *S. cavernicola*, but the spines are necessarily closer together. The tibia is also armed much as in that species, but the subsidiary spines among the longer spines of the ventral

[1] *Abh. Ver. Hamburg*, XIII, p. 44.

[2] The young of all species are pale in colour and have relatively short arms.

margin are obsolete, while on the dorsal margin the first of the three long spines is situated in about the middle of the length of the joint, as in females of *S. cavernicola*. This spine is preceded by an additional spine about half way to the base of the joint and nearly as long as the spine following the distal of the three long spines, which terminal spine is fully half as long as the three long spines. The granulation of the convex posterior surface of both femur and tibia is obsolete. The backs of the hand and finger are smooth. The hand is armed above by two spines of about equal length and not much shorter than the long spines of the upper margin of the tibia; it is armed below by one somewhat shorter spine opposite the distal of the two upper ones. The finger is armed above with three minute tooth-like spinules.

The *legs* are coloured in a similar manner to the rest of the body. They appear to have been long and slender, with the antenniform legs exceptionally long as in the other species of the genus, all of which are known to be cavernicolous. The hind femur scarcely exceeds the basal piece of the hind tibia in length by more than the length of the patella, which suggests that the remaining pieces, which are broken, may have been two instead of three in number.

Stygophrynus cavernicola (Thorell).[1]

The habits of this species have been described from specimens found, like the type specimen, in the Khayon or "Farm" caves near Moulmein.[2] The Indian Museum collection includes a number of specimens from the larger of these caves, and two from a small cave at Dhammathat. The species has been recorded from Saigon by Kraepelin.[3] Kraepelin had, however, insufficient material for the determination of specific characters[4], and geographical considerations render it very improbable that this determination is correct.

The *carapace* of specimens which are probably adult—no ovigerous females of this species ever appear to have been found—is about 9·5 mm. broad by 7 mm. long in the middle line. It is of a pale yellowish-brown colour, and is finely granular as in the preceding species.

The *arms* are always slender; in the female the femur is a little longer than the carapace is wide, in the male it is nearly twice as long. The femur and tibia are finely granular, with two smooth longitudinal bands on the convex posterior surface. There

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[1] *Charon cavernicola*, Thorell, *Ann. Mus. Civ. Genova*, XXVII, 1889, pp. 538-542.

[2] *Journ. Asiat. Soc. Bengal* [n.s.], IX, 1914, pp. 418-9.

[3] *Bull. Mus. Hist. Nat. Paris*, 1901, p. 265.

[4] This statement is based on an examination of specimens from Mentawei and Java, which Prof. Kraepelin showed me in Hamburg. They, too, are distinct and Prof. Kraepelin very kindly promised to send them to me for description whenever I should be ready to deal with them, a promise whose fulfilment the war has unfortunately made impossible.

is sometimes a small spine between the three long distal spines on the dorsal margin of the tibia and the base of the joint, especially in the female. The three long spines are succeeded by a spine of about half their own length, but the spines between them are never well developed and are often absent. The hand is armed above and below with one very long spine, succeeded by a series of much shorter ones, of which the distal are longer than the proximal, the dorsal spines being somewhat longer than the ventral. The long dorsal spine bears at its base a strong backwardly directed spinule, and this is often succeeded in adults by a short row of very much smaller spinules on the margin of the long spine. The finger is unarmed.

The *legs* are pale in colour like the rest of the body.

Stygophrynus longispina, n. sp.

(Plate xxxi, fig. 10.)

Two male and two immature specimens were collected by Mr. Buxton in a cave on Langkawi Island off the west coast of the Malay Peninsula.

The *carapace* of the adults is about 12 mm. broad by 9 mm. long in the middle line. It is of a very dark brown colour, and is somewhat more coarsely and sparsely granular than is that of the preceding species, with a few strong tubercles among the granules.

The *arms* are very short and stout, their femora being little if at all longer than the carapace is wide. Their femora and tibiae are more coarsely granular than in *S. cavernicola* and the smooth bands on the convex posterior surface are invaded by scattered rows of granules. The three long spines on the dorsal margin of the tibia are followed, as in *S. cavernicola*, by a spine of about half their own length (perhaps a little shorter in the present species), and a similar but even longer spine occurs between the last two of them, serving to distinguish this from all other species known to me. The hand (pl. xxxi, fig. 10) is armed as in *S. cavernicola*, but is somewhat more coarsely and less extensively granular behind. The finger is unarmed as in that species.

The *legs*, especially the antenniform legs, are long and slender as in other species of the genus. They are dark in tint, harmonizing with the rest of the body though actually somewhat paler than the carapace and much darker than the abdomen.

Stygophrynus berkeleyi, n. sp.

(Plate xxxi, fig. 11.)

One male and several immature specimens were collected by Mr. Buxton in caves at Lenggong, Perak, Malay Peninsula. The species is named after Mr. H. Berkeley, the District Officer of Upper Perak, who greatly facilitated Mr. Buxton's work in the district.

The *carapace* of the adult male is 15 mm. broad by 10·5 mm. long in the middle line. It is paler in colour than is that of

S. longispina, but lacks the yellow tint of that of *S. cavernicola*. The immature specimens with it suggest that this is the normal colouration of the species. The granulation of the carapace is very coarse, and the tubercles are more numerous and more conspicuous than in *S. longispina*.

The *arms* are longer than in *S. longispina*, the femora being about 20 mm. in length (four-thirds as long as the carapace is broad), but are very stout. The granulation of the femora, tibiae and hands resembles that found in *S. longispina* (compare figs. 10 and 11, pl. xxxi). The only well-developed spines on the upper margin of the tibia are the three long ones near the distal end which are characteristic of the genus; all others are quite small, the contrast being more marked in the adult than in the immature specimens. The hand and finger resemble those of *S. longispina*.

The *legs* resemble those of other members of the genus, but the walking legs especially are of a much paler and more yellowish colour than in *S. longispina*, this colour difference between the two species being somewhat more marked in the legs than in the carapace.

Stygophrynus cerberus, Simon.[1]

(Plate xxxi, fig. 12.)

The habits of this species from the Jalor caves (Gua Glap or "Dark Cave", and Biserat) have been described elsewhere.[2] Cotypes have been presented to the Indian Museum by the Cambridge Museum.

This species closely resembles *S. berkeleyi*, but has all the integuments harder, much darker in colour, and more strongly granular (compare pl. xxxi, figs. 11 and 12).

Stygophrynus spp. indet.

In addition to the species from Saigon, Mentawei and Java already referred to (p. 444), mention may be made of "an animal allied to Phipson's Tarantula" found by Flower in the depths of the Batu Caves at Selangor,[3] which may well have belonged to this genus.

Genus **CHARON**, Karsch.

This genus is represented in the Indian Museum collection by one immature specimen of *C. grayi*, the only species recognized by Kraepelin in "*Das Tierreich.*" *C. annulipes*, Lauterer,[4] does not appear to be referred to in that work, but it cannot be recognized either from the description or from the figure. It is compared with *C. australianus*, Koch, a species now placed in the genus *Charinius*. Its position must remain uncertain till the type is re-examined.

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[1] *Proc. Zool. Soc. London*, 1901, pp. 76-7.
[2] *Journ. Asiat. Soc. Bengal* (n.s.), IX, 1914, p. 419.
[3] *Rep. Austr. Ass.* VI, 1895, pp. 413-4, pl. lii.
[4] *J. Straits R. Asiat. Soc.*, No. 36, 1901, p. 40.

Subfamily *PHRYNICHINAE.*

Kraepelin divides this subfamily into genera as follows :—

1. Tibia of fourth leg 1-jointed; hand of adult with basal of two dorsal spines rudimentary or absent.[1] *Phrynichus*, p. 447.
2. Tibia of fourth leg 2-jointed; both dorsal spines of hand strongly developed in adult ... *Damon*, p. 455.

Genus **PHRYNICHUS**, Karsch.[2]

Type *P. reniformis* (Linn.).

The generic identity of Linnaeus's *Phalangium reniforme*, which has an important bearing on the nomenclature of the subfamily, has been much in dispute. Kraepelin summarised the available evidence at the commencement of his "Revision der Tarantuliden"[3], and has given his final opinion as regards the correct nomenclature in "*Das Tierreich.*"[4] His conclusions have been confirmed by Lönnberg, who examined the type still preserved in the Zoological Museum at Upsala.[5]

The generic identity of *Phalangium reniforme* having been settled, its specific identity was for Kraepelin a simple matter, since, from the material at his disposal, he was unable to recognize more than two species in the genus. The rich material in the Indian Museum collection shows, however, that several of the names regarded by Kraepelin as synonymous with *Phrynichus reniformis* will have to be revived; and that even these will not cover all the species to which the name *P. reniformis* may conceivably belong. The description of *P. reniformis* is generic rather than specific, and the identity of the species must, I am afraid, remain a matter of doubt until the type is redescribed. Lönnberg says, "To judge from the descriptions and from the table given by Pocock, the Linnean specimen most closely agrees with '*Ph. deflersi*,' Simon." But the value of the characters used by Pocock in diagnosing this species is perhaps open to question; and it is more likely that the Linnean specimen belongs to one of the two well-known forms called below *P. ceylonicus* and *P. nigrimanus* respectively, than to a species only known otherwise from a single specimen from Obock.

The description of *P. lunatus* (Pallas) is also generic rather than specific; and the figures with which it is accompanied are too rough to be of any help. The identity of this species also must therefore remain in doubt.

P. ceylonicus (Koch) is clearly a large species found in Ceylon. Only one such species is known to me, and I have accordingly applied the name to it.

P. scaber (Gervais) comes from the Seychelles (? and Mauritius). It is probably distinct from the Indian and Ceylonese species, but

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[1] Except in *P. deflersi* (Simon).
[2] *Arch. Naturg.* XLV (1), 1879, p. 190.
[3] *Abh. Ver. Hamburg* XIII, 1895, pp. 1-53, 1 pl.
[4] See also *Zool. Anz.* XXVIII, 1904, pp. 201-203.
[5] *Ann. Mag. Nat. Hist.* (7) I, 1898, pp. 88-89.

the description is again generic, not specific, and as I have no specimens before me from these islands I cannot add to it.

P. nigrimanus (Koch) is from India. It is probably the species common in the Eastern Ghats, as has already been suggested by Hansen.[1] This is the only species known to me of which (spirit) specimens ever seem to resemble Koch's figure in colour.

P. deflersi (Simon) may be distinguished by the presence, even in large specimens such as the type of the species, of two well developed spines on the dorsal margin of the hand, as in the genus *Damon*. Both these spines are, however, present in the young of certain other species.

P. jayakari, Pocock, differs from all other known species in the presence of a pair of stout spines on the margin of the carapace in front of the lateral eyes.

P. phipsoni, Pocock, is a distinct species, apparently confined to the northern parts of the Western Ghats.

P. pusillus, Pocock, is a common Ceylonese form, allied to but distinct from *P. ceylonicus* (Koch) of which it may conveniently be regarded as a variety. It is much smaller than this or any other species of the genus known to me.

Phrynichus scullyi, Purcell, from S. Africa[2] is probably described from immature specimens, but as I have not seen any I cannot speak with certainty.

P. bacillifer (Gerst.) remains, of course, distinct.

The determinable species of the genus may be recognized thus:—

1.	Margin of carapace without strong spines ...	2.
	Margin of carapace with a pair of strong forwardly directed tooth-like spines in front of lateral eyes	*P. jayakeri*, p. 455.
2.	One spine only present on upper margin of hand of adult	3.
	Vertical basal spine as well as oblique spine distal to it persistent on upper margin of hand in adult	*P. deflersi*, p. 455.
3.	Anterior surface of femur of arm with 3-5 sharp spines, or simply granular; lower margin always with some sharp spines	4.
	Anterior surface of femur of arm with 2 or 3 blunt rounded bacilliform processes in the basal third; lower margin spineless	*P. bacillifer*, p. 455.
4.	A longitudinal row of granules present on lower surface of hand (pl. xxxi, fig. 14) ...	*P. ceylonicus*, p. 449.
	Lower surface of hand smooth (pl. xxxi, fig. 13).	5.
5.	Tibia of arm of adult with two long terminal dorsal spines preceded only by a minute tubercle[3]; basal dorsal spine of hand absent in adult, small or absent in young	*P. nigrimanus*, p. 453.
	Tibia of arm of adult with the two long terminal dorsal spines preceded by a short but well developed spine; basal dorsal spine of hand probably always well developed in young, represented by a tubercle in adult	6.

[1] *Ent. Med.* IV, 1894, p. 150. [2] *Ann. S. Afr. Mus.* II, 1900-1902, p. 206.

[3] This tubercle replaces a spine which is present in the young of this as of other species.

6. Terminal ventral spine of tibia of arm of adult small, more or less conical, not decumbent (much as in *P. ceylonicus*, pl. xxxi, fig. 14) ... *P. granulosus*, p. 454.
Terminal ventral spine of tibia of arm of adult long, parallel-sided, decumbent (pl. xxxi, fig. 13) *P. phipsoni*, p. 454.

Phrynichus reniformis (Linnaeus).[1]

The identity of this species can only be settled by a further examination of the type which is preserved in the Zoological Museum at Upsala (see above, p. 447).

Phrynichus lunatus (Pallas).[2]

Also an indeterminable species (see above, p. 447).

Phrynichus ceylonicus (Koch).[3]

(Plate xxxi, fig. 14.)

Three varieties of this species may be recognized as follows:—

A. ♂ & ♀ : width of carapace of adult 15-18 mm.; $\frac{\text{length of femur of arm}}{\text{width of carpace}} = 2\text{-}2{\cdot}2$ — *ceylonicus* (Koch), *s. str.*

B. ♀; width of carapace of adult 13-14·5 mm.; $\frac{\text{length of femur of arm}}{\text{width of carapace}} = 1{\cdot}5\text{-}1{\cdot}8$

C. ♂; width of carapace of adult 10·5-13 mm.; $\frac{\text{length of femur of arm}}{\text{width of carapace}} = 1{\cdot}8\text{-}2{\cdot}3$ — var. *gracilibrachiatus*, Gravely.[4]

D. ♂ & ♀; width of carapace of adult 8-10·5 mm.; $\frac{\text{length of femur of arm}}{\text{width of carapace}} = 1{\cdot}1\text{-}1{\cdot}5$ — var. *pusillus*, Pocock.[5]

1. PHRYNICHUS CEYLONICUS (Koch), *s. str.*

This form is remarkable for its ability to live in comparatively dry surroundings; it seems to live mainly in jungles where the soil is specially porous or the climate not very moist, and in houses in moister regions. Specimens from the following localities in Ceylon are preserved in collections belonging to the Indian Museum, to the Colombo Museum, or to Mr. E. E. Green:—

North East Province: Horowapotama, *ca.* 200 ft.; Moha-Illuppalama, *ca.* 300 ft.
Western Province: Wennappuwa, 10 mls. from Negumbo.
Central Province: Nalanda, *ca.* 900-1000 ft.; Galagedara, *ca.* 800-2000 ft.; Haragama, *ca.* 1200 ft.; Kandy, *ca.* 1500-2000 ft.; Peradeniya, *ca.* 1500 ft.
Southern Province: Ambalangoda, 0-100 ft.; Kottowa, 0-100 ft.

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1 *Systema Naturae*, 10th ed., p. 619.
2 *Spicilegia Zoologica*, fasc. IX, pp. 33-37, pl. iii, figs. 5-6.
3 *Die Arachniden*, X, p. 336, fig. 776.
4 *Spolia Zeylanica*, VII, p. 140.
5 *Ann. Mag. Nat. Hist.* (6), XIV, p. 296.

There must, I think, be some mistake about a specimen in the Indian Museum collection that is supposed to have been collected by Major Beddome in South India.

This is the largest form of *P. ceylonicus* known, and full-grown specimens may easily be distinguished from the varieties *gracilibrachiatus* and *pusillus* by their size. Younger specimens may be distinguished by the loss, at a time when the size of the specimen is greater than that at which these changes take place in the permanently smaller forms, first of the bright and chequered juvenile colouration, and later of the first of the three spines on the upper surface of the distal end of the tibia of the arm. But in the smallest specimens of all there appears to be no certain means of distinguishing the different forms.

The fully grown female of var. *gracilibrachiatus* is the only other form at all likely to be confused with this typical form. It approaches the typical form much more closely in size than do either the male of the same variety or either sex of var. *pusillus*; and, except when their maturity is made evident by the presence of embryos under the abdomen, the identity of these forms is very difficult to establish unless by comparison with a good series of typical specimens in various stages of growth.

The presence of a pair of well-developed semilunar lobes on the posterior margin of the third abdominal sternum of *P. ceylonicus*, *s. str.*, is useful in checking the identity of immature specimens, as in the varietal forms these are always proportionally smaller than is usual in the typical one, and they are often apparently absent altogether. But as, in a long series, every stage can be found from their absence in the varieties to their full development in the typical form, their condition does not in itself fully indicate to which of the three forms a specimen belongs.

The following measurements of the mature or approximately mature specimens in the Indian Museum collection will serve to indicate the proportions borne by the arms to the width of the carapace in adults of this form:—

Sex.	♂	♀ (with embryos).	♀	♂	♂	♂
Width of carapace in mm.	18	17·5	17	16	16	15
Length of femur of arm in mm.	40·5	35·5	34	33	33	31

2. P. CEYLONICUS var. GRACILIBRACHIATUS, Gravely.

The habits of this form resemble, so far as is known, those of the next variety.

The Indian Museum collection contains specimens from the following places in Ceylon:—

Central Province : Nalanda, *ca.* 900-1000 ft.; Galagedara, *ca.* 800-2000 ft.; Kandy, *ca.* 1500-2000 ft.; Peradeniya, *ca.* 1800 ft.

The sexes of this variety differ from one another in a more striking manner than do those either of the typical form or of the other variety of the species, and but for certain indications of an identical geographical distribution for the two and the fact that I have seen no female which superficially resembles the male of this variety, and no male which resembles what I believe to be its female, it would hardly, perhaps, have occurred to me to regard them as a single form. Thus the adult male is small,[1] often closely resembling var. *pusillus* in the size of its body, though always distinguished therefrom by its relatively longer appendages, the arms especially being very noticeably longer and slenderer, bearing about the same proportion to the width of the carapace as they do in adults of *P. ceylonicus, s. str.*; whereas the female is large, being intermediate in size between *P. ceylonicus, s. str.* and var. *pusillus*, and has proportionally shorter arms. Specimens in which maturity is not clearly indicated by the presence of embryos under the abdomen may therefore be very easily mistaken for immature specimens of *P. ceylonicus, s. str.*, since the proportion borne by the arms to the width of the carapace increases with growth.

So far as I know it is impossible to distinguish immature specimens of either sex of var. *gracilibrachiatus* from those of var. *pusillus*; and from this it may be concluded that the arms of the male of the former become greatly lengthened at about the time when maturity is reached (as do those of the male of *Charinides bengalensis*) and that previously they are no longer than in the latter variety.

In practice there is never any difficulty in distinguishing the adult male of var. *gracilibrachiatus* from the form most like it—the male of var. *pusillus*. But to distinguish adult females of var. *gracilibrachiatus* from immature females of *P. ceylonicus, s. str.*, of the same size is much more difficult except, as has already been pointed out, when the former bear embryos. The chief differences between the two are :—(1) the retention in (? all) specimens of the latter of a distinctly spiniform rudiment of the first of the three dorsal spines at the distal extremity of the tibia of the arm, a spine which has probably already disappeared in all specimens of the former; and (2) the size of the semilunar lobes on the posterior margin of the third abdominal segment, which are always present

[1] This difference in size and proportions shown by the two sexes is present in var. *pusillus* also, and probably in *ceylonicus*, s. str., as well; but in these two forms it is less striking, and only apparent in a series of measurements; whereas in var. *gracilibrachiatus* it is very noticeable at once—more so in fact than the measurements would lead one to suppose. The name *gracilibrachiatus* is an unfortunate one now that *pusillus*, Poc., has to be regarded as a variety and not a species; for it is from this form only that var. *gracilibrachiatus* is distinguished by the slenderness of its arms, and not from *P. ceylonicus*, s. str. It was as a variety of *P. pusillus*, Poc., that *gracilibrachiatus* was originally described.

and usually well developed in *P. ceylonicus, s. str.* but are either small or absent in var. *gracilibrachiatus.*

The following measurements (in mm.) were used in calculating the proportions given for this variety in the table on p. 449 :—

Sex.	♀ (with embryos).	♀	♀ (with embryos).	♀	♂ (type)	♂	♂	♂	♂	♂	♂	♂
Width of carapace.	14·5	13	13	13	13	13	12	11·5	11·5	11	10·5	10·5
Length of femur of arm.	25	23	22	20·5	29·5	28·5	25	24	24	22·5	20·5	19

3. P. CEYLONICUS var. PUSILLUS, Pocock.

This variety is unable to live long in the absence of moisture. It is only known from the Central Province of Ceylon, and was first described from specimens caught at Punduloya by Mr. E. E. Green, who tells me he got them at an altitude of about 4200 ft. above sea level. It is represented in the Indian Museum collection by specimens from Nalanda, *ca.* 900-1000 ft.; Galagedara, *ca.* 800-2000 ft.; Kandy, *ca.* 1500-2000 ft.; Peradeniya, 1600-2200 ft.

The best means of distinguishing this variety from the last and from the young of *P. ceylonicus, s. str.*, have already been dealt with (pp. 450-451). One other character remains, however, to be noted here: it is quite common to find the first of the three dorsal spines at the distal end of the tibia of the arm represented in mature specimens of this variety by a distinct spiniform process. The process is, however, always very much smaller than in young specimens of equal size of *P. ceylonicus, s. str.* Thus the greatest length for this spine seen in an ovigerous female of var. *pusillus* was about 0·5 mm.; but in a specimen of *P. ceylonicus, s. str.*, of approximately the same carapace-width (former 8 mm. the latter 7·5 mm.) this spine is as much as 2 mm. long, and in a somewhat older specimen (carapace-width 9·5 mm.) it is 1·5 mm. long.

The following are measurements (in mm.) taken from the series of this variety in the Indian Museum collection :—

Sex.	♀ with embryos).	♀	♀	♀	♀	♀ (with embryos).	♂	♀ (with embryos).	♀ (with embryos).	♂	♂	♀	♂	♀ (with embryos).	♀	♀ (with embryos.)	♂	♂	♀ (with embryos).	♀
Width of carapace.	1 ·5	10	10	10	9·5	9·5	9	9	9	8·5	8·5	8·5	8·5	8·5	8·5	8·5	8	8	8	8
Length of femur of arm.	14·5	13·5	12·5	12	11	10·5	13·5	11·5	10	11·5	11	11	10·5	10	9·5	9	9·5	9	9	8·5

Phrynichus nigrimanus (Koch).[1]

The Indian and Madras Museums possess between them specimens from all but one[2] of the following localities, all of them on the eastern side of the Indian Peninsula :—

Orissa : Hills, 0·1000 ft., near Barkul, Chilka Lake ; Balugaon Chilka Lake.
Ganjam : Russelconda.
Vizagapatam District.
Nellore : Rambuga cave, Udyagiri droog.
Karnul : Bairani, Chelama Ry. Station, Nallamalais, *ca.* 2000 ft.
N. Arcot : Vellore.
Chengalpat : Pallavaram, 12 miles from Madras.
Salem : Shevaroy Hills.

Barkul is the only place where I have myself collected specimens of this species. They are quite common in the hills and in the jungle at the foot of them, but I failed to get any very large specimens or ovigerous females—though I went for this purpose in the rains, when *P. ceylonicus* breeds. None of the specimens found had lost the third spine on the dorsal surface of the distal end of the tibia of the arm ; but one of the largest of them, in which it was quite small (about 0·5 mm. long), did so on casting its skin after a few weeks' captivity, when the spine was reduced to a tubercle. The width of the carapace of the cast skin of this specimen is 12·0 mm., that of the specimen itself being 14·0. Probably mature specimens are at least 14 mm. across the carapace and live, as is more or less the case with other species, in the securest retreats.

In the hills further south the species attains a much greater size than at Barkul. This does not, however, appear to be the case near the coast since the width of the carapace of the Pallavaram specimen, in which the third spine on the dorsal surface of the distal end of the tibia of the arm is absent, is barely 13 mm. The third spine on the dorsal surface of the distal end of the tibia of the arm is over 2 mm. long in the specimen from Rambuga cave, the width of whose carapace is 11 mm. ; and it is nearly 2½ mm. long in two specimens from the Shevaroys whose carapaces are nearly 11 and a little over 12 mms. broad respectively. The largest specimen I have seen is that from Bairani, whose carapace is 20 mm. broad. It appears to be a mature female. The length of the femur of the arm is 38·5 mm., and the third dorsal spine at the distal end of the tibia of the same appendage is tuberculiform. This specimen belongs to the Madras Museum. It is possible that this form and the one common at Barkul may ultimately have to be recognized as distinct varieties or subspecies.

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[1] *Die Arachniden*, XV, p. 69, fig. 1464.

[2] The only specimen I have seen from Vellore belongs to Rev. J. E. Tracey, to whom my thanks are due for sending it. It is doubtless identical with the form described by Hansen (*Ent. Med.* IV, 1894) as common at Vellore.

Phrynichus granulosus, n. sp.

This species is represented in the collections of the Indian, Madras and Trivandrun Museums by specimens from the following localities :—

Cochin: State Forest Tramway 10th-14th mls., 0-300 ft.; Kavalai, 1300-3000 ft.

Travancore: Ponmudi, 2000-3000 ft.

The specimen which Pocock records in the "Fauna" from Trivandrum under the name *P. phipsoni* doubtless also belongs in reality to the present species.

This species, whose distinctive characters are given above (pp. 448-449), is intermediate in character between *P. nigrimanus* and *P. phipsoni*, resembling the former and *P. ceylonicus* in the shape of the terminal ventral spine of the tibia of the arm, and the latter in the other spines of both arm and hand. The integuments are more coarsely granular than in any other species with which I am acquainted. In this character the species presumably resembles *P. scaber* (Gervais) from the Seychelles. The male type—the largest specimen known to me—has a carapace 18 mm. broad, the femur of the arm being 31 mm. long. The female type has a carapace 15·5 mm. broad, the femur of the arm being 24·5 mm. long. Both these specimens are from jungle near the rubber estate between the 10th and 14th miles of the Cochin State Forest Tramway.

Phrynichus phipsoni, Pocock.[1]

(Plate xxxi, fig. 13.)

This species has been recorded by Pocock from Bombay and Trivandrum, and from various other localities by subsequent authors, who have apparently confused with it the earlier stages of other species, *i.e.* the stages which retain the third dorsal spine of the distal end of the tibia of the arm. I have little doubt that the Trivandrum specimen referred to by Pocock belongs in reality to the preceding species, and that *P. phipsoni* is confined to the more northerly parts of the Western Ghats.

Phrynichus scaber (Gervais).[2]

Gervais records this species from the Seychelles, and the same or an allied form from Mauritius. Its distinctive characters have yet to be described.

Phrynichus scullyi, Purcell.[3]

This species is recorded only from Cape Colony (Pakhuisberg in Clanwilliam Division, and Namaqualand). The specimens from which it was described were probably young, judging from their size and colour.

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[1] *Ann. Mag. Nat. Hist.* (6), XIV, 1894, p. 295, pl. viii, fig. 4.
[2] *Histoire Naturelle des Insectes, Apteres,* III, p. 3.
[3] *Ann. S. Afr. Mus.*, II, 1902, p. 206.

Phrynichus bacillifer (Gerstaecker).[1]

This species, according to Kraepelin, occurs from Madagascar and Zanzibar to Mozambique, Tanganyika and Lake Rudolph.

Phrynichus deflersi (Simon).[2]

Described from a single specimen from Obock in French Somaliland.

Phrynichus jayakeri, Pocock.[3]

Described from two specimens from Muscat in Arabia.

Phrynichus spp.

The above record of the distribution of various species of Phrynichus by no means exhausts the localities given by previous authors. Most of the additional localities refer to the composite "species" to which Kraepelin applied the name *P. reniformis;* others refer to species which have clearly been wrongly named. These localities, and those of certain immature specimens in the Indian Museum collection, show the distribution of the genus to be wider than appears above, and may therefore be recorded here:—

Africa: Natal; Mozambique; Kondoa (? French Congo); Massaua (Somaliland); several localities in Central Africa (Albert Lake, Kossenje; Kirk Falls south-west from Albert Lake; plains below Semliki; Awakubi).
Madagascar (east coast).
Asia: Arabia—Aden.
Assam—Sibsagar.
Siam—Chantaboon.
Cochin China—Saigon.
Malay Peninsula—Penang.

Genus **DAMON,** Koch.[4]

Type *D. variegatus* (Perty).

I have nothing to add to Kraepelin's account of this genus. It is mainly African, but Kraepelin records *D. variegatus* from Arabia as well.

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[1] *C. v. d. Decken's Reisen in Ostafrica,* III (2), p. 472.
[2] *Bull. Soc. Zool. France,* XII, 1887, p. 454.
[3] *Ann. Mag. Nat. Hist.* (6), XIV, p. 294.
[4] *Uebersicht des Arachnidensystems,* V, p. 81.

EXPLANATION OF PLATE XXXI.

FIG. 1. Four distal joints of arm of *Catageus pusillus* from above (diagrammatic, showing armature of dorsal margin).

,, 2. Basal joint of finger of *Phrynichosarax cochinensis.*

,, 3. ,, ,, ,, ,, *javensis.*

,, 4. ,, ,, ,, ,, *buxtoni.*

,, 5. ,, ,, ,, ,, *singapurae.*

,, 6. ,, ,, ,, ,, *rimosus.*

,, 7. Four distal joints of arm of *Sarax willeyi* from above (diagrammatic, showing armature of dorsal margin).

,, 8. Hand of *Sarax sarawakensis.*

,, 9. Four distal joints of arm of *Stygophrynus moultoni* from above (diagrammatic, showing armature of dorsal margin).

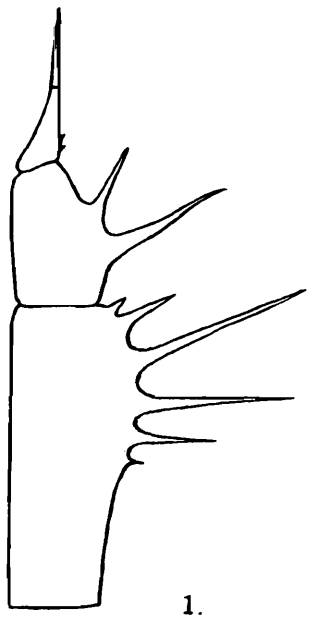
,, 10. Back of hand of *Stygophrynus longispina.*

,, 11. ,, ,, ,, *berkeleyi.*

,, 12. ,, ,, ,, *cerberus.*

,, 13. Hand and distal part of tibia of arm of *Phrynichus phipsoni* from below.

,, 14. Hand and distal part of tibia of arm of *Phrynichus ceylonicus*, *s. str.*, from below.



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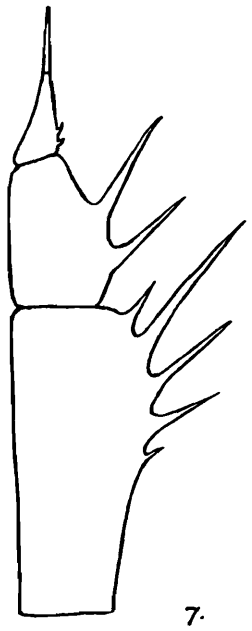

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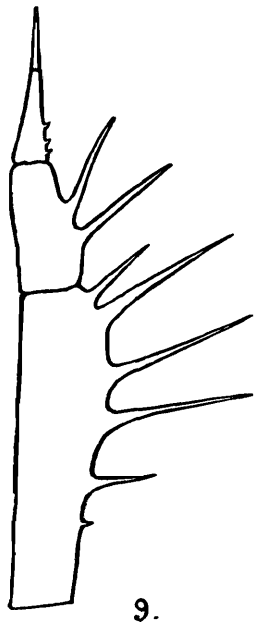

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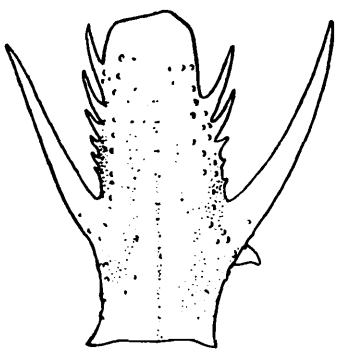

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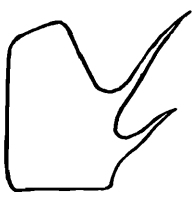

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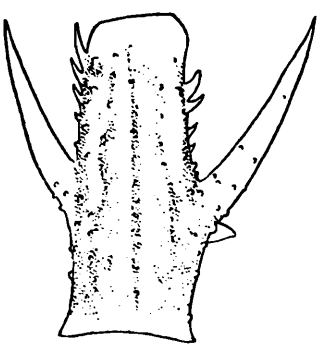

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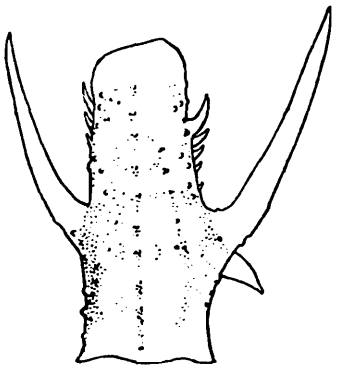

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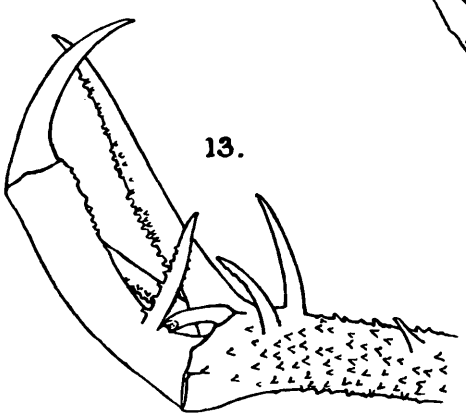

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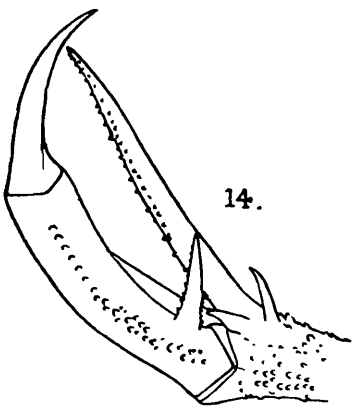

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F. H. G. & D. N. Bagchi, del.

Oriental Phrynichidae.

XXVII SOME SPONGES PARASITIC ON CLIONIDAE WITH FURTHER NOTES ON THAT FAMILY

By N. ANNANDALE, *D.Sc., F.A.S.B., Superintendent, Indian Museum.*

(Plate XXXIV.)

In a recent paper on the Clionidae of Indian seas (*Rec. Ind. Mus.* XI, pp. 1-24) I referred incidentally to other sponges parasitic in their burrows. I now propose to give an account of these sponges adding some additional notes on the Indian Clionidae.

The systematic position of the different species may be considered first, in taxonomic order, and then their biological relationships.

Part I.—SYSTEMATIC.

The following is a list of the species to be considered; all belong to the order Tetraxonida.

Grade **TETRAXONELLIDA.**

Family PACHASTRELLIDAE.

Stoeba plicata var. *simplex* (Carter).

Family STELLETTIDAE.

Stelletta vestigium, Dendy.

Grade **MONAXONELLIDA.**

Family EPIPOLASIDAE.

Coppatias penetrans (Carter).
Coppatias investigatrix, sp. nov.

Family CLIONIDAE.

Cliona carpenteri, Hancock.
Cliona mucronata, Sollas.
Cliona quadrata, Hancock.
Cliona kempi, sp. nov.
Thoosa hancocci, Topsent.

Family DESMACIODONIDAE.

Subfamily *ECTYONINAE.*

Rhabderemia prolifera, sp. nov.

Family AXINELLIDAE.

Amorphinopsis excavans, Carter.
A. e. var. *digitifera*, nov

Family CHONDROSIIDAE.

Chondrilla nucula, Schmidt.
Chondrilla mixta, Schulze.
Chondrilla distincta, Schulze.

Grade TETRAXONELLIDA.

Family PACHASTRELLIDAE.

Stoeba plicata (Schmidt).

1868. *Corticium plicatum*, Schmidt, *Die Spong. d. Kuste v. Algier*, p. 2, pl. iii, fig. 11.
1880. *Samus simplex*, Carter, *Ann. Mag. Nat. Hist.* (5) VI, p. 60, pl. v, fig. 26.
1888. *Stoeba simplex*, Sollas, *Challenger' Rep. Zool., Tetractinellida* (vol. XXV), p. 102.
1888. *Calcabrina plicata, id., ibid.*, p. 281.
1889 (1887). *Samus simplex*, Carter in Anderson's *Faun. Mergui* I, p. 75.
1894. *Dercitus plicata*, v. Lendenfeld, *Denk. Ak. Wien.* LXI, p. 105, pl. ii, fig. 10, pl. iii, fig. 43.
1895. *Dercitus plicatus*, Topsent, *Arch. Zool. expérim.* (3) III, p. 531, pl. xxii, figs. 6-10.
1903. *Dercitus simplex*, Thiele, *Abh. Senckenb. Natur. Gesellsch.* XXV, p. 20, pl. ii, fig. 1.
1903. *Dercitus simplex & D. plicatus*, v. Lendenfeld, *Das Tierreich, Tetraxonia*, pp. 81, 82.
1905. *Stoeba simplex & S. plicata*, Dendy in Herdman's *Ceylon Pearl Fisheries*, III, pp. 71, 230.

Carter mentions spicules of his *Samus simplex* as being among those he extracted from a specimen of dead coral in the late Dr. Anderson's Mergui collection. From the same specimen I have been able to extract numerous pieces of this sponge in sufficiently good condition to study its general structure and spiculation; the latter is evidently more varied than either Carter himself or Sollas realized and is apt to be not fully understood because certain spicules are practically confined to certain parts of the sponge. I am of the opinion that Topsent's suggestion (1895, p. 536) as to the specific identity of the species with Schmidt's *Corticium plicatum* is fully justified by the specimens I have examined.

The sponge, as it exists in dead coral, forms small oval or globular masses which entirely fill corresponding cavities. From these are given out slender, cylindrical or flattened branches, some of which join them to other similar masses, while others terminate in flattened and often ramifying lamellae. The latter make their way among interstices of the calcareous material. The larger masses contain a dense crowd of well-formed triaenes arranged with their sharply pointed shafts pointing outwards, but in the connecting branches the macroscleres are more scanty and more delicate in form, while they are practically absent in the distal parts of the lamellae. In the proximal parts thereof they have precisely the form of the small slender spicules figured by Topsent (1895, pl. xxii, *o'*, *d'*), whereas in the larger masses they agree equally well with the figures *o* and *d* on the same plate. The proportions of all these types of spicules also agree with Topsent's description. Spicules of the "calthrops" type are extremely scarce in my specimens. Indeed, I was for some time of the opinion that they were altogether absent. After a prolonged search through spicule-preparations, however, I at last succeeded in

finding one. The microscleres are a little larger than in Topsent's European specimens, measuring about 0·0162 mm. in length, and their spines are much shorter and more slender than is indicated in Schmidt's original figure. They are extremely numerous in the ectosome all over the sponge, but almost absent from the choanosome. The large cells containing brown granules to which Topsent and other authors refer are still conspicuous, after about 28 years in spirit.

S. plicata is common in dead coral in Indian seas, but in all the specimens I have examined seems to be associated with some species of *Cliona*. In places where the coral is of a crumbling consistency the external surface of the sponge is often covered with small calcareous granules of irregular form, while the larger masses of sponge often contain in their interior larger granules of a similar nature. These granules are larger than those produced by the activities of *Cliona*. The more slender processes of the *Stoeba* are as a rule in contact with the *Cliona* and often contain *Cliona*-spicules in their ectocyst and choanosome.

In consideration of its method of life and growth this Indian form of *Stoeba plicata* is perhaps worthy of a varietal name and should be known as *S. plicata* (Schmidt) var. *simplex* (Carter), for Topsent (1895) in his elaborate account of the species, as it occurs in the Mediterranean, makes no mention of the peculiarities noted in the preceding paragraph.

Family STELLETTIDAE.

Stelletta vestigium, Dendy.

1905. Dendy in Herdman's *Ceylon Pearl Fisheries*, III, p. 78, pl. ii, fig. 7.

My specimens of this species are from the same fragments of dead coral as those in which the specimens of *Stoeba plicata* var. *simplex* described above were found. They permeate the coral in a fine network of slender strands and in part, at any rate, occupy the excavations of *Cliona viridis* (Schmidt), spicules of which adhere to their ectosome. The original specimen is described as "irregular in shape, massive, encrusting, and containing many foreign bodies." Possibly it commenced its growth in the same manner as the example from Mergui, which agrees with it closely in spiculation and, so far as it is possible to say, in general structure.

The species is only known from Ceylon and Tenasserim.

Grade **MONAXONELLIDA**.

Family EPIPOLASIDAE.

Coppatias penetrans (Carter).

1880. *Tisiphonia penetrans*, Carter *Ann. Mag. Nat. Hist.* (5) VI, p. 141, pl. vii, figs. 44*a–d*.

1905. *Coppatias* (*Tisiphonia*) *penetrans*, Dendy in Herdman's *Ceylon Pearl Fisheries*, III, p. 231.

A minute sponge of which the spicules agree well with Carter's description and figures occurs in abundance in dead reef-coral from Port Mouat in the Andamans, occupying the burrows of various boring organisms and in particular those of *Cliona ensifera* and *C. lobata*. The form of the sponge is precisely that of the cavity it occupies. It is of solid structure, the natural cavities being small except when occupied, as is often the case, with fragments of calcareous matter. Specimens treated with acid are apt to appear cavernous owing to these fragments being dissolved. The ectosome, which is in contact with the wall of the burrows occupied, is thin but somewhat impenetrable by liquids and it is difficult to clear specimens in oil of cloves. The whole structure of the organism is on so minute a scale that it could only be elucidated properly by means of sections of specially preserved material, which I do not possess.

Coppatias investigatrix, sp. nov.

(Plate xxxiv, figs. 1, 2.)

This sponge is closely related to *C. penetrans*, with which it agrees in habits, but the macroscleres are as a rule spined near the tips and the microscleres exhibit much greater diversity of form. Unlike *C. penetrans* it is a deep-sea species.

Sponge.—In its early stages the sponge consists of minute masses of an irregularly oval form. These penetrate into the burrows of Clionids in shells, then increase in size and assume the shape of the spaces they occupy; before doing so completely, they give out relatively slender, blunt, finger-like processes. The internal structure appears, so far as can be seen, to resemble that of *C. penetrans*.

Spicules.—Both macroscleres and microscleres are very variable. The majority of the latter are slender, spindle-shaped amphioxi about 15 to 30 times as long as broad, smooth for the greater part of their length, but bearing scattered, sharp, erect spines near the two extremities, the actual tips being smooth. Smaller absolutely smooth amphioxi also occur.

The microscleres are of three kinds, *viz.* (*a*) oxyasters with spined tips, (*b*) spherasters with spined tips, and (*c*) smooth spherasters. Intermediate forms occur, however, in all cases.

The spiny oxyasters have as a rule six cladi, but may have only four, or occasionally more than six. The tips are sharply and gradually pointed and bear sharp erect spines scattered rather densely. There is no distinct central nodule and the bases of the cladi are smooth.

The spiny spherasters are merely more compact forms of the same type, with a larger number of shorter and stouter cladi fused together at the base. They are, as a rule, smaller than the oxyasters, but every intermediate form of spicule can be found.

The smooth spherasters have still shorter and more numerous cladi than the spiny ones and a relatively larger central sphere.

The degree to which the spines are developed on the spherasters is, however, as variable as the proportions of their several parts.

Measurements of Spicules.

