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XV. NOTES ON CRUSTACEA DECAPODA IN THE INDIAN MUSEUM

X. *HYMENOSOMATIDAE.*

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The small crabs belonging to the family Hymenosomatidae are singularly unobtrusive in habit and unless very abundant are liable to escape notice. A few species are found in salt water of no great depth, and are not infrequently taken on coral reefs or living under stones between tide-marks; but the majority (at any rate on the Indian coast) appear to inhabit estuaries or lagoons where the water is of low or variable salinity. Two species of the family have, indeed, succeeded in establishing themselves in pure fresh water and one has been taken in lakes 3,000 ft. above sea level.[1]

Most of the species prefer a bottom composed of mud, which, when matted with the fine hairs on their bodies, doubtless assists them in escaping detection. In many instances the mud forms such a dense coating on the carapace and appendages that it is almost impossible to remove it without injury to the specimen. The legs are very brittle; some species appear to throw them off almost without provocation, and this so constantly occurs with *Elamena* (*Trigonoplax*) *unguiformis* that it is almost impossible to preserve a perfect example.

Among the crabs recently collected on the Indian coasts several species of Hymenosomatidae are represented. Alcock in his memoir on the Indian Catometopes[2] was able to give an account of five species and two more have since been recorded. Six others, all of which have not hitherto been described, are here added, bringing the total number of known Indian forms up to thirteen.

The new Indian species were all obtained in brackish water. Four were found by myself in Portuguese India, one being a very abundant species which has also been collected by Dr. F. H. Gravely in the Cochin backwaters. The other two were taken by Dr. Annandale and myself in the vicinity of Calcutta. Both these species exhibit very peculiar structure and one of them, obtained on the banks of the River Hughli, cannot be included in any of the genera hitherto described. There can be no doubt that numbers

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[1] *Halicarcinus lacustris* (Chilton) [see p. 247, footnote] and *Rhynchoplax introversus*, sp. nov.

[2] Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 385 (1900).

of additional species yet remain to be discovered on the Indian coasts.

I have included descriptions of two new forms obtained by Dr. Annandale during his recent tour in the Far East. One of these is from the Tai Hu in the Kiangsu province of China, a lake which is fresh at all times of the year; the other was found in brackish water in the Tale Sap in Lower Siam.

We are at present very far from possessing a clear knowledge of the species referred to this family. The descriptions and figures of many of the older authors are a constant source of difficulty and the identity of numerous species described in the earlier half of the nineteenth century still remains obscure. The confusion is accentuated by differences of opinion regarding the genera. Many authors appear to have distributed their species almost at random and Haswell,[1] who places all the Australian forms in the genus *Hymenosoma*, has expressed the opinion that " the subdivision.

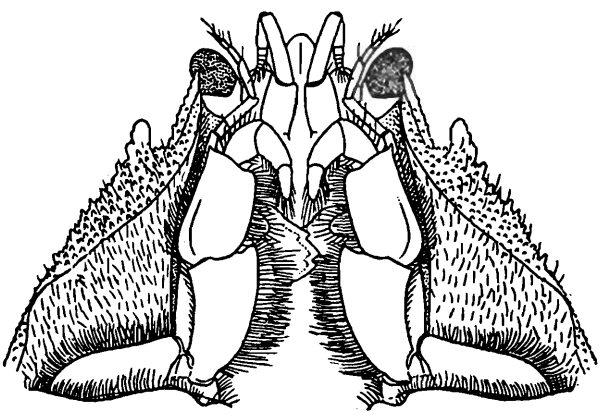

FIG. 1.—*Hymenosoma orbiculare*, Desmarest.
Anterior part of carapace, seen from below.

into the genera *Hymenosoma*, *Hymenicus* and *Halicarcinus* appears to be unnecessary and based on extremely slight points of distinction." This view finds no support from subsequent writers, and it is evident that its author was unaware of the characters of the true *Hymenosoma*; nevertheless, as explained below, I believe him to have been right in uniting *Hymenicus* and *Halicarcinus*.

The following notes on the genera are based on the material in the Indian Museum, which contains in addition to twelve Indian species, a number of specimens from China, Australia, New Zealand, S. Africa and the Falkland Is., all the known genera with one exception being represented.

Hymenosoma was described by Desmarest in 1825,[2] the type species being *H. orbiculare* from the Cape of Good Hope. It is one of the most clearly defined of the genera comprised in the family, differring widely from all others in the complete absence of the epistome (text-fig. 1). The external maxillipedes almost encroach

[1] Haswell, *Cat. Australian Crust.*, p. 114 (1882).
[2] Desmarest, *Consid. gén. Crust., Paris*, p. 163 (1825).

on the bases of the antennules and the buccal cavern is not limited anteriorly by a ridge. The ischium of the external maxillipedes is a little longer than the merus; both segments are slender and, when normally folded, gape in the middle line, the underlying appendages being partially visible. In the abdomen of the male the sutures of all the segments are distinct. The regions of the carapace, as in most genera of the family, are defined by fine-cut grooves.

Numerous species have from time to time been placed in *Hymenosoma*, but in the majority of instances the reference is erroneous and it is now practically certain that the genus is monotypic. Stimpson's *H. geometricum*[1] is synonymous with *H. orbiculare* and Guérin Méneville's *H. gaudichaudii*,[2] though included in the genus by Milne-Edwards,[3] is evidently a species of *Halicarcinus*.