Length of spiny macroscleres	0·098—0·205 mm.
Length of smooth macroscleres	(average) 0·115 ,,
Diameter of oxyasters	0·0126—0·0252 ,,
Diameter of spiny spherasters	(average) 0·0126 ,,
Diameter of smooth spherasters	,, 0·0115 ,,

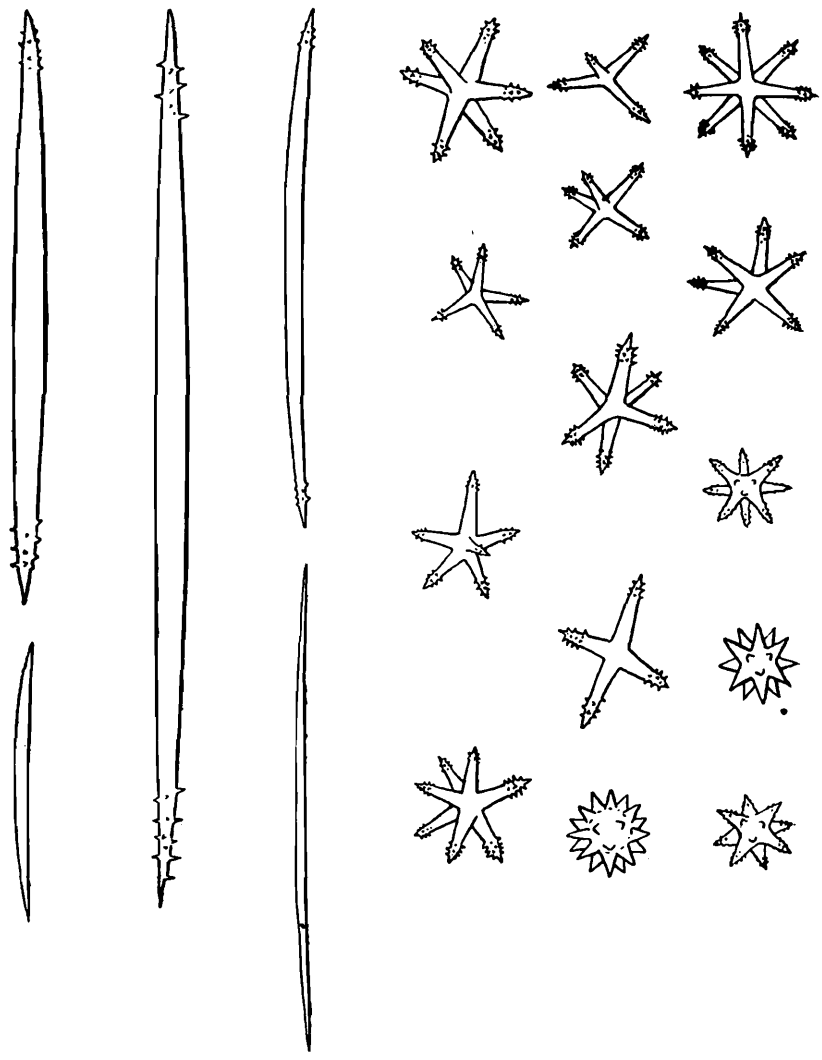

FIG. 1.—Spicules of *Coppatias investigatrix*, sp. nov.

Type.—No. 64 5/7 ZEV, *Ind. Mus.*

Locality.—Off Ceylon in 703 fathoms: with *Thoosa investigatoris* in a dead Gastropod shell (in alcohol).

At points at which the *Coppatias* comes in contact with the *Thoosa*, the latter secretes a thick horny covering through which the tips of its own macroscleres penetrate (pl. xxxiv, fig. 2).

Family CLIONIDAE.

The following notes on the Clionidae are based on a small collection recently made by Mr. S. W Kemp at Port Blair in the Andamans. All the specimens are from shallow water and, except the first, from dead reef-coral.

Cliona carpenteri, Hancock.

Shells of edible oysters (*Ostrea viriginiana*, Gmel.) from the head of Port Blair harbour are riddled with the galleries of this sponge, precisely as shells of the same species of oyster are riddled with those of *C. vastifica* in lagoons on the east coast of continental India.

Cliona mucronata, Sollas.

Well preserved specimens of this peculiar sponge occur in fragments of dead reef-coral with those of the two following species. They agree closely with Sollas's original figures in respect of the structure of the characteristic diaphragms.

Cliona quadrata, Hancock.

1849. *Cliona quadrata*, Hancock, *Ann. Mag. Nat. Hist.* (2) III, p. 344, pl. xv, fig. 6.
1881. *Cliona warreni*, Carter, *ibid.* (5) VII, p. 370, pl. xviii, fig. 6.
1900. *Cliona quadrata*, Topsent, *Arch. Zool. expérim.* (3) VIII, p. 54.

Topsent is undoubtedly right in regarding Carter's *C. warreni*, which came from the Gulf of Manaar, as synonymous with Hancock's species of unknown *provénance*. Well-preserved specimens are present in Mr. Kemp's collection.

Cliona kempi, sp. nov.

This species is closely allied to *C. lobata*, Hancock and *C. michelini*, Topsent, but is distinguished from both by the complete absence of microscleres.

The galleries are almost cylindrical but swell out slightly at intervals. They branch sparingly, giving off slender lateral branches that bifurcate acutely. The whole growth is slender and sparse. Diaphragms containing spicules that lie transversely occur at irregular intervals. The galleries lie completely in one plane, parallel to and only a short distance below the surface of the coral.

The papillae are numerous but of very small size. They are each guarded by a dense mass of upright spicules which, at any rate in the centre of the papilla, have a somewhat spiral arrangement.

There are numerous large cells in the parenchyma that contain granules of a comparatively pale brown colour.

The *spicules* are small, moderately slender and all of one kind. They are by no means numerous except in the papillae; in the galleries, except in the diaphragms, they lie parallel to the surface. They are somewhat variable in form, but are all tylostyles with well-developed heads. These are usually subglobular but may be trilobed or irregular; occasionally they contain a single relatively large dilatation of the axial canal There is occasionally a projecting annulus a short distance below the head. The shaft is as a rule slightly curved; its curvature may be of a general nature or confined to the uppermost third. Immediately below the head the shaft is slightly constricted; lower down it swells slightly but never becomes quite as broad as the head; the broadest part is usually situated in the upper half and the lower half tapers very gradually to a fine point.

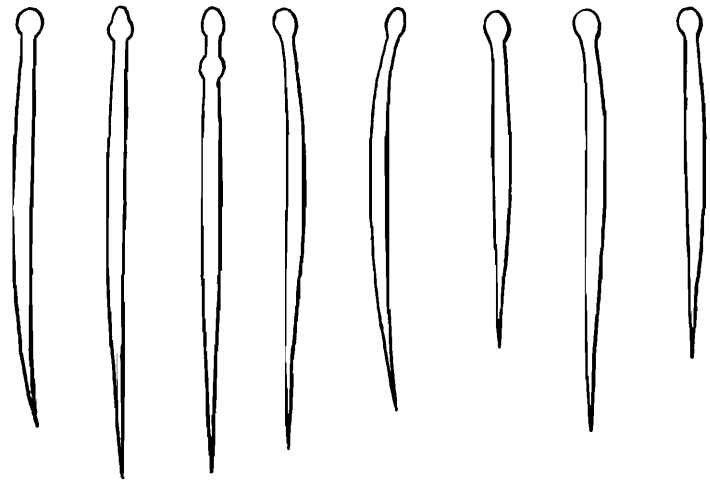

FIG. 2.—Spicules of *Cliona kempi*, sp. nov.

Measurements of Spicules.

Length of spicule	0·127—0·205 mm.
Greatest breadth of shaft	0·0041—0·0082 ,,
Diameter of head	0·0082—0·0125 ,,

Type.—No. 6956/7 ZEV, *Ind. Mus.* (on slide in Canada balsam).

Locality.—Port Blair, Andaman Is., Bay of Bengal: in dead reef-coral with *Cliona lobata* and *C. mucronata.*

Thoosa hancocci, Topsent.

1915. *Thoosa hancocci,* Annandale, *Rec. Ind. Mus.* XI, p. 21.

The species is evidently common in dead coral in the Andamans. Specimens in Mr. Kemp's collection all possess nodular amphiasters, but these spicules, which are confined to the papillae, are present only in very small numbers. In some papillae they are altogether absent, and there are never more than about half a dozen in any one papilla. These specimens, therefore, which

are well preserved in spirit and had evidently reached their full or about their full development, on the whole bear out what I have said in the paper cited on the possible disappearance of the nodular amphiasters in certain phases of the species.

Family DESMACIODONIDAE.

Subfamily *ECTYONINAE.*

Rhabderemia prolifera, sp. nov.

(Plate xxxiv, fig. 3.)

The *sponge* forms an excessively thin film, much less than 1 mm. thick, and coats the burrows of *Cliona* in dead coral. Its surface bears numerous small rounded buds, each of which con-

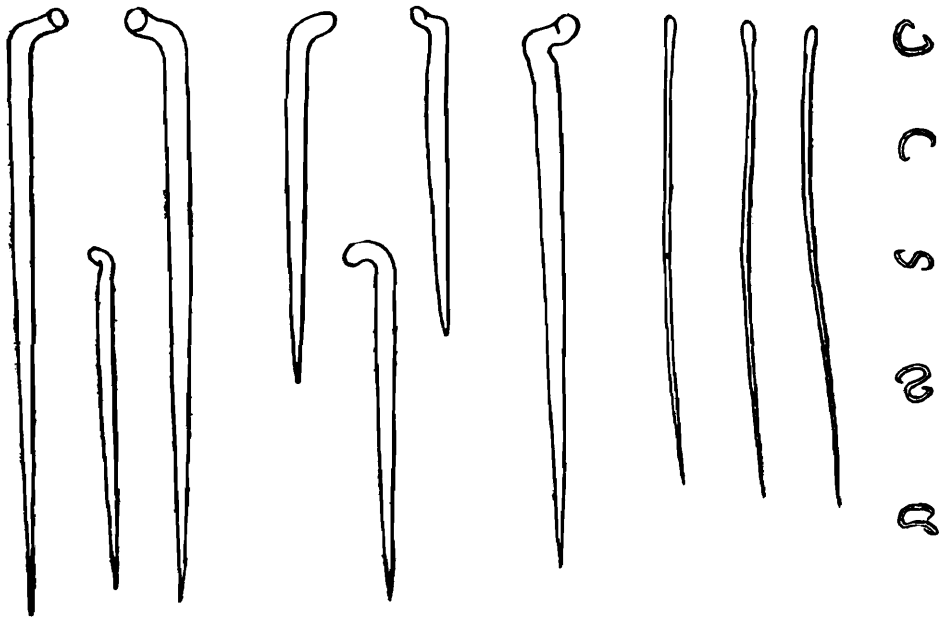

FIG. 3.—Spicules of *Rhabderemia prolifera,* sp. nov.

tains in its centre a particle of calcareous matter. In dried specimens the surface is hispid, but this character may be artificial. The apertures are very small and cannot be detected with certainty in dried specimens. There is a very thin, colourless basal membrane. Owing to the manner of growth, specimens extracted from the coral by the use of acid often appear to be turned completely inside out, or else to contain large irregular cavities in their interior; both appearances are easily explained if the small size of the chambers occupied by the sponge is remembered, and also its own filmy form. The masses that seem to be inside out are merely hollow membranes that have lined the walls of small chambers of corresponding form and size and the surface exposed when the coral is dissolved away is the basal surface of the sponge that was in contact with the wall, while the existence of relatively large spaces of irregular shape in masses in which the true

external surface is outermost is due to the fact that they have grown round projecting fragments of coral at the angles of the Clionid's galleries and that these fragments have disappeared owing to the action of the acid.

Spicules.—There are three kinds of spicules, *viz.* (*a*) comparatively stout, smooth styli of the type called rhabdostyles by Topsent[1] in his definition of the genus, (*b*) much more slender, almost hair-like tylostyli, which are shorter than the longest rhabdostyles and (*c*) small, much contorted sigmata.

The rhabdostyles are perfectly smooth and have their heads almost truncate, not at all swollen and as a rule spirally contorted in two whorls. They are actually rather slender and vary greatly in length; indeed, two series may perhaps be distinguished as regards size, but intermediate forms occur. Those of the larger series are on an average about 0·176 mm. in length; those of the smaller series not more than 0·099 mm. The shaft tapers gradually to a fine point.

The dermal tylostyles are curved or sinuous, perfectly smooth, very slender and almost hair-like in appearance; they are longer than the shorter rhabdostyles. Their heads are of an elongate oval form and often not at all clearly differentiated.

The sigmata are fairly uniform in size, small and slender, variable in shape but never having a complete twist or knot in the centre and never enlarged at the extremities.

Skeleton.—The skeleton is very degenerate and the number of spicules present is comparatively small. The rhabdostyles stand separate and semi-erect, with their contorted heads resting on the basal membrane and their shafts pointing obliquely upwards. The tylostyles lie horizontal in ill-defined bundles, which are often comparatively broad and sometimes form as a whole well-marked curves, but are never reticulate. The sigmata are scattered sparsely without definite arrangement. The slender tylostyles are more numerous than either of the other two kinds of spicules.

Measurements of Spicules.

Length of rhabdostyles	0·0902—0·209 mm.
Diameter of shaft of rhabdostyles	0·0057—0·0082 ,,
Length of slender tylostyles	0·147 mm.
Length of sigmata	0·0123 ,,

Type.—No. 6420/7 ZEV, *Ind. Mus.* (mounted in Canada balsam on a slide).

Locality.—Port Mouat, Andaman Is., Bay of Bengal ('*Investigator*').

The type-specimen occupies the galleries of *Cliona viridis* in a piece of dead Madreporarian coral. The external surface of the

[1] *Rés. Camp. Sci. Monaco*, fasc. II (Spongaires de l'Atlantique Nord), p. 115 (1892).

coral is much eroded owing to the attacks of various burrowing organisms and part of the galleries excavated by the *Cliona* have completely broken down, leaving a fairly large open cavity. The growth of the *Rhabderemia* appears to have commenced in this cavity and then to have proceeded inwards along the excavations of the other sponge, parts of which it had completely surrounded and was apparently in the act of engulfing.

The buds to which reference has been made are merely portions of the sponge that have grown over projecting fragments of coral in the angles of the galleries and have then become constricted at the base.

The specimen, though dry, is in good condition, having originally been preserved in spirit.

The species is very closely related to *R. pusilla* (Carpenter)[1], of which it should perhaps be regarded as a variety. It is distinguished, however, by its larger sigmata, which are of a slightly different type, its longer slender styli (or tylostyli), and its stouter and more variable rhabdostyli. Topsent describes *R. pusilla* as an excessively thin "éponge jaune pâle revêtante." The only Indian sponge hitherto referred to the genus *Rhabderemia* is Dendy's *R. indica*[2] from Ceylon. It has short roughened styli and sigmata that are often twisted into a complete knot in the centre; the skeleton is reticulate.

Family AXINELLIDAE.

Genus **Amorphinopsis**, Carter.

1887. *Amorphinopsis*, Carter, *Journ. Linn. Soc. London* (*Zool.*) XXI, p. 77.
1896. *Spongosorites*, Topsent, *Mém. Zool. Soc. France* IX, p. 117.
1900. *Spongosorites*, *id.*, *Arch. Zool. exbérim.* VIII, p. 265.
1905. *Spongosorites*, Dendy in Herdman's *Ceylon Pearl Fisheries*, III, p. 182.

In examining a fragment of the piece of dead sponge-riddled coral described by Carter in 1887 I came across a small sponge that afforded me much difficulty, until I had compared my preparations with others made from the material sorted out and named by that author. On making a comparison I could not remain in doubt that this sponge was the same as the one named by him *Amorphinopsis excavans*; indeed, it was probably a schizotype of that species. Carter's descriptions are as a rule remarkably clear and accurate, but this was not the case in the present instance, in which his figures are actually misleading. He gave no separate description of *Amorphinopsis*, the generic characters of which he left to be inferred mainly from his specific diagnosis.

The sponge agrees with Topsent's description of *Spongosorites*, except in the fact that its spicules are not "biangulate." In Car-

[1] *Microciona pusilla*, Carter, *Ann. Mag. Nat. Hist.* (4) XVIII, p. 239, pl. xvi, fig. 51 (1876) and Topsent, *Mém. Zool. Soc. France* 1889 (II), p. 41, fig. 7.
[2] In Herdman's *Ceylon Pearl Fish.* III, p. 180, pl xii, fig. 10 (1905).

ter's figure the amphioxi are shown as having a regular curve, but this is by no means always the case and though they are not swollen in the middle they are often distinctly geniculate at or near that point. With Dendy's redefinition of *Spongosorites* the species agrees precisely. All this is made abundantly clear when *A. excavans* is compared with the form here described as *A. excavans* var. *digitifera.*

The genus *Amorphinopsis* may now be redefined as follows :—

> Axinellidae of encrusting, reticulate or massive shape, sometimes bearing upright branches or conuli ; the skeleton composed of stout spicule-fibres containing little horny material and forming a coarse and irregular reticulation. The fibres consist of large, smooth styli or amphioxi, or of a mixture of smooth styli and amphioxi, lying parallel to one another. Smaller spicules of the same types surround the fibres and as a rule form a horizontal layer in the ectosome. Some or all of the spicules are geniculate in the middle; sometimes they are also inflated at this point.

Amorphinopsis excavans, Carter.

1887. *Amorphinopsis excavans,* Carter, *op. cit.*, p. 77, pl. v, figs. 12-15.

The sponge in Carter's specimen consists of a thin external crust and a network of fine cylindrical basal branches that ramify in the excavations of Clionidae in dead coral. The external crust is remarkable for the curious little prominences or bosses with which it is ornamented and for the strands of spicules that radiate from them. The regularity of their arrangement is somewhat exaggerated in Carter's figures. The prominences seem to me to be no more than incipient, or possibly abortive, conuli or branches. Each probably contains an osculum obliterated by contraction. There is a dense external covering of smaller spicules lying horizontally and matted together on the surface of the sponge. The internal or basal branches rarely contain more than a single stout strand of spicules, but they ramify and anastomose in accordance with the ramifications and anastomosings of the cavities they occupy. A horizontal reticulation of fibres occurs near the surface.

The spicule-fibres, whether on the surface or inside the coral, consist mainly of the larger spicules, which are for the most part true amphioxi. Occasionally a slender sub-stylote spicule is to be found amongst them, while a comparatively large number of true styli are also present. The last are as stout as the stoutest amphioxi, but usually shorter. All the amphioxi are more or less curved and most are crescentic in form ; a few are, however, distinctly geniculate at or near the middle and forms (which must be regarded as mere abnormalities) may be found in which there is a regular angle near one end.

The smaller spicules, which surround the fibres in an irregular manner as well as forming a layer on the surface of the sponge, comprise both amphioxi and styli. The former resemble the

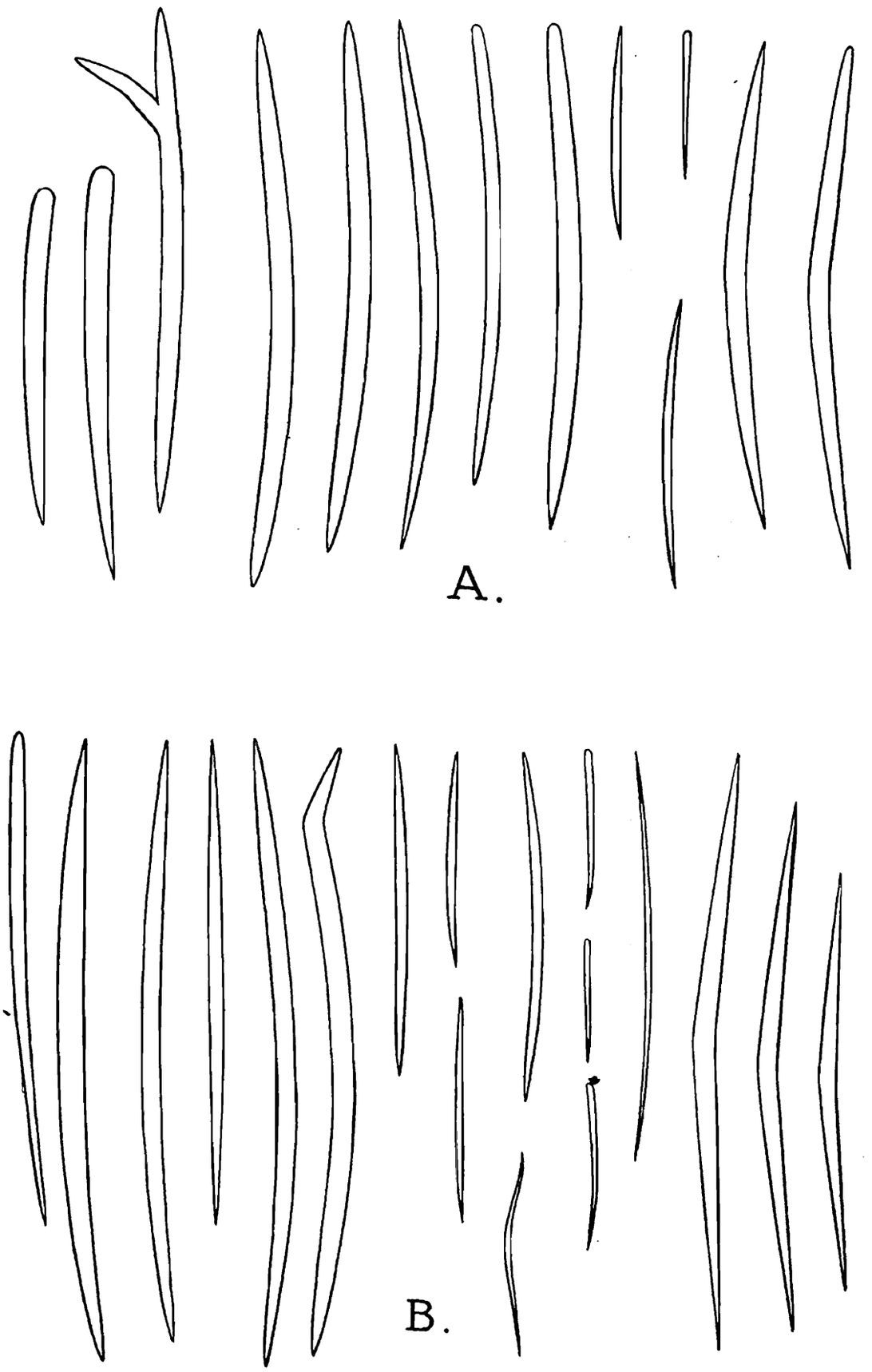

FIG. 4.—Spicules of *Amorphinopsis excavans*, Carter.
A. From the type of the species.
B. From the type of var. *digitifera*, nov.

larger amphioxi in shape and proportions, but the latter are usually straight or nearly so.

Schizotype.—No. 6597/7 ZEV, *Ind. Mus.* (dried specimen).

Spicules of *Cliona* often occur in the parenchyma and films of *Chondrilla* sometimes envelop the basal branches.

var. **digitifera**, nov.

1913. *Spongosorites* sp., Sewell, *Journ. As. Soc. Bengal* (n.s.) IX, p. 346.

I have had by me for some years a sponge that I identified provisionally for Capt. Sewell as a new species of *Spongosorites*. A comparison with Carter's *A. excavans* shows an absolute identity of skeletal structure, though the external form is very different and slight differences in spiculation can be detected. I propose therefore to regard this sponge as a variety of *A. excavans*, of which it may be no more than a growth-phase.

The sponge consists of a number of short, pointed, somewhat compressed upright branches of rather irregular outline, united by means of a crust in which are embedded numerous small stones (non-calcareous) and dead shells of Lamellibranchs and Balanidae. The longest branches are about 30 mm. long and about 14 mm. broad at the broadest point; their thickness is about 7 mm. The shortest axis is directed towards the centre of the mass. The whole specimen is about 100 mm. long by 40 mm. broad, but has probably formed part of a larger mass. In spirit the colour is dirty white. The sponge is rather hard but can be torn easily.

The external surface is in places obscurely and minutely reticulate, elsewhere distinctly hispid. No external orifices

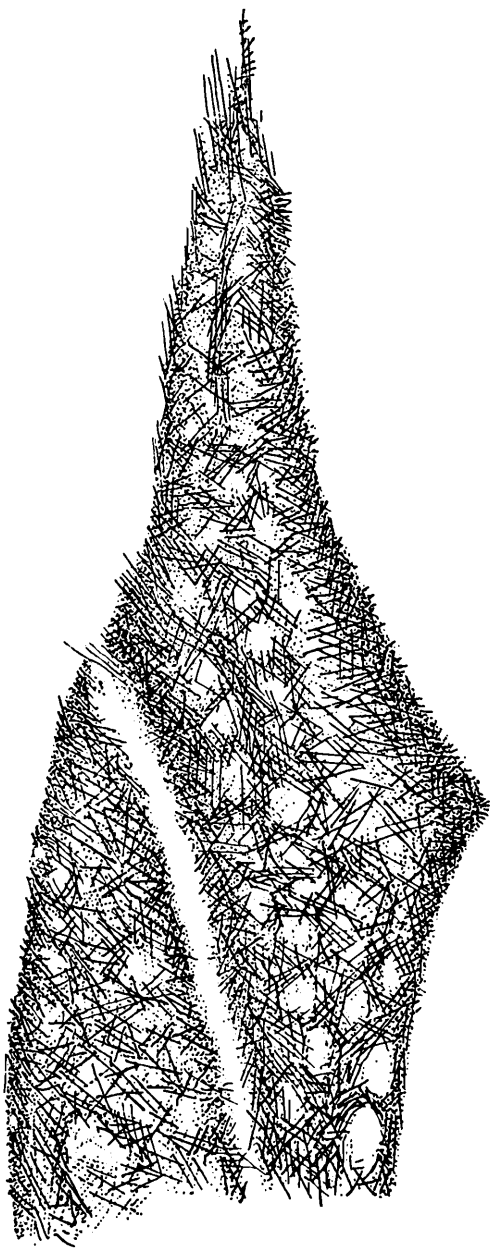

FIG. 5.—Vertical section through the skeleton of the distal part of a branch of *Amorphinopsis excavans* var. *digitifera* (enlarged).

can be detected and it is probable that both oscula and pores are highly contracted.

The internal structure of the sponge is somewhat cavernous and several large canals run vertically up each branch, one situated in the middle being as a rule of greater calibre than the others. Probably the oscula are situated near the tips of the branches and the pores on the hispid parts of the surface.

The skeleton forms a dense, irregular network. In the branches its fibres curve upwards and outwards towards the external surface; as a rule they are directed mainly towards the inner side of the branch. They frequently fuse together to form strands of great thickness, but seem to contain little or no horny matter. There is a horizontal reticulation of fibres below the external layer of small spicules. The larger spicules are closely packed together in the fibres and lie quite parallel to one another. The external layer of small spicules is horizontal over the greater part of the surface but in the hispid parts the spicules are vertical and little upright bunches can sometimes be detected that project through the dermal membrane. The bunches are arranged with considerable regularity at fairly equal distances. Sometimes they coincide in position with the terminations of skeletal strands, but this is not always so.

The spiculation differs from that of the typical form in the complete absence of large stout styli and in the fact that the large amphioxi are on an average considerably shorter.

Type.—No. 5010/7 ZEV, *Ind. Mus.* (in spirit).

Locality.—Rock-pool at Fisher Bay, Tavoy I., off the coast of Tenasserim.

This sponge approaches *Dactyella*, Thiele[1] in structure and fully bears out Dendy's[2] suggestion as to a possible relationship between the two genera. Indeed, I doubt whether they are distinct.

Family CHONDROSIIDAE.

Chondrilla nucula, Schmidt.

1862. Schmidt, *Spong. Adriat. Meeres*, p. 39, pl. iii, figs. 22, 22*a*.
1877. Schulze, *Zeitschr. Wiss. Zool.* XIX, p. 108, pl. ix, figs. 11-18.
1881. Carter, *Ann. Mag. Nat. Hist.* (5) VII, p. 384.
1889 (1887). ? *Id. (Cliona stellifera ?)* in part, Anderson's *Fauna of Mergui* I, p. 62.
1891. Keller, *Zeitschr. Wiss. Zool.* LII, p. 327.
1892. Topsent, *Rés. Camp. Sci. Monaco*, fasc. II, p. 54.

A re-examination of part of Carter's original material leaves no doubt that the provisional species he described in 1889 under the name of *Cliona stellifera* ? was founded on the association of spicules of a *Cliona* with those of a *Chondrilla*. The *Cliona* was in all probability *C. viridis*, while the *Chondrilla* was either *Ch. nucula*, *Ch. mixta* or *Ch. distincta*, if it was not composed of all

[1] Stüd. ü. pacif. Spongien, *Bibl. Zool.* XXIV (i), p. 55 (1898).
[2] In Herdman's *Ceylon Pearl Fisheries*, III, p. 182 (1905).

three species. *Cliona viridis* is particularly abundant in the masses of dead coral from which he extracted the spicules on which he based his description, or rather indication, and it is frequently covered by a thin film, of one or other of the Chondrillae. The only other species of *Cliona* [1] present is *C. ensifera*, which Carter distinguished from "*stellifera*."

The specimens of *Ch. nucula* I have examined from this material consist of extremely thin films much less than 1 mm. thick and spread out over the surface of *Cliona viridis*, *C. ensifera* and *Stoeba simplex* in their excavations in dead coral. The spicules correspond well with the figures cited above and agree in dimensions (diameter 0·01 to 0·2 mm.) with those of a specimen from the Red Sea examined by Keller. They are densely crowded in the ectosome and frequently touch one another in that part of the sponge. The colour, after some 28 years in spirit, is pale brown. The film is usually uniform, but sometimes reticulate. The fragments extracted have been very imperfect.

Ch. nucula is cosmopolitan in distribution. It has been recorded from the Mediterranean, the Azores, the Red Sea and the Gulf of Manaar. The specimens referred to above are from King I. in the Mergui Archipelago, which lies off the coast of Tenasserim, the southern extension of Burma.

Chondrilla mixta, Schulze.

1877. Schulze, *op. cit.*, p. 113.
1891. Keller, *op. cit.*, p. 327.

In the same fragments of dead coral, and in precisely similar conditions, I find imperfect examples of another *Chondrilla* which agrees well enough with Schulze's description of *Ch. mixta* so far as the shape and arrangement of the spicules are concerned. The film it forms in these circumstances is still more delicate than that formed by *Ch. nucula* and is quite colourless. The spicules include both oxyasters and spherasters, the largest of both of which are not more than 0·012 mm. in diameter.

Distribution.—Red Sea (*Schulze*); Mergui Archipelago, Burma.

Chondrilla distincta, Schulze.

(Plate xxxiv, figs. 4, 4*a*.)

1877. Schulze, *op. cit.*, p. 133, pl. ix, fig. 19.
1903. Thiele, *Abh. Senckenb. Natur. Gesellsch.* XXV, p. 67, pl. iii, fig. 20.

Still in the same fragments of coral from Burma a third species of *Chondrilla* occurs, in the same circumstances. It is undoubtedly *Chondrilla distincta*, Schulze, with which its spicules agree in every respect.

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[1] Not having Carter's full material in my hands, I have been unable to find the spicules he associated in his provisional species *Cliona sceptrellifera?* In any case this species, if it exists as such, is clearly not a *Cliona*.

Owing to the more robust form of this sponge it has been possible to extract larger and more complete pieces, which exhibit its manner of growth in the burrows of *Cliona*. The specimens were found in the centre of a piece of coral about 4 cm. thick. No part of the sponge was visible on the surface of the coral. It consisted of irregular cylindrical, ramifying and even reticulate masses, the component branches of which were about 2 mm. thick. The colour was deep purple-brown, except at the extremities, where it was much fainter, if not altogether absent. The surface was for the most part smooth, but crater-like pits surrounded by a particularly dense zone of spicules occurred sparingly. Large oval cells containing brown pigment-granules could be detected in the choanosome. At many points the greater part of the ectosome was entirely concealed by spicules, mostly spherasters. Oxyasters occurred sparingly in the choanosome.

The most interesting feature of the sponge, however, consisted in little tentacle-like club-shaped branches (pl. xxxiv, fig. 4*a*) the free extremities of which were densely covered with spherasters, while the cylindrical portions were bare of spicules or almost so. In some cases the tips of these branches were in contact with the surface of other sponges or of tubes constructed among them by Polychaete worms. Wherever this occurred the tip was splayed out and, if the sponge touched was a *Cliona*, the latter was protected by a dense layer of its own macroscleres and by a chitinous sheath (pl. xxxiv, fig. 4). Some cases were seen in which the expanded tip of a branch of the *Chondrilla* was actually spreading out in a thin, colourless film over the surface of another sponge or of a worm-tube. We have here proof of actual aggression on the part of the *Chondrilla*, and evidence of the methods by which *Cliona* defends itself against such aggression. This subject is discussed later (p. 476). In every case, on the other hand, in which *Stoeba plicata* is the sponge attacked by this or other species of *Chondrilla* its ectosome, with the microscleres abundant in that part of the sponge, had disappeared where the attacking sponge had covered it.

Part II.—BIOLOGICAL.

The large proportion of the sponges referred to in this paper were found in two small pieces of dead Madreporarian coral, neither weighing more than a few ounces. One piece came from the Andamans, the other from the Mergui Archipelago. The former is a portion of a somewhat larger specimen examined by Carter many years ago and described by him in his account of the sponges collected by the late Dr. John Anderson. He found in it examples of no less than 8 species of sponges and yet it is clear that his examination was not exhaustive, for (in addition to the majority of the species he noticed) the fragment now in the Indian Museum contains at least four others. There seems to be a stage in the decay of the more solid Madreporarian corals at which their

skeletons become peculiarly attractive to a large number of small sponges, some of which are true excavators, while others are primarily thin encrusting forms able to exist on a solid even surface but preferring an irregular one, and capable of penetrating into its interstices. Sponges of both kinds play an important part in the final disintegration of both corals and calcareous algae.[1]

I have recently pointed out elsewhere[2] that sponges which excavate their burrows in molluscan shells are often liable to be killed by the growth of encrusting forms. The association of such species as *Cliona vastifica* and *Laxosuberites aquaedulcioris*, though it may be physically intimate, is evidently quite fortuitous; the *Laxosuberites* merely happens to grow on the surface of the oyster-shells in which the *Cliona* has burrowed, and its presence, though ultimately fatal, is not correlated with the presence of the other sponge; it grows on many shells that the Clionid has not attacked and is in no way prejudiced by so doing.

Off the coast of Orissa and the north of the Madras Presidency oyster-shells are often attacked by another species of *Cliona*, recently described as *Cliona acustella*,[3] which ultimately eats away the entire surface, leaving it deeply and densely pitted. Apparently the excavator retires deeper into the shell when this occurs. The roughened surface it has produced is, however, attractive to at least two kinds of very thin encrusting sponges, both of which belong to the genus *Eurypon*. They are not content with the surface, however, but pursue the *Cliona* into its retreats, coating the walls of its galleries and apparently driving it before them. In other Lamellibranch shells (of *Ostrea*, *Malleus* and *Tridacna*) from Indian seas I have found the remains of sponges of similar habits that belong to allied but probably undescribed genera and have little doubt that the species originally described by Hancock as *Cliona purpurea*[4] is a form of the kind There is no evidence that any of these Desmaciodonid sponges actually attack the Clionid with which it is associated, and I have never found spicules of the latter family embedded in the substance of one of the former; they merely overwhelm them or suffocate them and usurp their place. Unfortunately the remains of sponges of this kind now in my hands are insufficiently preserved to justify technical descriptions.

The Tetraxonellid sponge *Stelletta vestigium* (*antea*, p. 459) goes a little further. It is a more massive species than those alluded to in the preceding paragraph and makes its way into the burrows of Clionidae, not by merely growing along their walls, but by thrusting practically solid processes into them. When these processes come in contact with the rightful owner of the burrow

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[1] Carter has described a collection of boring organisms from calcareous algae from the Gulf of Manaar. See *Ann. Mag. Nat. Hist.* (5) VI, p. 150 (1880).

[2] *Mem. Ind. Mus.* V, p. 35 (1915).

[3] *Rec. Ind. Mus.* XI, p. 14 (1915).

[4] See Topsent, *Arch. Zool. expérim.* (4) VII, p. xvi (1907).

its spicules adhere to and are even incorporated in what we may call for this purpose the " skin " of the aggressor.

Amorphinopsis excavans has similar habits, but takes the borrowed spicules into its own internal parts.

Stoeba plicata var. *simplex* differs from these species in that it possesses independent powers of excavation and only uses the burrows of Clionidae as the basis of its own operations. It adapts and enlarges these burrows and at the same time not merely attaches the spicules of its host to its own surface, but takes them into its own inner parts and possibly even utilizes them in strengthening its own attenuated and delicate terminal processes.

Coppatias investigatrix—and possibly also *C. penetrans*—attack in a similar manner, but its parasitic character is more marked, in that, having once penetrated into the burrows of a Clionid, it is content with them and so far as its external form is concerned becomes a mere cast of them. Moreover, it enters the burrows at a comparatively early stage of development and appears to have only a short-lived and very inconspicuous encrusting phase.

All these sponges may be classed, in greater or less degree, as parasites, in that they appropriate the fruit of the labours of other species and even possibly make use in some cases of the spicules of the sponges they attack. There is no evidence, however, that they feed on the bodies of their victims. In the case of the three species of *Chondrilla* and of *Rhabderemia prolifera* it is possible that the attacking species does so, for the Clionid is actually overwhelmed and engulfed, not merely thrust before the invader. The method of attack is not the same in the case of the Chondrillae as in that of the *Rhabderemia*. The former give rise to peculiar capitate tentacle-like processes when they approach the Clionid or any other body with which they may come in contact. The heads of these processes, which are armed with spicules, spread out over any surface that they happen to touch. If they do so on the surface of another sponge they surround it and absorb it completely.

The *Rhabderemia*, on the other hand, which forms a much thinner film as a whole, spreads bodily round portions of the Clionid, which it ultimately absorbs in a similar manner.

It is noteworthy that the great majority of all these parasitic sponges are known to have free encrusting phases or varieties, which are able to exist independently of the labours of other species. *Coppatias penetrans* and *C. investigatrix*, and possibly *Rhabderemia prolifera*—if the latter is to be regarded as specifically distinct from *R. pusilla*—are apparently exceptions. They seem to have become specially adapted for a parasitic life, but it is very desirable that further investigations should be made into their minute structure.

Most of these sponges are probably able to enlarge the burrows that they occupy, though there is no evidence that *C. investigatrix* and *C. penetrans* do so, by the mere expansion of their

growth. If the material into which they have penetrated is at all soft or crumbling this causes it to split or even to fall in pieces, and the final result of the parasitism of most of the invading sponges must be to produce a state of affairs in which it is necessary for them, unless they are to perish altogether, to assume again an independent form of existence. Sooner or later they destroy the walls of their retreat and so are once more exposed.

The species of *Stoeba* and *Coppatias* do not depend solely on expansion as a means of penetration, for they are able to break off fragments of calcareous matter. These are more or less rounded in form and are stored up in the interior of the sponge. How the fragments are broken off we do not know, but it is evident that the sharp points of the spicules play an important part in the operation. Even in the case of the Clionidae the precise method by which the burrows are excavated is not yet by any means clear. It has been shown [1] that the action of acid is absent, and it seems most probable from the disposition of the spicules in the growing points of the sponge that little pieces of shell or coral are broken off, not merely by impact of the spicules, but also by a rotary action. The points of a number of macroscleres are probably directed in a circle covering a small area of the surface on which they are to work. The heads of these spicules may be then rotated by what would be called in an animal more highly organized than a sponge, muscular action. The fragments observed in the interior of *Coppatias* and *Stoeba* are as a rule larger and of less regular shape than those produced by the activities of *Cliona* or *Thoosa*, and it seems probable that the operation by which they are produced is of a less specialized nature than in the case of the Clionidae. Moreover, the manner in which the spicules are arranged appears to be much more haphazard, and we can only suppose that their action is less concerted.

The fragments of calcareous matter removed by *Rhabderemia prolifera* are certainly separated by an entirely different process. The species of *Coppatias* and *Stoeba* that invade Clionid burrows grow forwards as bodies that are practically solid, whereas the *Rhabderemia* merely coats the walls of the excavations it invades as an extremely thin film. This film grows round projecting fragments of coral and separates them from the walls by constricting itself round their bases. There is no evidence that the contained particles of calcareous matter are of any utility to the other species, but to this sponge they are probably directly useful. The film that surrounds each fragment contracts away from the main body of the sponge and forms a bud that separates itself from its parent and doubtless aids in the distribution of the species by so doing. The fact that it has a solid core of relatively heavy material must aid it considerably by causing it to fall away more readily.

[1] For a full discussion see Topsent, *Arch. Zool. expérim*, (2) V ?, pp. 59-71 (1887).

The fact that a considerable number of small encrusting sponges are in the habit of invading and occupying the excavations of Clionidae to the detriment of the latter is quite clear from the foregoing notes, and I have abundant evidence that the parasitic species described form only a very small proportion of the sponges of similar habits that exist in Indian seas, more particularly on the decaying parts of coral reefs. The question naturally arises, How do the Clionidae protect themselves? No direct observations on this point have been made in the field but in the case of *Thoosa investigatoris* and *Coppatias investigatrix* the fact that the invading sponge was evidently in a comparatively early developmental phase enabled some interesting deductions to be made. Fig. 1 on pl. xxxiv shows a young sponge of *C investigatrix* which has just penetrated into the outer part of a burrow of *T investigatoris*. The shell has been dissolved away and one sees in the lower part of the figure the base of an exhalent papilla from below, the middle of the figure is occupied by the *Coppatias*, while in the upper part a confused mass of spicules belonging to the Clionid is shown. The invading sponge appears to have made its way through an inhalent papilla that has degenerated into a mere confused mass; it is shown in the upper part of the figure. The *Coppatius*, however, has not merely penetrated the papilla, for it contains small cavities that apparently represent fragments of calcareous matter detached by itself. Fragments of precisely the same shape and size were observed *in situ* in preparations in which the action of the acid used in extracting them from the shell had not gone so far.

There are several points of interest to be noted in this preparation. Firstly, the Clionid has secreted a horny membrane [1] (*h.c.*) wherever it is in contact with the invading sponge. Secondly, the exhalent papilla (*e.p.*) at the base of which the invading sponge has entered the shell is distorted and has its armature of macroscleres greatly extended and increased. Thirdly, the inhalent papilla through which the *Coppatias* has apparently made its way is as already stated completely disorganized. Fourthly, the invader is very minute and forms a compact mass that does not spread out over the surface of the shell.

Fig. 2 represents a later stage in the attack in the same case. The *Coppatias* has penetrated well into the burrows of the Clionid and has to some extent adapted itself to their form. The Clionid has shrunk considerably in its excavation and has secreted round itself a thick horny coat, not merely where it is in actual contact with the *Coppatias*, but also at those points at which it was liable to

[1] It is noteworthy that there are none of the characteristic nodular amphiasters present in the parenchyma of the Clionid. As I pointed out in my original description of this species (*Rec. Ind. Mus.* XI, p. 20), these spicules often occur in great abundance in association with a horny membrane covering projecting parts of the sponge, in circumstances that suggest that they are utilized in excavating fresl. papillae. It is now evident that the secretion of horny substance is not necessarily correlated with their development.

be attacked by a flank movement. A number of its macroscleres project through the horny covering into the body of the invader.

When *Cliona ensifera* or *C. viridis* is attacked by a *Chondrilla* a similar horny coating is produced and a mass of macroscleres is formed lying parallel to the tranverse axis of the part with which the attacking sponge is in contact. This also occurs when *C. viridis* is attacked by *Rhabderemia prolifera*, but the horny coating is very thin.

It therefore appears that the mode of defence adopted by the Clionid is not always precisely the same, even in cases in which it can be adduced with practical certainty from observations made on preserved material. There are other methods of defence that can only be surmised from general considerations. One of these is possibly the production of diaphragms in the galleries of the Clionidae. In *C. mucronata* these structures are remarkably well developed and are protected by highly specialized spicules. It is perhaps more than a coincidence that I have not found any examples of this species that were overwhelmed or even attacked by other sponges.

I have pointed out elsewhere[1] that the gemmules of the Clionidae are possibly useful in permitting regeneration after the parent sponge has been suffocated by the growth of encrusting forms over its papillae. The production of gemmules in *C. annulifera* and *Thoosa investigatoris* at a depth of over 700 fathoms is particularly interesting, because at depths of such magnitude it is probable that conditions remain identical, so far as temperature, currents, etc., are concerned, throughout the year. It is only in a very few species of Clionidae that resting bodies of the kind have been discovered and I am convinced that they are not as a rule produced in Indian species other than the two just mentioned and the shallow-water form *C. vastifica*. In both the deep-sea species the gemmules are of a highly specialized character. In *C. annulifera* they are provided with spicules of a type that does not occur in the vegetative part of the sponge. These spicules are microscleres of an unusually large size; they cover one surface of the somewhat lens-shaped gemmule in a dense horizontal layer, forming a regular shield, but are entirely absent from the other surface. The surface that they protect is the one in contact with the parent sponge, that is to say the one with which an invading sponge would come in contact if it made its way along the galleries already excavated. The naked surface is in contact with the walls of the excavations, which protect it in the natural position.