Halicarcinus was established by White in 1846,[4] the type

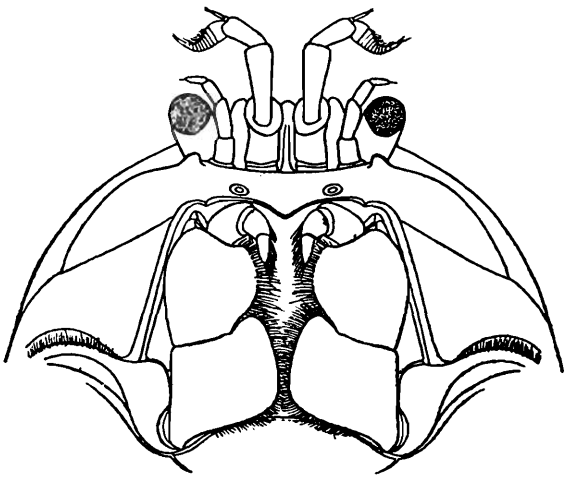

FIG. 2.—*Halicarcinus planatus* (Fabr.).
Anterior part of carapace, seen from below.

species being Fabricius' *Leucosia planata*[5] from Tierra del Fuego. In this genus the epistome is a conspicuous plate, and the buccal cavern is bounded anteriorly by a transverse ridge (text-fig. 2). The ischium and merus of the external maxillipedes are of similar size and are broad segments, completely or almost completely closing the buccal cavern. As in *Hymenosoma* the grooves on the upper surface of the carapace are clean cut and, in the abdomen

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[1] Stimpson, *Proc. Acad. Sci. Philadelphia*, X, p. 108 [54] (1858) and *Smiths. Misc. Coll.*, XLIX, p. 144 (1907). Stebbing, in *Marine Invest. S. Africa*, IV, p. 50 (1905) and *Ann. S. African Mus.*, VI, p. 332 (1910), retains *H. geometricum* as a distinct species, but has since agreed that it is synonymous with *H. orbiculare* [see *Trans. Roy. Soc. Edinburgh*, L, ii, p. 270 (1914)].

[2] Guérin Méneville, *Voy. de la 'Coquille'*, II, ii, 1re div., p. 21 and *Atlas, Crust.*, pl. ii, figs. 12-18.

[3] Milne-Edwards, *Ann. Sci. nat., Zool., Paris* (3), XX, p. 222 (1853).

[4] White, *Ann. Mag. Nat. Hist.* (1), XVIII, p. 178 (1846).

[5] For references see Stebbing, *Proc. Zool. Soc. London*, 1900, p. 524; Doflein and Balss, *Mitth. naturhist. Mus. Hamburg*, XXIX, p. 35 (1912) and Chilton, *Subantarctic Is. of New Zealand*, p. 609 (1910).

of the male, the sutures of all the segments are distinct. In my interpretation of its limits, *Halicarcinus* comprises species with simple rostra as well as those in which it is trilobate or tridentate.

Lucas's *Hombronia*,[1] suggested as a generic name for Jacquinot's *Hymenosoma depressa*[2] from the Auckland Is. and Nicolet's *Liriopea*,[3] based on two species from Chili, are generally regarded as synonyms of *Halicarcinus*, and Dana's *Hymenicus*[4] is separated by such slight distinctions that it cannot in my opinion be retained as a separate genus. In describing *Hymenicus* Dana says: "In this genus the front has not the three teeth of *Halicarcinus* (between which the flexed first antennae are seen), but a simple rounded or trilobate prominence forms the front, and the first antennae are covered. The feet are much longer and more slender than in any of the species of *Halicarcinus*, seen by the author." On comparing *H. varius*, the type species of *Hymenicus*, with *Halicarcinus planatus*, the points to which Dana has drawn attention are readily appreciated. The difference, however, is in reality of very slight morphological importance and is entirely due to the greater development of the front in *H. varius*, the disposition and structure of the related parts being as nearly as possible identical. Examination of allied forms shows that a wide variation exists in the form of the front and affords conclusive evidence that the character is of specific rather than generic value. The comparatively great length of the legs in *H. varius*—the only other point mentioned by Dana—is clearly insufficient as a generic criterion; the external maxillipedes are almost identical in structure with those of *H. planatus* and, as in that species, the sutures of all the segments of the male abdomen are distinct.

But though Dana's *Hymenicus* must, through the characters of its type species, be placed in the synonymy of *Halicarcinus*, it does not follow that all the species hitherto referred to *Hymenicus* must be transferred to White's genus. The two Indian species described by Alcock,[5] together with four others dealt with below, appear to offer distinctive characters. In most particulars they agree with *Halicarcinus*, but the external maxillipedes are much more slender, with the ischium conspicuously smaller than the merus; when normally folded they gape widely in the middle line, leaving parts of the underlying appendages exposed (see text-fig. 7, p. 259). In the abdomen of the male, moreover, the 3rd, 4th and 5th segments are fused, with complete obliteration of the sutures (see text-fig. 9, p. 259). The rostrum is variable in form, but is normally tridentate or trilobate.

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[1] Lucas, in Hombron and Jacquinot's *Voy. au Pôle Sud, Zool.*, III, Crust. p. 62 (1853).