The gemmule of *T. investigatoris* is very different from that of *C. annulifera*. It has neither a horny covering nor spicules of any kind, but is hidden away in a special chamber excavated in some unknown manner for its reception, and is only connected with the parent sponge by an extremely fine strand of living matter enclosed in a narrow canal.

[1] *Mem. Ind. Mus.* V, p. 35 (1915).

Both these Clionids are known only from specimens taken in a single haul of the ' Investigator's ' net, and it is impossible therefore to say much about their enemies. We know, however, that *T investigatoris* is attacked by *C. investigatrix*, and I have not been able to find any example of the latter that is drawn out into a sufficiently fine filament to make its way into a gemmular chamber of the Clionid.

The information conveyed in the foregoing biological notes may be summarized as follows :—

1. The Clionidae are liable to be attacked in their burrows by a large number of small sponges belonging to several different families.

2. The majority of these invading species are known to exist also as ordinary encrusting forms but in a few instances (*e.g.* that of *Coppatias investigatrix*) the sponge has possibly become a pure parasite.

3. In most cases the invader merely occupies the burrow of the Clionid, which it thrusts before it, but in some instances it is possible that it actually engulfs and digests the proper occupant.

4. Different species of Clionidae protect themselves against invasion in slightly different manners, but all secrete a horny coat where the invader comes in contact with them.

5. The production of transverse diaphragms in the galleries of the Clionidae is possibly a means of protection against invading sponges, especially in the case of *C. mucronata*, in which these diaphragms are of an unusually elaborate nature.

6. The production and elaboration of gemmules in the Clionidae is perhaps another means of defence against similar enemies, particularly in the case of the deep-sea species *C. annulifera* and *T investigatoris*.

7. The cases of invasion investigated represent only a small proportion of those in which similar phenomena occur.

EXPLANATION OF PLATE XXXIV

Figs. 1, 2.—*Thoosa investigatoris* attacked by *Coppatias investigatrix.*

1. A young *Coppatias* that has just made its way into the burrows of the *Thoosa* in a Gastropod shell, seen from below (× 16).

2. Portion of an older sponge of the same species in contact with the *Thoosa*, seen from the side (× 65).

A, A′ = the *Thoosa*: B = the *Coppatias*: S = Gastropod shell in section: *c* = cavity from which calcareous matter has been removed by acid: *e p.*=exhalent papilla of the *Thoosa*: *h.c.*=horny coat secreted by the *Thoosa.*

In fig. 1 the young invading sponge has apparently made its way through an inhalent papilla of the *Thoosa*, which is represented by a confused mass of spicules (A′). The adjacent exhalent papilla (A) is distorted and greatly enlarged.

Fig. 3.—*Cliona viridis* attacked by *Rhabderemia prolifera.*

A = *C. viridis*; B = *Rh. prolifera*: *c* = cavity from which calcareous matter has been removed by acid: *c′* = passage between two calcareous masses coated with the sponge.

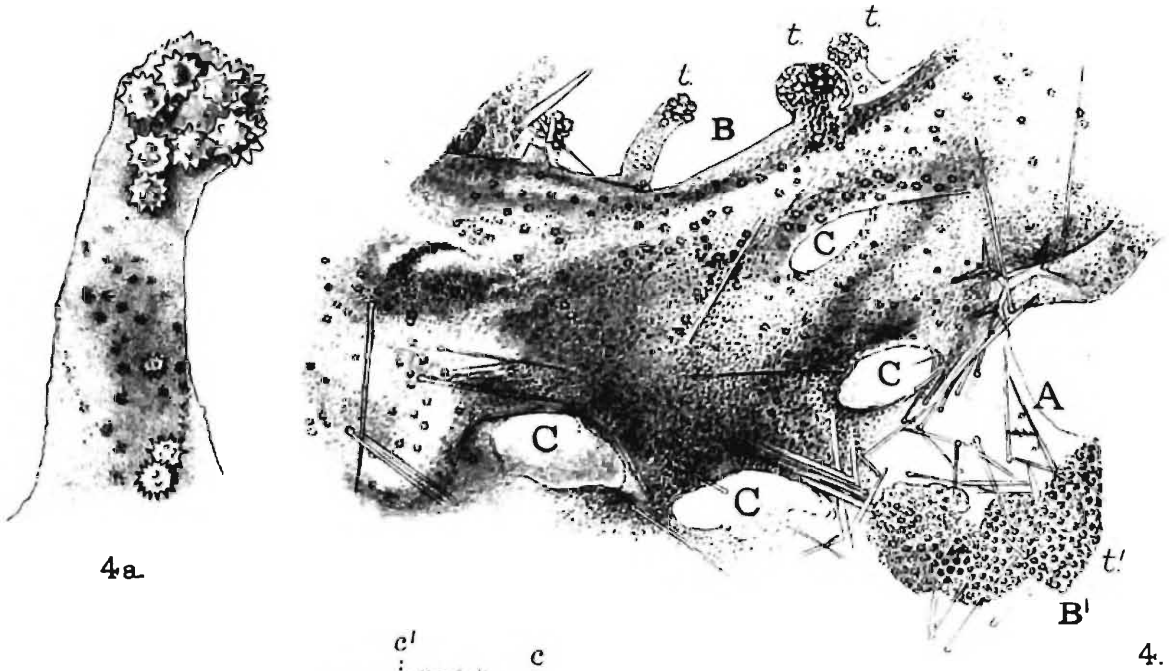
Figs. 4, 4a.—*Chondrilla distincta* attacking *Cliona ensifera.*

4. A mass of the *Chondrilla* sending out tentacle-like branches to envelop the *Cliona* in dead coral (× 75).

4*a*. A single tentacle-like branch more highly magnified (× 255).

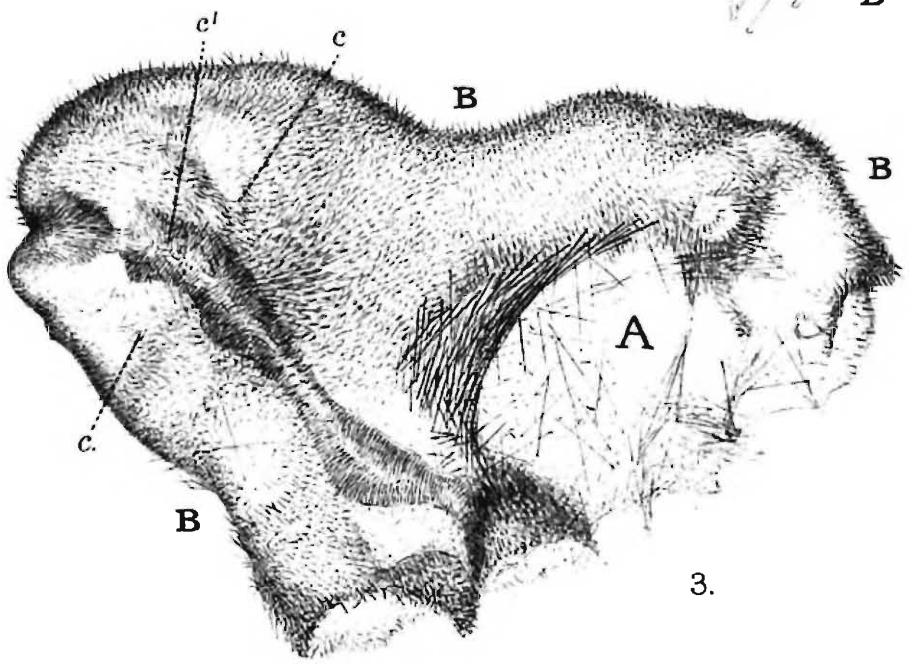
A = *C. ensifera*: B, B′ = *Ch. distincta*: C = cavity from which calcareous matter has been removed by acid: *t* = tentacle-like branch.

At B′ a tentacle-like branch has grown out from behind over the surface of the *Cliona*, which it is enveloping.



4a.

4.



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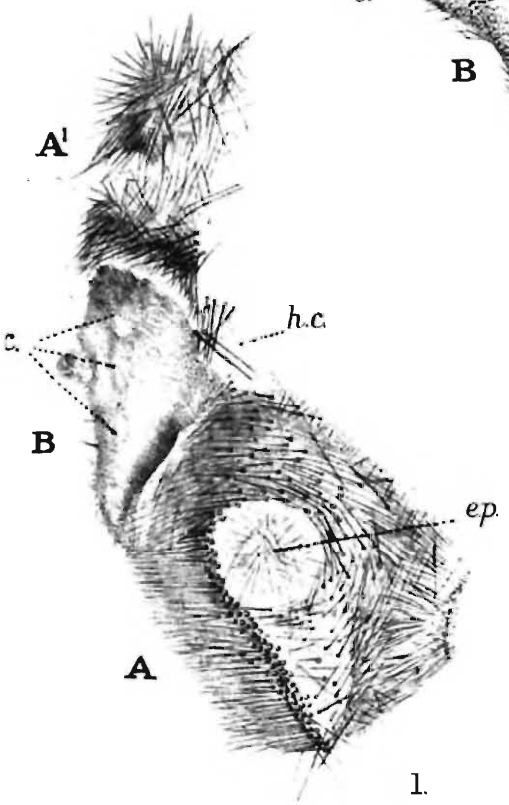

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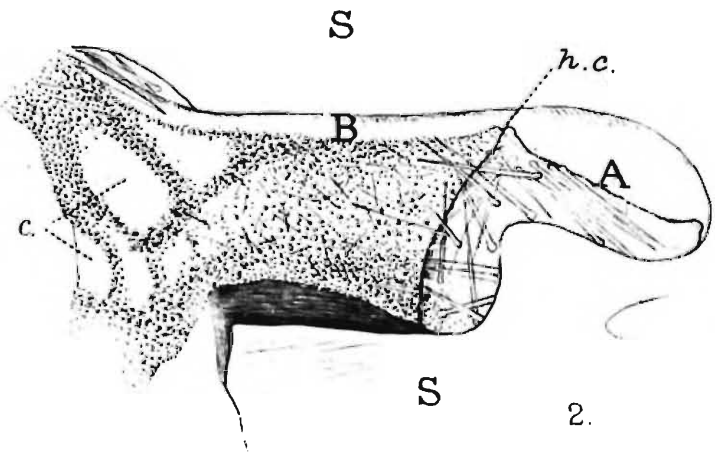


2.

A.C. Chowdhary, del.

Bemrose, Collo., Derby

SPONGES PARASITIC ON CLIONIDAE.

XXVIII REPORT ON A COLLECTION OF MOLLUSCA FROM THE OUTSKIRTS OF CALCUTTA.

By H. B. PRESTON, *F.Z.S.*

Class GASTROPODA.

Order *PULMONATA.*

Suborder *GEHYDROPHILA.*

Family AURICULIDAE.

Scarabus plicata, Fér.

Prodrome, p. 101.

Chingrighatta, outskirts of Calcutta.

Order *PROSOBRANCHIATA.*

Suborder *PECTINIBRANCHIATA.*

Family NASSIDAE.

Nassa denegabilis, Preston.

Rec. Ind. Mus., X, 1914, pp. 297-298.

Canal near Chingrighatta, outskirts of Calcutta (a single young specimen).

Nassa orissaënsis, Preston var. **ennurensis,** Preston. (MS.)

Canal near Chingrighatta, outskirts of Calcutta (a single specimen).

Nassa fossae, sp. n.

Shell allied to *N. orissaënsis*, Preston, but differing from that species in its larger size as compared with the type and both larger size and much broader form as compared with the above variety; the subperipheral band is of a whitish colour and the spiral lirae are considerably coarser and very much more numerous, the aperture is much broader and the columella margin is distinctly curved; it is 6 whorled.

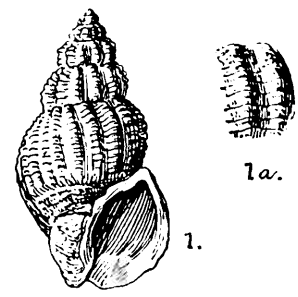


FIG. 1.—*Nassa fossae*, sp. n., ×3.
,, 1*a*.— *do.*, sculpture, ×6.

Alt. 9·5, diam. maj. 5·5, diam. min. 4·5 (nearly) mm.

Aperture: alt. 4, diam. 2·75 mm.

Hab.—Canal near Chingrighatta, outskirts of Calcutta.

Family TIARIDAE.

Tiara (Striatella) tuberculata (Müller).

Hist. Verm. 1774 (as *Nerita*).

Canal near Chingrighatta, outskirts of Calcutta (a small form).

Tiara (Tarebia) lineata (Gray).

Wood., *Index Test. Supp.*, 1828, fig. 68 (as *Helix*).

Canal near Chingrighatta, outskirts of Calcutta.

Family RISSOIDAE.

Iravadia princeps, sp. n.

Shell imperforate, elongately fusiform, in dead condition whitish; whorls 7, the first smooth, submammillary, the remainder sculptured with fine, acute, regular and slightly distant, spiral lirae, the interstices being occupied by very fine, transverse riblets; suture impressed; columella margin porcellanous, narrowly outwardly expanded and reflexed, continuous with the labrum which is varicosely thickened, bevelled behind and rather markedly angled at each termination of the spiral lirations, aperture a little oblique, rather broadly ovate

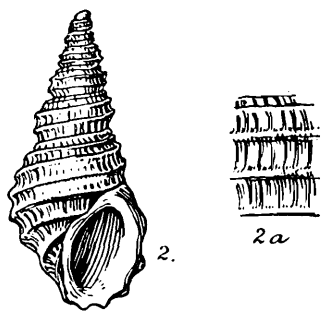


FIG. 2.—*Iravadia princeps*, sp. n., × 6.

,, 2a.— *do.*, sculpture, × 15.

Alt. 6·5, diam. maj. 3, diam. min. 2·25 mm.

Aperture: alt. 2, diam. 1·5 mm.

Hab.—Canal near Chingrighatta, outskirts of Calcutta.

Family ASSIMINEIDAE.

Assiminea francesiae, Wood.

Ind. Test. Supp., 1828; *A. fasciata*, Benson, *Zool. J.*, 1835, p. 463.

Canal near Chingrighatta, outskirts of Calcutta.

Family NERITIDAE.

Septaria crepidularia, Lamarck.

Anim. s. vert., VI, 2, 1822.

Canal near Chingrighatta, outskirts of Calcutta.

Septaria depressa (Reeve).

Con. Icon., *Neritina*, 1855, sp. 86, pl. xviii, figs. 86*a*, *b*.

Canal near Chingrighatta, outskirts of Calcutta.

The above two species seem to the author to be very doubtfully separable.

Class LAMELLIBRANCHIATA.

Order *TETRABRANCHIA.*

Suborder *MYTILACEA.*

Family MYTILIDAE.

Brachydontes emarginata (Reeve).

Con. Icon., Modiola, 1858, sp. 60, pl. x, fig. 73.

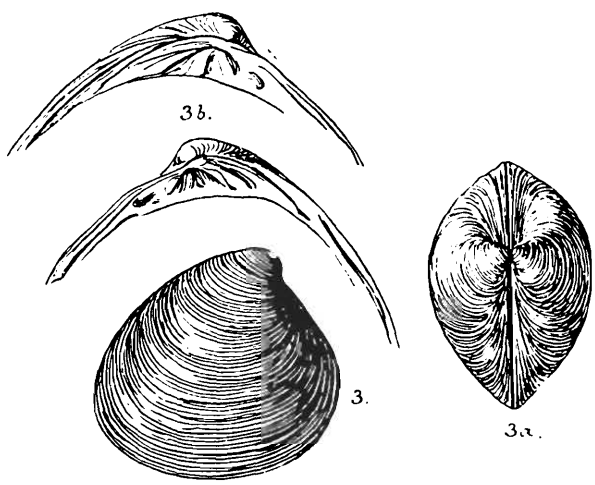
Canal near Chingrighatta, outskirts of Calcutta.

Suborder *CONCHACEA.*

Family VENERIDAE.

Sinodia jukes-browniana, sp. n.

Shell irregularly trigonal, inflated, yellowish-white, both valves closely concentrically ridged throughout; umbones small, curved



FIGS. 3, 3*a*.—*Sinodia jukes-browniana*, sp. n. (nat. size).
,, 3*b*.— ,, ,, ,, hinge, × ½.

inwards, not prominent; lunule large, cordiform; dorsal margin sharply arched; ventral margin anteriorly slopingly rounded, posteriorly gently rounded; anterior side sloping above, rather sharply rounded in the median part; posterior side slightly produced below, steeply sloping and very gently rounded above; teeth in both valves normal; interior of shell pinkish, shading to pure white towards the ventral, anterior and posterior margins.

Long. 27·5, lat. 25·5 mm.

Hab.—Canal near Chingrighatta, outskirts of Calcutta.

Family CYRENIDAE.

Cyrena bengalensis, Lamk.

Anim. s. vert., Cyrena, 10.

Salt Lakes near Chingrighatta, Calcutta.

Order *DIBRANCHIA.*

Suborder *TELLINACEA.*

Family TELLINIDAE.

Macoma gubernaculum, Hanley.

Proc. Zool. Soc., 1844, p. 142.

Canal near Chingrighatta, outskirts of Calcutta.

Suborder *ANATINACEA.*

Family CUSPIDARIIDAE.

Cuspidaria annandalei, Preston.

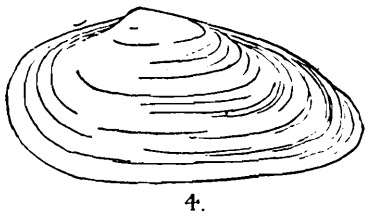
Rec. Ind. Mus., XI, 1915, p. 308.

Canal near Chingrighatta, outskirts of Calcutta.

Family ANATINIDAE.

Anatina induta, sp. n.

Shell small, oblong, cuneiform, gaping anteriorly, thin, whitish, covered by a very thin, transparent, very pale brownish periostracum, smooth, but for somewhat distant, concentric growth lines; umbones small, somewhat flattened, dorsal margin gently arched ; ventral margin almost straight, a little contracted in the median part ; anterior side rounded ; posterior side produced, sharply rounded, wedge-like.



4.

FIG. 4.—*Anatina induta*, sp. n., × 6.

Long. 4, lat. 8·75 mm.

Hab.—Canal near Chingrighatta, outskirts of Calcutta.

XXIX NOTES ON THE HABITS OF INDIAN INSECTS, MYRIAPODS AND ARACHNIDS

By F. H. GRAVELY, *M.Sc., Assistant Superintendent, Indian Museum.*

(Plates XXII—XXV).

The preparation of a course of popular lectures during the summer of 1914 necessitated the completion, so far as opportunity permitted, of a number of more or less casual observations that I have chanced to make from time to time on the habits of insects and spiders of Calcutta, and the production of figures to illustrate them. The present, therefore, seems a favourable opportunity of putting on record both these and certain observations made in other parts of India, in Burma and in Ceylon during the last five or six years, incomplete though they are in some cases.

Although a number of notes on the habits of Indian insects have been published from time to time, they are still regrettably few, considering the richness and interest of the fauna with which they deal; and they are so scattered that the discovery of their existence, by anyone in a position to make use of them, is a matter of great uncertainty.

In order to bring all these notes together search would have to be made through a number of European journals; but the results of such a search would probably be very small in comparison with the amount of time it would occupy. Indeed, the time would probably be better employed in making fresh observations.

Since, however, observations on living Indian animals must almost necessarily be made in India, many of them will naturally be recorded in Indian journals, which are comparatively few. And I have tried, in the following pages, to combine with the record of my own observations such references to those of others as I have been able to find in journals, chiefly Indian, up to the end of 1914. The necessity for this became more and more apparent as the work of compilation progressed; for I found that several of my own observations were simply confirmatory of those of others; and that in several instances observations having a very definite bearing upon one another were recorded by different authors, sometimes in different parts of the same journal, without any reference to one another

It has been extremely difficult to find convenient limits to the subject in hand; for notes on habits pass by almost imperceptible gradations into notes on mimicry, development, crop-protection, sanitation, etc. I have not attempted to go through the rapidly increasing literature on Indian "economic" entomology; because, although it undoubtedly contains much that is of scientific interest, I doubt whether the records obtained would be worth the time involved—especially as a large proportion of these have already been brought together in Lefroy's "*Indian Insect Life*", Patton and Cragg's "*Text-book of Medical Entomology*", Fletcher's "*South Indian Insects*", and Stebbing's "*Indian Forest Insects*", text-books all of comparatively recent date.

Nor have I attempted to go through all the literature on Indian Butterflies, a very large proportion of which appears in the Journal of the Bombay Natural History Society. Much of the earlier work done on this group was brought together in Marshall and de Nicéville's well known "*Butterflies of India, Burma and Ceylon.*" It may therefore be mentioned here that the Indian Museum possesses the latter author's file copy of this work, extensively interleaved with published and unpublished notes and figures, and continued in manuscript to deal with Pierinae and Papilioninae. The remaining parts were sent to Col. Bingham for use in connection with the unfinished butterfly volumes of the "Fauna of British India" series, and unfortunately appear to have been lost at the time of his death.

Such observations on butterflies and their larvae and pupae as have come under my notice have been carefully sifted, and only those that seem likely to be of general interest have been referred to below. But in other groups recorded observations are so comparatively few that even the most trivial often seems worth noting; and I have thought it best to include as wide a range of them as possible. I am indebted to Dr. N. Annandale, Mr. T. Bainbrigge Fletcher, Mr. C. Beeson and Mr. E. E. Green for a number of references. I am also indebted to these and other observers for several original notes, each of which is separately acknowledged.

INSECTA.

THYSANURA.

Cunningham ("*Plagues and Pleasures*"[1], p. 190) notes that "fish-insects" prefer "size" to paper, but eat the latter also. Lefroy (*J.B.N.H.S.*[2] XIX, pp. 1006-7), who used *Acrotelsa collaris*, Fabr., as food for the larvae of *Croce filipennis*, Westw., reared the former from the egg, feeding it entirely on paper. The eggs, which were white, soft, and of an oval shape, were laid loosely among the paper.

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[1] "*Plagues and Pleasures of Life in Bengal*" by Lt.-Col. D. D. Cunningham, C.I.E., F.R.S. (London, 1907).

[2] *Journal of the Bombay Natural History Society.*

DERMAPTERA.[1]

Burr notices the habits when attracted to light of *Labidura lividipes* (*J.A.S.B.*[2] [n.s.], II, p. 391), and the feeding habits, etc., of *Diplatys gladiator* (*J.A.S.B.* [n.s.], VII, p. 772). The attraction of a giant stinging neetle for various kinds of earwigs is also noted in the latter place.[3]

The habits and development of *Diplatys longisetosa* and *D. nigriceps* are described by Green (*Trans. Ent. Soc. London*, 1898, pp. 381-390, pl. xviii and xix).

Willey records the maternal instincts of a Ceylonese earwig (*Spolia Zeylanica*, VI, p. 53).

ORTHOPTERA.

Blattidae.

Annandale notes that *Pseudoglomeris flavicornis* lives under the bark of trees (*Mem. A.S.B.*, I, p. 207).

C. Drieberg notes that cockroaches are common in beehives in Ceylon and appear to attack the combs (*Spolia Zeylanica*, IV, p. 33).

Annandale (*J.A.S.B.* [n.s.], II, pp. 105-106) and Shelford (*Rec. Ind. Mus.*, III, p. 125-7) refer to the amphibious habits of cockroaches of the geuus *Epilampra*. These cockroaches are common among stones at the edge of streams in many parts of India.

Green (*Spolia Zeylanica*, VI, p. 135) and Annandale (*Rec. Ind. Mus.*, V pp. 201-2) describe cockroaches (*Periplaneta australasiae* and *americana* respectively) preying upon winged termites.

Leucophaea surinamensis is ovo-viviparous. When the egg-capsule is protruded it splits along one side, and the young (about 30 in number) at once escape, leaving what looks like a mass of exuviae behind with the capsule. This observation was made at Peradeniya.

Phasmidae.

The development and habits of *Phyllium scythe* and *Pulchriphyllium crurifolium* are described by Murray (*Edinburgh New Phil. Journ.* [n.s.], III, pp. 96-111, pl. vi-viii), Morton (*Bull. Soc. Vaud. Sci. Nat.*, XXXIX, pp. 401-7, pl. iii), St. Quentin (*Entomologist*, XL, pp. 73-75 and 147, pl. iv) and Leigh (*Proc. Zool. Soc. London*, 1909, pp. 103-113, pl. xxviii; *Rep. and Trans. Manchester Ent. Soc.* 1912, pp. 22-29). Green records an authenticated case

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[1] See also Annandale "Notes on Orthoptera in the Siamese Malay States", *Ent. Rec.*, XII, 1900, pp. 75-77 and 95-97.

[2] *Journal of the Asiatic Society of Bengal.*

[3] The statement in the same place that *Labidura riparia* and *bengalensis* occur under stones between tide-marks by the Chilka Lake must not be taken to imply that this insect is amphibious, for this lake has since been found to have its level so greatly affected by winds and by flooding that regular tides can scarcely be said to exist. High-water marks at all times are more likely to be due to the most recent flood than to a tide (see *Mem. Ind. Mus.* V, pp. 10-11, pl. i).

of parthenogenesis in the latter species (*Spolia Zeylanica*, VII, p. 54).[1]

T. V. Ramakrishna Aiyer describes the life-history of stick-insects hatched from eggs laid in a group on a wooden rafter instead of singly and loose (*J.B. N.H.S.*, XXII, pp. 641-3, 1 pl.).

I have never seen any record of the fact that, in some Phasmids at least, copulation and oviposition go on simultaneously. This is certainly so in the case of a large stick-insect[2] common near Kurseong in the rains. The union continues for several days on end, perhaps longer; and eggs are protruded from an apperture ventral to that occupied by the penis of the male.

Mantidae.

Anderson (*Proc. A.S.B.*, 1877, pp. 193-5) and Willey (*Spolia Zeylanica*, II, pp. 198-9, 2 pl.) describe the floral simulation of *Gongylus gongylodes*. Willey (*Spolia Zeylanica*, III, pp. 226-7) describes the stridulation of this species, and an account of its development has been published by Williams (*Trans. Ent. Soc. London*, 1904, pp. 125-137). Annandale (*Proc. Zool. Soc. London*, 1900, pp. 839-854, 2 text-figs.) gives an account of the habits of the flower-mimicing *Hymenopus bicornis* and of other Malayan species.

Browne (*J.B.N.H.S.*, XII, pp. 578-9) records the killing of a sunbird, *Arachnechthra minima*. by a large mantis, "probably *Hierodula bipapilla*." An immature specimen of a large green mantis was recently sent to the Indian Museum by Mr. Matilal Ganguli, who had found it surrounded by six or seven sparrows that were attempting to kill it. When they tried to peck at it, it ran very fast towards the assailants, making darts at them which caused them to withdraw. The struggle was still in progress when the specimen was captured.

The food of mantises, with an account of the gradual eating of the male of an American species by the female during and without interfering with copulation is described by Mosse (*J.B.N.H.S.*, XX, pp. 878-9) and Coleman (*J.B.N.H.S.*, XX, pp. 1167-8). I have seen newly hatched young of a big green mantis feeding on minute Chloropid flies (*Pachylophus adjacens*, Brun., MS.) on a bush of *Zizyphus jujuba* on the Calcutta maidan—a bush which always attracts these flies during the rains, when they sit about on its leaves in large numbers.

Acridiidae.

Alcock (*J.A.S.B.*, LXV [II], pp. 539-540; reprinted *J.B.N.H.S.*, XI, pp. 149-150) records the behaviour of a bear towards *Aularches*

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[1] Concerning parthenogenesis in Phasmidae see also Hanitsch, *J. Straits R. Asiatic Soc.*, July 1904, pp. 35-38 (*Eurycnema herculanea*). Fryer records polymorphism in a Ceylon stick-insect (*Journal of Genetics*, III, pp. 107-111, pl. iii).

[2] Belonging apparently to the subfamily Lonchodinae. The female is a very heavily built stick-insect, the male more moderately stout.

miliaris (Linn.) as an instance of the natural repellent effect of "warning colours." This species when irritated, besides exuding a pungent-smelling frothy fluid, makes a curious hissing sound. Precisely how it does so I have been unable to determine. Legs and wings commonly vibrate synchronously with the production of this sound when the insect is held by the body; but when any or all of these appendages are prevented from moving the sound may still be produced, though the insect is usually less readily disposed to produce it under these conditions. There is no perceptible vibration of the body wall such as occurs when a fly or wasp buzzes. The breeding and other habits of this locust are described by Green (*Cir. R. Bot. Gardens, Ceylon*, III, pp. 227-235).

The "terrifying attitude" assumed by a grasshopper (*Acridium violascens*) when attacked by a myna (*Acridotheres tristis*) is described by Manders (*Spolia Zeylanica*, VII, pp. 204-5).

Kershaw gives a note on the habits and development of a Chinese "*Mastax* or *Eumastax*" (*J.B.N.H.S.*, XXII, pp. 416-7, pl. B, part).

Mr. Fletcher informs me that when he was in Coorg last year he found an Acridiid eating a large spider, a curious reversal of the normal course of events.

Cotes and others between 1890 and 1907 contributed a series of notes to the Journal of the Bombay Natural History Society, many of them of considerable length, on the habits, and especially on the migrations, of Indian locusts.

Locustidae.

Green has described the stridulation of the common green locustid of Peradeniya (*Spolia Zeylanica*, VII, p. 56). A very similar but slightly stouter insect occurs in Calcutta. It has a different note, which has been described by Cunningham ("*Plagues and Pleasures*", p. 171). This note is, however, not unlike the last syllable of the Peradeniya insect, though somewhat harsher and less prolonged. When the insect is in full song in the open a distinct click is audible alternating with the somewhat rapid succession of these notes. *Mecopoda elongata* has a somewhat similar note which it repeats indefinitely in a similar manner, but this note is louder and still more raucous. All three of these insects are nocturnal

Concerning the habitual attitude assumed by *Sathrophyllia rugosa* ("*Acanthodis ululina*") see Willey (*Spolia Zeylanica*, II, p. 199, 1 fig.) and Annandale (*Mem. A.S.B.*, I, p. 209).

Green (*Spolia Zeylanica*, VI, pp. 134-5) has described the habits of a leaf-rolling species of *Gryllacris*, presumably a close ally of, if not identical with, a species—*Gryllacris aequalis*—found in the Calcutta Botanical Gardens by Wood-Mason (see Griffini, *Atti. Soc. Ital. Sci. Nat.* LII pp. 237-239, where references to other nest-

making Orthoptera will be found[1]). Gryllacrids are also sometimes to be found in holes in trees, under loose bark, and under the eaves of buildings.

Annandale and Gravely have described the habits of the Stenopelmatinae found in Burmese and Malay caves (*J.A.S.B.* [n.s.], IX, p. 413). In the Cochin Ghats Stenopelmatids are common under logs of wood.

Alarming colour and attitude in *Capnoptera*, spp., and a possible use of the spines on the thorax of *Eumegalodon blanchardi*, are described by Annandale (*Proc. Zool. Soc., London*, 1900, pp. 854-5 and 866).

Gryllidae.

The habits of a noisy burrowing cricket—doubtless *Brachytrypes portentosus* ("*achatinus*"[2])—are described at length by Cunningham ("*Plagues and Pleasures*," pp. 161-170). I have never seen "molehill-like heaps of loose earth cast out of the mouths of almost finished diggings" of these crickets. Sometimes there is a small and untidy collection of loose earth, but I have usually found the burrows somewhat difficult to locate in spite of the vigour with which the insects proclaim their whereabouts.[3]

A cricket closely resembling *Brachytrypes achatinus*, but much smaller, often flies to light in Calcutta. Like many still smaller species it has a way of partly unfolding its wings and then rapidly vibrating them. Why it should do this I have been unable to determine. The action, which is performed equally by both sexes, looks like stridulation, but only the faintest rustling sound is produced, and the male stridulates loudly in the ordinary way.

Mr. Fletcher tells me that *Liogryllus bimaculatus* is neither exclusively vegetarian nor exclusively carnivorous, feeding on both vegetable matter and dead insects when both are offered.

Nothing yet appears to have been recorded of the Calcutta house-cricket. It is a fair-sized, mottled, grey-brown insect, flightless in both sexes. The female is entirely wingless, but the male has well-developed elytra provided with a stridulating organ of the usual Gryllid type, with the aid of which he sings even more persistently, though fortunately more quietly, than *Brachytrypes portentosus*, going on from evening far into the night. This familiar song is, however, not the only one that he is capable of pro-

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[1] See also Rutherford, *Spolia Zeylanica*, X, p. 77.

[2] For synonymy see Kirby's "*Synonymic Catalogue*" (British Museum).

[3] Mr. Bainbrigge Fletcher tells me that most of the burrowing is done before the insect becomes mature and begins to sing. Concerning the singing he says "The male first looks out of its burrow, then runs out rapidly and retreats again as quickly, having apparently brought up a little earth; sometimes it repeats this two or three times. Satisfied that the coast is clear, the cricket runs boldly out onto the little platform of earth outside its burrow, turns round facing its hole and with its head almost in the entrance, raises itself on its legs which are well spread out, slightly opens out its tegmina and commences to shrill. A slight quivering of the tegmina is all that can be seen, the motion apparently being too rapid for the eye to follow."

ducing; and when courting a female he changes it for a low whirring sound accompanied at regular short intervals by an abrupt squeak.

The first occasion on which I heard this was early in the rains of last year. I had three or four adult males in a glass jar. They stridulated as usual till I chanced to catch a couple of females which I put with them, when a change in their behaviour was at once apparent. First one and then another would approach one of the females and commence his courting notes, vibrating his elytra to produce the continuous whirring sound to all appearance just as when producing his ordinary song, but giving them periodic jerks which synchronized with the sudden squeaks. And this in spite of the fact that the females were all in their penultimate stage, and so failed to respond to any advances.

Some time later I heard these peculiar notes under different circumstances. On entering my office on a holiday, when the room was quite quiet, I heard what I at first took to be the squeaking of an electric fan. But it came from a direction where there were no fans, and on following it up I became aware of a low whirring sound accompanying it which suggested that I might be on the track of a pair of crickets, courting under natural conditions, although it was still early in the afternoon. The noise was located in a narrow covered space open at both ends, and on inserting a stick at one end a pair of common house-crickets soon appeared at the other. Unfortunately one of them escaped, so I was unable to make further observations upon them.

On another occasion, when attracted by the normal note of a male, I found him to be accompanied by a female to whose posterior end a small white body—presumably a spermatophore—was attached. So it may be customary for the male to entertain his mate for a time with his normal song after the pairing is over. Shortly afterwards I saw the female put her head between her legs, seize the spermatophore in her jaws and devour it. She was in a jar with several males, and I chanced to notice during the next morning that another spermatophore had been attached. This disappeared soon after, but I do not know how.[1]

EMBIOPTERA.

The first Indian Embiid whose habits appear to have attracted any attention was *Oligotoma michaeli*, of which specimens were transported from India to England in orchid roots, among which they lived in silken tunnels, and to which they proved destructive (see Michael in *Gardener's Chronicle*, Dec. 30, 1876 and M'Lachlan *J. Linn. Soc. London, Zool.* XIII, pp. 373-384, pl. xxi). The first observations made in India appear to be those of Wood-Mason on

[1] Changes in the notes of American locusts, and their association with courtship, are noted by Allard (*Ent. News*, XXV, 1914, pp. 463-466). They have, I believe, been noted in other Orthoptera saltatoria also, but I do not know where the observations have appeared.

Oligotoma saundersi published in 1883 (*Proc. Zool. Soc. London*, pp. 628-634, pl. lvi). Lefroy published a short note on this species in 1910 (*J.B.N.H.S.*, XIX, pp. 1009-1010). In 1911 Imms published an account of the habits and life-history of *Embia major* (*Trans. Linn. Soc. London, Zool.* XI, pp. 167-195, text-figs. 1-6, pl. xxxv i-xxxviii.)

ISOPTERA.[1]

A brief note on the tapping noises made in unison by termites was published by Fedden (*Proc. A.S.B.* 1866, p. 19). A paper by Bugnion (*Bull. Soc. Ent. Suisse*, XII, Berne 1912, pp. 125-139, pl. ix) deals with the same subject. These noises were frequently heard last year on some trellis-work in the Indian Museum compound, though I failed to notice any rythmic unison in their production. The trellis was covered with the mud shelters of termites, and when approached or tapped myriads of faint clickings were clearly audible. The sound at first suggested the cracking of the mud; but it was to be heard in the morning before the sun fell on the trellis (which faced west) as well as in the evening. If, moreover, the mud were broken away while the clicking was in progess, termites were always found beneath; whereas if the disturbance causing the clicking were kept up for a few minutes the clicking would cease, and then no termites would be found. This clicking is of course quite different from the clicking of *Capritermes*, which appears to be produced by the combined action of the remarkable jaws of the soldier, and sounds like the sudden cracking of a piece of thin glass. The force expended by *Capritermes* in producing it often flicks the producer up into the air.

A note on the repairing of a damaged termite nest was published by Millett in 1902 (*J.B.N.H.S.*, XIV, pp. 581-2), and one on strange mortality of termites among tea bushes by Green in 1905 (*J.B.N.H.S.*, XVI, pp. 503-4). Doflein, in his paper on termite truffles published in the same year (*Ver. Deutschen Zool. Ges.*, XV, pp. 140-149, 2 text-figs.; translated, *Spolia Zeylanica* III, pp. 203-9), notices the food of termites. In 1906 Petch noticed the habits of some Ceylon termites in his paper on the fungi of certain termite nests (*Ann. R. Bot. Gard., Peradeniya*, III, pp. 185-270, pl. v-xxi). Green in 1907 recorded the occurrence of two queen termites in one royal cell (*Spolia Zeylanica*, IV, p. 191). Escherich's "*Termitenleben aus Ceylon*" (Jena, 1911) deals extensively with habits. In 1913 Assmuth described the habits of many species of termites in his paper on "Wood-Destroying Termites of the Bombay Presidency (*J.B. N.H.S.*, XXII, pp. 372-384, pl. i-v), and Petch described those of *Eutermes monoceros*, the black termite of Ceylon (*Ann. R. Bot. Gard., Peradeniya*, V, pp. 395-420, pl. vi-xiv). During the same year Green's "Catalogue of Isoptera recorded from Ceylon" (*Spolia Zeylanica*, IX,

[1] See also Escherich, "Die Termiten" (Leipzig 1909); and Wasmann's "Neue Beiträge zur Kenntnis der Termitophilen und Myrmecophilen" *Zeitschr. wiss. zool.* CL, 1912, pp. 70-115, pl. v-vii.

pp. 7-15), and John's "Notes on some Termites from Ceylon" (*Spolia Zeylanica*, IX, pp. 102-116) were published, and in both the habits of a number of species are referred to. The most recent paper on the habits of Ceylon Termites appears to be by Bugnion [1] (*Bull. Mus. Hist. Nat. Paris*, 1914, no. 4, pp. 3-37, pl. i-viii).

Termites usually "swarm" in the rains; but in some species at least winged adults are ready to emerge even in the cold weather, and need only the stimulus of rain to bring them out. The cold weather of 1914-5 was remarkable in Calcutta for several periods of exceptionally damp and chilly weather. On each occasion numbers of termites were seen flying above the Maidan. On one occasion (16-i-15) I found a dense swarm emerging from a nest and collected specimens, which have been identified by Mr. Fletcher as a species of *Odontotermes*, probably new.

PSOCOPTERA.

Green describes the habits of Scaly-Winged Psocids (*Spolia Zeylanica*, IV pp. 123-125) and of Psocids which combine to spin extensive webs on trees (*Spolia Zeylanica*, VIII, 1912, p. 71, 1 pl., 2 text-figs.).

The habits of Psocids, and the occurrence of fatal epidemics among gregarious species, are referred to by Cunningham ("*Plagues and Pleasures*", pp. 151-5).

ODONATA.

Observations on the food of dragonflies have been recorded by Young (*J.B.N.H.S.*, XV, p. 530), Lefroy (*J.B.N.H.S.*, XX, pp. 236-8), Fulton (*J.B.N.H.S.*, XX, p. 876), and Green (who publishes information supplied him by Mr. John Pole, *Spolia Zeylanica*, VIII, p. 299). The oviposition of dragonflies is described by Cunningham ("*Plagues and Pleasures*", pp. 133-5). The vitality of dragonfly larvae out of water form the subject of a note by Green (*Spolia Zeylanica*, V, pp. 104-105).

NEUROPTERA (*s. str.*).

Annandale notices the habits of an Indian *Sisyra* larva (*J.A.S.B.* [n.s.], II, pp. 194-5, pl. i, fig. 3).[2]

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[1] Other papers by this author are scattered in various journals. The following list of those dealing to some extent with the habits of Oriental Termites is compiled from reprints sent to Mr. T. Bainbrigge Fletcher:—"Le Termite noir de Ceylan" *Ann. Soc. Ent. Fr.* 1909, pp. 271-281, pl. viii-x; another paper with the same title, *Bull. Soc. Vaud. Sci. Nat.*, XLVII (173), pp. 417-437, figs. 1-5; "Observations relatives à l'Industrie des Termites", *Ann. Soc. Ent. Fr.*, 1910, pp. 129-144; "*Eutermes lacustris*, nov. sp. de Ceylan", *Rev. Suisse Zool.*, XX, 1912, pp. 487-505, 1 text-fig., pl. vii-viii; "*Le Termes Horni*, Wasm. de Ceylan, *Rev. Suisse Zool.*, XXI, 1913, pp. 299-330, 1 text-fig., pl. xi-xiii; "Les Termites de Ceylan", *Le Globe, Organe Soc. Geogr. Genève*, LII, 1913, pp. 2-36, pl. i-viii.

[2] Not fig. 2 as stated in the text of the paper. This probably represents the larva of a Trichopteron, not a beetle.

The habits of Myrmeleonid and Ascalaphid larvae from tree-trunks are described by Gravely and Maulik (*Rec. Ind. Mus.*, VI, pp. 101-3, pl. v). Perhaps the "ant-lion" which Ryves found dead in a spider's web in a mango tree (*J.B.N.H.S.*, X, pp. 152-3) belonged to a species with similar habits.

The life-history of *Helicomitus dicax* is described by Ghosh (*J.B.N.H.S.*, XXII, pp. 643-8, 1 pl.). The larva of this Ascalaphid lives on the ground and covers itself with dust.

"The Indian Nemopterid and its food" is the title of a note by Lefroy on the larva of *Croce filipennis* (*J.B.N.H.S.*, XIX, pp. 1005-7, 1 text-fig.). Further studies on *Croce* have since been published by Ghosh (*J.B.N.H.S.*, XX, pp. 530-532, 1 pl.) and Imms (*Trans. Linn. Soc. London, Zool.* XI, pp. 151-160, pl. xxxii).

TRICHOPTERA.

A viviparous caddis-fly is described by Wood-Mason under the provisional name *Notanatolica vivipara* (*Ann. Mag. Nat. Hist.* [6], VI, pp. 139-141, text-figs. *a-b*).

HYMENOPTERA.

Miscellaneous.

The habits of various Indian Hymenoptera are very briefly referred to by Wroughton (*J.B.N.H.S.*, IV, pp. 26-37). The habits of a number of Indian Aculeata are described by Dutt (*Mem. Dept. Agric. India, Entom. Ser.* IV, pp. 183-267, pl. xi-xiv, 22 text-figs.).[1]

Chalcidae.

Cunningham devotes the third chapter of, and an appendix to, his "*Plagues and Pleasures of Life in Bengal*" to fig-insects. The particular insects whose habits are described are those which are associated with *Ficus roxburghii* in Calcutta, and his observations are clearly the result of his work on the fertilization—if such it may be called—of this fig by these insects (*Ann. R. Bot. Gardens, Calcutta*, I, Appendix 2, 1889, 37 pp., 5 pl.).

The habits of *Syntomosphyrum indicum* are described by Silvestri in *Div. Ent., Hawaii Board Agric. and For.*, No. 3, pp. 125-127.

Ichneumonidae.

Ramsay describes the oviposition of a species of *Rhyssa*—probably a species found in the Himalayas (*Entomologist*, XLVII, pp. 20-22, 3 text-figs.).

Braconidae.

A note on a species of *Apanteles* parasitic in the caterpillar of a Death's Head Moth has been published by Green in *Spolia Zeylanica*, V, p. 19, 1 pl.

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[1] A note on the capture of a leaf-mining caterpillar by a wasp is contributed by Ridley to *J. Straits R.A.S.*, July 1905, pp. 227-8.

Chrysidae.

Bingham refers to the habits of *Chrysis fuscipennis* in *J.B.N.H.S.*, XII, p. 586, Cretin to those of *Stilbum splendidum*, *J.B.N.H.S.*, XIV, pp. 823-4.

Mutillidae.

Wroughton refers to the habits of an Indian Mutillid (*J.B.N.H.S.*, VI, p. 118).

Pompiliidae.

The food of several members of this family is recorded by Bingham, who also describes the capture of a Galeodid by *Salius sycophanta* (*J.B.N.H.S.*, XIII, pp. 178-180).

Sphegidae.

Bingham mentions the food of several species of Sphegidae, and a remarkable concentration of the nests of a variety of *Sphex umbrosus* (*J.B.N.H.S.*, XIII, pp. 177-8).

Notes on the habits and food of *Sphex lobatus* are contributed by Lefroy ((*J.B.N.H.S.*, XV, pp. 531-2), and by Beadnell (*J.B.N.H.S* , XVII, p. 546).

Wickwar describes the habits of *Sceliphron violaceum* (*Spolia Zeylanica*, VI, p. 179), Cory those of *S. intrudens* (*J.B.N.H.S.*, XXII, p. 648), and Field those of *S. coromandelicum* (*J.B.N.H.S.*, XXIII, pp. 378-9).

Eumenidae.

Concerning *Eumenes conica* see Bingham (*J.B.N.H.S.*, XII, pp. 585-6), and Ramakrishna Aiyer (*J.B.N.H.S.*, XX, pp. 243-4). The former author deals with the construction of the nest and with pugnacity displayed towards a parasitic *Chrysis*, and the latter with breeding habits and development.

For notes on *Eumenes dimidiatipennis* see Cretin, *J.B.N.H.S.*, XIV, pp. 820-824.

Odynerus punctum is recorded as cleaning out and using empty cells of *Eumenes dimidiatipennis* (Cretin, *J.B.N.H.S.*, XIV, p. 824).

Vespidae.

Battles between wasps and bees are recorded by Hewett (*J.B.N.H.S.*, IV, p. 312) and by Drieberg (*Spolia Zeylanica*, IV, p. 33). In the former case the wasps were *Vespa magnifica* and the bees "the large jungle bees" (? *Apis dorsata*). A battle between two kinds of wasp, apparently *Vespa cincta* and *Polistes hebraeus*, is recorded by Cunningham ("*Plagues and Pleasures*", p. 31). The habits of the former wasp are dealt with on pp. 29-33 of the same book, and of the latter on pp. 23-28. Mr. Fletcher has given me the following additional note on this subject: "Last

July, when travelling by train, a specimen of *Vespa cincta* flew into the carriage carrying a *Polistes hebraeus* which it had captured. *V cincta* and various other large *Vespa* spp. are determined captors of honey-bees as these enter or leave the hive."

The capture of a small Pyralid moth by *Vespa cincta* is recorded by Green (*Spolia Zeylanica*, II, p. 197).

Apidae.

In addition to the notes just referred to recording battles between wasps and bees, the following references to bees may be given.

Douglas contributes information about the hive-bees indigenous to India and the introduction of the Italian bee (*J.A.S.B.*, LV [II], pp. 83-96).

Storey records the poisonous action of the nectar of *Lapindus emarginatus* on bees (*J.B.N.H.S.*, V, p. 423).

Eardley-Wilmot refers to an instance of a man who, having disturbed a bees' nest, was attacked by its inhabitants, and later in the day was singled out from his companions for attack by bees from other nests which he chanced to approach (*J.B.N.H.S.*, XI, pp. 741-2).

Bingham describes the habits of *Megachile disjuncta* and its parasite *Paravaspis abdominalis* (*J.B.N.H.S.*, XII, p. 587).

Several parasites from the nests of *Xylocopa tenuiscapa* have been recorded by Green (*Ent. Mo. Mag.* [2], XIII, pp. 232-3). In an article in *Spolia Zeylanica* (I, pp. 117-9) on the mites which inhabit the remarkable abdominal pouch of this species, references to two other papers dealing with these mites are given. These are Perkins, *Ent. Mo. Mag.*, [2], X, pp. 37-9; and Oudemans, *Zool. Anz.*, XXVII, pp. 137-9. The latter contains further references.

A note on the effects of the sting of *Xylocopa tenuiscapa* is contributed by Green (*Spolia Zeylanica*, VI, p. 134).

Notes on the habits of *Apis dorsata* are contributed by Willey (*Spolia Zeylanica*, VI, p. 181, 1 pl.).

The characteristic odour of leaf-cutting bees is described by Green (*Spolia Zeylanica*, VII, p. 55).

Castets contributes an article entitled "Les Abeilles du sud de l'Inde" to the *Revue des Questions Scientifiques* (Brussels, Oct. 1893). He deals with the habits of the three Indian species of *Apis* and of *Mellipona iridipennis*. An abstract of this article will be found in the *Tropical Agriculturalist* (XXX, 1908, pp. 48-54).

The peculiar way in which a bee "painted in alternate bands of shining black and the brightest, purest cobalt"—doubtless an *Anthophora*—collects pollen, and its way of resting for the night, are described by Cunningham ("*Plagues and Pleasures*", pp. 37-8).

The burrows of *Anthophora* (or *Podalirius*) *pulcherrima* are described by Annandale (*Rec. Ind. Mus.*, III, p. 294, 1 text-fig.), who notes that they open in a direction which prevents rain from entering them to any great extent.

Formicidae.

The habits of a number of different species are referred to by Rothney (*Trans. Ent. Soc. London*, 1889, pp. 347-374; reprinted *J.B.N.H.S.*, V, pp. 38-64), Wroughton, (*J.B.N.H.S.*, VII, pp. 13-60 and 175-202, pl. A-D), and Cunningham ("*Plagues and Pleasures*", pp. 40-54).

The care of Lycaenid larvae by ants is described by de Niceville (*J.B.N.H.S.*, III, pp. 164-8, pl. 26-7).

Bingham contributes a note on the habits of *Diacamma* (*J.B.N.H.S.*, XII, pp. 756-7).

Green describes the web-spinning of *Oecophylla smaragdina* (*Proc. Ent. Soc. London*, 1896, p. ix and *J.B.N.H.S.*, XIII, p. 181). Some earlier papers on this subject, and the fact that *Oecophylla smaragdina* does not spin a cocoon in which to pupate, are noticed by Green (*Spolia Zeylanica*, I, pp. 73-4), and the matter forms the subject of notes by Fletcher (*Spolia Zeylanica*, V, p. 64), Ridley (*J Straits R. Asiatic Soc.* No. 22, Dec. 1890, pp. 345-7) and Shelford (*J Straits R. Asiatic Soc.* June 1906, pp. 284-5).

A living chain of *Oecophylla smaragdina* spanning a gap of 3 inches is described by Green (*Spolia Zeylanica*, VII, pp. 53-4). The capture of a living butterfly (*Catopsilia crocale*) by this species is recorded by Henry (*Spolia Zeylanica*, IX, pp. 142-3). A lengthy note on the habits of the same species in the Malay Peninsula will be found in *Fasciculi Malayenses*, Zool. III, pp. 27-30.

A remarkable illustration of the very large quantities of grain carried away and stored by ants is given by Fraser (*J.B.N.H.S.*, XX, p. 877).

The carrying away of a partially disabled caterpillar by a party of ants is described by Sladen (*J.B.N.H.S.*, XXII, p. 649).

COLEOPTERA.[1]

Passalidae.

I have already once gathered together as much information as I could obtain about the habits of Indian Passalidae (see *Mem. Ind. Mus.*, III, pp. 339-340). Since then Mr. T. Bainbrigge Fletcher has taken *Episphenus neelgherriensis* at light in Coorg, and has obtained eggs of *Macrolinus rotundifrons* from under a log at Peradeniya where they were found "in a circular chamber partly filled with gnawed wood." In view of the suggestion made in the "*Fauna of British India*" (Lamellicornia, I, p. 20) that the Passalidae are a viviparous family the latter observation is of great interest. It may not be out of place to note here that when, during my visit to Berlin in 1913, I called the attention of Dr. Ohaus to the suggestion, he immediately refuted it by the production of eggs of American species preserved in his fine private collection.

[1] Concerning stridulation in this Order, with which several of the following notes are concerned, see Gahan, *Trans. Ent. Soc. London*, 1900, pp. 433-452, pl. vii; and Arrow, *Trans. Ent. Soc., London*, 1904, pp. 709-750, pl. xxxvi.

My suggestion (*Mem. Ind. Mus.*, III, p. 215) that *Pleurarius brachyphyllus* is probably not a gregarious species has proved to be incorrect. This species is abundant in the evergreen jungles of the lower western slopes of the Western Ghats in Cochin. Occasionally isolated pairs were found in a log, but usually numbers were found together. It is scarcely possible that insects of this species are able to fly; for although the wings are well developed the elytra are fused. How this fusion takes place I was unable to determine, as only one pupa was found, and no stages intermediate between this and the almost fully blackened adult. The elytra are not fused in the pupa.

The conclusion that *Episphenus indicus* is to some extent gregarious, and that *E. neelgherriensis* is not, was confirmed by my observations in Cochin. All of the three last mentioned species burrow more deeply into logs than does *Leptaulax bicolor* which, together with its larvae and pupae, was only found close under the bark. *Pleurarius brachyphyllus*, especially, makes galleries well below the surface, a fact which probably accounts for its comparative rarity in the collections I had previously seen. It often burrows in somewhat hard wood and is very difficult to dig out; but I found it even commoner in Cochin than *Episphenus indicus*, a species which was distinctly commoner than *E. neelgherriensis*.

The larvae of *Pleurarius brachyphyllus* and *Episphenus indicus* —I got very few of *Episphenus neelgherriensis* and *Leptaulax bicolor* —were commonly found widely separated from adults. In some cases no adults at all could be found, and it is curious, in view of Ohaus's observations on American species, that although all the larvae which I attempted to keep thrived for a time, whether associated with adults or not, only those without adults survived the journey to Calcutta; and that of these one or two lived for between one and two months. I regret now that I did not make an effort to keep single families by themselves. This was, however, rendered almost impossible, firstly by the difficulty of recognizing a single family as it occurred scattered along one or more of the groups of burrows made by the various members of the colony, and secondly by an insufficient supply of separate tins.

Stridulation in adults of both *Episphenus* and *Pleurarius* is brought about by movements of the abdomen, and is faintly audible at a yard or two's distance from the ear. In larvae it is much fainter. I never saw any indication of its being used as a means of communication, and this agrees with Mr. Kemp's experience of species found in the Abor Country. Adults, at least, appear to stridulate whenever they are disturbed, presumably in order to drive off the enemy.

The stridulating organs resemble those of *Popilius* (*Passalus*, auct.) *cornutus* and *Pentalobus barbatus*[1] described by Babb (*Ent.*

[1] The abdominal part resembles that of *Proculas goryi* also; but the wings are not reduced as in that species. I cannot understand Schulze's statement that in *P. goryi* the abdominal part is situated on the fifth segment, for his figure (in which the first segment is omitted) clearly shows it on the sixth, where it is

News, XII, p. 271 [1]) and Schulze (*Zool. Anz.*, XL, pp. 209-216, figs. 5-7). The organs to which Ohaus attributed stridulatory functions (*Stettin Ent. Zeit.* 1900, pp. 167-169) are also well developed. In a footnote to the first page of Schulze's paper Ohaus says, "Was die von mir l. c. beschriebene Bildung für eine Bedeutung hat, ist bis jetzt noch nicht festgestellt. Sie findet sich bei den meisten, vielleicht allen, holzbewohnenden Lamellicorniern und hat vielleicht den Zweck, das Eindringen von Wasser, vielleicht auch von Schmarotzern, in die Räume zwischen den Tergiten und Flügeln zu verhindern. Speziell die Passaliden sind an den Rändern der Tergite häufig mit Milben besetzt."

In order to test the possible stridulating powers of the two sets of organs I removed the wings of a *Pleurarius*. Although the abdomen subsequently moved as if trying to stridulate no sound was produced. A good deal of fluid escaped, however, from the places where the wings had been inserted, which might have affected the vibrations; so I then cut off the ends of the wings of another specimen of the same species. Its abdomen moved vigorously but only a very faint sound was produced, a sound which I attribute to a small portion of the stridulating surface of the wing having escaped removal. I then took a specimen of *Episphenus indicus*, in which the elytra are not fused and can consequently be opened, and found that so long as the folded wings were pressed down on to the abdomen by a needle the insect could stridulate as well as before, even though the elytra were held right away from the sides of the abdomen.

I have never heard any Passalid emit notes of more than one kind, and all have been fainter than those produced artificially by rubbing the end of the wing of a softened specimen of *Proculus goryi* on the plate beneath it.

Lucanidae.

Nigidius dawnae lives in hard dry pieces of wood on the higher slopes of the Dawna Hills. Both adults and larvae were found in one such piece (see *Rec. Ind. Mus.*, XI, pp. 427-429). Mr. Kemp informs me that *N. impressicollis* lives, in both the larval and adult condition, in thoroughly damp and rotten wood. Mr. Beeson informs me that *N. distinctus*[2] lives in dead wood of Malatta (*Macaranga pustulata*) in the Duars.

Dynastinae.[3]

The stridulating ability of *Xylotrupes gideon* has been recorded by Cunningham ("*Plagues and Pleasures*", pp. 126-7, pl. ii,

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situated in the specimen of *P. goryi* that I have examined, and also in *Pentalobus barbatus*, *Pleurarius brachyphyllus*, etc.

[1] See also Sharp, *Ent. Mo. Mag.* (2) XV (XL), 1904, pp. 273-4.

[2] Concerning the identity of this species see *Rec. Ind. Mus*, XI, p. 430.

[3] Attention may be called here to the occurrence, in a paper on Paussidae,

fig. 5; quoted in *Fauna of British India*, Lamellicornia, I, p. 265).[1]

Concerning the action of the stridulating organs of *Oryctes rhinoceros* nothing yet seems to have been published. I have had great difficulty in obtaining any evidence as to the use of the so-called stridulating organ found in the larva (pl. xxii, fig. 1). When a specimen is tightly held by the head, however, it may be seen to move the mandibles and maxillae in a manner likely to bring the organ into action, and a faint rasping sound may sometimes be heard if the specimen be brought close to the ear. No definite vibrations have been felt, and the movements of the mandibles and maxillae are those which would probably be used, in order to free itself, by any insect similarly placed. Pressure on the body does not seem to induce any such movements, but they are sometimes indulged in by larvae which find themselves on their backs on a hard surface in the open. The movements are often greater in extent than their use for stridulatory purposes requires; the mandibular part of the organ is, indeed, sometimes fully exposed at intervals, and could not then be scraped at all by the maxillary portion. The rasping seems, nevertheless, to be produced only when these movements occur. It is therefore probable that it is produced by the organs in question, and it is noteworthy that the movement of the mandibles and maxillae is often very small—as it should be to keep the two parts of the organ in contact—and that this does not interfere with the sound produced.

The pupa, in which no stridulating organs appear to have been described, stridulates quite audibly when disturbed. The sounds are produced as the result of backward and forward movements of the abdomen, movements which cause a pair of scrapers situated on the dorsal part of the anterior margins of segments 2-6 to rub over the faintly ridged surface of the hard chitinous walls of oval depressions on the posterior parts of segments 1-5 (pl. xxii, figs. 2-3), producing vibrations through the whole pupa, as well as sound. The organs are very conspicuous in living specimens, but in preserved ones they are apt to be largely hidden between the terga. The organ between segments 6 and 7 is rudimentary.[2]

I have heard the adult stridulate, but not loudly. The sound appears to be produced by the rubbing of the well-known ridges on the posterior end of the abdomen against the posterior ends of the elytra (pl. xxii, fig. 4), but I have not yet been able to investigate this as fully as I would like.

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where it is most unlikely to attract the attention of those interested (*J.A.S.B.*, XII, pp. 421-437), of a coloured figure of *Eupatorus hardwickei* from the summit of the Gogur Range, 9000 ft., in Kumaon.

[1] See also Rutherford, *Spolia Zeylanica*, X, p. 77.

[2] Similar structures are present in the pupae of several other beetles—e.g. *Adoretus* (Rutelinae) and *Hectarthrum* (Cucujidae)—but they do not appear to be stridulatory on any segments in them.

Rutelinae.

Leaves of *Lagerstroemia* bushes in the Indian Museum compound are frequently eaten extensively by a nocturnal insect, and by searching among them after dark a few Melalonthids and a large number of Rutelids have been obtained. All of the latter belong to the genus *Adoretus*, and Mr. Arrow has identified almost all of them as *A. versutus*. Occasional specimens have been found feeding on *Bauhinia*, *Canna*, and a leguminous shrub (? *Cassia*); but they are found in much greater abundance on *Lagerstroemia* than on anything else.[1]

Mr. Arrow informs me that nothing is yet known of the manner of feeding in this genus, and I have been able to make the following observations.

At night, after emerging from the ground in which it has been buried all day and to which it returns before morning, the beetle flies to a leaf, and settles either on the upper or under side, usually the latter. It never settles on the edge. The claws of two or three tarsi, often all on the same side of the insect, grasp the edge; the others rest on the surface.

In beetles of this genus, the mouth is divided into two by a median process of the labrum (pl. xxii, fig. 5). When the insect wishes to take a bite, therefore, it turns its head slightly on one side; and although the mouth-parts of both sides work simultaneously, the bite is effected by those of one side only.

The strongly toothed extremity of the maxilla forms the principal biting organ. When a specimen begins to feed both mandibles and maxillae are opened widely. Then the maxillae are exserted between the mandibles and the median process of the labrum, the maxilla of whichever side of the head has been turned nearest the leaf scooping out a small quantity of the soft tissue of which the leaf is composed between the principal veins. This tissue does not appear to offer the slightest resistance to the maxilla, which seems to scoop it up as easily as if it were soft wax; and so far as I have been able to see the beetle makes no special effort to keep the leaf from being pushed away instead of cut into. I do not even think that the median process of the labrum is lowered against it, as I have been unable to see this organ during the process. Had it been lowered it must, I think, have come into view.

Three or four bites are required to make a hole right through the leaf, after which bigger bites can be made. The general method is the same, but the end of the maxilla is passed through the hole, and as far beyond the edge as it will go, so that it bites each time through the whole thickness of the leaf. Here again

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[1] A few specimens of *A. duvauceli* have also been found on *Lagerstroemia* and of *A. lasiopygus* on *Hibiscus*. *A. versutus* has been found in great abundance on Cannas since the above was written, and its larvae and pupae have been found among their roots.

the tissues of the leaf appear to offer no resistance, but as the maxilla passes back into the cavity between the mandible and labral process close to the concave part of the serrate margin of the latter, there is probably some amount of scissor action between them.

The mandible closely follows the maxilla in all its movements, and forms a sheath above it. Precisely to what extent it functions as a biting organ is most difficult to see with certainty. Its smooth dorsal face works along the serrate transverse edge of the labrum from end to end, and its distal end slides past the serrate longitudinal edge of the labral process as it follows the maxilla into the cavity behind. Probably the mandible makes all the transverse cuts that are required, and it could no doubt make longitudinal cuts as well should the maxilla fail to work properly; but no transverse cutting seems to be left for it under ordinary circumstances, and the tracks of the maxillary teeth can be distinctly seen on each freshly bitten surface. One of the chief functions of the mandible appears to be to protect these teeth, when they are not in use, by closing in the cavity between the labrum and the labium, in which they lie when at rest.

Intervals of varying length between the bites are devoted to mastication. During this process the gnathites of the two sides work simultaneously as before, but the maxillae are not exserted —i.e. they remain in the cavity between the mandibles, their extremities being exposed between (and posterior to) the mandibles and the labral process each time they are opened. At the same time the labral process and labium are alternately separated a little and brought together again. Mastication presumably takes place chiefly between the large molar teeth, situated one at the base of each mandible (pl. xxii, fig. 6), the triangular thickened area on the inner side of the labium (pl. xxii, fig. 6), and the somewhat similar convexity on the inner side of the labrum. It is possible, however, that the terminal teeth of the maxilla take some part in it also, for those of opposite sides are not quite alike, and when pressed together after removal of the labrum, the teeth of one side may be seen to fit into the spaces between the teeth on the other, although the teeth can never be brought together thus during the process of biting.

This method of feeding differs in several respects from the method of feeding observed by Ohaus (*Stett. Ent. Zeit.*, 1909, pp. 12-13) in Rutelinae of the *Geniates* group, South American insects whose mouth is also divided longitudinally into two parts. *Geniates* and its allies always cling to both sides of the leaf at the same time instead of to one side only, commencing to feed at the edge instead of on the upper or under side; they also exude such large quantities of saliva that it escapes from the mouth and stains the bitten margin of the leaf—a thing which has never been observed in *Adoretus*.

The difference in the method of biting the leaf is associated with differences in the structure of the mouth parts. *Geniates*

and its allies[1] are said to take the edge of a leaf in their mouths and cut a piece out by a scissor-like action between the mandibles and labrum and the maxillae and labium. The mandibles are likely, therefore, to have a very strongly developed cutting edge in front. This is the case in *Geniates impressicollis*, a species in which there is in addition a narrow posterior part, forming an imperfect sheath for the maxilla, at right angles to the cutting part. The cutting portion of the mandible of *Geniates* appears to be homologous with the greater part of the sheathing mandible of *Adoretus*. The maxillae of *Geniates impressicollis* are well developed, but are prismatic in form rather than scoop-like; they presumably aid in cutting only by dragging the leaf down over the sharp edge of the labium.

The mouthparts of *Leucothyreus trochantericus*, the only other species of the *Geniates* group that I have been able to examine, are more difficult to understand. The mandibles are so massive that it is difficult to see how the edge of a leaf is ever introduced into the mouth. Presumably, however, this must be the manner of feeding; for the species whose feeding habits were actually observed by Ohaus included some of the genus *Leucothyreus*. The maxillae are small and are not in any way sheathed by the mandibles, whose anterior edge appears to overlap the edge of the labrum when closed and so to be useless for cutting. Presumably the cutting is done by the leaf being dragged down across the edges of the labrum and labium by the main mass of the mandible, though even this is a little difficult to understand.

Coprinae.

The stridulating habits of *Heliocopris mouhotus* are described by Annandale (*Fasciculi Malayenses*, Zool. I (II), p. 283).

Specimens of a somewhat smaller species of *Heliocopris*—probably *H. bucephalus*, Fabricius—sent to me by Mr. Bainbrigge Fletcher, stridulated loudly, but with the hind, not the middle, coxae I failed to associate any form of stridulation with the middle coxae although these moved as freely as the others in life, and an exceedingly faint sound could be produced by moving them artificially after death. The front legs produced strong but inaudible vibrations, but whether in the coxal cavities or between the coxae and femora, I was unable to determine. I have been unable to reproduce these vibrations on dead insects.

Cicindelidae.

Notes on the habits of a number of species are recorded by Annandale and Horn in the "*Annotated List of the Asiatic Beetles in the Collection of the Indian Museum*," Part I (Calcutta, 1909). The habits of some tiger-beetles from Orissa form the subject of a

[1] *Leucothyreus* and *Bolax* appear to have been the actual genera observed (*loc. cit.*, pp. 18-21).

note by Gravely (*Rec. Ind. Mus.*, VII, pp. 207-9). In both places the habits of the littoral *Cicindela biramosa* are mentioned. An earlier communication with regard to this species was made by Fletcher (*Spolia Zeylanica*, V, pp. 62-3), who has recently published a note on tiger-beetles from Coorg (*J.B.N.H.S.*, XXIII, p. 379).

The breeding places of common Indian Cicindelidae have been discussed by Lefroy (*J.B.N.H.S.*, XIX, pp. 1008-9) and the life-history and habits of *Collyris emarginata* in the Sunda Islands by Koningsberger (*Med. 'Slands Plant.*, XLIV, p. 113, fig. 59) and Shelford (*J Straits R. A. S.*, June 1906, pp. 283-4).

Carabidae.

Calosoma orientale is recorded as an enemy of locusts by Cotes (*J.B.N.H.S.*, VI, p. 416).

Paussidae.

Some Indian representatives of this family form the subject of a paper by Boyes, in which some account of their habits is given (*J.A.S.B.*, XII, pp. 421-437, 3 pl.).

Malacodermidae.

The flashing in unison of swarms of fire-flies is discussed by Cameron, Clark, Fry and others (*Proc. Ent. Soc. London*, 1865, pp. 94-5 and 101-2, the former reprinted in *J.A.S.B.*, XXXIV [II], pp. 190-2); Theobald (*J.A.S.B.*, XXXV [II], pp. 73-4; reprinted *Proc. Ent. Soc. London*, 1866, pp. xxvii-xxviii); Fedden (*Proc. A.S.B.*, 1866, p. 19); Severn (*Nature*, XXIV, p. 165); Annandale (*Proc. Zool. Soc. London*, 1900, pp. 864-5); and Cunningham ("*Plagues and Pleasures*", pp. 129-130). I have only once seen an example of this phenomenon. I was walking after sunset near Dhammathat on the Gyaing River above Moulmein when I noticed that all the fire-flies of the neighbourhood seemed to have congregated round an isolated tree, and were flashing in unison with wonderful effect.

Aquatic fire-fly larvae are described by Annandale (*Proc. Zool. Soc. London*, 1900, pp. 862-4, and *J.A.S.B.* [n.s.], II, pp. 106-7).

Green notices the luminosity of *Harmatelia bilinea* and *Dioptoma adamsi* (*Trans. Ent. Soc. London*, 1912, pp. 717-719, and *Spolia Zeylanica*, VII, pp. 212-4, 1 pl.).

A glowworm with nine pairs of lights has been recorded from Ceylon by "M" (see *Proc. Ent. Soc. London*, 1865, p. 101).[1]

The large yellow-edged black larvae of *Lamprophorus tenebrosus* are luminous, but do not shine as brilliantly as do the mature females, which are uniformly yellowish in colour. The female may

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1 See also Rutherford, *Spolia Zeylanica*, X, pp. 72-74 (*Dioptoma adamsi*).

sometimes be found at dusk in vegetation by the road-side at Peradeniya, sitting curled up on the ground with the tail erected so as to expose her light to the best advantage. Males fly up with a loud buzzing sound, but without lights, and drop close to her. They then become faintly luminous and run round about her. When copulation takes place the female uncurls, and her lights die down till they give only a faint ventral glow. If the pair be separated the female lights up again at once. Males are often attracted to lights in houses, when they emit a steady bluish glow from the posterior part of the abdomen (see also Green, *Trans. Ent. Soc. London*, 1912, p. 719).

Cleridae.

The habits and life-history of a Clerid near *Thanasimus nigricollis*, which is predaceous on Scolytidae, is described by Stebbing (*J.A.S.B.*, LXXII [II], pp. 104-110).[1]

Anthicidae.

Ant-mimicry by a *Formicomus* is the subject of a note by Fletcher (*J.B.N.H.S.*, XXII, p. 415).

Meloidae.

Blistering powers are recorded in *Cantharis rouxi* by Coleman (*J.B.N.H.S.*, XX, pp. 1168-9).

Green notices that *Cissites debeyi* lays its eggs in masses inside the galleries made by the Carpenter Bees with which the species is associated (*Ent. Mo. Mag.* [2], XIII, pp. 232-3).[2]

Cerambicidae.

Saunders states that adults of *Batocera rubus* feed on the round buds, but not on the leaves, of the Pipal tree (*Trans. Ent. Soc.*, I, 1836, pp. 60-61). The development and habits of several Longicorns which bore in *Ficus elastica* are described by Dammerman (*Med. Afd. v. Plantenz.*, No. 7, Batavia, 1913, 43 pp., 3 pl.).

Larvae of *Stromatium barbatum* attack furniture in Calcutta. *Xystocera globosa* was present in large numbers in a tree which died recently on the Calcutta Maidan. All stages of *Logaeus subopacus* were found in a rotten log at Kavalai, *ca.* 2000 ft., in the Western Ghats in Cochin on Sept. 26, 1914. Similar larvae were abundant in rotten wood both there and at the base of the Ghats at about the same time of year, but later stages were only found in the one instance.

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[1] Since named *T. himalayensis*, Stebbing. See *Indian Forest Insects*, London, 1914, p. 186.

[2] See also E. Bugnion "Le *Cissites testaceus*, Fabr. des Indes et de Ceylan. Métamorphoses—Appareil Génital", *Bull. Soc. Ent. Egypte*, 1909 (Cairo, 1910), pp. 182-200, pl. i-iii.

Scolytidae.

The supposed effect of moonlight on the attack of the "shot-borer" is discussed in the *Journal of the Bombay Natural History Society* by Troup (XVII, p. 526), Barton-Wright (XVII, pp. 1026-7) and Stebbing (XVIII, pp. 18-26).[1]

Strohmeyer (*Ent. Blät.*, 1914, pp. 103-107) suggests that the group of bristles and processes on the head of the female of *Spathidicerus thomsoni* serves for the transport of ambrosia fungus spores. Mr. Beeson tells me that he has found inside the frontal processes of the swarming female of *Diapus furtivus* bunches of small cell-like bodies of similar appearance to the clusters of ambrosia which occur in its galleries. They stain with cotton blue, but he has been unable to germinate them. The male of this species, he tells me, possesses a group of minute pores near the apex of each elytron, which secrete a white wax. The wax is moulded into a cylindrical tube which projects about a third of an inch from the entrance-hole in the bark of the host-tree. The male brings up the pellets of excrement from the sapwood galleries, in which the larvae live, into the wax-tube and, collecting a mass of material in a deep concavity at the posterior end of the abdomen, suddenly jerks the body outward and shoots the pellets for a distance of several feet from the trunk of the tree.

Mr. Beeson also tells me that the large concavities in the front of the head and the lateral processes on the antennal scape of the female of *Crossotarsus bonvouloiri*, and the processes on the mandibles of the female of *Diapus quinquespinatus*, are used for picking up the eggs and carrying them about in the galleries.

Curculionidae.

How a leaf-rolling weevil (*Apoderus* sp.) rolls up leaves and lays its eggs is recorded by Sage (*J.B.N.H.S.*, VI, pp. 263-4).

The habits and life-history of an aquatic weevil are described by Annandale and Paiva (*J.A.S.B.* [n.s.], II, pp. 197-200, figs. 1A-F).

Alcides collaris is noticed by Lefroy as a gall-producer (*J.B.N.H.S.*, XIX, p. 1007).

Notes on the habits and life-history of *Cyrtotrachelus longipes* are given by Witt (Indian Forester, XXXIX, pp. 265-272, pl. v).

Concerning the development and habits of *Aclees birmanus*, a borer in *Ficus elastica*, see Dammerman (*Med. Afd. v. Plantenz.*, No. 7, Batavia, 1913, pp. 29-30, 1 text-fig., pl. i, figs. 10*a-b*).

STREPSIPTERA.

Green records the occurrence, in the Jassid *Thompsoniella arcuata*, of parasites belonging to this Order (*Spolia Zeylanica*, VII, p. 55).

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[1] Mr. Beeson informs me that the species referred to in this discussion is *Platypus biformis*, Chap.

LEPIDOPTERA.

Rhopalocera.

Cases of butterfly migration are noted in the *Journal of the Bombay Natural History Society* by Aitken (XI, pp. 336-7 and XIII, pp. 540-1), Prall (XI, p. 533), Dudgeon (XIV, pp. 147-8), Nurse (XIV, p. 179), and Andrewes (XIX, p. 271); and in *Spolia Zeylanica* by Wickwar (III, pp. 216-8), Green (III, pp. 219-220), Fletcher (IV, pp 178-9), Daniel (V, pp. 106-7) and Willey (V, pp. 186-8).[1]

Prall records the rate of flight of certain butterflies (*J.B.N.H.S.*, XI, pp. 533-4).

Henderson records the occurrence of *Melanitis ismene* at sea (*Spolia Zeylanica*, IX, pp. 45-6).

Ormiston contributes a note on the length of life of butterflies as winged insects (*Spolia Zeylanica*, IX, p. 143).

The enemies of butterflies are discussed in the *Journal of the Bombay Natural History Society* by Nurse (XV, pp. 349-350), Lefroy (XV, p. 531) and Aitken (XVI, pp. 156-7).

The capture of *Huphina remba* by a Lycosid spider is recorded by West (*Spolia Zeylanica*, V, p. 105).

Green refers to "the habits of the leaf-butterfly" (*J.B.N.H.S.*, XVI, p. 370), and Cave publishes "a note on *Kallima inachus*" (*Spolia Zeylanica*, V, p. 142).

The climatal changes of *Melanitis*, etc., are discussed by Manders (*J.B.N H.S.*, XVII, pp. 709-720); and Aitken (*J.B.N.H.S.*, XVIII, pp. 195-197).

Some effects of moisture on the behaviour of butterflies are described by Cunningham ("*Plagues and Pleasures*", pp. 103-8).

Green describes the oviposition and early larva of *Jamides bochus* (*Spolia Zeylanica*, II, pp. 204-5), and the gregarious habits of the larva of *Parata alexis* (*Spolia Zeylanica*, III, p. 157).

An account of the habits of the leaf-cutting caterpillar of *Suastus gremius* is given by Willey (*Spolia Zeylanica*, VI, pp. 124-130, 7 text-figs.), who further notes (p. 125) the ability of the adult of this species to emit a loud clicking sound.

A note on the development and larval habits of *Aphnaeus hypargyrus* is contributed by Fraser (*J.B.N.H.S.*, XX, pp. 528-530, 1 pl.).

Mimicry in unpalatable caterpillars (*Papilio polytes*) is the subject of notes in *J.B.N.H.S.*, IV, by Hart (pp. 229-230) and Aitken (p. 317).

Carnivorous habits and cannibalism in caterpillars of butterflies are recorded in *J.B.N.H.S.*, XVIII, by Fischer (pp. 510-1), and Lefroy (pp. 696-7).

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[1] See also Shelford, *J. Straits R.A.S.*, June 1903, pp. 203-4 (*Cirrochroa bajadeta*, Moore).

Heterocera.

Lefroy records carnivorous habits and cannibalism in the larvae of moths (*J.B.N.H.S.*, XVIII, pp. 696-7). The coccidiphagous habits of *Eublemma* larvae, which are mentioned in this note, have also been recorded in *J.B.N.H.S.*, XIII, by Dudgeon, (pp. 379-380), and Green (p. 538).

The aerial dissemination of the larvae of a wingless moth is noted by Aitken (*J.B.N.H.S.*, V, p. 421).

Troup records a plague of the web-spinning caterpillars of *Naxa textilis* var. *hugeli* on the Silang tree, *Olea fragrans* (*J.B.N.H.S.*, XII, pp. 775-6).

Certain *Drosera*-eating larvae and their habits are described by Fletcher (*Spolia Zeylanica*, V, pp. 26-27, figs. 3-7 and pp. 95-97).

The larval habits of the Tineid moth *Melasina energa* form the subject of a note by Fryer (*Trans. Ent. Soc. London*, 1913, pp. 420-422, pl. xxi).

Green gives an account of the curious Scolopendriform caterpillar of *Homodes fulva* (*Spolia Zeylanica*, VII, pp. 166-7, figs. 8*a-b*), of a Geometrid caterpillar (*Comiboena biplagiata=Uliocnemis cassidara*) which disguises itself by attaching small pieces of leaves and withered flowers to paired fleshy processes of the body (*Spolia Zeylanica*, I, p. 74), and of the efficacy of the hair of a small Lithosiid caterpillar as a protection against ants (*Spolia Zeylanica*, VI, p. 135). Wise states that the hair which *Nepita conferta* works into its cocoon serves the same purpose, and calls attention to the male-attracting power possessed by females of this species (*J.B.N.H.S.*, II, pp. 54-5). Aitken, however, shows that the hair of the larvae of *Nepita conferta* does not protect them against toads (*J.B.N.H.S.*, XI, pp. 337-8).

The method by which certain Saturniidae cut their way out of their cocoons is described by Kettlewell (*J.B.N.H.S.*, XVII, pp. 541-2).

Meyrick (*Ent. Mo. Mag.* [2], XXV, p. 220) records Fletcher's discovery of a moth, to which he gives the name *Brachmia xerophaga*, symbiotic with *Stegodyphus* at Guindy near Madras. I have examined specimens of the spider with which it was found, and have identified them as *Stegodyphus sarasinorum*. More recently I have myself obtained the same species of moth from nests of the same species of spider near Balugaon in Orissa. All the moths I saw were on the outside of the nest, but the caterpillars were inside.

Fletcher mentions the occurrence of several specimens of *Ophideres fullonica* and *Cephonodes hylas* at sea (*Spolia Zeylanica*, III, p. 202). He also contributes a note on the significance of the stridulation of the Death's Head Moth (*Spolia Zeylanica*, IV, pp. 179-180).[1]

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[1] See also Rutherford, *Spolia Zeylanica*, X, pp. 77-78. For collected observations on the stridulation of European Death's Head Moths see Tutt "British Lepidoptera," IV, pp. 406-8 and 447 (larva), 432 (pupa) and 444-453 (imago). According to a notice long exhibited in the insect gallery of the Indian Museum

Stridulating organs on the wings of certain Indian moths have been described by Hampson (*Proc. Zool. Soc. London*, 1892, pp. 188-193, 6 text-figs.).

With regard to the supposed stridulating organ found in males of the genus *Arcte* (pl. xxiii, fig. 7) Mr. Henry has sent me the following note on an observation he made a few years ago in the Matale District of Ceylon. "I was walking through jungle at dusk and noticed two dark moths with light patches on the underwings, which I am sure were *Arcte caerulea*, flitting up and down and round each other, and producing a curious clicking noise. Unfortunately at that time I was not specially interested in moths, so I neglected to preserve the specimens or to make a note of the occurrence. I was merely struck by the curious fact of moths producing a sound. It may have been a pair of males fighting (and I incline to this opinion) or a male courting a female."

Alarming colour and attitude, and also mimicry in certain caterpillars, are described by Annandale (*Proc. Zool. Soc. London*, 1900, pp. 855-857).

DIPTERA.

Psychodidae.

Concerning *Phlebotomus minutus* see Howlett, *Ind. J Med. Res.*, I, pp. 34-8, 1 fig.

Cecidomyidae.

Stebbing describes the life-history and habits of a Cecidomyid which produces false cones on *Pinus longifolia* (*Indian Forester*, XXXI, pp. 429-433, pl. xxxviii).

Chironomidae.

The habits in all stages of the Colombo Lake Fly—since described by Kieffer (*Rec. Ind. Mus.* VI, pp. 136-137) under the name *Chironomus ceylanicus* (see Green, *Spolia Zeylanica*, VII, p. 50)—are referred to by Green, *Ind. Mus. Notes*, V (3), pp. 191-193, and Chalmers, *ibid.*, pp. 195-197.

The larva of a Chironomid, since described by Kieffer as *Chironomus fasciatipennis*, is recorded by Annandale as feeding on —and in its very early stages sometimes feeding—*Hydra orientalis* (*J.A.S.B.* [n.s.], II, pp. 112-116; see also *Fauna of British India*, Freshwater Sponges, Hydroids and Polyzoa, pp. 155-6). Other Chironomid larvae (*Chironomus* and *Tanypus* spp.) are recorded by the same author as living in association with *Spongilla carteri* (*J.A.S.B.* [n.s.], II, pp. 190-4, figs. 2A-B). He also notices some Indian blood-sucking midges (*Rec. Ind Mus.*, IX, pp. 246-7).

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the Indian species of Death's Head Moth stridulate by rubbing the tip of the proboscis on the ridged lower surface of the same appendage. I have had no opportunity of investigating this on a living specimen, but found no difficulty in artificially producing sound in this way on a freshly killed specimen that I once received.

Culicidae.

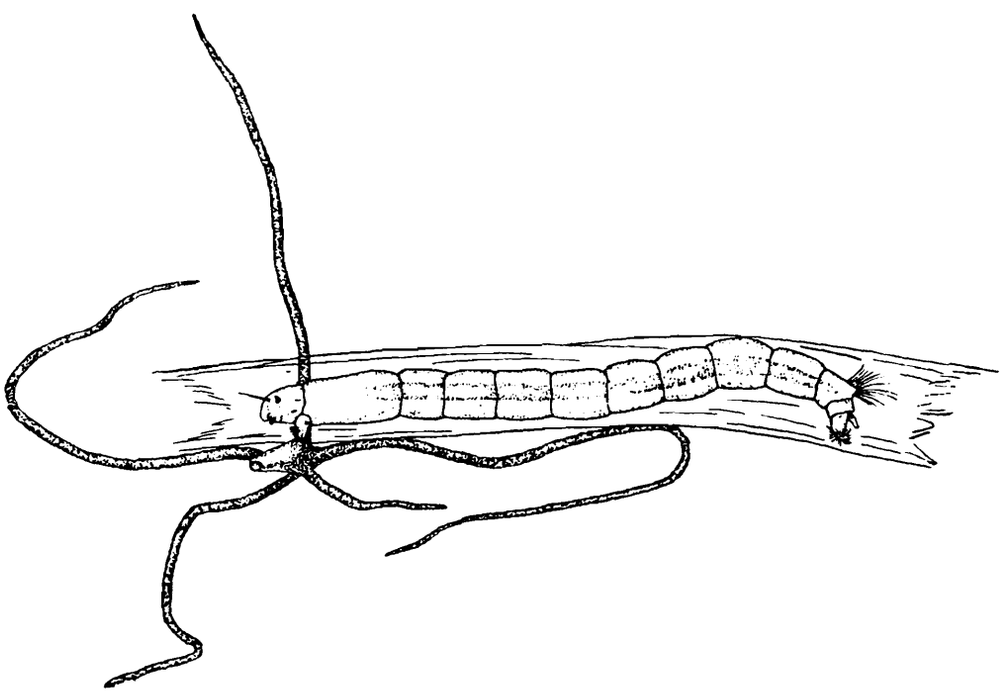
Ridley records the breeding of mosquitoes in pitchers of *Nepenthes* (*J Straits R.A.S.*, No. 22, Dec. 1890, p. 430).

MacDougall notices the habits of *Corethrella* (=*Ramcia*)[1] *inepta* (*Spolia Zeylanica*, VIII, p. 71).

The habits of *Toxorhynchites immisericors* are described by Green (*Spolia Zeylanica*, II, pp. 159-164, 1 pl.; and *Rec. Ind. Mus.*, VII, pp. 309-310) and Paiva (*Rec. Ind. Mus.*, V, pp. 187-190).

Green has seen *Culex vishnui* sucking a syntomid moth (*Spolia Zeylanica*, IV, p. 180).

Paiva records the habits of *Aediomyia squammipenna* (*Rec. Ind. Mus.*, V, p. 202).



Chironomus larva attacking *Hydra*.

Tipulidae.

Conosia irrorata usually sits with the front legs and middle femora stretched forwards, the distal parts of the middle legs bent outwards at a right angle, the hind legs stretched backwards, and the body and wings pointed obliquely upwards. All the legs lie flat on the supporting surface. In this position the fly looks more like a scrap of rubbish caught in a cobweb, than like a fly.

Tabanidae.

Annandale gives an instance of adaptation in the habits of a Tabanid (*Rec. Ind. Mus.*, IX, pp. 245-6).

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[1] This synonymy is based on information sent by Mr. F. W. Edwards to Dr. Annandale.

Asilidae.

Notes on the food of Asilidae are contributed by Bell (*J.B.N.H.S.*, XVII, p. 807) and Annandale (*Mem. A.S.B.*, 1, p. 213) Notes on their oviposition are contributed by Kershaw (*J.B.N.H.S.*, XXI, pp. 610-3, pl. A-B) and Sen (*J.B.N.H.S.*, XXI, pp. 695-7, 1 fig.).

Phoridae.

Apiochaeta ferruginea, a fly capable of reproducing and developing in the alimentary canal of living human beings, is the subject of two papers by Brunetti (*Rec. Ind. Mus.*, VII, pp. 83-86 and 515-6).