[2] Jacquinot, Atlas to above, *Crust.*, pl. v, figs. 34-39 (1842-53); Chilton, *Ann. Mag. Nat. Hist.* (7), XIX, p. 146, pl. v (1907). It is perhaps doubtful whether this species really belongs to *Halicarcinus* as here defined, for the grooves on the upper surface of the carapace are not shown in either of the figures.

[3] Nicolet, in Gay's *Hist fisica y politica de Chile, Zool.*, III, p. 158 (1849).

[4] Dana, *U. S. Explor. Exped., Crust.*, I, p. 387 (1852).

[5] Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 388 (1900).

As a generic name for this group of species I have employed Stimpson's *Rhynchoplax*,[1] though unfortunately I cannot be altogether certain that its application is correct. Stimpson does not state that any parts of the male abdomen are fused and his reference to the external maxillipedes is decidedly confusing, his only remark being "ischium-joint. scarcely longer than meros," a description that applies if anything better to *Halicarcinus* than to the group of Indian species. On the other hand *Rhynchoplax messor*, the type species of the genus from Simoda in Japan, appears specifically to be an exceedingly close relative of Alcock's "*Hymenicus*" *wood-masoni*, both species, apart from other resemblances, possessing a series of teeth on the upper border of the merus of the chelipede. The question cannot finally be settled until further specimens of *Rhynchoplax messor* are examined. The types were, I understand, destroyed by fire in 1871 and the species has not been recorded since Stimpson's time.

To distribute the numerous described species correctly beween the genera *Halicarcinus* and *Rhynchoplax*, as here defined, is a matter of very great difficulty, but from the figures and descriptions which have been published I conclude that the following species may safely be referred to the genus *Halicarcinus*,[2]—*Hymenosoma gaudichaudii*, Guérin Méneville,[3] *Halicarcinus pubescens*, Dana,[4] *Hymenicus pubescens*, Dana,[5] *Hymenicus varius*, Dana,[6] *Halicarcinus ovatus*, Stimpson,[7] *Hymenosoma tridentata*, Jacquinot,[8] *Hymenosoma rostratum*, Haswell,[9] *Elamene pilosa*, A. Milne-Edwards,[10] *Hymenosoma laeve*, Targioni-Tozzetti,[11] *Hymenicus marmoratus*, Chilton,[12] and *Hymenosoma lacustris*, Chilton.[13]

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[1] Stimpson, *Proc. Acad. Sci. Philadelphia*, X, p. 109 [55] (1858) and *Smiths. Misc. Coll.*, XLIX, p. 147 (1907).

[2] In addition to the type species of the genus I have seen specimens of *H. ovatus, H. varius, H. rostratus* and a species from the Australian coast which is perhaps undescribed.

[3] Guérin Méneville, *loc. cit. supra* p. 245.

[4] Dana, *U. S. Explor. Exped., Crust.*, I, p. 386, pl. xxiv, fig. 8.

[5] Dana, *ibid.*, p. 388, pl. xxiv, figs. 11 *a-c*.

[6] Dana, *ibid.*, p. 387, pl. xxiv, fig. 9.

[7] Stimpson, *Proc. Acad. Nat. Sci. Philadelphia*, X, p. 109 [55] (1858) and *Smiths. Misc. Coll.*, XLIX, p. 146 (1907); Stebbing, *Proc. Zool. Soc. London*, 1900, p. 525, pl. xxxviA. Chilton, in *Subantarctic Is. New Zealand*, p. 609 (1910) suggests that *H. ovatus* is synonymous with Jacquinot's *H. tridentata*.

[8] Jacquinot, in Hombron and Jacquinot's *Voy. au Pôle Sud, Zool., Atlas, Crust.*, pl. v, figs. 27-33. Usually regarded as a synonym of *H. planatus*. Chilton, *loc. cit.*, 1910, p. 609, suggests its retention at least in a subspecific significance.

[9] Haswell, *Proc. Linn. Soc. N. S. Wales*, VI, p. 550 (1882) and *Cat. Australian Crust.*, p. 116 (1882); Baker, *Trans. Roy. Soc. S. Australia*, XXX, p. 114, pl. iii, figs. 2, 2*a,b* (1906).

[10] A. Milne-Edwards, *Nouv. Arch. Mus. Paris*, IX, p. 322, pl. xviii, figs. 6, 6*a-e* (1873).

[11] Targioni Tozzetti, *Crost. Viaggio Magenta*, p. 179, pl. xi, figs. 3*a-c* (1877).

[12] Chilton, *Trans. N. Zealand Inst.*, XIV, p. 172, pl. viii, figs. 1*a-c* (1881).

[13] Chilton, *Trans. N. Zealand Inst.*, XIV, p. 172 (1881) [as *Elamena? lacustris*]; *ibid.*, XLIV, p. 128 (1912); *ibid.*, XLVII, p. 316, fig. 1 (1915); Fulton and Grant, *Proc. Roy. Soc. Victoria*, XV, p. 59, pl. viii (1902); Grant and McCulloch, *Proc. Linn. Soc. N. S. Wales*, XXXII, p. 153 (1907).

The generic position of a number of other species is doubtful, but I think it will eventually be found that all those from southern latitudes hitherto referred to the genera *Hymenicus* and *Hymenosoma*[1] belong in reality to *Halicarcinus*. *H. planatus*, if the records are to be trusted, is circumpolar in distribution and the species listed above are without exception from southern latitudes. The forms that can be referred to *Rhynchoplax* are, on the other hand, all found on the Asiatic coasts, from which no representative of *Halicarcinus* has yet been obtained.

The genus *Rhynchoplax*, in my estimation, comprises Stimpson's two species, *R. messor* from Japan and *R. setirostris* from Hong Kong, de Man's *Elamene filholi*[2] from near Batavia, Alcock's *Hymenicus wood-masoni* and *H. inachoides* from India and six other species described below. It probably includes also Miss Rathbun's *R. coralicola*[3] from Singapore.

A species of Hymenosomatidae found on the banks of the R. Hughli, near Calcutta, does not appear to be admissible into any of the genera hitherto recognized; it is described below under the name *Hymenicoides carteri*. In its structure this species shows a high degree of specialization and generically is related to *Halicarcinus* and *Rhynchoplax*. It agrees with the former of these genera in having the sutures of all the segments of the male abdomen distinct and with the latter in the slender form of the basal segments of the third maxillipedes: it differs from both in the remarkably elongate dactylus of the latter appendages and in the entire absence of a rostrum (see text-fig. 16, p. 267).

In *Hymenicoides* the antennule is completely exposed in dorsal view. This character has frequently been used as a generic criterion, but in my opinion is of specific importance only, being due almost entirely to the extent to which the rostrum is reduced. In *Rhynchoplax* the rostrum is normally trilobate and well developed, but in *R. nasalis*, sp. nov., the lateral portions are suppressed, with the result that the antennules, just as in *Hymenicoides carteri*, are visible from above.

The genus *Elamena* was established by Milne-Edwards in 1837,[4] the type species being Desmarest's *Hymenosoma mathaei*[5] from the Ile de France. Haswell's suggestion that this species is merely the young of *Halicarcinus planatus*[6] has been contested by Stebbing and is certainly incorrect. That Rüppell's identification[7] of Desmarest's species is correct may be assumed from the

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[1] Except, of course, *Hymenosoma orbiculare* and the synonymous *H. geometricum*.

[2] De Man, *Arch. f. Naturgesch.*, LIII, i, p. 386, pl. xvii, fig. 3 (1887).

[3] Rathbun, *K. Danske Vid. Selsk. Skrift.* (7), *naturvid. og math.*, V, p. 316, text-fig. 5 (1910).

[4] Milne-Edwards, *Hist. nat. Crust.*, II, p. 33 (1837).

[5] Desmarest, *Consid. gén. Crust., Paris*, p. 163 (1825). I have not seen this species.

[6] Haswell, *Cat. Australian Crust.*, p. 114 (1882).

[7] Rüppell, *Beschreib. Abbild. 24 Arten Krabben, Frankfurt*, p. 21, pl. v, fig. 1 (1830).

fact that his description and figure is quoted by Milne-Edwards, who, as Stebbing has remarked, probably had Desmarest's specimen before him when he wrote. Paulson's figure[1] differs considerably from that given by Rüppell; the carapace is of much greater proportionate length and bears grooves on its upper surface much as in *Halicarcinus* and *Rhynchoplax*. Stebbing has pointed out (*loc. cit.*) that Milne-Edwards' subsequent reference to the species in 1853[2] is almost certainly erroneous; the genus is here credited with a tridentate rostrum, a character not found in Desmarest's species

In *Elamena*, as represented by the species in the Indian Museum, the carapace is very greatly depressed, sometimes of wafer-like thinness, and the regions of its upper surface are not defined by the fine-cut grooves found in the other genera. The epistome is conspicuous and sometimes of great length. The external maxillipedes completely close the buccal cavern and the ischium, though somewhat variable in size, is always longer than the merus (see text-fig. 25, p. 276). As in *Rhynchoplax* the 3rd, 4th and 5th segments of the male abdomen are fused, and the sutures between them obliterated. The front, or rostrum, is simple, never trilobate.

I agree with Alcock[3] that *Trigonoplax* is, at most, only a subgenus of *Elamena*. It was described by Milne-Edwards in 1853,[4] the type species being de Haan's *E. unguiformis*.[5] As has been pointed out above, Milne-Edwards when writing in 1853 appears to have misunderstood the characters of his own genus *Elamena*, and the foundation of *Trigonoplax* seems to have been a direct result of this mistake The only constant differences that I am able to find between *Elamena* and *Trigonoplax* do not appear to be important and it is probable that when the characters of the species are better understood, the latter will come to be regarded as a synonym of the former.

Six species of *Elamena* have been found on the Indian coasts and are referred to below; of these three (perhaps four) belong to the subgenus *Trigonoplax*. Other representatives of the genus are *E. mathaei* (Desmarest),[6] the type species, found at Réunion and in the Red Sea, *E. producta*, Kirk[7] (with which *E. kirki*, Filhol,[8] is

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[1] Paulson, *Crust. Red Sea, Kiew*, p. 71, pl. ix, figs. 3, 3*a*,*b* (1871).

[2] Milne-Edwards, *Ann. Sci. nat., Zool., Paris* (3), XX, p. 223, pl. xi, figs. 4, 4*a* (1853).

[3] Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 386 (1900).

[4] Milne-Edwards, *Ann. Sci. nat., Zool., Paris* (3), XX, p. 224 (1853).

[5] De Haan, in Siebold's *Fauna Japonica, Crust.*, p. 75, pl. xxix, fig. 1, pl. H (1839).