Muscidae (*s. lat.*).

Limosina equitans, Collins (*Ent. Mo. Mag.*, 1910, pp. 275-279), was described from specimens found by Fletcher on a living Coprid beetle. See also Green (*Spolia Zeylanica*, IV, p. 183, and VII, p. 107).

Howlett describes the attraction of citronella oil for male specimens of two species of *Dacus* (*Trans. Ent. Soc. London*, 1912, pp. 412-418, pl. xxxix-xl).

A species of *Anthomyia*[1] is recorded by Cotes as parasitic on the eggs of locusts (*Proc. A.S.B.*, June 3, 1891, p. 94; and *J.B.N.H.S.* VI, p. 416).

Attacks of numbers of *Ochromyia jejuna* on a swarm of winged termites are noticed by Nangle (*J.B.N.H.S.*, XVI, p. 747),[2] Green (*Spolia Zeylanica*, III, p. 220 and IV, pp. 183-4) and Poulton (*T Ent. Soc. London*, 1906, pp. 394-6). The observation that this fly has been seen taking away grains of sugar from large ants suggests that it may have been this insect which I several times saw taking the food of big ants in Cochin. On one occasion I saw a specimen flying about with a piece of food attached to its proboscis and a big ant attached to the other side of the piece of food.

Interesting observations on the feeding habits of certain blood-sucking Muscidae are recorded by Patton and Cragg (*Ind. Journ. Med. Res.*, I, pp. 11-25).

HEMIPTERA.

Pentatomidae.

The reaction of a Loris to *Aspongopus singhalanus* suggest that the taste of this bug, though at first startlingly pungent, is distinctly agreeable. The odour of the bug, though also pungent,

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[1] *Anthomyia peshawarensis* (Bigot *nom. nud.*), Cotes, *Ind. Mus. Notes*, III, pp. 34-5—notes and figures but no description.

[2] Concerning the identity of the fly mentioned in this note see *Spolia Zeylanica*, IV, p. 184.

somewhat resembles essence of jargonelle (Green, *Spolia Zeylanica*, I, p. 73).

Canthecona furcellata eats Noctuid, Saturniid and Limacodid larvae (Antram, *J.B.N.H.S.*, XVII, pp. 1024-5).

Kershaw and Kirkaldy contribute biological notes on *Antestia anchorago* (*J.B.N.H.S.*, XIX, pp. 177-8, pl. B), on *Zicrona coerulea* (*t.c.*, pp. 333-6, 2 pl.), and on *Erthesina fullo* (*t.c.*, pp. 571-3, 2 pl., 1 text-fig.).

Concerning *Anasida orientalis*, *Plautia fimbriata*, *Nezara viridula* and *Aspongopus janus* see Mann (*J.B.N.H.S.*, XX, pp. 244-5 and 1166-7, 2 text-figs.).

Concerning *Coptosoma cribraria* see Ramakrishna Aiyar (*J.B.N.H.S.*, XXII, pp. 412-4, 1 pl.).

Coreidae.

Concerning the development and habits of ? *Dalader acuticosta* see Annandale (*Trans. Ent. Soc. London*, 1905, pp. 55-59, pl. viii).

Serinetha augur and *abdominalis* are said to be predaceous (*Indian Insect Life*, pp. 684-5). Green, however, points out (*Trop. Agric.*, Dec. 1909, pp. 482-3) that they suck fruit and seeds, and are preyed upon by a mimetic Pyrrhocorid *Antilochus nigripes*.

Mr. Beeson informs me that *Serinetha augur*, Fabr. is attracted to Kusum oil in October and December in Dehra Dun.

Lygaeidae.

Concerning *Lygaeus equestris* see Paiva (*Rec. Ind. Mus.*, I, p. 174).

Kershaw and Kirkaldy describe the development and habits of *Caenocoris marginatus* (*J.B.N.H.S.*, XVIII, p. 598, pl. figs. 1-7).

Galls formed on *Clerodendron phlomidis* by *Paracopium cingalense* are described by Fischer (*J.B.N.H.S.*, XX, pp. 1169-1170, 4 figs.).

Pyrrhocoridae.

Ipomoea seed is recorded by Paiva as a food of *Lohita grandis* (*Rec. Ind. Mus.*, I, p. 175, 1 fig.).

Kershaw and Kirkaldy describe the development and feeding habits of *Dindymus sanguineus* (*J.B.N.H.S.*, XVIII, pp. 596-7, 4 text-figs., 5 pl. figs.).

Henicocephalidae.

Green's observations on the habits of *Henicocephalus telescopicus* are recorded by Distant (*Fauna of British India*, Rhynchota, II, pp. 194-5).

Henicocephalus basalis lives under bricks with small red ants, on which I believe it to feed.[1] Females, usually winged but

[1] I have never managed to see this species feeding, but on one occasion a wounded ant was introduced unnoticed into a killing tube with one of them, and I have little doubt that it was introduced on the tip of the proboscis, from which it must have fallen off later.

occasionally apterous, do not appear to venture out at all by day, but males are sometimes to be found running about in the evening or early morning near bricks frequented by females.[1]

In Cochin I found a specimen of *Henicocephalus* sp. sucking a termite. The colony from which this termite was taken has been identified for me by Mr. Bainbrigge Fletcher as belonging to the genus *Anoplotermes*.

Reduviidae.

Kinnear gives an instance of blood-sucking propensities in *Nabis capsiformis* (*J.B.N.H.S.*, XIX, pp. 534-5).

Concerning the occurrence of *Conorhinus rubrofasiatus* as a parasite of man see Green (*Spolia Zeylanica*, VII, p. 50).

Harpactor flavus ("*chersonesus*") when on the wing resembles a small bee, *Melipona vidua*, on which it has been seen to feed (*Fasciculi Malayenses*, Zool. II, p. 263).

Millipedes are recorded as the food of *Physorhynchus linnaei* (*Spolia Zeylanica*, III, p. 159 and VII, pp. 55-6) by Mr. E. E. Green, who tells me that, of all the Ceylon millipedes, pill-millipedes appear to be the only ones which are able to withstand the attacks of this bug. I have seen large millepedes killed and eaten by *Physorhynchus* in Ceylon and in Cochin.

Physorhynchus linnaei stridulates by rubbing the tip of its proboscis between its front legs (Green, *Spolia Zeylanica*, VIII, p. 299). I have observed this mode of stridulation in *Conorhinus rubrofasciatus*, *Ectomocoris cordiger*, *Pirates arcuatus*, *Pirates affinis* and *Isyndus pilosipes*.[2] The stridulating organs of *Conorhinus rubrofasciatus* and *Ectomocoris cordiger* are shown on pl. xxiii (figs. 23-24). That of the latter insect, in which the posternum is greatly prolonged between the anterior coxae, is more finely striated and produces a louder sound than that of the former.

A specimen of *Isyndus pilosipes* was found in June, 1914, near Darjeeling, sitting on a leaf with its proboscis inserted into the carcass of a small Elaterid beetle. As I approached with a view to capturing it with its prey, it quickly took fright; but instead of flying away it struck a menacing attitude, and, standing as high as possible on its middle and hind legs, it raised the front legs into a more or less horizontal position, extending them obliquely forwards and outwards; the antennae, which were similarly extended, were rapidly vibrated; and the proboscis, which had been withdrawn from the body of the Elaterid, was brought well into view by being bent downwards to its greatest possible extent.

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[1] Most of my observations on this species were made in Mr. Green's garden at Peradeniya. After I left he noticed that males were much more abundant in the early morning than in the evening.

[2] See also A. Handlirsch "Zur Kenntniss der Stridulationsorgane bei den Rhynchoten. Ein Morphologisch-biologischer Beitrag" (*Ann. K. K. Naturhist. Hofmus. Wien*, XV, 1900, pp. 127-141, 15 text-figs., 1 pl.; and E. A. Butler "Stridulation in British Reduviidae" (*Ent. Mo. Mag.* (2) XXIII, 1912, p. 65).

I gathered the leaf, with the bug still standing in this attitude over its prey, and watched it for some minutes. Occasionally the front legs were lowered for a moment to grasp the edges of the leaf, the posterior end of the insect being on these occasions even further elevated than before, but they were never allowed to remain down long.

Finally I seized the bug by the thorax in order to transfer it to a killing bottle, when it at once set up a faint but distinct squeaking noise, something like that produced by longicorn beetles. The beats of this noise were found to correspond in time to the movements of the proboscis, whose tip was being rubbed vigorously up and down a well marked median longitudinal groove on the prosternum; and the noise was evidently produced by these movements.

Mr. C. A. Paiva tells me that a specimen of *Acanthaspis rama*, which he once found in a fissure of a large tree at Katihar in the Purnea District of Bihar, struck a menacing attitude when he tried to catch it. This species also possesses a stridulating organ between its front legs, and so do many other Indian Reduviids.

The habits of bugs belonging to the genus *Eugubinus* are very peculiar. The genotype (*E. araneus*, Distant [1]) is said to have been "found living in the nest of a spider (*Theridium* sp.)" at Uran near Bombay (Distant, *Fauna of British India*, Rhynchota, II, p. 207). I have found specimens at Ernakulam in Cochin (*E. intrudans*, Distant [1]), and in the Salt Lakes area near Calcutta (*E. reticolus*, Distant [1]). In both cases they were found in webs of *Cyrtophora ciccatrosa*, an Argiopid spider which spins a dome-shaped web. The web of this spider is really a horizontal orb-web pulled out of shape by a supporting framework of numerous irregular strands; it presents an appearance very unlike that of the orb-webs characteristic of other genera of Argiopidae, and superficially very like the irregular webs characteristic of the Theridiidae. Conspicuous web-spinning Theridiidae, though common round about Kandy and in the Cochin Ghats, seem to be comparatively rare in most parts of India, where *Cyrtophora ciccatrosa* is usually abundant; and it may be doubted whether one of the solitary webs of the Theridiidae would supply the bug with sufficient nourishment for development. I am inclined to think therefore, that the web from which the genotype was taken must also have belonged to *Cyrtophora ciccatrosa* and not to a Theridiid.

Eugubinus, like many other bugs of the sub-family Emesinae to which it belongs, is an excessively slender insect. It was originally described as being apterous and having two-jointed tarsi; but these are larval characters. So far as my observations go the adult is always winged and has three-jointed tarsi. It flies well, but does not appear to take flight very readily. When it settles

[1] *Entomologist*, Jan. 1915, pp. 8-9.

on a *Cyrtophora* web, instead of getting entangled it seems quite at home. When, however, it wishes to make its way into the inner parts of the framework, its long legs appear to be much in the way. If it cannot find room to get between the strands in the direction in which it wishes to go, it proceeds to cut some of them with its raptorial front legs; but these seem ill-adapted for the purpose, and progress is often very laborious and slow. Presumably, therefore, the unusual habits of the genus have been somewhat recently acquired.

Cyrtophora ciccatrosa is inclined to be gregarious, and although each spider makes for itself a separate dome, the frameworks of several webs are usually united. Males (which are minute) and young live in small domes in the common framework of the group and each female arranges her pear-shaped egg-cocoons in a string above the centre of her dome.

Eugubinus is often seen making its way towards the string of egg cocoons, and I suspect that their contents form its staple food. A specimen let loose in some webs in the Museum compound was seen more than once, soon after mid-day, with its proboscis inserted into one of the cocoons. This is not, however, the only food that it is able to take; for when I introduced some sweepings from among grass into a cage containing specimens that had had little or no food for several days, they began to investigate even grass seeds, and finally one of them made a meal off a moribund spider (? *Tetragnatha* sp.). Perhaps the ancestors of *Eugubinus* found insects caught in the outer parts of the frame-work of *Cyrtophora* webs an easy prey, and later found their way to the eggs in the interior.

The excessively slender body and legs of *Eugubinus*, and their variegated colour, make the bug somewhat difficult to distinguish among the strands of the webs of *Cyrtophora*, especially as only webs in shady situations seem to be frequented. But this alone seems insufficient to explain why the bug is allowed to destroy the spider's offspring. When specimens were let loose in webs in the Museum compound they shook the webs somewhat as they fell upon them. A spider immediately rushed out to one of the bugs, ran half way along its body, and seemed just about to strike when, instead of the bug writhing in its grasp as I expected, the spider fled back to its dome. I supposed that the bug must have emitted something highly distasteful to the spider; but next morning this very spider was seen making a meal off one of the bugs!

Green records the frequenting of the webs of *Archiopsocus* sp. by *Ploiariola polita*, and believes this Reduviid to be predatory on the Psocids in the webs (*Spolia Zeylanica*, VIII, p. 71).

Cimicidae.

The bat *Scotophilus kuhli* is recorded by Kunhikannan as a host of *Cimex rotundatus* (*J.B.N.H.S.*, XXI, p. 1342).

Cragg describes fertilization in *Cimex* (*Ind. J Med. Res.*, II, pp. 698-705). The spermatozoa are introduced through an aperture on the fourth abdominal segment.

Cicadidae.

In the preface to his "Monograph of Oriental Cicadidae" Distant refers to the natural enemies of the group, and to the voices of the males. Later (p. 1) he gives references "to most of the published information respecting the structural details of the wonderful sound-producing organs" (p. vi). Observations on the production of sound by Indian species have been recorded by Middlemiss (*Nature*, XXXIII, pp. 582-3).

Annandale describes the habits of *Dundubia intemerata* and *Huechys sanguinea* (*Proc. Zool. Soc. London*, 1900, pp. 859-862).

The liquid discharge made by Cicadas is noticed by Biscoe (*J.B.N.H.S.*, X, pp. 535-6).

A captive specimen of *Lemuriana apicalis*, which was recently watched in the Indian Museum, emitted from time to time a jet of colourless liquid with considerable force from its hinder end, while feeding on the sap of a piece of the tree on which it had been caught. The note of this cicada is not unlike that of a cricket, and may frequently be heard in trees round about (and even in) Calcutta during the rains; but this is almost the only specimen I have seen and the only one I have managed to catch.

Huechys sanguinea is sometimes plentiful on *Zizyphus* bushes near Calcutta in the spring. Dr. Annandale tells me that when in the Malay Peninsula he noticed that this cicada frequented bushes rather than big trees.

Dracott describes the emergence of cicadas from their nymphal skins, and the nymphs from the ground (*J.B.N.H.S.*, XXIII, pp. 379-380). His observations were made at Gangtok in Sikkim at an elevation of about 6000 ft. above sea level, on a plot of ground from which large numbers of specimens have been seen to emerge year after year.

Fulgoridae.

Annandale shows that the peculiar prolongation of the head found in certain Fulgoridae is probably of use in jumping (*Proc. Zool. Soc. London*, 1900, pp. 866-868).

Concerning *Salurnis marginellus*, *Geisha distinctissima*, and *Neomelicharia furtiva* see Kershaw, *J.B.N.H.S.*, XXI, pp. 607-9, pl. A-B.

Concerning *Phromnia marginella* see Imms, *Mem. Manchester Lit. Phil. Soc.*, LVIII (4), 12 pp., 2 pl.

Membracidae.

Chatterjee describes the development and habits of *Oxyrhachys tarandus* (*Indian Forester*, XL, pp. 75-79, pl. iii-iv).

Several species of Membracidae are common on a number of different kinds of shrubs. They are usually sluggish insects and slip round the branch on which they are seated when disturbed. Only as a last resort do they jump or fly, although they can do both quite well. The posterior end of the female is armed with two pairs of fine lancets in a protecting sheath. With the aid of these the eggs are laid in rows embedded horizontally in the bark of the twig, from which only one end of each protrudes (pl. xxiii, figs. 16-17). The larvae (pl. xxiii, figs. 20-22) are brown or black, with an eversible reddish appendage at the posterior end of the body (fig. 22). They are commonly more or less gregarious. Even adults (pl. xxiii, figs. 17-19) seem to scatter little if at all when not compelled to do so. Consequently very large numbers are usually found living together on an infected bush. They are generally attended by big black ants (pl. xxiii, fig. 17).

Cercopidae.

The habits of *Machaerota guttigera* have been described by Westwood from notes supplied to him by Mr. S. Green (*Trans. Ent. Soc. London*, 1886, pp. 329-333, pl. viii).

The habits of *M. planitiae*[1], which is common on *Zizyphus jujuba* in Calcutta (pl. xxiii, fig. 13), are very similar. The larva (pl. xxiii, figs. 9-12) always lives head-downwards in its tube, which, though closed at the base, is not entirely shut off from the twig to which it is attached. I have never seen the larva come out to feed, as Westwood supposed that of *M. guttigera* must do; and it is so helpless when removed from its tube that I doubt if it could safely do this. It must, I think, obtain all its nourishment from the supporting twig through the pore at the base of the tube, through which its stylets may sometimes be seen to protrude when the tube is separated from the twig.

As Green watched the commencement of tube-building by some newly-hatched larvae of *M. guttigera*, he felt that "it must be a close fit by the time they are ready to assume the perfect state." The difficulty is overcome by each larva producing two tubes—first a small one, and then a larger one. A separate small tube is always found at the base of each big one (pl. xxiii, fig. 8), I have seen the larva of another tubicolous form, protected only by a frothy fluid, at work commencing the latter at the base of the former.

The habits of another insect, *Hindoloides indicans*, Distant[2], which is common here on *Zizyphus jujuba*, are similar to those of *Machaerota*. I have, however several times watched the emergence of its adult at about sunset. In *Machaerota guttigera*, according to Green, emergence occurs shortly after sunrise, and I think this is probably also the case with *M. planitiae*.

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[1] I am indebted to Mr. Distant for this identification.

[2] *Ann. Mag. Nat. Hist.* (8) xv, pp. 506-507.

The tubes of the *Hindoloides indicans* (pl. xxiii, fig. 14) are easy to distinguish from those of *Machaerota planitiae* by their more wrinkled appearance, and by their form, the free portion being shorter and less straight. This may perhaps account for the curious fact that although adult of *Machaerota* are often much more abundant than those of *Hindoloides*, the reverse is the case with their tubes; for most of these tubes are always found to be old and empty, and presumably the long straight distal portion of the tube of *Machaerota* soon gets broken off.

The larvae of the two genera are much alike; in their later stages they can, however, be distinguished by the size of the developing process of the scutellum (compare figs. 12 and 15, pl. xxiii).

Machaerota planitiae is recorded in "*Indian Insect Life*" (p. 733) from *Zizyphus jujuba* (ber), from *Aegle marmelos* (bael) and from cotton, as well as from "other plants in India." Early in February of this year I found its tubes common at Pusa on ber and on cotton. On the former it was accompanied by tubes of some species of another genus of which I failed to obtain adults. Only *Machaerota* appeared to occur on cotton. I doubt whether any of the tubes found on bael belonged to this genus. As the mixture of genera on *Zizyphus* has been so long unnoticed, it is not unlikely that the genera and species to be found on different plants will prove to be greater than has hitherto been supposed.

Jassidae.

Annandale notes that the phenomenon of "weeping trees" is sometimes due not to Cercopidae, but to Jassidae (*Rec. Ind. Mus.*, III, pp. 293-4). Other families of Homoptera appear also to take part in its production.

Lefroy (*J.B.N.H.S.*, XX, pp. 235-6) notes that the Mango Jassid *Idiocerus* appears only to breed when mango trees shoot freely. In the district where his observations were made this occurred in March only for five years in succession. During the sixth year, however, an exceptionally wet season caused the trees to shoot again in September. "Whether from this reason or not, the *Idiocerus* also bred and one distinct brood was produced at a season when we have never before observed it breed at all." A similar restriction of the breeding season may perhaps account for the freedom of Calcutta during the greater part of the year from the notorious "green-fly" (*Nephotettix bipunctatus* and *apicalis*) which appears every year towards the end of the rains in such myriads that it is often almost impossible to approach a glowing arc-lamp near the open maidan.

Concerning the eggs of *Tettigoniella spectra* see Lefroy, *J.B.N.H.S.*, XX, p. 236.

Aleurodidae.

Peal describes the function of the vasiform orifice of the Aleurodidae (*J.A.S.B.*, LXXII [II], pp. 6-7).

Coccidae.

Imms records the occurrence of *Dactylopius citri* in ants' nests (*Rec. Ind. Mus.*, VI, p. 111).

MYRIAPODA.

The habits of a number of Malay Myriapods are described by Flower (*J. Straits R. Asiatic Soc.* No. 36, 1901, pp. 1-25).

Concerning the food of Scolopendridae see Wells-Cole, Okeden and Cumming (*J.B.N.H.S.*, XII, p. 214; and XV, pp. 135, 1 pl., and 364-5 respectively).

Mr. G. Mackrell tells me that *Ethmostigmus pygomegas* is common on his tea garden in Sylhet just below the surface of the ground. Specimens are sometimes found in earth round the roots of grass growing at the bottom of a bush; but they more often crawl into light soil leaving no visible hole, or in between clods of earth. In captivity they appear to be nocturnal, and to shun light. Their food consists chiefly of worms and small insects, and they seem to be fond of Acridiids and Gryllids.

I have already described the stridulation, apparently to attract attention away from the creature that had cast it, of a detached leg of *Scutigera decipiens* (*J.A.S.B.* [n.s.], IX, pp. 415-6). More recently I noticed a detached leg of a Cochin species moving in the same manner, and on holding it to my ear was able to hear it squeaking. In this case, however, the squeak was much fainter, and was produced by legs which remained *in situ* as well as by others.

The occurrence of purplish-red millipedes in herds is noticed by Cunningham ("*Plagues and Pleasures*", p. 193). I have sometimes seen such herds on the muddy banks of the Havildars' Tanks on the Calcutta maidan, especially, if I remember rightly, in the spring.

Some of the larger species of Indian millipede exude an evil smelling coloured fluid when disturbed. The common big black species in the Cochin Ghats does this, but nevertheless falls an easy prey to its enemy the Reduviid bug *Physorhynchus*. A still larger black species, in which the middle of each segment is girdled with extra thick chitin, and the caudal horn is exceptionally long, emits a particularly virulent fluid which not only smells, but also stains and burns one's hands. This species was only found near the head of a small valley at Kavalai (Cochin Ghats) where, however, it was much commoner than the common form of the district. I regret that I did not also try *Physorhynchus* with it.

Arthrosphaera aurocincta[1], Pocock, a pill-millipede common in the Cochin Ghats—the commonest round Parambikulam at the end of the State Forest Tramway—surprised me by the vibrations which it usually set up when caught. On holding it to the ear a squeaking noise was heard. The noise would, however, have passed unnoticed but for the vibrations which called attention to it. I would have put this forward in support of Arrow's theory (*Fauna of British India*, Lamellicornia, I, p. 14) that the object of stridulation is often not noise, but vibrations that will bring discomfort to an enemy on contact, but that the pill-millipede seems to require no greater protection than its excessively hard carapace. Pillmillipedes, as already pointed out (p. 511), appear to be the only millipedes capable of withstanding the attacks of *Physorhynchus*.' The fact, however, that stridulation always took place when the animal was seized and rolled itself into a ball points to its association with the instinct of defence. I have only noticed stridulation in the one species, although I specially looked out for it in other species found in Cochin. I never heard or felt it in an open specimen; consequently I found it impossible to locate the organ which produced the sound.

ARACHNIDA.

XIPHOSURA.

Notes on the habitat and breeding habits of *Limulus moluccanus* and *L. rotundicauda* are contributed by Annandale (*Rec. Ind. Mus.*, III, pp. 294-5). Sewell (*Rec. Ind. Mus.*, VII, pp. 87-8) records the capture of the former species in a surface townet in water of about 10 fms. depth. See also Flower, *J. Straits R. Asiatic Soc.*, No. 36, July 1901, p. 26.

SCORPIONIDEA.

Parturition in a scorpion is the subject of a note by Dreckman (*J.B.N.H.S.*, III, pp. 137-8, fig. facing p. 69). The species dealt with is incorrectly named, and evidently belongs to the genus *Heterometrus*, perhaps to the species *H. phipsoni*.

Pocock describes the habits in captivity of *Parabuthus capensis* and *Euscorpius carpathicus* (*J.B.N.H.S.*, VIII, pp. 287-294). Neither of these are, however, Indian species.

Newnham (*Nature*, LVI, p. 79; reprinted in *J.B.N.H.S.*, XI, pp. 313-4) records the carrying off of a large flower by *Parabuthus liosoma* one evening at Aden. The scorpion was holding the flower over its back in one of its claws. When camping at the foot of the Ghats in the Ratnagiri District I once saw a scorpion in the same way carry off a piece of white paper that had fallen from the table at which I was working in the open after dark.

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[1] I am indebted to Dr. F. Silvestri for this determination.

The stinging power of scorpions forms the subject of notes by Green, Coomaraswamy and Drieberg (*Spolia Zeylanica*, III, pp. 197 and 215-6, and IV, p. 33).

Concerning the habits of *Archisometrus mucronatus* and other Malaysian species see Flower, *J. Straits R. Asiatic Soc.*, No. 36, July 1901, pp. 30-36.

PEDIPALPI.

Thelyphonidae.

The earliest mention of the habits of Indian Thelyphonidae appears to be by Stoliczka (*J.A.S.B.*, XLII [II], p. 127), who records his own observations and those of Mr. Peal. Peal's observation that "the *Thelyphoni* are generally found underneath the bark of decayed wood in groups, rarely singly" is somewhat surprising. All the specimens presented by him to the Indian Museum are, however, *Uroproctus assamensis*, a species whose habits have rarely come under my observation.

The next reference is by Wood-Mason (*Proc. A.S.B.*, 1882, pp. 59-60).[1] Observations of a similar nature to those made by Stoliczka and Wood-Mason are recorded by Oates (*J.A.S.B.*, LVIII (II), pp. 4-5).

Flower refers to the habits of the Siamese *Thelyphonus schimkewitschi* (*J Straits R. Asiatic Soc.*, No. 36, July 1901, pp. 37-9).

A brief note by Green on the habits of *Thelyphonus sepiaris* will be found in *Spolia Zeylanica*, IV p. 181, and one by myself on those of *Labochirus proboscideus* in *Spolia Zeylanica*, VII, pp. 44-46, fig. B.

A further contribution to the subject is made by Fischer, who describes the courtship dance of *Thelyphonus sepiaris* (*J.B.N.H.S.*, XX, pp. 888-9).

The habits of *Uroproctus assamensis* as observed by Kemp during the Abor Expedition are referred to in my note on the Pedipalpi collected on that Expedition (*Rec. Ind. Mus.*, VIII, p. 127).

I am now able to describe in greater detail the habits of several Indian species of Thelyphonidae. My earliest and most extensive observations were made on *Labochirus proboscideus*, and these will be described first.

Labochirus proboscideus is not uncommon under logs of wood and large stones in the jungles of the Kandy district of Ceylon; but it is only to be found when the ground has been thoroughly

[1] Stoliczka does not refer to the fluid of his Thelyphonids as *inodourous*, as stated by Wood-Mason, but as not having any *offensive* odour. In some species it is violently pungent and resembles acetic acid. In others it is more like essence of jargonelle and, although not very pleasant, is by no means pungent—individual opinions would probably differ as to whether it was offensive or not. In Wood-Mason's specimens the odour was "exactly like that of a highly concentrated essence of pears, but . when deeply inhaled had all the characteristic smell and pungency of strong acetic acid." Compare pp. 509-510, above.

wetted by the rains, or occasionally near water in the dry weather. Thus before the rains I only obtained two or three specimens, and these were all found under stones on moist (but not swampy) ground within a few yards of the Mahawelli Gunga.

Specimens are always found on the ground, never on the under side of their shelter. When first uncovered they usually remain quite still for a time before attempting to hide. Sometimes a burrow is found under the shelter. In this case the *Labochirus* usually sits facing it, and disappears down it as soon as any attempt at capture is made. In other cases any burrow there is must be throughout its length in contact with the shelter.

In dry weather, when *Labochirus proboscideus* is difficult to obtain, it presumably burrows till it reaches soil that it finds comfortably moist and then remains there. If unable to find moisture it dies in a few days; and I found it impossible to keep this species in captivity for any length of time unless the floor of its cage was kept covered with moist soil, when no difficulty was experienced.

Both sexes construct burrows in which to live, digging the soil away with their second pair of appendages. As the excavation deepens they enter it head first, collect some soil between the second appendages, and then back out and deposit it at a little distance from the entrance. The tibial apophyses seem to enable them to carry more soil than would otherwise be possible. Of two very young (probably one year old) specimens kept in captivity one made a U-shaped burrow with one entrance under cover and the other exposed; but I have not been able to recognize any other instance of this being done.

Labochirus appears to be incapable of inflicting any injury on man. When irritated it usually extends its pedipalps to their fullest extent, and would no doubt use them in defence against a sufficiently small opponent; but it is a nervous creature and prefers retreat. It will not attack even a defenceless cockroach if it is very large, but will gladly kill and eat small ones.

The stink-glands are no doubt of service in self-defence. On two occasions I have seen the fluid ejected as a small cloud, but this is rare; one of the specimens noticed was a female, the other was almost certainly a male but escaped capture. According to Wood-Mason (*Proc. A.S B.*, 1882, p. 60) the stink-glands are larger in female Thelyphonids than in males. The apertures of these glands are easily seen on each side of the medially situated caudal appendage (dorsal) and anus (ventral). If some object is placed near these appertures when the creature is irritated the drop of fluid ejected will be found upon it. It has "all the characteristic smell and pungency of strong acetic acid", but in this species I have never noticed any odour "like that of a highly concentrated essence of pears" (Wood-Mason, *l.c.*).

It is almost impossible to observe the feeding habits of these nocturnal animals in their natural haunts; and even in captivity they are very shy of any light that may be brought to bear upon

them when they have emerged from their hiding-places in search of food. What their usual food is, and how often they get it under natural conditions I am unable to say. In captivity they appear to feed as often as suitable food is given, suitable food being winged termites, small locustids, blattids, etc., especially when these are disabled. But of larger insects and of very active ones they are easily frightened. A disabled locustid will be snatched at eagerly if held in front of a specimen ; when however, it is presented alive and kicking *Labochirus* will extend the second pair of appendages as if to seize it, but in reality as a menace, and will then back away.

Food is seized between the second appendages and held between them and the head. In the male of this species little or no use is made of the chelae, though at times the long movable finger may be embedded in the prey and bent over so as almost to meet the tibial apophysis. The very long gnathobases of the second appendages appear to be of some use in supporting the food above the ground and keeping it in the neighbourhood of the mouth. In the female the second appendages are much shorter and stouter than in the male, and the form of the tibial apophysis renders it scarcely possible that the movable finger of the chela should be brought into apposition to it ; the gnathobase is also very much shorter. How far these structural differences affect the mode of feeding I am unable to say, as the only female kept in captivity, was, I believe, damaged when caught, and died after a few days without having taken any food.

Concerning the part played by the chelicerae in feeding I am also unable to say anything, as they were always obscured by the anterior end of the carapace and by the food itself; presumably they are used much as in *Phrynichus* (see below). Another function of the chelicerae was, however, repeatedly seen, namely the use of the brushes with which they are provided for cleaning the terminal joints of the legs Hansen (*Arkiv för Zool.*, II [8], p. 8) says " The function of such hairs, blood hairs ', is no doubt to intercept the blood of the prey when this has been cut to pieces." Doubtless they function to some extent in this way, but their use for cleansing purposes is manifested every time a specimen gets its feet a little soiled.

In *Labochirus*, and probably in all the Thelyphonidae, the antenniform legs are ordinarily held directed forwards and usually somewhat outwards in an arched posture. As the animal moves along they are lowered from time to time till the tip comes in contact with the ground, and then raised again, but the two are lowered alternately, not simultaneously.

I found it very difficult to determine whether these creatures drink water, as so many Arachnids do. I believe, however, that they do so, and on one occasion I saw a specimen apply its mouth to water placed in its cage on a leaf, although it refused to take any notice of this until a lamp that was near had been removed. I could not see whether any sucking movements were set up or not.

With regard to the breeding habits of this species my information is of the scantiest, but I believe, from the evidence of dissections, that the time for egg-laying was rapidly approaching when I left Ceylon in August. The young appear to attain a length of about 1 cm. (exclusive of the tail) during the summer after they are hatched, and to take two years more to come to maturity; but the evidence for this is not so extensive as in the case of *Charinides* and *Phrynichus* (see below, pp. 531-532).

It was not until August[1] of last year that I saw the courtship "dance" of a whip-scorpion. The specimens concerned were a pair of *Thelyphonus sepiaris* which I caught in Orissa and brought back with several others alive to Calcutta. Their positions, when I first noticed what was going on, were those described by Fischer (*J.B.N.H.S.*, XX, pp. 888-9). They are shown in pl. xxiv, fig. 25. The left antenniform leg of the female was crossed above the right, and about three joints of the tarsus of each of these legs were left exposed by the chelicerae of the male. The pair walked slowly round the cage in which they were confined, the male going backwards and the female following him. Once or twice they passed an unattached male, when the mated male left go his hold of the antenniform leg of the female on the side next the possible rival and seemed to prepare for defence. But none was needed.

Soon this type of "dance" ceased, the female raised her abdomen in the air, and the male commenced stroking her genital segment with his antenniform legs. These legs usually passed between the third and fourth legs of the female but sometimes behind the fourth; their tips were usually crossed, the right being above the left as a rule. The chelae of the male were held open and were kept slightly moving over the dorsal surface of the abdomen (pl. xxiv, fig. 26).

I expected this to lead up to the culminating action. But the female was a small one, and her genital segment was not fully developed. Probably she was immature. For this reason, perhaps, the first type of "dance" was soon resumed and continued till I went to bed. It was in progress at about 7 A.M. next day, but ceased soon afterwards. Next night it was repeated. After that the female died.

Thelyphonus sepiaris is much better able to withstand draught than is *Labochirus proboscideus*. It lives in much drier situations, and will live in a dry cage without water for several weeks at least, without apparent discomfort. It seems, too, to be of a somewhat less timid disposition. Green (*Spolia Zeylanica*, IV, p. 181) says that it emits an odour resembling strong acetic acid. The defensive odours of the Thelyphonids I have met with vary in character from this to something closely resembling essence of

[1] Mr. Fischer informs me that his observations (see above, p. 519) were made after dusk in June. Rain had fallen and brought out the Thelyphonids, which climbed about his tent. The dance took place on his writing table in the tent.

jargonelle, and I regret that I have not made notes of the scents of the various species.

Mr. H. N. Ridley has sent me several specimens of *Thelyphonus linganus*. He compares their defensive odour to that of chlorine gas, and says he knows of no other animal able to emit so widely diffused and powerful an odour for its size. This species eats crickets, woodlice, etc., and Mr. Ridley once found a specimen eating a cricket in the day-time, though usually the species is nocturnal. The modification of one or more of the sixth to eighth tarsal joints of the antenniform legs of the female of this and allied species of *Thelyphonus* is perhaps due to the development of special organs for use during courtship; for it is at about this point that these appendages are held in the chelicerae of the male during that process in the only species of *Thelyphonus* in which it has been described.

The odour emitted by *Uroproctus assamensis* resembles essence of jargonelle. This species lives in a damp region, and does not seem able to withstand drought in the way that *Thelyphonus sepiaris* can.

Mr. G. Mackrell tells me that *Hypoctonus oatesi* exudes a fluid smelling like acetic or formic acid, though perhaps a little more pungent. It inhabits country where stones are not to be found, living in the banks of roads and cuttings and in the vacated burrows of ants. In June specimens usually have to be dug out from a depth of about 18 inches, but in August they are often found at the entrance of their holes. On one occasion two females were found in a nest swarming with ants. Both had young clinging to their abdomens.

I have found several species of *Hypoctonus* under stones in Burma. I have not been able to study their habits in captivity, but there seems every reason to believe that they are very like those of *Labochirus proboscideus* and *Thelyphonus sepiaris*.

I do not think any of the Thelyphonids I have studied can be luminous as suggested by Sorensen (*Ent. Med.* 1894, pp. 175-177); and I can hardly believe that the sting described by Flower (*Journ. Straits R. Asiatic Soc.*, July 1907, pp. 38-39) was really due to the *Thelyphonus schimkewitchi* that he was handling when he received it. I have handled other species frequently without receiving any harm.

Schizomidae (Tartarides).

The only species which I have myself found in any abundance are *Schizomus* (*s. str.*) *crassicaudatus*, *S.* (*Trithyreus*) *peradeniyensis*, and *S.* (*T.*) *vittatus*, all from Ceylon, and it is only to these that the following account refers.[1] The Calcutta form—*S.* (*T.*) *lunatus*—I have found under bricks on somewhat moist stiff clay; and so

[1] A preliminary note on the habits of these species appeared in *Spolia Zeylanica*, VII, p. 46, fig. C. Nothing else beyond a brief note on a species from caves near Moulmein (*J.A.S.B.* [n s.], IX, p. 417) appears to have been written about the habits of Indian species.

far as I know its habits are much the same as those of the Ceylon species.

Schizomus crassicaudatus was only found under bricks, etc., on or close to open ground (usually grassy lawns) more or less shaded by trees, while the other two Ceylonese species named were found only among dead leaves, especially where these formed a layer of considerable depth and were matted together by fungal hyphae, in the midst of the shrubberies in the Peradeniya Botanical Gardens. *Schizomus crassicaudatus* was never found in company with the other two.

The ground was more or less moist, especially in the shrubberies, during almost the whole time I was at Peradeniya; but shortly before the break of the rains I found specimens (probably *Schizomus crassicaudatus*) on a very dry slope a few yards away from a little stream. A specimen of *S. peradeniyensis* subsequently lived in a corked tube in Calcutta without food or water for about three months. When a drop of water was placed near it by means of a fine pipette the soil was so dry that it was some time before the water began to be absorbed, but the *Schizomus*, after examining it carefully with the mobile tips of its antenniform legs, took no further notice, and made no attempt to drink.

I have only once seen a Tartarid take food. On this occasion a minute white centipede (*Scutigerella*) was seized by the second pair of appendages in much the same way as a fly is seized by the chelicerae of a spider. When secured it was carried off into a burrow to be eaten.

On one occasion I put two specimens (both female) of *S. peradeniyensis* in a tube partly filled with soil, and two of *S. vittatus* in another. Before very long the individuals of both pairs were found to be facing each other, their antenniform legs extended obliquely forwards, those of the one crossing those of the other. This futile hostility continued for several hours, after which the specimens were separated. Apparently neither dared either to attack the other from in front, or to leave her rear unguarded for a moment. When, however, a larger number of specimens are similarly confined, but on the slippery glass bottom of a tube without any soil, they frequently become panic-stricken and then attack each other in the same way as they attack their natural prey. But even a large number of specimens may safely be collected together in a tube when loose soil is provided for them to run about on.

When touched from in front *Schizomus* usually tries to escape by giving a sudden jump backwards. The stink-glands are no doubt used for defence; and when a number of specimens are caught and put together in a tube they may be observed to emit a distinct odour of acetic acid.

The chelicerae and second pair of appendages, besides being used for offensive and defensive purposes, are used for cleaning the feet; and the form of the second appendages allows them to

be used simultaneously with the chelicerae for rubbing the feet, and not only for holding them in position.

A specimen of each of the three Ceylon species was kept alive by itself in a separate tube about one-third full of carefully packed soil. Each made two or three burrows before very long; but they rarely entered any of them even by day, and when disturbed they never seemed to know where to find them though the whole diameter of the tubes was little more than two centimetres. It is therefore rather difficult to believe that these burrows are used as permanent homes, and this is borne out by the following facts concerning the habits of *Schizomus crassicaudatus* in the open.

Whenever a specimen of this species was discovered by the removal of the brick under which it had been hiding, it would dart spasmodically about looking for somewhere to hide again, with no more idea than one of the captive specimens just mentioned as to where to find a suitable hole; and the hole into which it finally disappeared seemed to me to be as a rule a wormtrack or something of that kind. Further, it is apparently possible to go on collecting specimens from under one brick two or three times a week for an indefinite period, each time removing every specimen found; which seems to prove conclusively that they can have no fixed abode, but wander about from place to place among the roots of the grass not far from which they are always found.

In the case of the shrubbery forms which occurred in extensive layers of dead leaves it was impossible for such observations to be made; but if these species habitually lived in burrows it is difficult to understand why they were most abundant among the leaves and not in the soil below them; and why a specimen in captivity entirely without cover very rarely entered any of the two or three burrows that it made.

Of what use, except for reproductive purposes, the burrows can be it is difficult to see; but of the three specimens which made burrows in captivity only one—*Schizomus crassicaudatus*—produced eggs. This one constructed a little cavity against the side of the glass tube in which it was confined, at a depth of about 15 mm. below the surface of the soil (pl. xxiv, fig. 27). As far as I could see this nest had no opening, and the *Schizomus* never left it to my knowledge till the eggs disappeared. It was lined with soil cemented together in some way; when this lining was shaken free from the glass (to which it was similarly cemented) the damage was quickly repaired; but unfortunately I never saw this being done. The eggs were seven in number, subspherical (flattened at the poles), of a glistening white colour, and were neither tightly pressed together nor enclosed in a brood-pouch of any kind. They were arranged so that one of them was above and one below the centre of a ring composed of the five others; the general shape of the mass as a whole was approximately spherical, and it appeared to be attached to the abdomen only in the region of the genital aperture. The abdomen was carried at an angle to the rest of the body as shown in the figure. As a rule the creature

rested on one of the sides of the nest with the thorax vertical and the abdomen horizontal, but it was impossible to see it sufficiently clearly in that position for it to be drawn. The nest and eggs were first noticed on Sept. 12, about three weeks after the creature's arrival in Calcutta, but they may have been produced a few days earlier; no changes were seen to take place in them, and eventually they disappeared and the mother left her nest. The mother had been captured and placed by herself in a tube at Peradeniya on August 14.

Tarantulidae.

The habits of the cavernicolous Charontinae, *Stygophrynus cavernicola*, *S. cerberus*, and *Catagius pusillus*, have been described by Annandale and myself (*J.A.S.B.* [n.s.], IX, pp. 417-420).

A small species of Charontinae, *Charinides bengalensis*, is common in Calcutta. I have been able to study its habits in greater detail than those of the cavernicolous species. They closely resemble those of the Ceylonese species of *Phrynichus* on which a preliminary note has already appeared (*Spolia Zeylanica*, VII, pp. 43-4, fig. A) and also those of *Phrynichus nigrimanus* [1], a species not uncommon in the Eastern Ghats. The habits of all of these may now be considered together, the few differences between them being noticed as occasion arises. There is no reason to suppose that the habits of cavernicolous species differ in any essential points from those of these species, apart from the fact that *Stygophrynus* does not habitually live under stones or logs of wood, but on the walls of caves.

All species that I have observed [2], except those of the genus *Stygophrynus*, live in crevices among bricks or stones, or under logs of wood, where there is room for them to move about freely. They are almost always found on the under side of the object beneath which they hide. *Charinides*, and doubtless other Charontinae also, having pulvilli on its feet, can walk up a vertical piece of polished glass, or even across its lower surface; but *Phrynichus*, which has no pulvilli, cannot do this. It is unlikely that any Tarantulids can burrow; and a specimen of *Phrynichus ceylonicus* that was brought to me after being dug out of a hole it had been seen to enter, can hardly have made the burrow for itself.

Phrynichus ceylonicus, *s. str.*, appears to be a regular inhabitant of bungalows; but its variety *pusillus* and *Charinides bengalensis* seem to visit them rarely, and it is very doubtful, on account of the inability of these species to live in the absence of moisture,

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[1] This and other species of *Phrynichus* have been provisionally grouped by Kraepelin under the one name *P. reniformis*, Linn. See *Rec. Ind. Mus.*, XI, pp. 447-448.

[2] Mr. Ridley informs me that *Sarax singapurae* is found under bricks and among dead leaves; he thinks the latter form its usual home. When specimens are collected from under the bricks, others quickly take their places.

whether they ever make them a permanent abode.[1] That *P. ceylonicus*, *s. str.*, does this there can, I think, be no doubt. The first specimen I saw alive was found in Mr. Green's workshop after dark; it was sitting on the wall close to a large bookcase behind which it retreated as soon as I attempted to catch it. It must have been several days at least since it first came there, for a cast skin, which from its size appeared to have belonged to it, was found close by upon the wall, with cobwebs attached to it; and the animal itself had already become thoroughly hard and dry. On the following night the specimen (I have no doubt it was the same) was found again in the same place and captured; it lived healthily in a bare breeding cage for over two months, when I preserved it prior to leaving Ceylon. These striking creatures are also well known to residents in the island who frequently mention some particular room as one in which a specimen is often seen.