[6] For references see p. 248, footnotes 4, 5. *Elamene truncata*, Lenz (not A. M.-Edw.), *Abhandl. Senckenberg. Naturforsch. Ges. Frankfurt*, XXVII, i, p. 367, pl. xlviii, figs. 15*a*,*b* (1902) is apparently synonymous.

[7] Kirk, *Trans. N. Zealand Inst.*, XI, p. 395 (1878); Filhol, *Recueil de Mém. Inst. France, Miss. à l'île Campbell, Zool.*, p. 404, pl. l, figs. 1, 2 (1885); Chilton, *Rec. Canterbury Mus.*, I, p. 294 (1911).

[8] Filhol, *loc. cit. supra*, p. 405, pl. xlvii, figs. 6, 8 (1885).

apparently synonymous) and *E. longirostris*, Filhol,[1] both from New Zealand. The position of *E. quoyi*, Milne-Edwards,[2] *E. mexicana*, Milne-Edwards[3] and *E. whitei*, Miers,[4] is doubtful. *E. pilosa*, A. Milne-Edwards, as already pointed out, is probably a species of *Halicarcinus*, while *E. filholi*, de Man, appears to belong to *Rhynchoplax*. *E. minuta*, A. Milne-Edwards,[5] whatever it may be, is certainly not an *Elamena*.

Elamenopsis was established by A. Milne-Edwards in 1873 for *E. lineatus*,[6] a species found in New Caledonia I have seen no specimens of the genus and have not been able to satisfy myself regarding its position in the family. It is said to form a link between the Hymenosomatidae and Pinnotheridae. From the description it appears to be related to *Rhynchoplax*, but the walking legs are much shorter and stouter than in any species of that genus that I have seen.

The principal characters of the other five genera may be summarised in the following way:—

I. There is no epistome. [The external maxillipedes are slender and do not nearly close the buccal cavern. In the abdomen of the male the sutures of all the segments are distinct] ... ... *Hymenosoma*, Desmarest.

II. The epistome is well defined and frequently very long.
A. The regions of the carapace are defined by sharp-cut grooves. The ischium of the external maxillipedes is not longer, frequently much shorter than the merus.
1. A rostrum is present and is frequently trilobate or tridentate. The dactylus of the external maxillipedes is short (normal).
a. The external maxillipedes are broad and completely, or almost completely, close the buccal cavern. In the abdomen of the male the sutures of all the segments are distinct ... ... *Halicarcinus*, White (=*Hymenicus*, Dana).
b. The external maxillipedes are slender and do not nearly close the buccal cavern. The 3rd, 4th and 5th segments of the male abdomen are fused and the sutures obliterated ... . *Rhynchoplax*, Stimpson.
2. The rostrum is altogether absent. The dactylus of the external maxillipedes is abnormally long, reaching the hinder limit of the buccal cavern. [The external maxillipedes are very slender and do not nearly close the buccal cavern. In the abdomen of the male the sutures of all the segments are distinct]... *Hymenicoides*, gen. nov.

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[1] Filhol, *loc. cit. supra*, p. 403, pl. xlvi, fig. 7 (1885).
[2] Milne-Edwards, *Ann. Sci. nat., Zool., Paris* (3), XX, p. 223, pl. xi, fig. 3 (1853).
[3] Milne-Edwards, *ibid.*, p. 224.
[4] Miers, *Cat. Crust. N. Zealand*, p. 52, pl. i, fig. 4 (1876).
[5] A. Milne-Edwards, *Nouv. Arch. Mus. Paris*, IX, p. 324, pl. xviii, fig. 5 (1873).
[6] A. Milne-Edwards, *ibid.*, p. 324, pl. xviii, fig. 4.

B. The surface of the carapace is smooth, rarely uneven; its regions are never delimited by sharp-cut grooves. The ischium of the external maxillipedes is longer than the merus. [The rostrum, when present, is simple. The external maxillipedes are broad and completely close the buccal cavern. The 3rd, 4th and 5th segments of the abdomen of the male are fused and the sutures obliterated] ... ... *Elamena*, Milne-Edwards.

Of these genera only the last three are found on the Indian coasts.

Genus **Rhynchoplax**, Stimpson.

1858. *Rhynchoplax*, Stimpson, *Proc. Acad. Sci. Philadelphia*, X, p. 109 [55].
1900. *Hymenicus*, Alcock (not of Dana), *Journ. Asiat. Soc. Bengal*, LXIX, p. 387.
1907. *Rhynchoplax*, Stimpson, *Smiths. Misc. Coll.*, XLIX, p. 147.

The carapace is circular, ovate or polygonal in outline and is depressed; the upper surface is sunken with the usual grooves sharply defined and the margin upturned. The rostrum is tridentate or trilobate, the lateral processes very rarely absent. The epistome is of good length and the buccal cavern is bounded anteriorly by a sharp ridge. The external maxillipedes are comparatively slender and, when normally folded, gape widely in the middle line; the merus is longer than the ischium and the dactylus is, as usual, short. The chelipedes in both sexes are stouter than the walking legs. In the abdomen of the male the 3rd, 4th and 5th segments are fused and the sutures between them completely obliterated.

This genus is very closely related to *Halicarcinus*, but is distinguished by the more slender merus and ischium of the external maxillipedes and by the fact that certain segments of the male abdomen are fused.