The difference between *Phrynichus ceylonicus* and its variety *pusillus* in their ability to stand dryness is very marked.[2] The former will live healthily for at least a fortnight, and usually longer, in a bare cage with a wooden base and frame, glass sides and a perforated zinc top, whereas the latter always dies in a few days if not supplied with constantly moist soil. *P. ceylonicus*, variety *pusillus*, appears to be confined to the moist jungles of the lower hills of Ceylon. *P. ceylonicus, s. str.*, on the other hand, seems to be most abundant in places where climate or a porous soil produce drier conditions. On the only occasion on which I was able to test the capacity of *P. ceylonicus*, variety *gracillibrachiatus*, one specimen of this form and one of variety *pusillus* were put into a bare cage in which two specimens of *P. ceylonicus*, *s. str.*, were living, after giving them ample opportunity of satisfying their thirst. Variety *pusillus* was found dead next evening and variety *gracillibrachiatus* on the following evening.

It may be noted here that *P. ceylonicus*, variety *pusillus*, besides requiring damper surroundings than *P. ceylonicus*, *s. str.*, appears to be a much more thirsty animal; and I am inclined to think that small specimens of the latter are of a more thirsty disposition than old ones, though the evidence for this needs amplification.

Charinides bengalensis also requires a certain amount of moisture in its surroundings, and no doubt it is on this account that it always choses for its abode some pile of bricks in a sheltered place where the ground is moistened nightly in the dry cold weather of Calcutta by a heavy dew.

Tarantulids, like other Pedipalpi, are nocturual feeders; by day they hide themselves away. When one is exposed by turning over its shelter, it crouches flat down, and when eventually it darts suddenly away it rarely tries to escape to other stones, how-

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[1] I have no evidence on this point with regard to *P. nigrimanus* and other species.

[2] *P. nigrimanus* probably resembles *P. ceylonicus* in this respect, but the evidence is somewhat conflicting.

ever good the cover they may offer. I have several times chased a specimen of *P. ceylonicus*, variety *pusillus*, round and round a stone in this way for some minutes before being able to catch it, when the stone was resting on a mass of others among which the creature could have got away with the greatest ease, had it thought of doing so. *P. ceylonicus, s. str.*, and *Charinides bengalensis* appear to be equally prejudiced in this respect.

When caught, even the large *P. ceylonicus* is apparently quite incapable of inflicting any injury. All species of *Phrynichus* are, however, able to give a distinct (but painless) nip between the terminal finger of the second appendages and the distal spines of the tibia, and when caught are apt to claw viciously at one's hands as often as they get the chance.

No stink-glands are known in Tarantulids, and I have never noticed any particular smell associated with them.

What Tarantulids live upon when left to find their own food I cannot say; but in captivity cockroaches, crickets, and sometimes a green locustid will be taken by *Phrynichus*. *P. ceylonicus, s. str.*, naturally manages larger specimens than *P. ceylonicus*, variety *pusillus*, can do. I believe that *Charinus bengalensis* will take very small cockroaches (? and woodlice) and have seen it eat swarming termites that have shed their wings. Tarantulids are extremely nervous beasts and winged termites are far too active for them. A specimen of *P. ceylonicus, s. str.*, became pitifully panic-stricken when one or two of these were placed in its cage, raising itself upon its legs with a start every time a termite touched it.

The following account, based on a particular instance, will serve to show how Tarantulids obtain their food.

A recently captured *Phrynichus* was sitting under a tile where it had been hiding all day, when it became aware of a wingless cockroach (*Dorylaea rhombifolia*) engaged in feeding upon a lump of bread in one corner of the cage. The *Phrynichus* left its retreat and cautiously approached to within a short distance of the cockroach when, after extending both arms, it made a sudden grab; but only the bread was secured, and this was not appreciated. For a few moments the *Phrynichus* waited in a defiant attitude, slightly raised upon its long legs, with its arms partially extended then it subsided flat on the ground again. In the meantime the scared cockroach had retreated into another corner of the cage, where it was soon followed by the *Phrynichus* which made another grab at it. This time it was caught and brought within reach of the chelicerae, with the assistance of which it was finally demolished. Another cockroach was killed and partly eaten later on during the same night, after which the *Phrynichus* fasted for six days, when it ate another cockroach. This fast of several days after each meal appears to be the normal habit of all the species of *Phrynichus* I have studied; and the remarkable eagerness which newly caught specimens always show for food leads me to believe that in the wild state they are rarely able to secure as much food as they would like. This suggestion is further supported by the

difficulty which they always seem to experience in the capture of active prey.

It is very difficult to observe the method of capture on account of the rapidity of this action; but repeated observations have convinced me that although both arms are shot forwards in any attempt to sieze the prey, the actual capture is usually between the terminal claw and the spines near the end of the second appendage of one side only. As will be seen on reference to fig. 28 (pl. xxiv) these spines are so arranged as to form a very effective hand, the terminal claw being apposable to the proximal of the two long dorsal spines at the distal end of the tibia, and the spine on the penultimate joint to the distal of these. As the claw and all three spines are rigid and sharply pointed it would be not unnatural to suppose that when grasping the prey they enter its body in such a way as to render its escape quite impossible. As a matter of fact, however, the strength necessary for this is apparently absent, and I have seen even a soft-bodied cricket unsuccessfully attacked time after time as its movements brought it within reach of a *Phrynichus*; and although once or twice it appeared to have been secured by one hand the other was never used to assist in holding it, with the result that it escaped before it could be brought within reach of the chelicerae.

Once within reach of these appendages, however, all chance of escape disappears. The prey, which remains alive for a time, is held between the two hands, often with the terminal finger embedded in its tissues, whilst parts of it are scooped into the region of the mouth by the terminal joint of the chelicerae, the sharp saw-like armature of their under surface perhaps being of use in severing pieces of a suitable size from the main mass. When such a piece had been secured by the chelicerae it is thoroughly masticated by vertical, combined with slight longitudinal, movements of these appendages, which rub it against each other and against the gnathobases of the second appendages. As the terminal joint is apparently kept closed except when required to scoop in a fresh piece of the edible material it is difficult to see any use to which the double row of teeth on the basal joint can be put. The long anteriorly projecting sternal spine no doubt assists in keeping the food from falling to the ground when it passes into the immediate neighbourhood of the mouth.

I have only once seen *Charinides* feed. Unlike *Phrynichus* it captured its prey between the two second appendages, not in one hand, the terminal claw and the spines of the hand and finger being unable to close against the spines at the end of the tibia (pl. xxiv, fig. 29). The terminal claw pressed into the body of the prey, probably penetrating the tissues, and other spines appeared to help to some extent. The capture was extremely sudden, and the details were only seen by repeatedly removing the captured prey until the *Charinides* became nervous, and acted more slowly.

It has already been mentioned that *Phrynichus ceylonicus*, variety *pusillus*, is a much more thirsty animal than *P. ceylonicus*, *s. str.* When thirsty, however, specimens of both species behave much alike if water is sprinkled into their cage. As long as small drops only are met with these are caught up between the spines of the hand, whose arrangement, when the hand is closed, is admirably adapted for this purpose. The drop is conveyed by the hand to the chelicerae which suck it off with movements like those of mastication. When, however, a small pool is found on a leaf or other receptacle the chelicerae are inserted directly into this and with the same movements proceed to suck it up. Once when I attempted to give water to a specimen of *P. ceylonicus*, variety *pusillus*, which did not want it, a drop that had been placed on the chelicerae was drawn off into one of its hands, and flung aside by a sudden movement of the arm. I have not seen *Charinides* drinking.

The brushing up of the other appendages by the chelicerae may often be seen in all species. I am inclined to think that this is sometimes done chiefly for the sake of the moisture upon them, small though this must be; at least the evident relish with which it is sometimes done after water has been sprinkled about, and before the creature has found any separate drops, emphatically suggests this. When the feet have to be brushed they are supported in position by the hands. The great care which is taken to keep the tips of all the appendages free from dirt is very striking. In the case of the second appendages this is probably due to the presence on the two terminal segments of an elaborate system of spines, clubbed hairs and pits, which may perhaps constitute an organ of taste or smell, functioning as a test of the suitability for food of anything that is captured. In the case of the feet it is probably necessary for the pulvillus in *Charinides*, and the pulvillus-like pad in *Phrynichus*, as well as the claws, to be kept perfectly clean if they are to be used effectively; and it is not unlikely that tactile organs may be concentrated in this region.

That the antenniform legs should be kept clean, not only at the tip (as are the other appendages), but also throughout a considerable part of their length, is clearly necessary on account of their great service to the animal as feelers. When *Phrynichus* moves sideways (at it usually does) these legs are extended outwards, their mobile extremities feeling cautiously about in all directions; when it moves forwards they are extended forwards somewhat as in the Thelyphonidae; and I have seen them, too, when the animal was at rest, extended straight outwards and then slowly rotated, the one forwards and the other backwards, so as to sweep as large an area as possible round the body. When undisturbed their position is rarely very different from that shown in *Spolia Zeylanica*, VII, p. 43, fig. A.

To what extent the sense of vision has been replaced in these creatures by senses localized in the anteniform legs I am unable to state with certainty. When a specimen is first found and

exposed to light by turning over the stone on which it is resting, instead of at once trying to escape it crouches close down upon the stone as already noted, and remains motionless for a time, no doubt trusting to its inconspicuousness when in this position for safety. When eventually it darts round to the under side of the stone this may be due to its preference for an inverted position and not necessarily to its dislike of light. A touch from a foreign body upon the antenniform legs or other part of the animal instantly puts it to flight. That *Phrynichus* is sensitive to light, however, becomes inconveniently evident as soon as one attempts to study its habits; and I am inclined to believe that its sight is of use in seeking for prey, though I have not been able to apply any conclusive test of this.

All Indian and Ceylonese species probably breed at about the same time of year.[1] I first found egg-laden females of *P. ceylonicus*, variety *pusillus*, on July 20th at Peradeniya, but the eggs were all well advanced in development. This was also the case with similar specimens of variety *gracillibrachiatus* found at Nalanda a week later. The embryos are carried under the abdomen, where they are supported by a membrane secreted for the purpose. All egg-laden specimens kept in captivity died before the young were hatched, but it is probable that the maternal habits closely resemble those of *Charinides*, which are described below. The number of eggs carried by a female *Phrynichus* appears to be about fifteen for *P. ceylonicus* variety *pusillus*, about 40 for variety *gracillibrachiatus* and about 60 for *P. ceylonicus*, s. *str.*

Charinides bengalensis breeds in July and August, and sometimes earlier. A specimen in captivity produced eggs on June 26. An egg-laden female, caught on Aug. 29 and kept in captivity, hatched its young on Sept. 23. These were six in number. Before the evening of the day on which they appeared all of them had freed their appendages and climbed on to the dorsal surface and sides of the abdomen of the mother; they were entirely white, though their bodies became faintly darker next day, and their second appendages lacked the characteristic spines of the adult. Two or three eggs which failed to hatch remained for a time attached to the abdomen of the mother as before. On the night of Sept. 27-8 all six of the young ones cast their skins; they then assumed a distinctly greenish colour, and the characteristic spiny armature of the second appendages appeared. The young and their cast skins remained upon the mother during that day, but by the next morning the former had wandered away by themselves, and the latter had disappeared.

Immediately after the first moult the carapace is a little over 1 mm. in width. From a series of over twenty specimens

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[1] *P. nigrimanus* appears to breed somewhat later than some others. I failed to find any ovigerous females at Barkul in Orissa when I went to look for them at the beginning of August, and saw no young ones likely to have been newly hatched.

collected one evening in September, it appears that during the first year its width increases to about 2 mm., during the second year to about 2 5 mm., and during the third to about 3 mm. At this period the arms of the male assume their distinctive length, and maturity is probably reached. Whether large specimens reach their maximum size at the same time, or whether this maximum (about 3·5 mm. thorax-breadth) is only reached subsequently, I am unable to say.

In *Phrynichus ceylonicus*, variety *pusillus*, and probably in other Phrynichinae also, the period of growth appears to be about the same; but the difference between the one-year-old specimens (thorax-width about 4 mm.), which are of a chequered green and yellow colour with conspicuously banded legs, and the much larger two-year-olds (thorax-width 7-8 mm. as a rule), of darker and more uniform colour, is very much more marked than between these and the adults, which as a rule are very little larger than them.

SOLIFUGAE.

C. E. C. Fischer contributes some notes on the habits of *Galeodes indicus* to the *Journal of the Bombay Natural History Society* (XX, pp. 886-7).

ARANEAE.[1]

Miscellaneous.

An instance of an apparently unprovoked assault by a spider on man is given by Cunningham (" *Plagues and Pleaures* ", p. 209). The spider was dislodged with difficulty, but no after effects of the bite are recorded.

A spider's web suspended from a beam, and apparently kept taut only by the weight of a stone over four feet from the ground, is recorded by Sawrey-Cookson (*J Sarawak Mus.*, I, p. 123).

Avicularíidae.[2]

Wood-Mason's account of the discovery of stridulating organs in a member of this family—*Chilobrachys* (" *Mygale* ") *stridulans*—is recorded in the *Proceedings of the Asiatic Society of Bengal* for 1875 (p. 197). It has been reprinted in the *Annals and Magazine of Natural History* ([4] XVII, p. 96). A more detailed account is to be found in the *Transactions of the Entomological Society of London* (1877, pp. 281-2, pl. vii). In view of the fact that the stridulating organs of *C. fumosus* appear to be of a more primitive type than those of *C. stridulans* (*J.A.S.B.* [n.s.] X, pp. 416-417, pl. xxi, figs. 5-6) I noticed with interest when at Kalimpong that,

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[1] See also Workman, " *Malaysian Spiders* " (Belfast, 1896).

[2] Theraphosidae, Pocock, *Fauna of British India*, Arachnida. I have followed Simon's classification and nomenclature (*Histoire Naturelle des Araignées*, I and II, Paris 1892 and 1897) on account of its completeness.

although the former species behaves like the latter when angry, it can only produce a faint rattling sound. The latter is said by Wood-Mason to hiss loudly.

Notes on the habits of large " bird-eating " spiders, doubtless of this family, are contributed by Macpherson and by Morris (*J.B.N.H.S.* I, pp. 28-29, and IV, pp. 69-70). In both cases the species is identified as " *Mygale* " *fasciata*, a name now confined to a Ceylonese species of *Poecilotheria*. The subjects of the former note lived in burrows, so probably belonged to the genus *Chilobrachys*. The genus of the subjects of the latter note may possibly have been *Poecilotheria*, but the species was an Indian one.

Pocock (*J.B.N.H.S.* XIII, pp. 121-2) discusses notes on the habits of " bird-eating " spiders, and records observations showing that the genus *Poecilotheria* is arboreal. Annandale (*Mem. A.S.B.* I, p. 216) states that *P. striata* is apparently not uncommon on *Acacia arabica* near Pamben. Flower refers to the habits of the Malaysian *Coremiocnemis cunicularius* (*J Straits R. Asiatic Soc.* No. 36, July 1901, p. 42).

Walsh notices the habits of a trapdoor spider from Orissa, which he describes as *Adelonychia nigrostriata* (*J.A.S B.* LIX [II], pp. 269-270). Specimens which he sent to O. P. Cambridge were described by the latter at about the same time under the name *Diplothele walshi*, by which the species is now generally known.

The nests of *Sason cinctipes* were pointed out to me at Peradeniya by Mr. Green. They are constructed on flat moss-covered rocks and walls, and are roofed in by two rounded flaps of equal size, hinged together to form a single 8-shaped structure, and attached to the lower part of the nest at either end of the hinge. These flaps are covered with fragments of moss, etc. and are flush with the moss growing round about them. Consequently they are very hard to see. The spider sits beneath them, and can get out by raising either of them.

All species with which I am acquainted belonging to the subfamily Ischnocoleae live under stones and logs of wood. They do not appear to make burrows.

Cyriopagus (" *Melopoeus* ") *minax* [1] lives in silk-lined burrows which are not closed by a door of any kind.

Uloboridae.

Most of the Indian Uloboridae known to me live in groups, often in association with a web spinning spider of some other family. In Cochin I found a nest of the common gregarious spider, *Stegodyphus sarasinorum*, with the orb-webs of a small Uloborid spread around it. When disturbed the Uloborids retreated in among the *Stegodyphi*. I gathered the branch and destroyed most of the Uloborid webs in so doing ; but the spiders

[1] Concerning the generic name of this spider see *Rec. Ind. Mus.* XI, p. 281.

came out during the night and made fresh ones, in the centres of which they remained so long as they were not disturbed.

Uloborid webs were several times seen grouped round the web of *Psechrus alticeps* in Cochin. One species seems to be definitely associated with *Cyrtophora ciccatrosa* in the Indian Museum compound, though I never saw it here till towards the end of last year. A somewhat larger species lives in groups of orb-webs in the Museum compound, but does not appear to be specially associated with any other spider. This species, and perhaps one other of similar habits, occurs also at Pusa, where Uloborids are found in association with *Nilus* sp., *Gasteracantha brevispina*, and *Cyrtophora ciccatrosa*. Another species found at Pusa spins solitary orb-webs over slight depressions on the sunny side of the trunks of smooth-barked trees.

One Uloborid found singly in Cochin spins two horizontal orb-webs, one above the other. The upper web is flat and finely spun, with a meshed hub on the under side of which the spider rests. The lower web is funnel-shaped with open hub, and is of coarser build.

Psechridae.

Psechrus ? singaporensis has been found in the Batu Caves, Selangor, out of reach of daylight (Flower, *J Straits R. Asiatic Soc.* No. 36, July, 1901, p. 45).

Psechrus alticeps spins a large irregular web not unlike that of a Theridiid. One end of this web is always in contact with a tree-trunk, stone or bank of earth, to which the spider escapes with extraordinary rapidity when disturbed. The species is very common in the Cochin timber forests, but very difficult to catch.

A species of *Psechrus*, common at Pashok and Kalimpong in the Darjeeling District (*ca.* 4000 ft.), constructs a large and coarsely spun tunnel, the upper part of which spreads out to form a somewhat extensive roof-like snare—something like a *Pardosa* web (see below) inverted, but coarser in every way. The structure of the snare resembles that of the snare of *Stegodyphus* described below. I have not been able to examine a fresh snare in detail, but a microscopic examination of an old one showed that the silk was also very like that of *Stegodyphus* both in structure and in variety.

Eresidae.

The genus *Stegodyphus* is represented in India by several species; but only one, *S. sarasinorum*, seems to be abundant. The abundant and widely distributed form whose habits are described by Jambunathan (*Smithsonian Misc. Coll.* XLVII, pp. 365-372, pl. L.[1]) must presumably therefore have belonged to this species, on the habits of which Fischer has since contributed a few notes (*J.B.N.H.S.* XVIII, pp. 206-7).

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[1] Banks has added a useful bibliography of the literature on social spiders to this paper.

Fischer's observations on the way in which these social spiders treat their victims is not in accordance either with Jambunathan's observations or my own. Instead of the prey being left to die as stated by Fischer, I have always found that anything caught in the web, whether by day or by night, is at once attacked. Under suitable conditions, however, very extensive snares may be spun, and it is possible that insects caught in the part of a large snare furthest from the nest may not attract attention so readily as do those caught near the nest.

The nest in which the spiders hide by day is a tough mass of cobweb mixed with dead leaves, insect integuments, etc. (pl. xxv, fig 30). At dusk the spiders come out and float threads of silk from the upturned abdomen in the usual way, till one or more of them gets attached to some object at a little distance from the nest. These threads are then strengthened, and form the foundations of irregularly meshed snares (pl. xxv, figs. 30-31). The foundations of these snares are composed of one or more strands of relatively coarse silk. Between, and often along, these strands, strands of another kind are laid (pl. xxv, figs. 31-33). These are broader and have a softer and more woolly appearance ; when carefully examined they are found to consist of a fine central thread overlaid with irregularly twisted threads and a sticky foam-like silk that I suppose to be the product of the cribellum. The hind legs may always be seen working against this organ when these strands are produced. The second type of strand is not only very sticky but also very elastic. Strands of this type unite the foundation lines in all directions, and when an insect gets caught among them they give before its struggles, and are not liable to break. Snares seem, however, to suffer from the weather ; and many strands may be broken as the captured prey is dragged along towards the nest to be eaten.

Repairs and extensions are always carried out after sunset ; but the spiders seem to be ready for food at any time. A fly thrown into the snare always brings them out at once. How the presence of prey in the snare is detected I have not been able to determine with certainty. If the snare is disturbed by one's finger the spiders hastily retreat into the nest. This suggests that sight is of use in this connection ; but a dead fly was found to attract no attention. A specimen of the Rutelid beetle *Adoretus*, on the other hand, was at once pounced upon when placed in the snare although its movements were quite unlike those of the fly. Perhaps, therefore, touch calls the attention of the spiders to the presence of something in the snare, and sight determines their action towards it. The slaying of a large and strongly chitinized insect like *Adoretus* is a much more difficult feat for the spiders than is the slaying of a fly ; but they persist until it is accomplished.

Associations of other animals with African species of *Stegodyphus* have been recorded by Marshall (*Zoologist*, [4] II, pp. 417-422) and Pocock (*Ent. Mo. Mag.*, [2] XIV [XXXIX], pp. 167-170).

Marshall describes a dormouse which lives in *Stegodyphus* webs and ultimately drives out the spiders; and both authors refer to a Microlepidopteron which lives with the spiders in their nests. Such a moth has recently been found associated with *Stegodyphus sarasinorum* in India (see above, p. 506). A Uloborid spider makes use of the webs of *Stegodyphus* (see above, pp. 533-534). Other associations, probably of a more casual nature, may also occur; and when pulling *Stegodyphus* nests to pieces in Orissa in order to obtain lepidopterous larvae I found in addition the following animals alive within them: one cribellate spider (? Dictynidae), one centipede (? Geophilidae), one large Lepismatid and two minute beetles (Anthicidae and Clavicornia).

Pholcidae.

Concerning *Artema atlanta* see Flower, *J Straits R. Asiatic Soc.* No. 36, July 1901, p. 43.

At least two species of Pholcidae are common in Calcutta, one much larger than the other. The former is usually found hanging by its long legs from its untidy web. The latter, which probably belongs to the genus *Pholcus*, is often seen in a similar position, but seems to be more of a wanderer, and I have twice seen it using its extraordinarily delicate legs as a snare for insects. On the first occasion the captive was an earwig (*Nala lividipes*). The earwig seemed much the stronger of the two antagonists, but was encircled by the spider's legs, which were too slender to be seized, and the spider's body was raised out of reach of danger by them. From time to time the spider lowered its body and struck at the earwig; but it was always restrained from effecting its purpose by a flourish of the earwig's abdomen. When the earwig tried to escape the spider went with it, taking care not to let it go from between its legs. Finally, however, the earwig's patience proved greater than the spider's, and it got away. On the second occasion the captive was a small Tipulid, and I have little doubt that the spider would soon have been victorious, but that the contest took place on a wall, from which both combatants ultimately lost their hold.[1]

Argiopidae.

An instance of a small bird being caught in the web of a large Argiopid—doubtless *Nephila maculata*—is recorded by Sherwill (*J.A.S.B.* XIX, pp. 474-5). The " young spiders (about eight in number and entirely of a brick-red colour) feeding upon the carcass " were probably either males or parasitic Theridiids.

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[1] More recently I have seen a hard-shelled jumping Chrysomelid beetle of considerable size (about 5 mm. long) similarly attacked by this spider. In this instance the spider had succeeded in attaching its silk to the victim and was busy spinning over it by the time it was seen. The spider stood high above its victim as usual, and appeared to be arranging the threads with its hind legs.

Further notes on the habits of *Nephila maculata* (? and other species) are given by Cunningham (" *Plagues and Pleasures*", pp. 203-5 and 210) and Fischer (*J.B.N.H.S.* XX, pp. 526-528 and 887-8, pairing habits). Brief notes on the habits of this species and of a few other Argiopids found in the Malay Peninsula are recorded by Flower (*J. Straits R. Asiatic Soc.*, No. 36, July 1901, pp. 43-4).

Argiope catenulata seems to be confined, near Calcutta,[1] to the Salt Lakes area, where it spins an orb-web surrounded by numerous irregular lines between bushes of the low holly-like mangrove, *Acanthus ilicifolius*. *Argiope pulchella*, which is common among larger bushes in the Salt Lakes area, as well as elsewhere, spins a simple orb-web.

Orsinome marmorea spins large and more or less horizontal webs between rocks above rapidly running streams at an altitude of about 1,500 ft. in the Cochin Ghats. Several webs are usually grouped together ; often they are stretched above waterfalls. When the spiders are disturbed they fall into the water, which washes them away. When they reach a rock they cling to it, and remain an inch or two below the surface till danger is over. Males and females were sometimes found together in the middle of a web with their heads in contact. Presumably they were pairing, but I had not time to investigate this fully.

Herennia ornatissima spins its orb-web close to a tree-trunk. Dr. Sutherland tells me that at Kalimpong he has found the female in the middle of her web, and sometimes the male in the web with her. In Cochin I always found the female [2] in a small silk-lined concavity on the tree-trunk near the web; and when a male was present it was in a similar nest close beside that of the female. The specimens were brownish in colour and they were very difficult to distinguish from irregularities of the bark.

The Indian species of *Cyrtophora*, like those of other countries, spin more or less dome-shaped webs ; and most of them are more or less gregarious. The web of *C. citricola* is spun horizontally in the midst of an irregular mass of supporting lines, and has the characteristically fine mesh and delicate texture of the domes constructed by its allies ; but it is scarcely raised in the centre. Mr. W H. Phelps informs me that the web is always made at night. First radial lines are constructed as if for an ordinary orb-web. Then the spiral is commenced, and fresh radii are run out from time to time between the others, this filling in of the radial spaces being done piece by piece, not by a succession of complete whorls. When the web is about half finished the centre is raised as far as it is intended to be by the attachment of lines from above, after which it is completed.

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[1] It is also recorded from places such as Peradeniya, where conditions are quite unlike those of the Calcutta Salt Lakes and there is no *Acanthus ilicifolius*.

[2] I did not however, find many specimens.

On one occasion Mr. Phelps saw a specimen of *C. ciccatrosa* construct its cocoon. A soft loose sheet about an inch and a half long and a quarter of an inch wide was prepared first, on this the eggs were laid, after which it was rolled up and suspended above the web. The eggs hatch about three weeks after they are laid, and the spiders develop very rapidly.

The occurrence of a predaceous bug in the webs of *C. ciccatrosa* has already been noticed (above, pp. 512-513). The eggs of *C. feae* are parasitized by a Hymenopteron, both sexes of which are winged.[1]

Thomisidae.

Trench describes how "a lemon-coloured spider with a tri angular body and long yellow legs" sitting "on one of those virulent mauve zinnias" where "there was no effect whatever of any protective colouration" captured a bee-hawk moth (*J.B.N.H.S.* XX, p. 876). The spider was presumably a Thomisid.

Mrs. Drake has sent me from Serampore a number of specimens of *Amyciaea* sp., a mimic of the red ant *Oecophylla smaragdina*, together with a specimen of a bug, *Armachanus monoceros*, which mimics both, resembling the spider even more closely than it does the ant. Of the habits of a female *Amyciaea*, which she kept in captivity, she writes: "It is interesting to watch her method of securing a red ant. When one is put under her glass it at once goes towards the spider, who backs away from it or lets herself down by a cable if there is no room to draw back, after which she follows up and springs on it from behind. Then comes the curious part. She does not retain her hold but leaps down and waits. Next, cautiously advancing to its head, she walks round it as if to make quite sure it is dead, and finally, after lightly touching it, she begins her meal, every now and then moving on with her prey held up just as the ants carry their finds. Her extreme carefulness looks as if she had instinctive knowledge of the power of the ant's jaws, for I suppose had she herself been bitten she would not have survived. I had a male killed by a red ant the other day. I have only seen this kind of spider near red-ant settlements, and of the ten seen at different times nine were eating red ants, and the tenth was letting itself down by a cable just over a red ants' road. I believe these drop lines help to entangle a stray foraging ant, and while it strives to free itself the waiting spider springs upon it."

Clubionidae.

The habits of the common Calcutta house-spiders of this family are described by Cunningham ("*Plagues and Pleaures*", pp. 206-

[1] Bugnion and Popoff have described from Ceylon *Baeus apterus*, a parasite with wingless females obtained from the eggs of a spider determined as *Argiope aetherea*, Walck. from which those of *A. catenulata*, Dol., were infected in captivity (*Rev. Suisse Zool.* XVIII, 1910, pp. 729-736, pl. v). The former spider has perhaps been incorrectly identified, for *A. aetherea* is a Papuan species which does not appear to be known from the Oriental Region (see Thorell, *Ann. Civ. Mus. Genova*, XVII, 1881, pp. 68-71).

208). These spiders are *Spariolenus tigris* and *Heteropoda venatoria*. They are probably about equally common, but the former is more often seen than the latter, as it seems to be less sensitive to light and the female often makes her home on the whitewashed wall of a staircase or bathroom, where she may be found day after day for weeks together. The male of *Spariolenus tigris* seems to be much rarer than the female, although the two sexes of *Heteropoda venatoria* are about equally common. Both species kill and eat cockroaches and crickets, which in some instances at least are not killed immediately they are bitten. Concerning *Heteropoda venatoria* see also Flower, *J. Straits R. Asiatic Soc.*, No. 36, July 1901, pp. 46, where *H. thoracica* is recorded as cavernicolous.

Lycosidae.

A species of *Pardosa*, common in hedge-bottoms in the plains of Cochin, spins a silken tube open at both ends, the upper end leading out on to a silken platform. Mature females may often be seen at the entrances of their tubes, each with a male (sometimes two) keeping guard on the platform outside. When disturbed the female disappears into the tube followed by the male. Egg-laden females are not attended by males.

Attidae.

Notes on ant-mimicing spiders are given by Rothney (*Trans. Ent. Soc. London*, 1889, p. 354; reprinted, *J.B.N.H.S.*, V, pp. 44-45) and Walsh (*J.A.S.B.* LX [II], pp. 1-4).

The mimicry of Mutillids by spiders is recorded by Green (*Spolia Zeylanica*, IV, pp. 181-2—spider *Caenoptychus pulchellus*, see *Spolia Zeylanica*, V, pp. 190-1; and *Spolia Zeylanica*, VIII, pp. 92-3, 1 pl.) and by myself (*Rec. Ind. Mus.* VII, p. 87). I take this opportunity of pointing out that my observations were made in Orissa, not in Calcutta as stated by Green.

Acari.

The habits of *Trombidium grandissimum* are described by Annandale (*Mem. A.S.B.* I, pp. 216-7).

EXPLANATION OF PLATE XXII.

Oryctes rhinoceros.

FIG. 1.—Mouthparts of larva from below, with left maxilla removed and turned over to show supposed stridulatory structures.

,, 2.—Pupa from above showing stridulating organs.

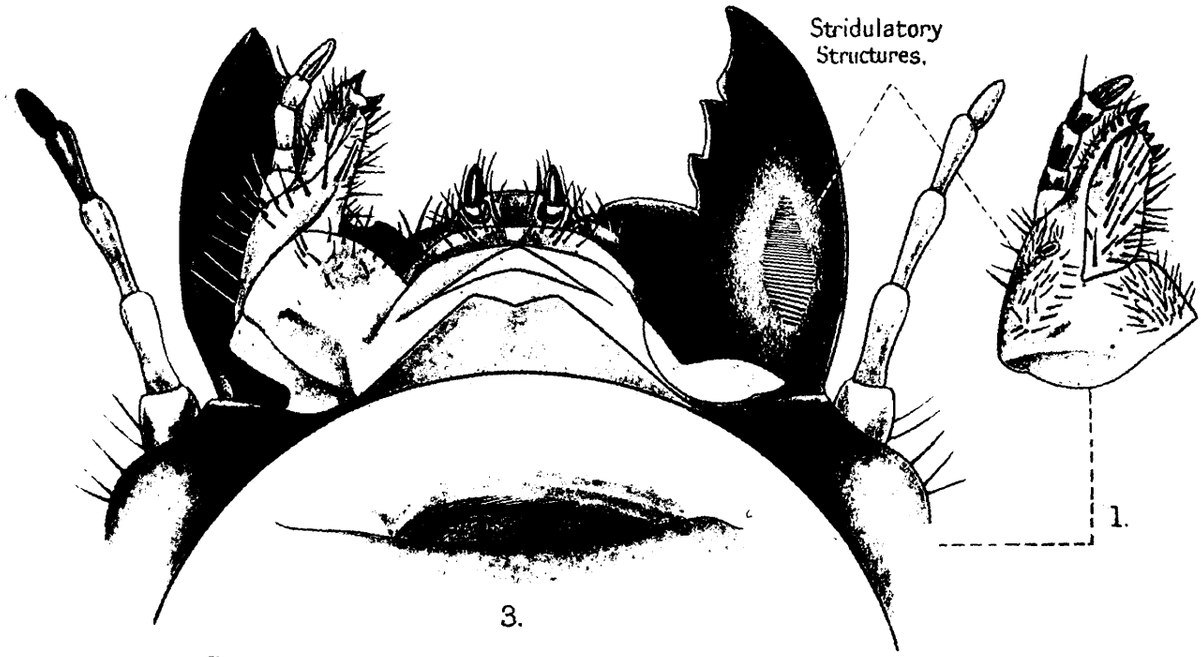
,, 3.—Left anterior stridulating organ of pupa more highly magnified.

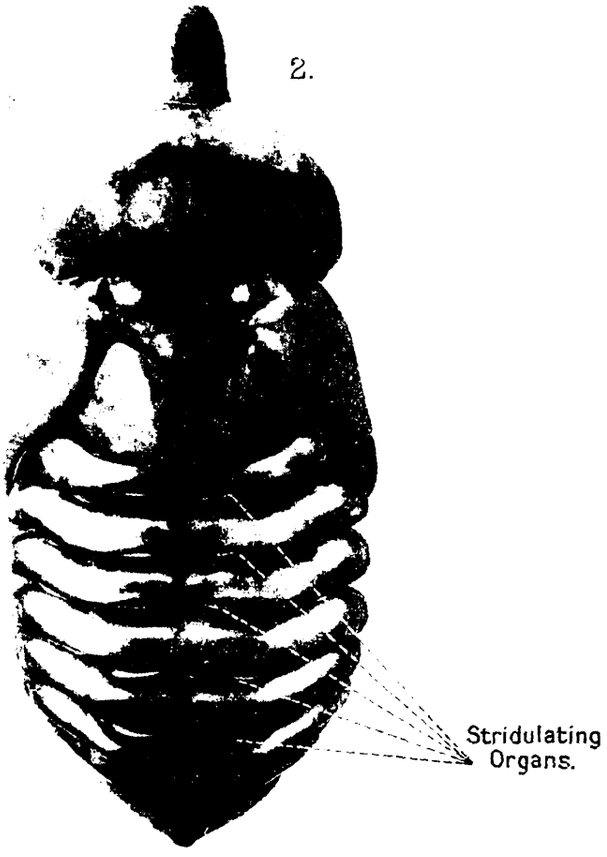
,, 4.—Posterior end of abdomen of adult, with left elytron removed, showing the ridges with the aid of which the insect appears to stridulate.

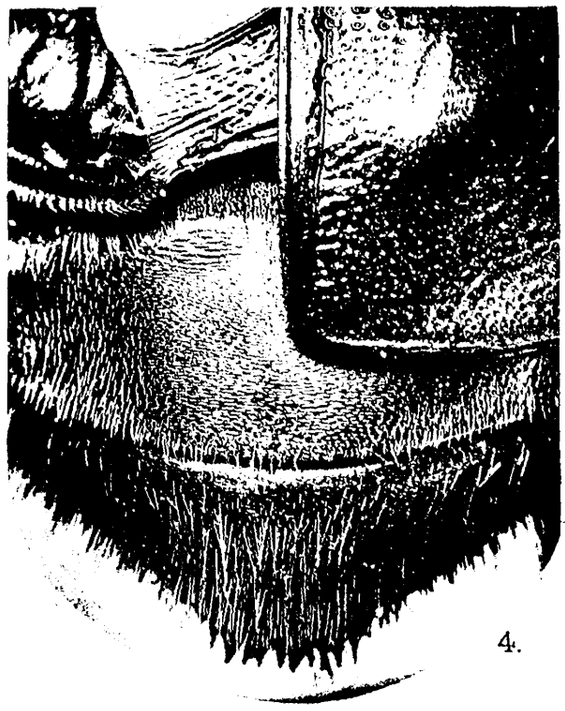
Adoretus spp.

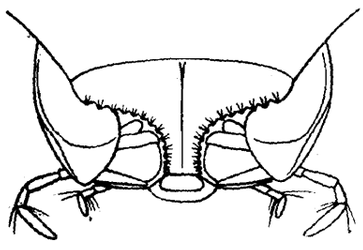
,, 5.—Mouthparts of *A. versutus*—the labrum slightly raised, the mandibles widely and maxillae more moderately opened.

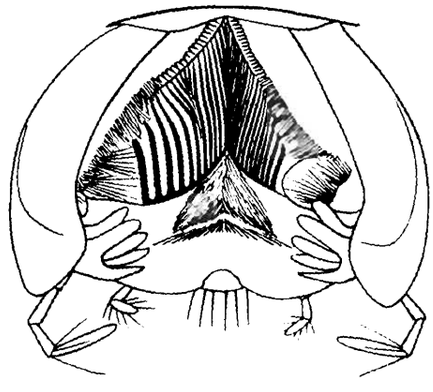
,, 6.—Mouthparts of *A. lasiopygus*—the labrum removed, the mandibles and maxillae very widely opened to show the molar teeth of the former. This figure is more highly magnified than the last.











D. N. Bagchi, del. S. C. Mondul, photo.

LAMELLICORN BEETLES.

EXPLANATION OF PLATE XXIII.

Arcte caerulea.

FIG. 7.—Posterior part of abdomen of male from above, after removal of the scales, to show the stridulating plate.

Machaerota planitiae.

,, 8.—Tubes on a twig of *Zizyphus jujuba*.

,, 9.—Larva.

,, 10.—A more advanced larval stage.

,, 11.—Last larval stage from above.

,, 12.—Last larval stage from the side.

,, 13.—Adult.

Hindoloides indicans.

,, 14.—Tube with larval exuvium and newly emerged adult.

,, 15.—Last larval stage from the side.

Otinotus oneratus.

,, 16.—Eggs in bark of *Zizyphus jujuba*, seen as a transparency.

,, 17.—Adult females with eggs, on stem of *Bauhinia varians*, accompanied by black ants (*Camponotus compressus*).

,, 18.—Adult from the side.

,, 19.—Adult from above.

,, 20.—Larva from above, with caudal filament partly exserted.

,, 21.—Larva from the side, with caudal filament retracted.

,, 22.—Larva from the side with caudal filament exserted.

Conorhinus rubrofasciatus.

,, 23.—Head and prothorax from below, showing stridulating organ.

Ectomocoris cordiger.

,, 24.—Head and prothorax from below, showing stridulating organ.

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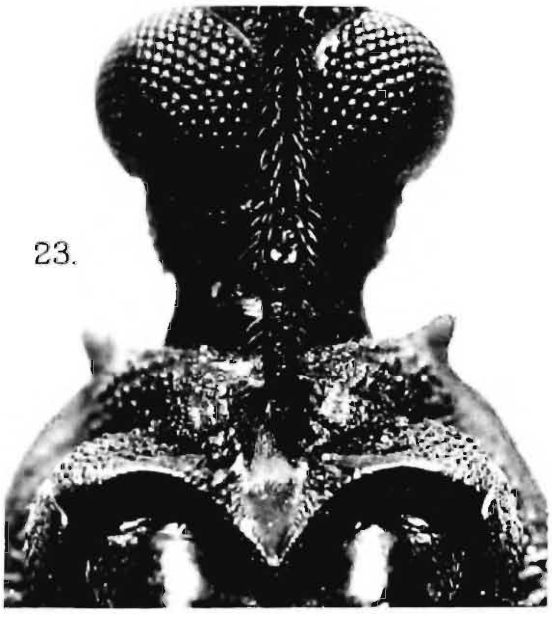

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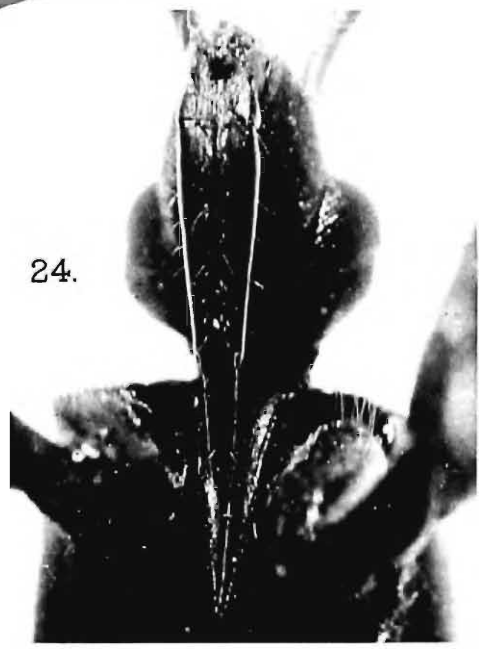

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LEPIDOPTERA AND HEMIPTERA.

EXPLANATION OF PLATE XXIV

Thelyphonus sepiaris.

FIG. 25.—Courtship "dance"; first position.

,, 26.—Courtship "dance"; second position.

Schizomus crassicaudatus.

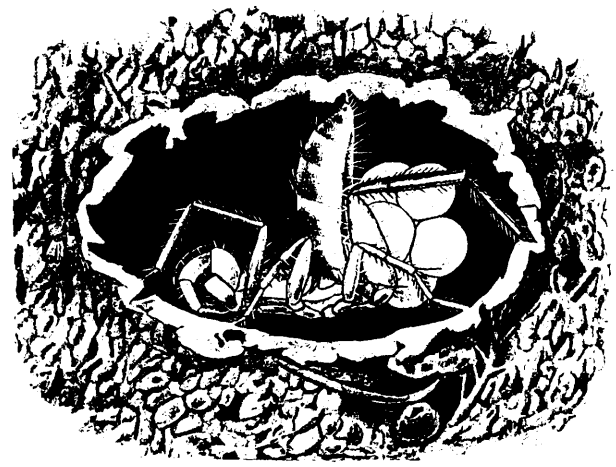
,, 27.—Female with eggs in underground nest.

Phrynichus ceylonicus, s. str.

,, 28.—Closed hand from above.

Charinides bengalensis.

,, 29.—Closed hand from above.



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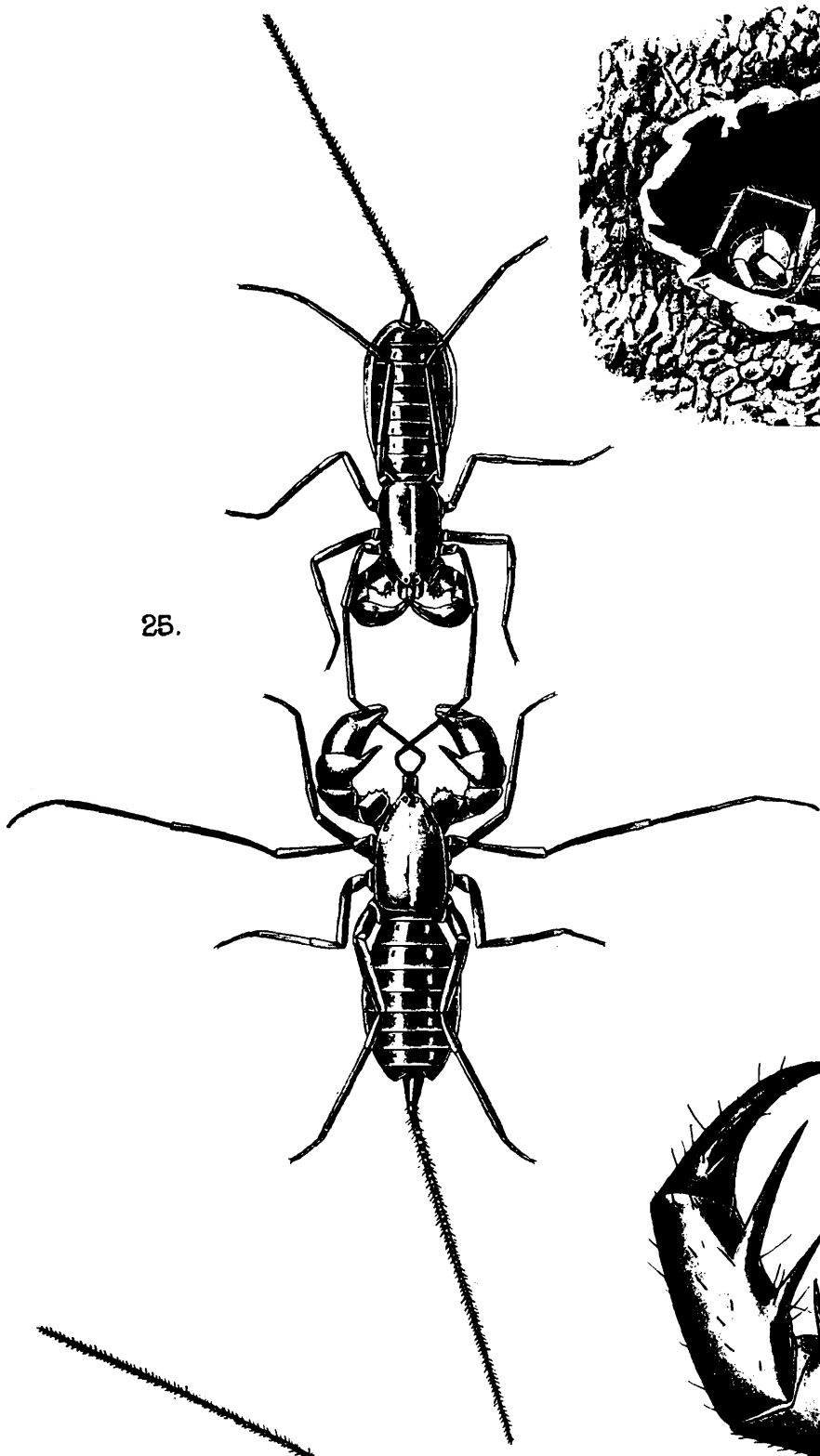

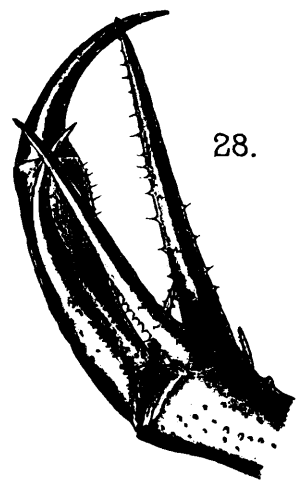

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Bemrose, Collo., Derby.

PEDIPALPI.

EXPLANATION OF PLATE XXV.

Stegodyphus sarasinorum.

FIG. 30.—General view of a nest, with small snares stretched between some of the outstanding leaves and the lower part of the stem of the plant on which it is constructed. (Much reduced).

,, 31.—Part of a snare, magnified to show its structure.

,, 32.—A double line of sticky silk, more highly magnified to show its component parts.

,, 33.—A double foundation line overlaid by sticky silk, still more highly magnified, showing the various thicknesses of silk used in making the snare.

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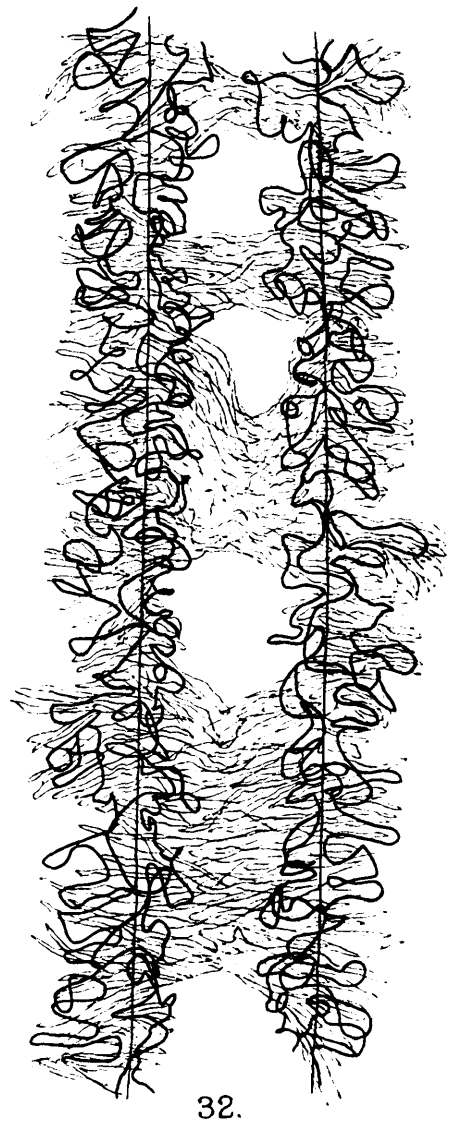

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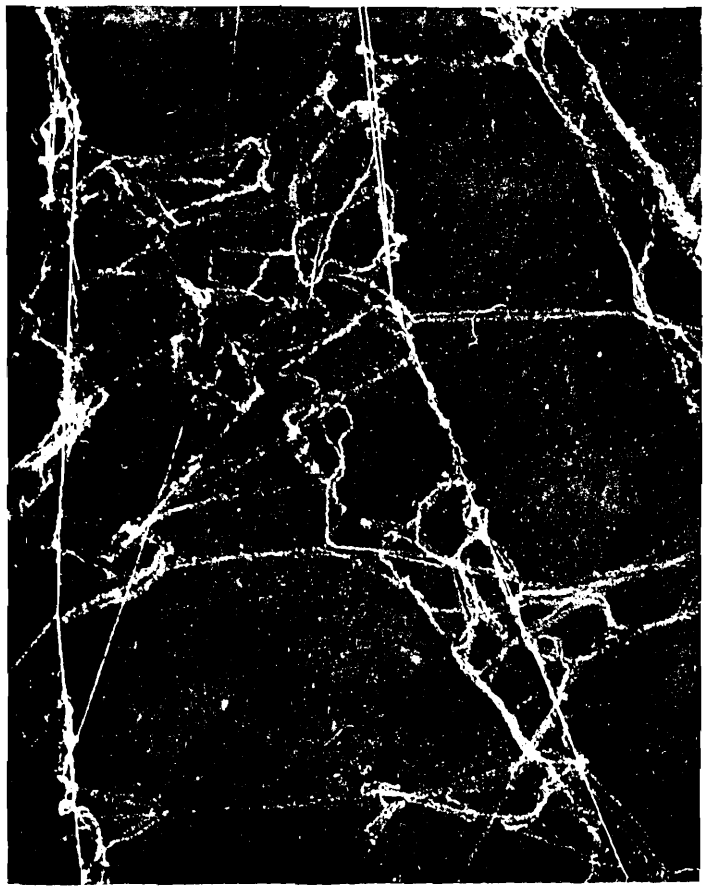

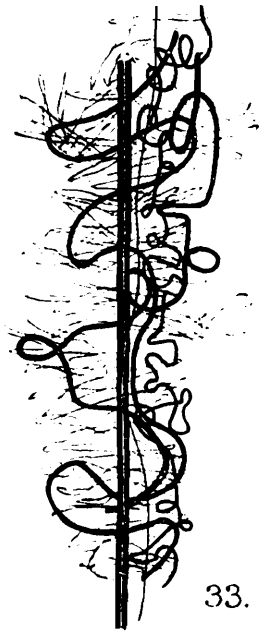

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D. N. Bagchi, del

S. C. Mondul, photo.

STEGODYPHUS SARASINORUM.

XXX. THE HYDROIDS OF THE INDIAN MUSEUM.

II.—*ANNULELLA GEMMATA*, A NEW AND REMARKABLE BRACKISH-WATER HYDROID.

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(Plates XXX, XXXa.)

CONTENTS.

The hydroid described in the following pages stands in several respects by itself. It combines in its structure and life-history peculiar features which are either new or have hitherto been found isolated in different species. Among these peculiarities are to be reckoned the occurrence in the vegetative hydroid phase of an alternation of free and fixed stages, the adoption of such singular methods of multiplication as the setting free of planula-like buds

and of a mode of transverse fission associated with the basal-bulb, and the structural uniqueness of the tentacles and of the chitin-covered basal-bulb itself.

The examples of this minute but interesting species occurred in a valuable and extensive collection of Hydroids received from the Trustees of the Indian Museum for identification. It was first observed and collected by Dr. Nelson Annandale, during his investigation of the brackish water fauna of India; and to the fortunate fact that some living examples were kept for a short period in an aquarium is due Dr. Annandale's record of the free-swimming medusoid generation.

PROVENANCE AND HABITAT.

So far the species has been found in only one locality—Port Canning, Lower Bengal; and in that locality it seems to be confined to a shallow brackish pond. At any rate careful search of material from other places in the neighbourhood of Port Canning has failed to reveal any trace of its presence. In the brackish water it occurs growing upon a delicate branched weed, the surface of which also bears many clusters of Acinetaria. The specimens were collected in the months of December, 1909 by Dr. N. Annandale, and in March, 1910 by Mr. F. H. Gravely and Dr. B. L. Chaudhuri, and the latter are registered in the Natural History collections of the Indian Museum under the number ZEV 3702/7.

DESCRIPTION OF THE HYDROID.

HABIT.

The individuals are solitary, growing as a rule far apart from, and independently of each other. In very rare cases two individuals may appear to be attached at their bases; but this is due to imperfect separation of their basal masses, which are held together in a common growth of mucus. There is no coenosarcal connection between such individuals, nor has any semblance to colonial development been observed.

Consideration of the structures of this curious hydroid leads me to believe that the attached stage is merely a temporary phase in the life-history. This stage is, however, repeated again and again, each two periods of attachment being separated by an interval during which the hydroid is free. Whether during the free periods it floats in the water of the brackish ponds, or creeps upon the bottom, I do not venture to guess; but the analogy of *Hypolytus peregrinus* suggests that the Indian species may yet be captured in a tow-net, floating at the surface. In such case its minuteness would render difficult its detection in a miscellaneous plankton collection.

The following facts point to the alternation of free and fixed stages. A hydroid individual in its attached stage consists of a

hydranth or polyp, with a long stalk-like extension of the body in older examples, and a unique basal development which I shall call the "basal bulb." The basal bulb, which alone is protected by perisarc, is the organ of fixation, actual adhesion being apparently due to a loose mass of debris-laden mucus which surrounds the bulb and spreads out upon the substratum. No part of the polyp, in its simplest condition, secretes perisarc or mucus. As will be found more fully described in a later section (p. 553) the bulb represents a method of vegetative reproduction, and is a temporary structure. Basal bulbs have been observed, both by Dr. Annandale and by myself, isolated and without any attached polyp. In such a case the polyp must either have disintegrated or have broken apart and become free. That the latter is the actual case is borne out by the condition of the isolated basal bulbs, which contain well-preserved coenosarc; and by the discovery of a polyp which has recently broken away from its base (pl. xxx, fig. 6).

Further, at the breaking-off period the released polyp possesses no means of attachment, although in course of time the lower end of the body secretes both perisarc and mucus, and gradually becomes modified into a new basal bulb. The details of these processes, so far as they have been traced, will be described in the paragraphs dealing with reproduction. The above more general observations, however, are sufficient to suggest that at certain phases the polyp is released from its old attachment, and that a period of freedom intervenes before a new organ of fixation has developed.

STRUCTURE OF THE HYDRANTH.

Form and Dimensions (see plate xxx, figs. 1-3).

An individual consists simply of an isolated polyp. There is no definite hydrocaulus, although the proximal end of the hydranth, especially in the more fully developed specimens, is extended into a stalk-like portion. Nor is there any stolon or hydrorhiza in the ordinary sense of the term, the functions of such being performed by the basal bulb.

In its living state, Dr. Annandale informs me, the hydroid is colourless.

The form of a normal adult resembles an Indian-club. The head of the club is ovate with a broad median zone on which the tentacles are placed. On both sides of the tentacle-zone the hydranth tapers gradually away: distally into a large conical hypostome on the truncated summit of which a shallow depression marks the position of the mouth; proximally into the long almost parallel-sided handle of the club. The total length of a well-grown individual varies from 0·63 mm. to 0·98 mm., the length of the "head" from 0·28 mm. to 0·52 mm., and the diameter of the tentacle-zone (the greatest diameter of the hydranth) from 0·16 mm. to 0·28 mm. In the youngest examples I have seen there was no proximal extension of the hydranth, and the "head"

was sessile or rested upon the basal bulb (pl. xxx, fig. 1). In such cases the hydranths measured 0·15 mm. to 0·27 mm. in length, and their greatest diameter varied from 0·14 to 0·21 mm.

The following table showing the dimensions of various representative polyps gives at the same time an idea of the progressive development of an individual, the relative age or developmental stage being approximately indicated by the number of tentacles. All the polyps, with the exception of the first, were collected at the same place and time, and were killed under identical conditions. The measurements are in millimetres.

DIMENSIONS OF *ANNULELLA GEMMATA*.

Tentacles.		*Polyp.*		*Stalk-like prolongation.*		*Basal Bulb.*	
Number.	Maximum length.	Total length.	Maximum diameter.	Length.	Diameter.	Depth.	Horizontal diameter.
4	0·17	0·27	0·21	none		0·04	0·1
5	0·13	0·15	0·14	none			0·08 no perisarc
6	0·44	0·63	0·16	0·35	0·11	broken	
8	0·75	0·84	0·21	0·42	0·1	0·15	0·21
9	1·46	0·81	0·25	0·35	0·17	0·13	0·15
12	1·38	0·98	0·28	0·46	0·14	0·2	0·25

Tentacles.

The tentacles are confined to a somewhat prominent median zone on the hydranth. Over this they are irregularly scattered, at least three or four distinct levels being recognisable. Their number varies from 4 and 5 on the youngest individuals observed to 12 in the largest, but the average seems to centre about 6.

The appearance of the tentacles is characteristic and beautiful. They bear throughout their length, at fairly close and regular intervals, batteries of cnidoblasts aggregated in large projecting rings, or globular masses which resemble beads strung upon the axis of the tentacle (see pl. xxxa, fig. 7). These rings or globes have a diameter averaging three times that of the tentacle proper. Between the larger batteries there are occasionally smaller clumps of cnidoblasts in narrow rings or tiny circular groups. A globular battery terminates each tentacle, but since its size does not much exceed that of the cnidoblast rings the capitate condition is not always very evident, especially in contracted tentacles.

The detailed structure of the tentacles was examined in serial sections (see pl. xxxa, fig. 8). The typical cell-layers are repre-

sented by a solid endoderm, an exceedingly thin mesogloea, and an ectoderm of greatly varying thickness.

The *solid endoderm* is composed of many thin-walled cells, with sparse protoplasmic content which often simply lines the cell-wall and includes a small oval nucleus. The cells appear to be arranged, but somewhat irregularly, in four radial series of hexagonal cells, the bases of which rest upon the mesogloea, while the pyramids which form their apical regions interlock towards the centre of the tentacle. A longitudinal median section of a tentacle, therefore, generally exhibits a series of lateral walls of endoderm cells at right angles to the mesogloea, and in the centre a zigzag line representing the junctions of the pyramidal apices. Both in the character of its cells and in their arrangement the solid endoderm of this form differs very markedly from the solid endoderm of general occurrence in the tentacles of hydroids. Instead of thick-walled (" notochordal") cells arranged with great regularity in a single series lying along the long axis of the tentacle, as is the general rule, there are here delicate, thin-walled, multiserial cells.

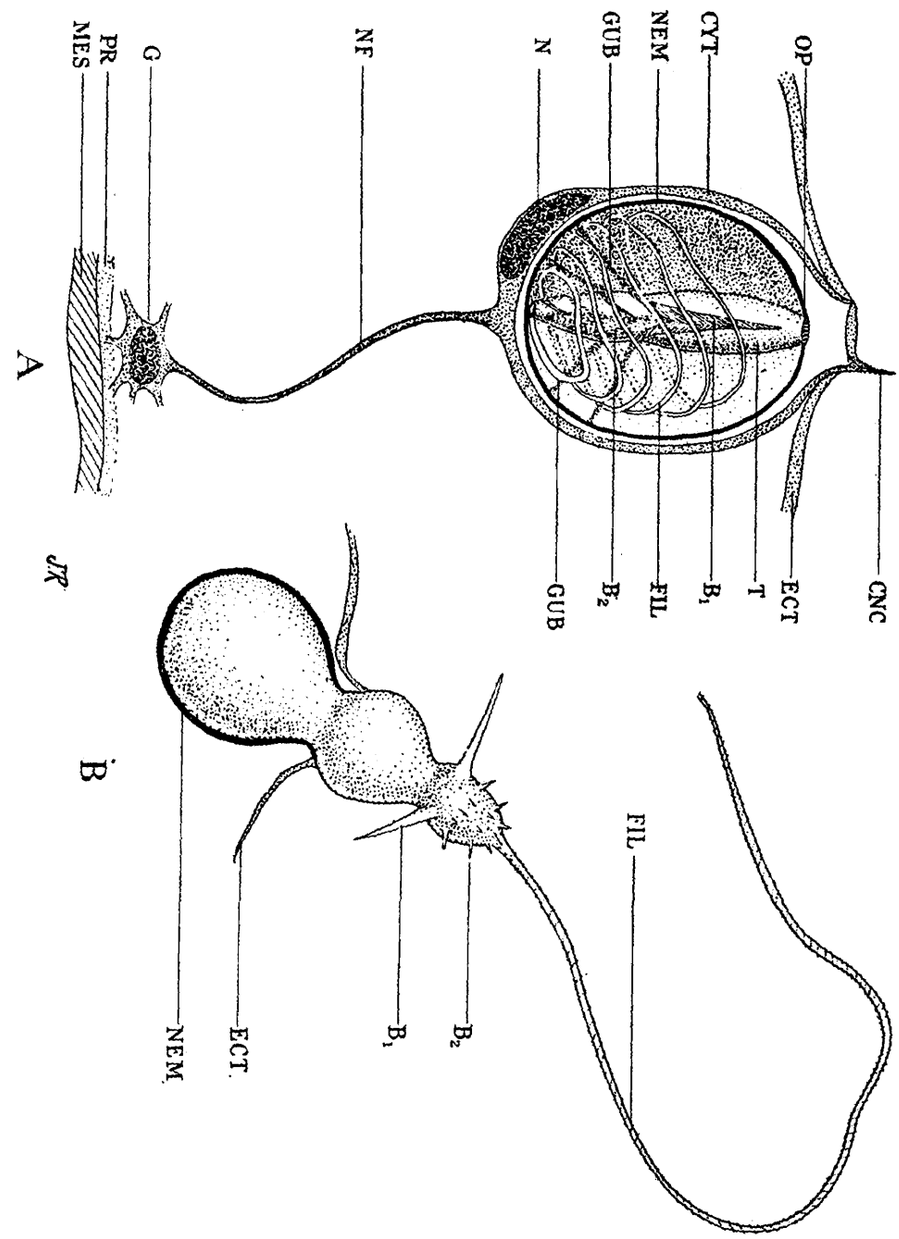
The *mesogloea* of the tentacle-cells calls for no remark except that it is of extreme tenuity scarcely exceeding 1μ in thickness throughout the whole length of the tentacle.

The *ectoderm* of the tentacles falls into two distinct zones, the ring-like or globe-like swellings, which I shall designate *nodes*, and the spaces between them (see pl. xxxa, figs. 7 and 8). In the inter-nodes or inter-annular zones the ectoderm, even when the tentacle, in contraction, is at its stoutest, consists of a very thin layer of much flattened epithelial cells. In an extended tentacle this layer owing to its tenuity becomes scarcely visible. A rare cnidoblast, similar to the lesser variety in the nodes, forms the only inclusion in the internodal cells.

The nodes are composed of a zone of large oval cushion-shaped cells, closely appressed to each other laterally in a single row. Occasionally, however, incomplete zones or isolated individuals of these cushion-shaped cells occur in the inter-nodal areas. At the junction of nodes and inter-nodes the internodal ectoderm conforms to the outline of the nodal cells, being banked up against their curved walls with a gentle slope. The size of the nodal cells varies with the contraction of the tentacle, but the short diameter (parallel to the long axis of the tentacle) usually lies between 15μ and 27μ, while the height varies from 12μ to 22μ. Apart from inclusions the nodal cells contain little cytoplasm, the greater part of their interior being occupied by a large vacuolar space. Upon the base of the cell, however, there lies a thin layer of cytoplasm, and a median nucleus, 5μ by 3μ in diameter, containing a small nucleolus and surrounded by a sparse coat of cytoplasm whence delicate strands radiate outwards. The whole structure of the cell appears to be organised in relation to its function as a battery cell. I shall, therefore, discuss here the arrangement and structure of its cnidoblasts.

Cnidoblasts of the nodal cells.

In surface view of a tentacle-node a regular arrangement of cnidoblasts is apparent (see pl. xxxa, fig. 7). Round an individual of large size circles a group of smaller cnidoblasts. The latter are set singly and more or less regularly on an imaginary circumference,



TEXT-FIG. 1.

Large type of cnidoblast (*macrocnide*) from nodal cell.

A. Undischarged cnidoblast and its connections *in situ* (× approximately 4000 diameters).

B. Discharged nematocyst (× approximately 3000 diameters).

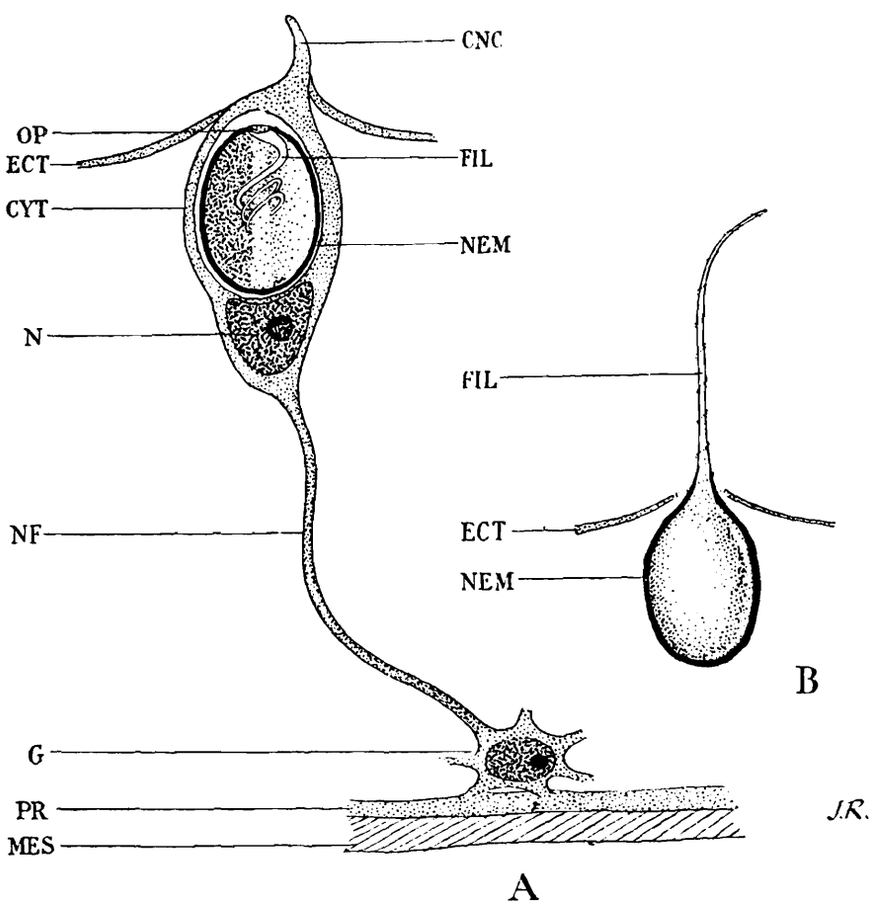
B_1, B_2, major and minor barbs; CNC, cnidocil; CYT, cytoplasm; ECT, external wall of ectodermal cell; FIL, filament; G, ganglionic mass, GUB, gubernaculum,—protoplasmic strand supporting central tube; MES, mesogloea of tentacle; N, nucleus; NEM, nematocyst; NF, nerve fibril; OP, operculum; PR, layer of protoplasm lining bottom of cell; T, central tube.

with generally seven but sometimes as many as eleven examples. In a single node about 8 to 10 large cnidoblasts are present with their attendant satellites—a total of approximately 80 individuals. As a rule each cell contains only one complete group, but occasionally the cell-wall appears to become obliterated so that several groups come to lie within a cell's boundaries. In median longitudinal section of a tentacle (pl. xxxa, fig. 8) the nematocysts are seen to lie at the periphery of the cell, radially inclined outwards from the mid-point of its base. There are considerable differences in the structures of the two types of cnidoblasts.

The larger individuals (*macrocnides*) (text-fig. 1) consist of an almost spherical nematocyst, 7μ to 8μ long by 6μ in diameter, surrounded by a thin and uniform covering of cytoplasm which pushes up the cell-wall, and is produced into a short delicate cnidocil. At some point in the proximal portion of this cytoplasm lies an elongated nucleus the inner profile of which conforms to the outline of the nematocyst. Contrary to the experience of Schneider (1890, p. 332) as regards *Hydra fusca*, the nucleus contains a distinct nucleolus. At the proximal end of the cnidoblast a delicate thread, the nerve fibre, leaves the cytoplasm, and passing across the vacuolar space of the cell merges with the cytoplasm surrounding the nucleus that lies on the floor of the cell. The nucleus and its surrounding cytoplasm seem to constitute a ganglionic mass to which radiate the nerve filaments of many or all the cnidoblasts in a group. The ganglion mass is in its turn connected with the layer of cytoplasm which covers the floor of the cell. None of the macrocnides possessed a simple broad cytoplasmic peduncle such as forms an attaching structure in examples from several other species of Hydrozoa.

The interior of the nematocyst is filled with a highly refractive fluid, which renders accurate observation of the internal structures a matter of some difficulty. At the distal pole of the nematocyst is a circular area—the operculum—of consistency different from that of the nematocyst wall. From this area, whence the filament escapes on its discharge, a cylindrical tube of considerable diameter projects into the cyst, passing along its longitudinal axis almost to the proximal wall. In its upper half the tube contains a prominent opaque triangle pointing upwards and almost reaching the distal wall of the cyst, and this represents the single whorl of three major barbs which encircles the lower portion of the ejected filament. Similar smaller and less well-defined structures are sometimes apparent in the lower half of the tube. The lower section of the tube is kept in position by a series of exceedingly delicate gubernacula—protoplasmic strands which attach it to the wall of the nematocyst, and which are to be observed only under specially favourable conditions of staining and lighting. The proximal portion of the tube narrows rapidly and at its base is continuous with the filament which lies near to the wall of the cyst in an ascending spiral of some six loose coils.

The everted portion of a discharged nematocyst is some three to three and a half times the length of the nematocyst, and consists of a smooth-walled basal bulb, a second and smaller bulb furnished with about four whorls of barbs of which the proximal whorl contains three large individuals, while those of the distal whorls are more numerous and insignificant. From the second bulb proceeds the filament which throughout its length is armed by a close spiral of exceedingly minute barbules ascending in a contra-clockwise direction (see text-fig. 1B).



Text-fig. 2.

Lesser type of cnidoblast (*microcnide*) from nodal cell.

A. Undischarged cnidoblast and its connections *in situ* (× approximately 4000 diameters).

B. Discharged nematocyst (similarly magnified).

Lettering as in text-fig. 1.

The second and smaller type of cnidoblast—*microcnide*—is of simpler structure. The nematocyst is similar in shape but is approximately half the linear dimensions of that of the large type, 4μ or 5μ by 3μ. The cnidocil is stouter and longer than in the macrocnides, and although the general arrangement of cytoplasm is the same the cytoplasmic coat is drawn out into an elongate oval shape to include a very large nucleus which lies against the proximal wall of the nematocyst. The nucleus varies in shape, but its inner surface is always closely moulded upon the nematocyst wall,

and it frequently assumes the deep helmet-shape shown in section in text-fig. 2A. It contains a large nucleolus. The cytoplasm is connected by a long delicate nerve fibre with the ganglionic mass on the floor of the cell. Occasionally, however, the connection becomes a comparatively broad protoplasmic strand resembling the peduncular attachment of some cnidoblasts.

The internal structure of a microcnide differs much from that of a macrocnide. The former contains only the filament, which proceeds directly from the operculum at the distal pole of the cyst in a loose descending spiral of about three small coils. These appear to encircle a central pillar of delicate consistency which may, however, be simply one of those phenomena of refraction which render so difficult the exact observation of the contents of nematocysts. In a discharged microcnide (text-fig. 2B) three points strike one as characteristic: the shortness of the simple filament, the length of which is only twice that of the nematocyst; the directness with which the filament projects from the nematocyst, for it invariably lies in line with the long axis of the nematocyst and is straight, except for a very regular curve towards the tip; and, lastly, the openness of the spiral of minute barbules, which performs only about ten revolutions in its contra-clockwise ascent.

Hydranth Body.

The *ectoderm* of the hydranth-body consists of a layer of irregular epithelial cells, between which lie small interstitial cells. The bases of the epithelial cells are produced into longitudinal muscle fibres which rest upon the mesogloea. The ectoderm averages in thickness some 7·5μ, but especially in the lower prolongation of the hydranth is arranged in slight horizontal ridges. The cells contain large rounded nuclei, and in parts a large number of cnidoblasts, but only some of the latter possess cnidocils and are functional, the remainder being under process of formation. The cuticle, if present, is of extreme delicacy, and no perisarc is secreted. At certain stages of development, however,—when a new basal bulb is being formed (see p. 555)—a number of hydranth cells take part, along with the cells of the basal bulb, in the secretion of a thick coating of hyaline mucus. In portions of this secretion masses of diatoms and other debris become entangled, and it is interesting to note that in this condition the diatoms appear to have continued a symbiotic existence, for the greater number show evidence, in their well-preserved protoplasm, of recent active metabolism. A similar state of symbiosis has been noted by Schaudinn in the case of the diatoms and algae which surround the body of *Haleremita* (Schaudinn, 1894, p. 226).

In the neighbourhood of the tentacle-zone and around the margin of the mouth the ectoderm is thickened. In the latter region it contains a close array of functional cnidoblasts, similar to the macrocnides of the tentacles. In the tentacle-zone, however, the majority of the cnidoblasts—macro- and micro-cnides—lie some distance below the surface and are in process of formation.

The great numbers of developing nettling organs in this region clearly indicate it as a localised manufacturing area whence migration of fully developed nematocysts to the tentacles takes place, conditions apparently of general occurrence in the Hydromedusae (see Hadzi, 1911).

The *mesogloea* is colourless and of almost uniform thinness of 2μ.

Endoderm.—The endoderm cells present more variety in their shape and in their inclusions than the ectoderm. As in many other hydroids they fall into three indefinitely bounded regions, in all of which, however, a few longitudinal ridges of elongated cells project into the coelenteron.

The hypostome endoderm consists of a series of regular, elongated, narrow, palisade cells resting upon the mesogloea and lacking inclusions. Between the distal ends of these cells are inserted many clavate gland cells, with a large nucleus resting in the wedged-in narrowing portion of the club, and a content of finely granular cytoplasm.

In the region of the tentacle-zone the endoderm is considerably deeper. The palisade layer of the hypostome is replaced by several irregular rows of small highly-vacuolar cells. Upon these rest large clavate nutritive cells, containing oval nuclei and coarsely-granular secretory products, as well as foreign bodies the recognisable portions of which consist mainly of the frustules of diatoms. Throughout the endoderm in this region there are scattered dark oval cells containing excretory products.

Lastly in the prolonged basal portion of the hydranth the cell-varieties of the former regions disappear, and the endoderm consists of a network of regular, highly vacuolar cells in which the cytoplasm and nuclei are ranged along the cell-walls. Here the cells are almost devoid of inclusions, only a rare individual with excretory products being observable; and although a narrow central lumen penetrates the region it is clear that the cells lining it take little part in the secretory or digestive functions.

The structure of the basal bulb will be discussed in the section dealing with reproduction (p. 553).

METHODS OF REPRODUCTION.

I. SEXUAL REPRODUCTION.

There is no conclusive evidence of the occurrence of a sexual type of reproduction in the specimens which I have examined, although in one there is present, arising from the tentacle-zone, a very small globular bud (0·045 mm. in diameter) composed of ectodermal and endodermal elements, which might possibly have developed into a sporosac or medusoid gonophore. Its position within the tentacle-zone agrees with the position rather of the sexual bodies than of the simple buds of most other hydroid species.

But Dr. Nelson Annandale, who kept examples of the hydroid alive in an aquarium for some time wrote in a note accompanying some of the specimens: " The gonosomes, which develop into free medusae, are borne in a circle round the hydranth, below the tentacle"; and again, in reply to a request for examples of the medusa or for further information " I am sorry that I have not any specimens of the medusae of the little Hydroid from Port Canning. The only one I have seen escaped in my aquarium. It was so small that I could only just see it with a very powerful hand lens. "

In view of the minuteness of the structures concerned it is possible but unlikely, that a naturalist even of Dr. Annandale's acumen and experience, might have mistaken one of the planula-like buds to be afterwards described, for a medusa.

In any case the elucidation of the sexual phase must be left to new collections of material gathered possibly at a different season of the year.

II. ASEXUAL REPRODUCTION.

Lateral Budding.

A few hydranths possess lateral buds in various stages of development. The buds arise from the region below the tentacle-zone, and between it and the gentle narrowing which indicates the beginning of the stem-like basal prolongation. But they are not common on my specimens which were collected in the month of March, few hydranths possessing even a single bud, and two being the greatest number on any one hydranth.

The buds are of the simplest structure (see plate xxx, fig. 4). They arise as small hollow projections of ectoderm and endoderm, which increase in length much more rapidly than in breadth. So there is formed an elongated hollow sac with thin walls of single-layered ectoderm and endoderm. The base of the sac becomes much constricted at its point of junction with the hydranth, but the internal cavity retains connection with the coelenteron of the hydranth by a narrow passage. In due course the connecting neck of the bud becomes ruptured, and the bud, which is now vermiform and closely resembles the planula of many hydroids (except that it lacks cilia), breaks away and commences a free life.

A released and therefore mature bud contains no traces of sex cells, and it must be assumed that it gives rise directly to a new hydranth. The only free example which I have observed seems recently to have broken loose from the hydranth (plate xxx, fig. 5). It is almost cylindrical in shape, 0·30 mm. in length by 0·085 mm. in maximum and 0·065 mm. in minimum breadth, slightly narrower in its median region and widening gently to its rounded extremities The resemblance in shape to the planula of *Cordylophora lacustris*, as figured by Allman (1871, pl. iii, fig. 5*a*) is very marked. The proximal extremity still retains an opening representing the lumen which connected the bud cavity

with that of the hydranth, and as a slight ridge well furnished with nematocysts surrounds the opening, it is possible that here is foreshadowed the adult mouth.

Serial sections reveal the fact that at the place of origin of a bud considerable activity is shown by the endoderm of the hydranth, which is crowded with finely granular protoplasm and engulfed food particles. These features are carried into the endoderm of the developing bud, the cells of the proximal portions of which contain much secretory and food material. The mesogloea of the bud is somewhat less developed than that of the hydranth, and the ectoderm is remarkable for the regularity and high, narrow palisade-like structure of the cells at both extremities. These contain spherical nuclei similar in size to those of the endoderm (3μ in diameter), and many nematocysts of both types undergoing development. As the bud increases in size some of these approach the surface of the ectoderm and lie in position for functioning, although in none of the buds, attached or free, are cnidocils present. An extremely thin cuticle is excreted by the ectoderm. I have seen no indication of the presence of an external coat of cilia.

The neck joining bud to hydranth is formed of ectoderm, mesogloea and endoderm, and in spite of the narrowness due to increasing constriction there is no sign that rupture is preceded by the disappearance of the endoderm, as in the case of the hydroid of *Gonionemus murbachii* (see p. 561), or of the ectoderm, as in the cases of the basal bulb described below, or of the sporosac buds of species of *Dicoryne*.[1]

Longitudinal fission.

In a single specimen longitudinal fission appears to be in progress (see pl. xxx, fig. 3). From the neighbourhood of the tentacle-zone of a well-developed hydranth with in all eleven tentacles a secondary hypostome branches out as if due to the division of the original hypostome. Both hypostomes are normal in character and the mouth of each is connected in the usual way with the common coelenteron of the hydranth. The endoderm layer between one hypostome and the other is of uniform thinness and regularity, and shows no prolongations or other abnormalities in the neighbourhood of the fission angle. The smaller hypostome has appropriated some of the tentacles of the original hydranth, and new smaller ones are arising at its base. Whether this process is to be reckoned as a normal mode of reproduction or whether the instance described is rather an abnormal case of budding or duplication than an example of true fission, I have no means of deciding.

The Basal Bulb.

Reference has already been made to the significance of a structure which I have termed the basal bulb. To judge by the

[1] *See* Ashworth and Ritchie, 1915.

frequency of its occurrence this structure is of first importance in the propagation of the species, for every hydranth examined (except one) bore one and often two bulbs at varying stages of development. The solitary exception was a young individual with 5 tentacles, in which the proximal extremity ended in a sucker-like disc without perisarc, the equivalent of the basal disc or "Fussplatte" of *Hydra* and other forms. The universal presence of at least one basal bulb or its antecedent on these specimens can be readily understood by the fact that all the hydranths examined were growing upon a seaweed; and that as the basal bulb is the only means of attachment its presence was postulated by the stage of growth of the hydranths discovered. The only hydranths likely to be found lacking the basal bulb are individuals belonging to the unattached, probably planktonic, stage.

Position and General Structure of the Basal Bulb (pl. xxx, figs. 1-3). The basal bulb is situated at the lower free end of the hydranth in the position generally occupied by the hydrorhiza. Resemblance to a hydrorhiza is further to be found in the fact that it seems to be the habit of the basal bulb to lie with its long axis parallel to the substratum and at right angles to the hydranth. Basal bulbs have been found in the youngest hydranths as well as in the oldest individuals examined; in the former, the hydranth body springs directly from the bulb, in the latter the bulb terminates the stalk-like proximal prolongation of the hydranth.

At all stages the character of the bulb is obscured by masses of organic debris which adhere to it in a dense coating and spread from it for a short distance upon the hydranth. Within this debris, except in the very earliest stages, lies a more or less globular shell of chitin, thin, delicate, and colourless at first, but later becoming strong, immobile and tinted. During its impressionable stages the chitin of the bulb may be moulded upon the particular substance whereon it lies, and this produces considerable modification in the typical rounded form. The chitinous shell contains and protects a simple cellular sac, which in its more mature stages lies loosely within. This sac, the essential portion of the basal bulb, consists of a single layer of ectoderm and of endoderm. In its advanced stages it is connected with the proximal end of the hydranth by a narrow protoplasmic neck which passes through a small circular opening in the chitinous shell—the only aperture connecting the interior of the shell with the exterior.

Detailed Structure of Mature Basal Bulb (pl. xxxa, fig. 9). Well developed basal bulbs were examined in serial sections. In these specimens the cellular sac did not lie in contact with the chitinous investment; but since the chitin showed many regular growth-lines and could only have been secreted by the sac, the hiatus may be artificial, due to shrinkage in preservation.

No special features mark the single layers of ectoderm and endoderm which form the walls of the sac: the latter contains

small round nuclei and here and there groups of excretory products; the former contains many large nematocysts in process of formation, especially in the upper region near the aperture in the chitinous investment. It is curious that nematocysts should develop in an enclosed sac the ectoderm of which has no contact whatever with the exterior, but a similar condition has been observed in the hydrorhizal portion of *Myriothela cocksii* (Hardy, 1891, p. 512), and of *Corymorpha* (Torrey, 1907, p. 279), and I have noticed it in the case of some gonophores. In *Annulella* the history of the layers of the sac (see p. 555) offers a simple explanation. The walls of the sac are thin and leave a moderate space for a central cavity which is in direct communication with the coelenteron of the hydranth.

It is a remarkable fact that in the mature bulb there is no direct connection between the ectoderm of the hydranth and that of the basal bulb. At the constriction or neck uniting the two, the ectodermal layer disappears and the chitinous investment abuts against the mesogloea. This may be a preliminary to the severing of the neck at the time when the hydranth escapes from its hold-fast; as such at any rate it would fall into line with the well-defined process which precedes the release of the free-swimming sporosacs of species of *Dicoryne* (*see* Ashworth and Ritchie, 1915).

An unusual feature distinguishes the mesogloea of the basal bulb. It is continuous with the mesogloea of the hydranth, but just beneath the neck and within the aperture of the chitinous shell, it forms a very much thickened rim deeper than either endoderm or ectoderm. From the proximal margin of this ring the mesogloea suddenly tapers away, and throughout the remainder of the bulb forms a layer of extreme tenuity.

The chitinous investment of the basal bulb is of rudely spherical form, sometimes greatly modified by its contact with the solid substratum. The chitin is of very different densities, but the upper portions are always the more solid and deeply tinted. Round the small but very definite aperture through which the neck of the basal bulb passes there is a thickened ring slightly incurved. While the perisarc is well defined in the distal portions and there exhibit definite growth lines, in the central area of the floor of the bulb it gradually loses its compactness and merges into an amorphous gelatinous mass of much greater thickness (pl. xxxa, fig. 9*a*). In this mass are included, along with other debris, large quantities of diatom skeletons in some of which the protoplasm is so well preserved as to indicate that the algae continued to live after their inclusion. This unconsolidated basal area may add to the efficiency of the basal bulb as a hold-fast, or may provide for the expansion of the perisarc-shell during the growth of the sac within.

The secretion of perisarc is confined to the basal bulb, at the neck of which the chitinous covering ends abruptly. Yet masses of gelatinous material containing much debris not only surround the bulb but are continued for a short distance on the lower exposed portion of the hydranth.

Origin and Development of the Basal Bulb (see pl. xxx, fig. 6). The basal bulb is a modified portion of the hydranth body. This is clearly shown by a hydranth which has recently broken away from a former basal bulb, and is in process of forming a new one. The history of this specimen (fig. 6) may be taken as indicating the general development of a basal bulb, and appears to have been as follows.

The hydranth tapers away at its basal end almost to a point, and here the tissues are ruptured. This narrow portion is the neck of a former basal bulb, and the damaged tissues show where the narrow neck, already prepared by increasing constriction and by the disappearance of the ectoderm layer, has broken asunder, allowing the hydranth to escape from its former anchorage. The final rupture of the neck is no doubt due to mechanical strain brought about by the swaying of the hydranth in the water currents.

So far as one can judge the free stage of the hydranth must be of very limited duration, for even before the traces of rupture at the neck of the old basal bulb have disappeared, a new basal bulb is in process of formation.

Four modifications mark the development of a basal bulb. Its origin is first indicated by a slight constriction in the lower portion of the body of the hydranth. This constriction affects all the cell-layers: the endoderm and mesogloea are simply indented, but even at the early stage figured, there is already a disruption in the ectoderm, which, although not yet severed, is reduced to very thin dimensions at the level of the future neck. A second characteristic regards the differentiation of the ectoderm of the basal bulb. Distal to the constriction, that is on the unaltered hydranth, the ectoderm is of the normal ridged type with rather elongated cells, but proximal to the constriction the cells are smaller, more regular and flattened. In the third place, copious masses of mucus in which debris becomes entangled begin at once to be secreted by the ectoderm of the basal bulb; and lastly the formation of mucus is succeeded by the secretion of a chitinous investment, the perisarc, which at the stage figured had only begun to form in the lower regions. The folding over of the bulb until its long axis lies at right angles to that of the hydranth must be a subsequent development.

While the above mode of development of the basal bulb happens to have come to my notice and is, on account of its uniqueness, described in some detail, it probably represents only one of several methods by which a basal bulb may arise. It can hardly be doubted that the original basal bulb of a hydranth develops directly from the basal-disc or "Fussplatte" of the larva, and development from a lateral bud seems to be hinted at by the following facts.

In many cases there are two basal bulbs at the base of a single hydranth (see pl. xxx, figs. 2 and 3) and in such case they arise not in linear succession but one terminally and one laterally.

The latter may have originated as a bud. Of the two the terminal bulb possesses thicker perisarc and more contracted coenosarc and appears, though not the larger, to be the older individual.

Significance of the Basal Bulb. There is no direct evidence as to the reproductive function of the basal bulb: no young hydranths have been observed springing from the coenosarc of an old bulb, unless it be that where two basal bulbs occur on one hydranth, one represents the original bulb from which the hydranth grew while the other is a development of the hydranth itself.