The six Indian species of *Rhynchoplax* together with the two obtained by Dr. Annandale in Siam and China may be distinguished in the following manner:—

1. A large forwardly directed tooth or process on either side of carapace above base of 1st walking legs [rostrum tridentate; a sharp post-ocular tooth visible in dorsal view].
   A. Carapace subcircular, its antero-lateral border armed with one or two blunt teeth; merus of chelipede armed with several strong teeth on its upper border; dactyli of last three legs armed with a series of small teeth.
      1. Two teeth on antero-lateral border of carapace; chela of adult male more than twice as long as high, palm rounded below, fingers not gaping and armed with regular teeth ... ... *R. wood-masoni* (Alcock).
      2. Only one tooth on antero-lateral border of carapace; chela of adult male much less than twice as long as high, palm keeled below, fingers widely gaping and with irregularly disposed teeth ... ... *R. alcocki*, sp. nov.

B. Carapace octagonal; its antero-lateral border without teeth; merus of chelipede without teeth on its upper border; dactyli of last three legs with a single large tooth near apex ... ... *R. octagonalis*, sp. nov.

II. No tooth on side of carapace above base of 1st walking legs [no teeth on antero-lateral border of carapace].

A. Rostrum trilobate or tridentate; basal segment of antennular peduncle not visible in dorsal view; penultimate piece of abdomen of male longer than broad, without tubercle.

1. Rostrum composed of three very broad lobes; post-ocular tooth not visible from above; legs stout, dactyli without teeth ... ... *R. demeloi*, sp. nov.

2. Rostrum composed of three narrow lobes or teeth; post-ocular tooth visible from above; legs slender, dactyli with teeth.

a. Carapace not longer than broad; rostrum composed of three lobes; 2nd walking legs not more than $2\frac{1}{2}$ times length of carapace.

i. Postero-lateral border of carapace normal; dactyli of walking legs very strongly curved and with very large teeth; terminal segment of male abdomen broader than long ... ... *R. exiguus*, sp. nov.

ii. Side-walls of branchial region of carapace reflected upwards, forming a crest outside the true postero-lateral border; dactyli of walking legs moderately curved, with small teeth; terminal segment of male abdomen much longer than broad ... ... *R. introversus*, sp. nov.

b. Carapace much longer than broad, rostrum composed of three long teeth; 2nd walking legs more than 3 times length of carapace [dactyli of walking legs moderately curved, with small teeth; terminal segment of male abdomen as long as broad] ... ... *R. inachoides*, Alcock.

B. Rostrum composed of a single tooth-like process; basal segment of antennular peduncle completely visible in dorsal view; penultimate piece of abdomen of male broader than long, with a large tubercle at distal end [no post-ocular tooth; dactyli of last three legs with a single tooth] ... ... *R. nasalis*, sp. nov.

Rhynchoplax wood-masoni (Alcock).

1900. *Hymenicus wood-masoni*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 388, and (1902) *Illust. Zool. 'Investigator,'* pl. lxiv, fig. 4.

A few particulars regarding the structure of this species, some of which are additions to Alcock's description, are given below in the course of a comparison with the closely allied *R. alcocki*.

Stimpson's *Rhynchoplax messor* from Simoda appears also to be a related form, agreeing in the presence of a series of teeth on the upper aspect of the carpus of the chelipede. In the Japanese

species, however, the carapace is stated to be triangular, with only two teeth on the lateral border, and the median tooth of the rostrum points obliquely upwards, instead of being depressed as in *R. wood-masoni*. The carpus of the chelipedes bears on its upper surface three or four small teeth; in adult males of *R. wood-masoni* one such tooth is sometimes found near the meral articulation, but it is frequently absent. Stimpson states that each joint of the ambulatory feet, except the dactyli, is " dentigerous in the middle," a character not found in *R. wood-masoni* or in any other species of the genus that I have seen.

The only specimens of this species in the Indian Museum are those described by Alcock from the Andamans and from Port Canning near Calcutta.

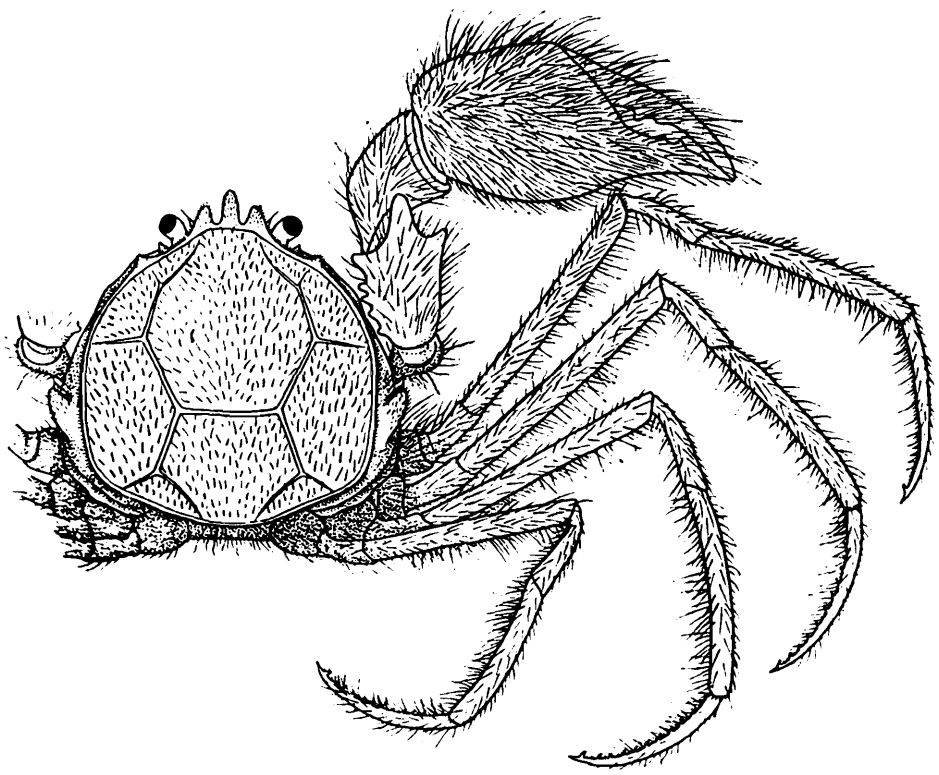

FIG. 3.—*Rhynchoplax alcocki*, sp. nov.

Rhynchoplax alcocki, sp. nov.

The carapace is subcircular, a little produced anteriorly and with its sides slightly flattened and nearly parallel. Its breadth is almost equal to its length, excluding the rostrum. The surface is hairy and sunken and the usual grooves are well defined. The entire margin is upturned and is continuous from side to side across the base of the rostrum. A sharp post-ocular tooth is visible in dorsal view and behind it, on the margin itself, there is a blunt tooth corresponding to the foremost of those found in *R. wood-masoni* (text-fig. 4*d*). Below the margin near the base of the first pair of walking legs there is a huge tooth-like process directed forwards, upwards and outwards.

The rostrum is composed of three narrow lobes with rounded extremities; the median lobe is longer than the two others, and its apex is situated on a lower level.

The antennules, when folded, are concealed beneath the rostrum; at their base they are separated by a prominent septum. The epistome is of moderate length. As in *R. wood-masoni* the external maxillipedes are slender and do not nearly close the

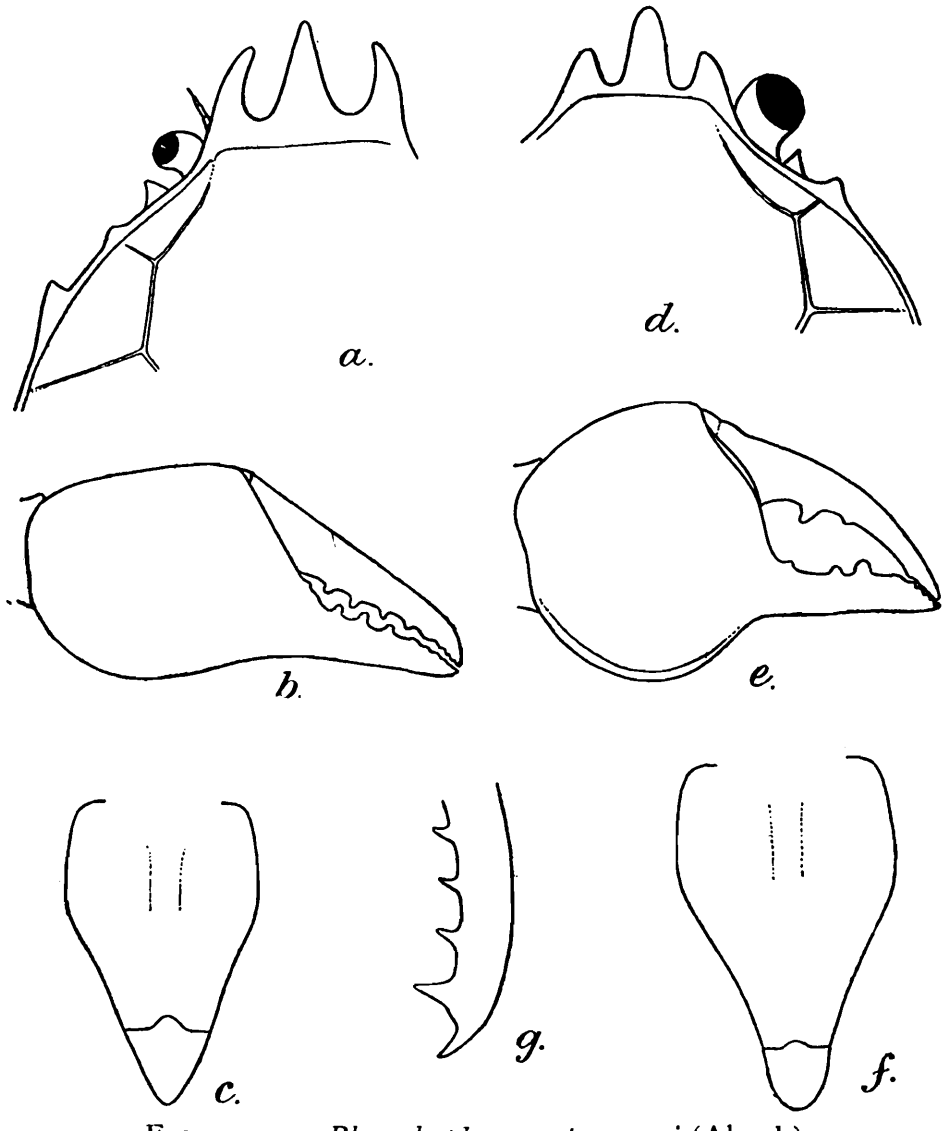

FIG. 4.—*a-c, Rhynchoplax wood-masoni* (Alcock).
d-g, Rhynchoplax alcocki, sp. nov.
a, d.—Rostrum, eye and antero-lateral margin of carapace.
b, e.—Chela of male (denuded).
c, f.—Abdomen of male.
g.—Terminal part of dactylus of penultimate leg.

buccal cavern. The ischium is produced at its inner distal angle and the merus is expanded antero-externally, partially concealing the exognath.