But the evidence of the structures and development of the bulb seem to point clearly to reproductive function. Thus the disappearance of the ectoderm at the junction of bulb and hydranth seems to be analogous with the similar retrogression in the sporosacs of *Dicoryne* and to indicate a regular preparation for the breaking away of the hydranth. An example of a recently released hydranth has been observed. Again basal bulbs are frequently found alone, and in these the coenosarc is in good preservation. Here we seem to have a parallel to the conserving power of the stolon as exhibited in the hydrorhiza of *Dicoryne conybearei* (Allman) in which, by the development of partitions of chitin within the lumen of the stolon the coenosarc is preserved unharmed in various sections during unfavourable conditions (see Ashworth and Ritchie, 1915). In *D. conybearei* the conservation of the coenosarc in this way is succeeded so soon as favourable conditions return, by a new development of hydranths produced by the coenosarc; and it seems highly probable that a similar recrudescence of hydranth life arises from the coenosarc of the basal bulb.

THE RELATIONSHPS OF *ANNULELLA GEMMATA*.

I have already drawn attention to the curious combination in *Annulella gemmata* of peculiar characters some of which have been found rarely, and generally one at a time, in other species. The most accurate conception of the significance of these resemblances will be attained by a short comparison of each with its analogues.

Unattached Hydroids.

Several genera of Hydroids share with the Pennatulid and a few other types of Alcyonarians, the character of gaining a more or less insecure anchorage by simply embedding their proximal end in the mud of the sea-floor. They are generally characterized by solitary habit and by the weak development or absence of perisarc. Amongst such are to be reckoned the Corynids—*Myriothela* and *Blastothela*; the Pennarid, *Heterostephanus*; and the Tubularids—*Corymorpha*, *Lampra*, *Gymnogonos*, *Monocaulus* and *Branchiocerianthus*. It is probable that with these should also be grouped the lake forms—*Moerisia* and *Caspionema*. Many of these gain firmer anchorage by the development of "rootlets," but the

majority or all of them have the power of slight movement, and it is possible that they may be able even to withdraw from the mud and creep along the bottom. In any case, as Hartlaub has pointed out [1] these forms, both in their systematic affinities and the in their habit, present a well-defined half-way house between permanently fixed species and those which are able to leave their attachment and move freely on the substratum or in the sea.

Amongst such temporarily creeping or floating forms we have the freshwater *Hydra*, and its relatives *Protohydra* and *Polypodium*; the Tubularid, *Hypolytus*; and *Haleremita* of uncertain relationship, but closely resembling the larval stage of *Gonionemus*. Here also I am inclined to include the Pennarid, *Trichorhiza*, which, found by Russell (1906) on the tentacles of *Corymorpha nutans*, was apparently caught in the act of moving. General but not universally present characters which link these forms (with the exception of *Trichorhiza*) are the almost total absence of perisarc and the presence of a basal thickening of coenosarc—the pedal disc. I have not included definitely recognized larval forms, but perhaps the floating stage of *Acaulis* ought to be mentioned here, since floating individuals bear well developed medusae buds and may be considered adult.

In a slightly more advanced category of unattached hydroids are to be placed the pelagic forms *Margelopsis* or *Nemopsis*, which represent the detached buds of such forms as *Tiarella* (see Bedot, 1911, p. 211); the unique *Microhydra* and the metagenic form of the Trachymedusan, *Liriope* which " is a true hydra, although its free-swimming mode of life and its superficial aspect caused it to be mistaken formerly for a gonosome " (Perkins, 1903, p. 752).

In none of these groups of unattached Hydroids is to be found an exact parallel to our Indian brackish-water species, the adults of which are at one stage firmly attached, and at another are released from their attached portions in order to lead a temporary free (? pelagic) existence. But, as we shall see in discussing the basal bulb, that structure links *Annulella* with the creeping type, especially common in the family Hydridae.

TENTACLES AND CNIDOBLASTS.

The arrangement of the cnidoblast batteries of the tentacles in well-defined projecting rings is characteristic of very few hydroid stages. It is, however, moderately common in the medusoid generations, being exhibited in such well-known forms as *Thamnostylus dinema*, or in the medusoids of *Corymorpha nutans*, *Stauridium* and *Syncoryne eximia*.[2] In the hydroid stage, so far as I know, it is confined to *Trichorhiza brunnei*, Russell 1906, *Heterostephanus annulicornis* (M. Sars 1859), *Hypolytus peregrinus*, Murbach 1899, *Asyncoryne ryniensis*, Warren 1908, and occurs to a limited extent

[1] Hartlaub, 1902, p. 29.

[2] Compare particularly the representations of the last species as drawn by Allman, 1871, pl. v, figs. 3-4.

in *Tiarella singularis*, Schulze 1876, with its three distal rings of cnidoblast batteries and in *Margelopsis stylostoma*, Hartlaub 1903, which has been shown by Bedot (1911, p. 211) to be the free bud of the preceding species.

It is a striking fact that annulated tentacles should be common in the free-swimming medusoid generation, and should occur in the hydroid generation only in a few species, which, with the exception of *Asyncoryne*, are outstanding on account of their free or partially free habit. The connection of habit and structure appears to be no coincidence, and, on the evidence before me, I would suggest that the arrangement of large cushion-shaped cells in prominent rings is an adaptation to a creeping or free-swimming life. Not only would the greatly enlarged surface area, due to the rings, add to the resistance offered by the organism to the surrounding water, and so check the rate of sinking, even were the organism immobile, but the very large vacuolar spaces, which the nodal cells of *Annulella gemmata* contain (and which in absence of direct evidence I assume to occur in the similar cells of other species), may act directly as buoying agencies. It is possible also that these vacuoles in the tentacular rings may by their enlargement and contraction supply in some degree the means of the daily vertical migrations so characteristic of most hydroid medusae.

In none of the cases mentioned above has the detailed structure of the cnidoblast rings been investigated. But the cushion-shaped cells of which the rings or nodes are made up in *Annulella* closely resemble in general appearance and detailed structure the isolated battery-cells which stud the tentacles of *Hydra*. A comparison of the description and figures of these batteries in *Hydra fusca*, as given by Schneider (1890, p. 332, Tab. xvii, fig. 20), with the description and figures of *Annulella* in this paper throws particular emphasis on this resemblance.

The resemblance to *Hydra* is further emphasized by comparison of the structures of the cnidoblasts themselves (see Schneider, 1890, p. 332 and pl. xvii). In *Annulella* I have recognized only two types of nematocyst, but both occur in almost identical form in *Hydra*. It is true that there are differences in detail; that Schneider describes no connection between the basal prolongation of the cytoplasm of the cnidoblast and a "ganglion mass," that he mentions neither the gubernacula within the macrocnides nor the spiral arrangement of barbules on the ejected filament. But these are negative evidences and in the examination of structures so notoriously difficult as cnidoblasts negative evidences are of even less moment than usual.

The conjunction of capitate and scattered tentacles suggests relationship with the family Corynidae, but the capitation is very slight and might be regarded as a terminal development of the tentacle nodes. Some cases of scattered tentacles (without capitation) occur in the family Hydridae.

The solid multiserial endoderm of the tentacles appears to be paralleled in only one other genus, *Tubularia*. Solid endoderm is,

indeed, characteristic of almost all Hydroids, but it consists of a single row of central thick-walled cells. Chun (1897, p. 316) says regarding the occurrence of such uniserial solid endoderm "Was zunächst ihr Vorkommen unter den Hydroiden anbelangt, so fehlen sie lediglich der durch hohle Tentakel ausgezeichneten Gattung *Hydra*. Alle übrigen Hydroidpolypen besitzen solide Tentakel, welche von einer einzigen Reihe derbwandiger centraler zellen gestützt werden." With the exceptional case of *Hydra* must be included that of the since described *Moerisia lyonsi*, Boulenger (1908), and possibly that also of *Caspionema pallasi*, Derzhavin (1912), regarding the endoderm of which the author makes no remark. In *Hydra* and *Moerisia* the endoderm consists of several longitudinal rows of thin-walled cells, penetrated by a fine central lumen. But in species of *Tubularia* which I have examined in detail, the lower or aboral whorl of tentacles contains a solid endoderm composed of many small thin-walled cells. These are not arranged in series but fill in irregularly the centre of the tentacles (see also Warren's account of *Tubularia betheris*, 1908, p. 282). The oral tentacles of *Tubularia* contain the ordinary type of uniserial endoderm.

The solid delicate-walled multiserial endoderm of *Annulella* bears no resemblance to the solid uniserial endoderm of the majority of Hydroids, but closely resembles in structure and arrangement (except that there is no central cavity) the multiserial endoderm in the tentacles of *Hydra* and *Moerisia*, and resembles in a general way the solid endoderm of the aboral tentacles of species of *Tubularia*.

BUDDING.

The phenomena of budding in the Hydroid Zoophytes may be divided into three types: (1) where the bud develops on the parent into a miniature adult and remains attached, thus giving rise to colonial formation; (2) where the bud develops on the parent into a miniature adult which is then set free; (3) where the bud is set free at a simple planula-like stage and develops into a miniature adult away from the parent.

(1) The colonial type of budding is exhibited by the majority of cnidoblastic and gymnoblastic hydroids. (2) The setting free of a miniature adult is much less common but is familiar through the example of *Hydra*, and occurs in a few forms such as *Moerisia* (Boulenger 1908, p. 363) and *Tiarella* (Schulze 1876, p. 411). (3) The escape of a planula-like bud is an exceedingly rare mode of propagation, and since it is the type exhibited by *Annulella* calls for some remark. In its ultimate results it closely resembles the phenomena of those peculiar propagating branches of many Hydroids, the separation of which—"Scissiparité"—has been most recently and ably investigated by Dr. A. Billard (1904). "Scissiparité," however, connotes the adaptation of an old structure, stolon or branch, to a new purpose, and can be reduced to a simple form of transverse fission in a portion of the hydroid

already existing. On the other hand, buds which ultimately become free seem to have evolved to this end alone: they are new structures the one purpose of which is the multiplication and distribution of forms like the parent. They are probably the most primitive of the budding types and the forerunners of the other types mentioned above.

Amongst the rare cases of escaping buds that of *Myriothela cocksii*, Vigurs [British specimens of which have been frequently misnamed *Myriothela phrygia* (Fabricius)] stands somewhat apart. In this species the buds are spherical masses attached to the parent by a thick stalk, and appear to reach a miniature adult stage before they are set free. Hardy, however, assures us that "all connection with the body of the parent is lost at a very early period, almost before the bud has reformed its ectoderm and endoderm and enteric cavity. It remains attached to the perisarc, however, by a sucker-like arrangement at the aboral pole until it is fully formed" (Hardy, 1891, p. 513 and pl. xxxvi, fig. 13). This might almost be regarded as a transitional stage, which although in fact a free bud, retains the aspect of an attached miniature adult.

Moerisia furnishes a more definite example of exparental development. The buds of this peculiar form are oval and are attached by short peduncles to the parent body, usually in the proximal region of the hydranth. As indicated above they "occasionally develop one or two tentacles" before they are set free, and some may therefore be regarded as attached miniature adults, but the majority of the buds "become completely detached from the parent body" before they begin to assume polyp structure (Boulenger, 1908, p. 363). Rare as such cases are, *Moerisia* is by no means a unique example.

Haleremita cumulans, Schaudinn, seems to depend entirely upon liberated planula-like buds for its dissemination and multiplication, for no trace of sex-cells has been discovered (Schaudinn, 1894, p. 227). The buds, which at the time of liberation are much elongated and planula-like, arise sometimes just beneath the tentacle zone and sometimes near the base of the hydranth and up to six may be found on a polyp at one time. After being set free they develop a mouth and creep upon the bottom, simple two-layered sacculae, which retain their simplicity for some 1½ months before the tentacles of the adult make their appearance. Some have been observed to develop buds of their own while yet in the saccula stage.

Much resemblance exists between the general structure and bud-formation of *Haleremita* and that of the larva of *Gonionemus murbachii* Mayer, described by Perkins (1903). The unusual stumpy conical shape of *Haleremita* is duplicated in the *Gonionemus* hydroid, and in both there are four tentacles set crosswise in a single whorl. Both lack sex-cells and both reproduce by planula-like buds. *Haleremita* is unusual amongst hydroids is possessing only one type of nematocyst, but Perkins' description (p. 786)

indicates that only one form, long and bean-shaped, is present in *Gonionemus*. It is possible that these resemblances points to the true relationship of the problematical *Haleremita*: that it is the metagenetic hydroid phase of a hydrozoon medusa, a larva which in due course will assume medusa form. It is interesting to find some confirmation of this view in the simplicity of structure (to be expected in a larval form) which has led to the relegation of *Haleremita* to the primitive family Hydridae; yet the bud-formation in the two is by no means identical.

Perkins describes some interesting features in the development of the *Gonionemus* hydroid buds. The buds, which occurred singly on the hydroids, arise about halfway between the base of the polyp and the ring of tentacles. During their early growth the endoderm is solid, and in this condition becomes isolated from the endoderm of the polyp by the gradual constriction of the ectoderm at the junction of the two. Finally the bud comes to be attached simply by a long thin neck of transparent ectodermal protoplasm. The release of the bud, in the only case followed throughout its complete development, was accomplished by the gradual stretching and final rupture of the ectodermal neck. The released bud settled down upon its former *free* or *distal* end, and at the other pole, formerly attached, a mouth and tentacles developed. This bud became attached near the parent polyp, but in most cases an escaped bud was discovered after a few days some distance from the parental form. During the interval "it seems probable that it is a creeping unciliated form, although my first conjecture that it was a ciliated planula has not been proved erroneous" (Perkins, 1903, p. 771). A general idea of the developmental period of such planula-like buds can be gathered from Perkins' observations. The development of a bud from its first appearance as a simple knob to the completion of the formation of the coelenteron and the appearance of tentacles, lasted from ten to fourteen days, distributed as follows:—"(*a*) the first period including as far as the detachment of the bud, 5 days; (*b*) motile form, 2 to 5 days; (*c*) from attachment to appearance of tentacles, 3 to 5 days (Perkins *loc. cit.*). Schaudinn found that the development of *Haleremita* buds, up to the point of escape from the parent, varied from 5 hours to 6 days (Schaudinn 1894, p. 230).

In all the cases above mentioned, as well as in that of our Indian form, the buds arose equally from ectodermal and endodermal elements, confirming the observations of Braem (1894) and contrasting with Lang's (1892) description of the purely ectodermal origin of Hydroid buds.

So far as can be determined from my examination of the comparatively few buds available in the Indian species, they agree most closely with those of *Haleremita cumulans*. In both species, in contradistinction to *Gonionemus*, the bud possesses a hollow structure from the beginning, and the internal cavity remains in connection with the coelenteron till the time of escape.

The special resemblances to *Gonionemus* buds are slight and of little account. In both the buds seldom occur more than one at a time on a polyp; and in both it seems that the usual polarity of hydroid buds is reversed, and that the free end becomes the area of attachment, and the attached end the oral and tentacle-bearing area. It may possibly be that this remarkable inversion of the general mode of hydroid development is not a regular habit, but simply emphasises that in hydroid buds there exists an indeterminate polarity ready to be determined by external physical conditions. Such has been shown experimentally to characterise the adult stems of forms like *Tubularia* and *Corymorpha*, or in closer analogy exists in the larva of *Corymorpha*. It is likely that here as in these larvae "external factors such as contact and possibly gravity determine the kind of structure (*e.g.* hydranth or holdfast) which will ultimately appear in connection with the area of differentiation. That is they determine the polarity of the adult." (Torrey, 1907, p. 292).

ANALOGUES OF THE BASAL BULB.

The normal organs of attachment of the vegetative stocks of the Hydrozoa fall into two broad classes: (1) those in which the base of the hydranth is simply modified into a fleshy disc or cylinder, occasionally naked, more often covered by a mucous secretion in which foreign debris becomes embedded, or rarely enclosed in a membranous film of chitin; (2) those in which a more specialized structure is apparent, the attachment being due to well-defined root-like strands of coenosarc, enclosed in a distinct coat of perisarc (the stolon or hydrorhiza) and forming simple threads, or branched "roots," or anastomosed networks, or even thick skeletal layers (as in *Hydractinia*).

It seems to me that these two types of hydroid attachment are homologous, that the simple fleshy attachment was the direct forerunner of the hydrorhiza, and may be regarded as a primitive characteristic in those forms in which it occurs. In known species of Hydroids it is possible to trace the steps by which the simple basal disc became branched and split to form a root-like organ, and by which the final complexity of the hydrorhiza was built up. A process parallel to that suggested by a survey of the attachment organs of adult hydroids seems to be followed in summary during the development of certain individuals. One need only point to the early life-history of the colonial form *Eudendrium ramosum*, after the planula has relinquished its free state and settled down, to illustrate the development of a facsimile of the basal disc into a complex hydrorhiza (see Allman, 1871-72, pl. xiii, figs. 12-16 and 2).

It would be out of place, however, to develop a thesis of the evolution of the hydrorhiza in this paper, and I shall merely indicate the forms which seem to stand most closely related to our Indian species as regards their mode of attachment.

The simplest definite attachment is that of the larval hydroid of *Gonionemus*. Here there simply occurs at that surface of the planula-like bud which comes in contact with the substratum an increase in the thickness of the cells, so that the ectoderm of the base becomes a columnar epithelium. There seems to be no secretion of masses of mucus, but at any rate "it has now secured a firm hold upon the bottom, being so closely applied that it is quite hard to dislodge it" (Perkins, 1903, p. 771). In the above sentence Perkins would seem to hint that the adhesion is physical. In *Haleremita* the attaching area has differentiated a stage further: for while it still consists of a simple layer of special elongated epithelium, there are associated with it many gland-cells which exude the secretion by means of which the polyp is attached to the substratum (Schaudinn, 1894, p. 228).

A clear advance is marked by the condition of *Hydra* and *Protohydra*, for here a first organ of attachment, as distinct from a mere differentiation of ectodermal cells, is apparent. Nevertheless this organ (the foot, pedal disc, disque pedieux, Fusscheibe, Fussplatte) retains the condition of elongate epithelium, with associated secretory cells the mucus of which acts as an accessory holdfast, but it is capable of grasping a firm surface and relinquishing its hold at will.

I regard as closely akin to the foot of *Hydra* in differentiation the "sucker-like" adhesive organs of the miniature adults of *Myriothela cocksii* ("*phrygia*"), mentioned by Hardy (1891, p. 513) as remaining attached to the surface of the parent during development.

Greater structural complexity is shown by the problematical "Basalscheibe" of the miniature-adult buds of *Tiarella singularis* minutely described by Schulze (1876, p. 412 and Taf. xxx, fig. 2). In shape and minute structure this curious organ bears a striking resemblance to the naked basal disc observed in one young individual of *Annulella* with five tentacles, to the basal bulb of young specimens (see plate xxx, fig. 1) or to a section of an adult bulb (pl. xxxa, fig. 9). On account of these resemblances I have no hesitation in discarding Hartlaub's suggestion that it may be "ein fur die pelagische Lebensweise wichtiges Organ" (Hartlaub, 1903, p. 34), and regarding it is an attachment organ developed in preparation for the settling down of the pelagic phase. In exactly the same category may be placed the basal discs of *Margelopsis stylostoma*,[1] *Margelopsis gibbesi*, and *Margelopsis haeckelii* discussed by Hartlaub (1903, p. 34).

Subsequent to fixation the flattened disc-like "Fussplatte" of the adult *Tiarella*, with its coats of both dark and amorphous perisarc, continuous with those of the hydrocaulus, seems to have degenerated from the larval state as regards cellular distinctiveness.

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[1] A designation which since it indicates simply a young phase of *Tiarella singularis*, must lapse (see Bedot 1911, p. 211).

A much greater advance in the differentiation of the simple basal attachment is exhibited in *Myriothela cocksii* Vigurs, well described by Allman (1876) under the name of *Myriothela phrygia.* In the long-tentacled, free-swimming larval stage, a few days old, an increase in the thickness of the ectoderm at the aboral extremity is noticeable (Allman, 1876, p. 567). This appears to be due to the formation of columnar epithelium (see Allman's figure 15, pl. 56). In any case a sucker-like pad is formed by which the larva attaches itself to the substratum (p. 565). At this early stage of fixation the aboral "sucker" is similar in appearance, structure and function to the pedal discs which have been mentioned above, but new developments soon set in. "The proximal extremity of the animal becomes bent at right angles to the rest of the body so as to form a sort of horizontal, stolon-like foot from which small fleshy processes with sucker-like extremities, and having a considerable resemblance to claspers, are emitted. The function of these processes, however, is very different from that of claspers; they serve to attach the animal permanently to some solid support, to which they fix themselves by their extremities. Along with the stolon-like foot they become clothed with perisarc, and the actinula has thus acquired all the essential characters of the adult trophosome" (Allman, 1876, p. 565).

There is some general resemblance here to the final result in *Annulella,* for although the perisarc-covered "foot" of the adult in *Myriothela cocksii* is a direct development of the larval basal disc, it is almost certain that the original basal bulb of any individual of *Annulella* follows the same course; but the absence of a narrow neck between the stolon-like foot and the hydranth of *Myriothela,* as well as the presence of specialized sucker-like processes, mark it as very distinct from the basal bulb of *Annulella.*

Almost as distinct is the perisarc-covered basal attachment of the Tubularid, *Corymorpha*; for not only does it bear many anchoring processes, but the perisarc is really a portion of that which at one time enveloped the whole hydranth and which by a process of recession became later confined to the lower section of the stem (see Torrey, 1907, p. 279).

As regards the development of its basal bulb directly from the proximal portion of the adult hydranth, and of the special development upon the basal bulb of a highly differentiated perisarc, *Annulella* stands alone. It seems to me that its closest affinity in respect of this organ may be with *Tiarella,* beyond the stage of which, however, it has made considerable advance in specialization. It is well to remember, however, that in its phylogenetic origin the basal bulb is undoubtedly a development of the much simpler naked basal discs characteristic of a primitive group of unattached hydroids.

BASAL TRANSVERSE FISSION.

Transverse fission as a means of multiplication in adult hydroids is not unusual, and varies from the separating of a minute

terminal section of branch or stolon, as in several Campanularians and Plumularians (Billard, 1904, p. 41 *et seq.*) to vital processes such as the exaggerated "decapitation" of *Moerisia* or the median division of *Hydra* or *Protohydra*.

So far as I am aware, transverse fission in a determinate region of the base of an adult individual, is a normal mode of multiplication in only one hydroid species other than *Annulella gemmata*. Even that solitary case differs from *Annulella*: for in *Hypolytus murbachii* the fission takes place near the proximal end of a distinct hydrocaulus; it proceeds gradually by means of constriction, but without any disappearance of ectoderm (so far as one can judge) so that there are set free successive small naked planula-like segments which, after more or less limited wandering, settle down and develop directly into new hydranths (Murbach, 1899). In *Hypolytus* a wandering "blastolyte" escapes from a free adult; in *Annulella* a wandering adult escapes from an attached basal section.

In this respect *Annulella* comes very near to the hypothetical form postulated by Murbach as a precursor of *Hypolytus* (Murbach, 1899, p. 353); but to me there appears to be no close relationship between the two forms.

The phenomena of transverse fission in *Annulella* naturally bears a general resemblance to other well-marked cases such as the strobilisation of *Moerisia* (Boulenger, 1908, p. 364) or the division of *Protohydra* (Chun, 1894, p. 217). But the transverse fission of *Annulella* stands by itself as regards the structural changes involved (such as the disappearance of ectoderm at the neck, paralleled only in the sporosacs of *Dicoryne*), and as regards the final results, since here a segment specially modified with a view to fission remains attached, while the hydranth which gave it origin escapes.

SYSTEMATIC POSITION OF *ANNULELLA GEMMATA*.

The majority of the outstanding features of *Annulella gemmata* are primitive in character, a few seem to be adaptive. Among the latter may be reckoned the annular arrangement of large cells upon the tentacles (see p. 558), the great length of the tentacles themselves, and the adoption of basal transverse fission. All of these bear upon the free-living stage, the last as the means of attaining freedom, the former as adjuncts to a (supposed) pelagic existence.

The primitive characters include the normal adoption of various types of vegetative budding; but even these are of simple nature. Thus the setting free of minute, non-tentacled, planula-like buds must probably have preceded in evolutionary development even the liberation of buds at a miniature adult-stage, as occurs in *Hydra* and occasionally in *Moerisia*, both of which are included in the family Hydridae. Further, the naked basal disc observed in one young specimen of *Annulella* appears to be homo-

logous with the similar structure common in adult members of the Hydridae and in young specimens of *Tiarella*, and the basal bulb in its first development phylogenetically and ontogenetically, may be taken as a highly specialized form of the basal disc or " Fussplatte."

Finally, the multiserial endoderm of the tentacles finds a close analogy in the similar (but hollow) endoderm of the Hydridae (*Hydra* and *Moerisia*).

Perhaps one ought to add that if faith be placed in Haeckel's hypothesis of the origin of a capitate tentacle as the thrusting out on a stalk of a cluster of nematocysts, then the capitation of the tentacles may also be placed amongst the primitive characters.

A survey of the systematic distribution of the distinctive characters of *Annulella* shows that they are confined to four families of the Hydroidae—Hydridae, Corynidae, Pennaridae and Tubulariidae; but that they preponderate towards the more primitive end of the series—the Hydridae and Corynidae. Systematists have long regarded the tentacles as a primary basis of distinction, special stress being laid upon their capitate or filiform condition and their distribution upon the hydranth body. This basis being adopted, the capitate and scattered tentacles of *Annulella* place it definitely in the family Corynidae, but there are clear affinities in the multiserial endoderm of the tentacles, in the simple budding, and in the basal disc and bulb to members of the family Hydridae.

In the Corynidae, where, agreeing with Mme. Motz-Kossowska (1905, p. 45), I would place *Tiarella*, in preference to the position with the Pennaridae assigned to it by Schulze, there is no genus closely comparable to *Annulella*. But it bears some relationship to *Tiarella* from which it differs most markedly in possessing scattered tentacles, and beyond which it has advanced in the specialization of its basal bulb and of the nematocyst rings on its tentacles. In respect of the distribution of tentacles and of the general absence of perisarc except on the basal extremity, *Annulella* approaches *Myriothela*, and, since no more satisfactory alternative presents itself, I rank it with this genus in the sub-family Myriothelinae.

In these days of many tentative classifications misunderstanding may be avoided if I state that I consider the family Corynidae to contain those Gymnoblastic Hydroids in which the tentacles are all capitate and are either scattered or distributed in several whorls; and that in its sub-family Myriothelinae I would place such Corynids as possess scattered tentacles, are solitary, and lack a supporting skeleton of perisarc.

GENERIC AND SPECIFIC DIAGNOSES OF *ANNULELLA GEMMATA*.

Annulella,[1] nov. gen.

GENERIC CHARACTERS.

Trophosome.—Ployps solitary and naked, with conical proboscis, and long, scattered, capitate tentacles bearing nematocyst batteries arranged in many rings and furnished with solid multiserial endoderm. During their fixed stage the polyps are attached by an adherent base, connected to them by a narrow neck and enclosed in perisarc. Multiplication by vegetative reproduction is the rule.

Gonosome.—? Gonophores producing free medusae.

Annulella gemmatta,[2] nov. sp.

SPECIFIC CHARACTERS.

Minute solitary polyps, 0·15 mm. to 1·0 mm. in height, bearing from 4 to 12 scattered capitate tentacles with nematocyst rings (nodes) along their whole length, and delicate solid endoderm. Tentacles and polyp-body are furnished with two types of nematocysts (macrocnides and microcnides). The polyp is alternately fixed and free, escaping from its basal bulb by rupture of the connecting neck, and again developing a new basal bulb by a modification of its proximal end.

Reproduction is normally asexual, by means of buds set free in a planula-like stage, by means of the detached basal bulb, and possibly by means of longitudinal fission. The type of sexual phase is not known with certainty.

Locality.—A brackish pond, Port Canning, Lower Bengal, India.

Type Specimens.—In the collections of the Indian Museum.

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[1] Feminine diminutive from Lat. *annulus*, a ring, signifying the ringed tentacles.

[2] Lat. *gemmatus*– budded.

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EXPLANATION OF PLATE XXX.

Annulella gemmata, nov. gen. et sp.

FIG. 1.—Young sessile polyp shortly after fixation, with four tentacles, and thin perisarc covering the basal disc (Fuss-platte), × 75. *b.b.* basal bulb; *deb.* coat of mucus and debris.

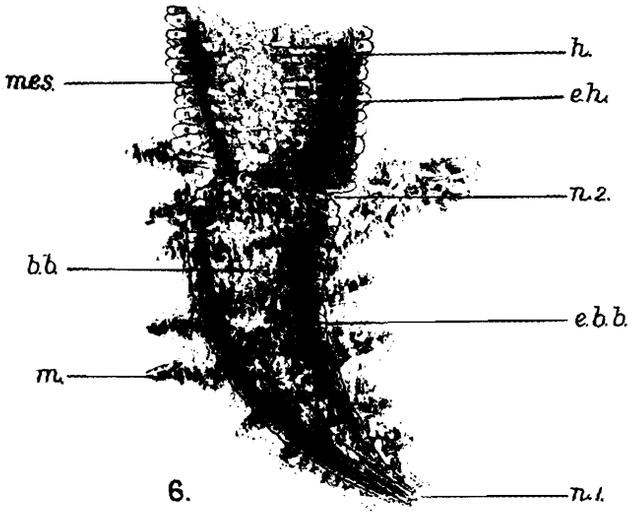
,, 2.—Adult polyp with twelve tentacles, lateral buds (*bud* 1 & 2, the latter possibly a young gonophore), and two basal bulbs; *b.b.* 1 & 2, the former terminal. In both bulbs the internal coenosarc-sac and external chitinous investment are shown, × 55.

,, 3.—Adult polyp with two hypostomes, *p.* 1 & 2, possibly in process of longitudinal fission, and two basal bulbs; *b.b.* 1 & 2, the former terminal, showing clearly the narrow connecting neck, and the perisarc investment, × 55.

,, 4.—Median longitudinal section of bud attached to wall of polyp, × 230. *cav.* large central cavity in communication with coelenteron; *cut.* cuticle; *mes.* mesogloea; *ect.* ectoderm; *end.* endoderm.

,, 5.—Optical section of bud after its release from polyp, and before it has settled down, × 230. *cav.* central cavity, now much constricted by increase of endoderm cells; *cut.* cuticle; *mes.* mesogloea; *end.* endoderm; *ect.* ectoderm; the pale area at the left pole (the end formerly attached) shows the position of the opening which probably persists as the mouth of the polyp.

,, 6.—Proximal end of an adult polyp, showing the origin of a new basal bulb, × 75. *h.* lower end of hydranth body; *e.h.* ectoderm of hydranth; *mes.* mesogloea; *n.* 2, constriction beginning to mark off neck of new basal bulb; *b.b.* basal bulb in process of differentiation; *e.b.b.* ectoderm of basal bulb; *m.* debrisladen mucus; *n.* 1, ruptured tissues indicating the broken neck of an earlier basal bulb, whence the polyp has escaped.



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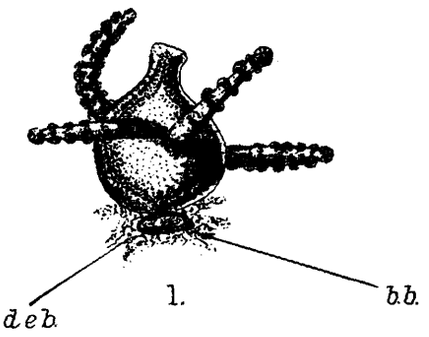

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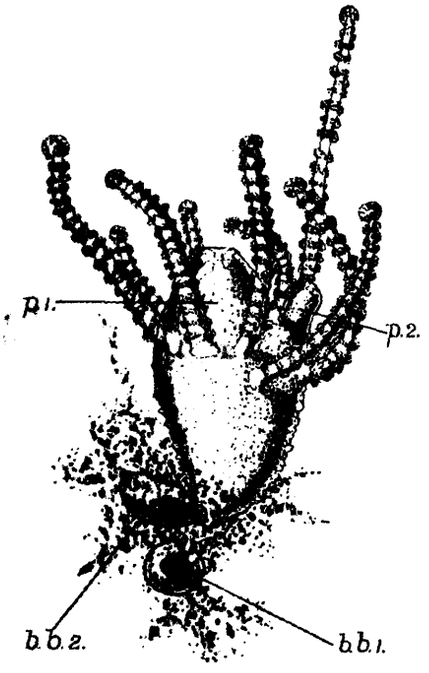

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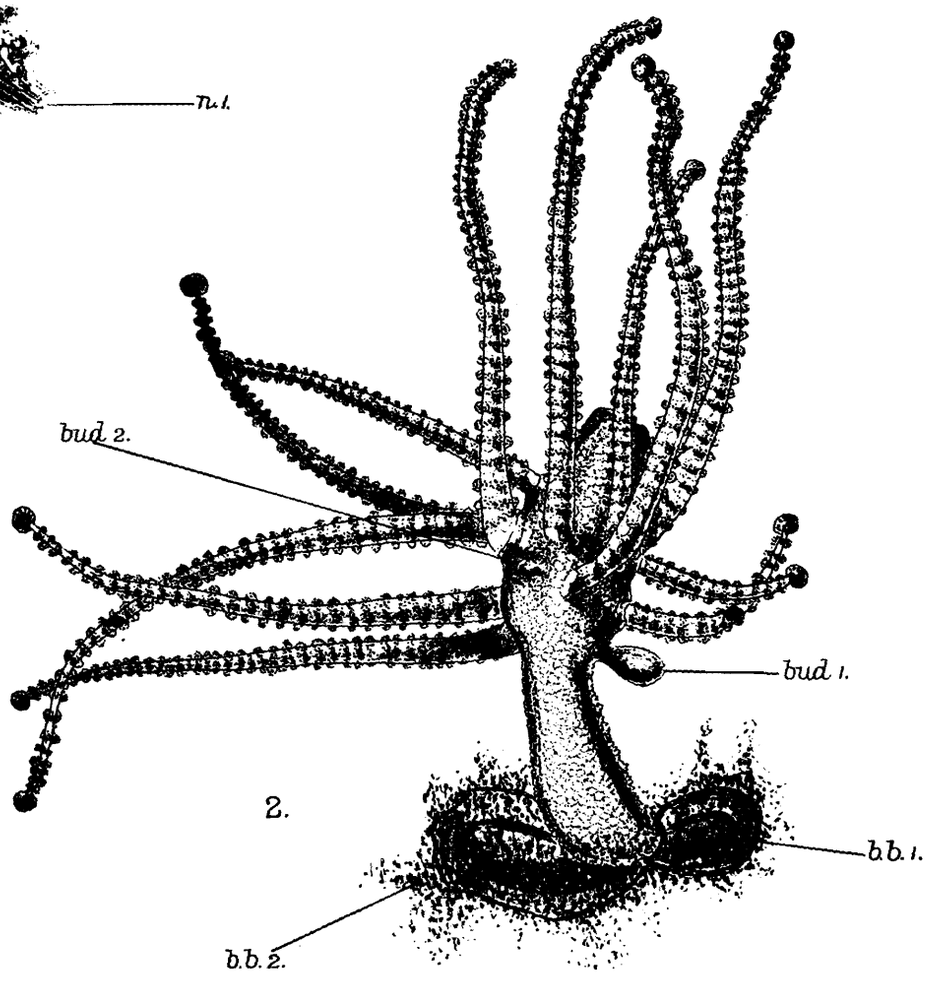

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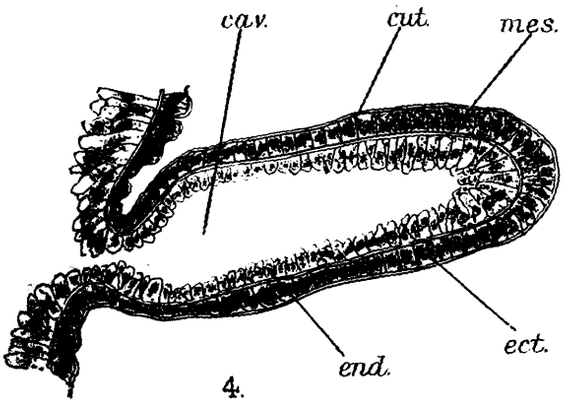

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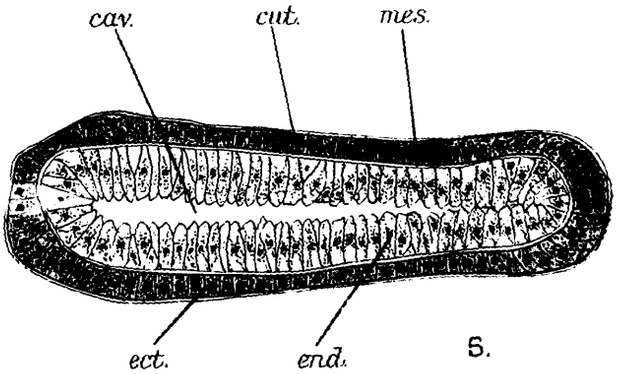


5.

James Ritchie, del.

Bemrose, Colls., Derby

EXPLANATION OF PLATE XXXa.

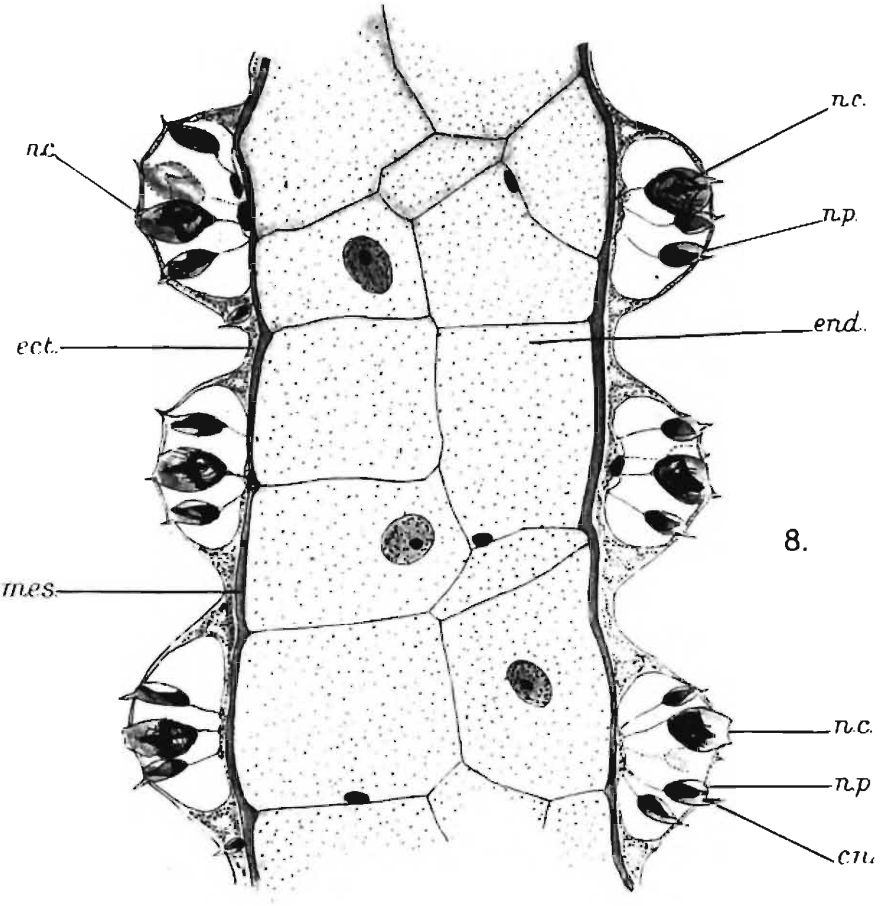
Annulella gemmata, nov. gen. et sp.

FIG. 7.—Portion from near tip of much extended tentacle, showing nodal and internodal areas, and arrangement of nematocysts in nodal cells, × 320.

,, 8.—Median longitudinal section of contracted tentacle, × 770. *n.c.* central nematocyst (macrocnide) of nodal cell; *n p.* peripheral nematocyst (microcnide) of nodal cell; *ect.* ectoderm; *end.* endoderm; *mes.* mesogloea; *cn.* cnidocil.

,, 9.—Median longitudinal section of lower portion of polyp and basal bulb, × 540. *ect.* ectoderm (absent at neck of basal bulb); *mes.* mesogloea (note great thickening within neck of basal bulb); *end.* endoderm; *coel.* coelenteron; *gel.* hyaline, gelatinous secretion (it is difficult to distinguish the relationships of this secretion to the cellular layers, in places it appears to be continuous with the walls of the ectoderm cells, and in one area it seemed to come in contact with the mesogloea); *per.* perisarc of basal bulb; *a.* unconsolidated area of debris-laden secretion into which the firm perisarc merges.

7.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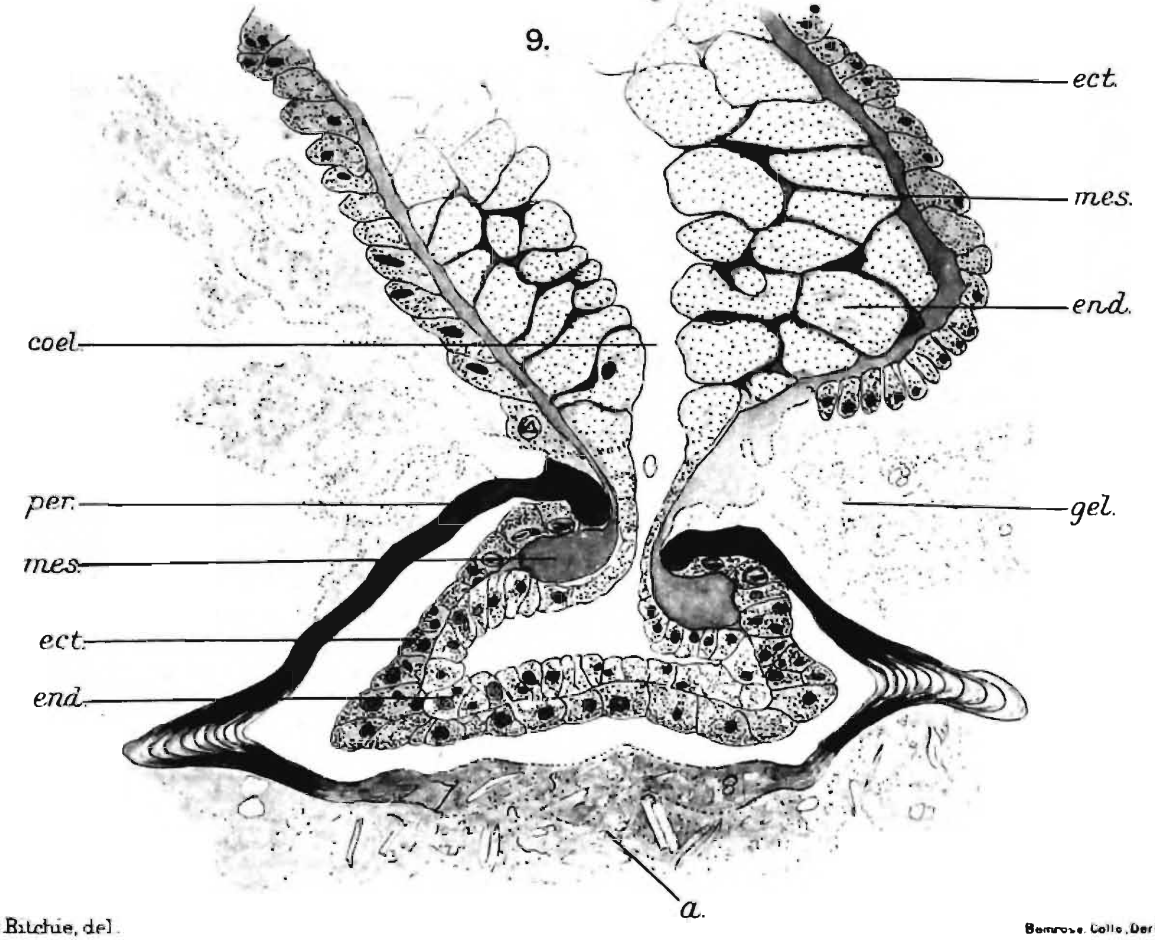
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