The chelipedes in both sexes are stouter than the walking legs, the chelae of the adult male being particularly large. In the male the merus bears a conical tooth near the end of its lower margin and a series of some five large blunt teeth superiorly.

The carpus is smooth. The chela is very greatly compressed and in adult males is little more than one and a half times as long as high. The palm in lateral view is nearly circular in outline (text-fig. 4*e*) and is slightly hollowed both internally and externally near the strongly compressed upper border. The lower border is convex and is keeled. The fingers gape very widely and meet only at their tips. The dactylus is almost twice the length of the upper border of the palm and bears in its basal third a single large tooth, in front of which a second smaller tooth is occasionally found. The fixed finger bears two large teeth in advance of those on the dactylus and one or two others, which are smaller, near the base. Near the apex, where they meet, the fingers are provided with four or five small interlocking teeth. In the female the teeth on the merus are obscure or altogether wanting and the chela is much narrower, fully twice as long as high; the fingers meet throughout their length and are armed with regularly spaced teeth.

The walking legs are very slender; those of the second pair are slightly the longest and are about two and a quarter times the length of the carapace and rostrum. The anterior border of the merus ends in a very obscure tooth. The dactyli are very slender and are curved; close to the apex each is armed with a large recurved tooth (text-fig. 4*g*) and in front of this, in the last three pairs, there is a series of 8 to 11 smaller teeth, also recurved and extending over practically the whole length of the posterior margin. The chelipedes and legs are clothed with hair, which is particularly long and thick on the chela of the male.

The sternum and abdomen are densely clothed with hair. The abdomen of the male resembles that of *R. wood-masoni*, but is slightly narrower. The terminal segment is scarcely longer than broad and is rounded at the apex (text-fig. 4*f*); the preceding portion is longer than broad, parallel-sided at the base and from the middle point onwards strongly narrowed.

A large male is only 4·8 mm. in length from the tip of the rostrum to the posterior margin of the carapace. Ovigerous females are smaller, sometimes not more than 4 mm. long. The carapace of living specimens, when brushed clean, was of a dull purplish brown colour with groups of small whitish spots.

R. alcocki is very closely allied to *R. wood-masoni*, Alcock, there being an almost exact resemblance between the two in the teeth on the merus of the male chelipede Apart from size, *R. wood-masoni* being much the larger form, the species may be distinguished by the following characters (*cf.* text-figs. 4*a-c* and 4*d-f*):—

R. wood-masoni, Alcock.	*R. alcocki*, sp. nov.
Carapace longer, its length excluding rostrum about one-tenth greater than its breadth.	Carapace shorter, its length excluding rostrum scarcely greater than its breadth.
Two teeth on antero-lateral margin of carapace.	Only one tooth on antero-lateral margin of carapace.

Rostral teeth slender.	Rostral teeth less slender.
Cornea of eye proportionately smaller.	Cornea of eye proportionately larger.
Chela of adult male not greatly compressed, more than twice as long as high, lower edge of palm rounded.	Chela of adult male very greatly compressed, much less than twice as long as high, lower edge of palm keeled.
Fingers of chela of adult male not gaping at base, armed with a regular series of teeth.	Fingers of chela of adult male widely gaping at base, armed with a very irregular series of teeth.
Terminal segment of abdomen of male apically pointed.	Terminal segment of abdomen of male apically rounded.

There are altogether about 100 specimens of this species in the Indian Museum. The greater number were found in Portuguese India in September 1916 and were obtained in the Rachol river at the head of Mormugao Bay above Cortalim Point and in the Mandavi river at Nova Goa. Some of the specimens were dredged on a muddy bottom in water from 1½ to 4½ fathoms in depth, while others were found at Betim Point opposite Nova Goa, living on the posts of a jetty densely covered with Hydroid. All the specimens were found in brackish water, the specific gravity (corrected) varying from about 1·0010 to 1·0060. There are also in the Museum a few specimens found by Dr. F. H. Gravely in September 1914 in the Cochin backwaters near Ernakulam.

The types are from Portuguese India and bear the number 9735/10 *Zool. Surv. Ind.*

Rhynchoplax octagonalis, sp. nov.

The carapace, rostrum excluded, is a trifle broader than long and is distinctly octagonal in outline. The surface, in an ovigerous female, is very little sunken; it is rather closely covered with short hairs and the usual grooves are well defined. The margin is continuous from side to side across the base of the rostrum and is entire, the blunt teeth found on the antero-lateral borders in the two preceding species being absent. On the side wall above the base of the first pair of walking legs there is a large and sharp procurved tooth (text-fig. 5).

The rostrum in dorsal view is seen to consist of three sharp isolated spines, the lateral ones a little shorter than the median and directed obliquely outwards and upwards. The greater part of the eye can be seen from above, together with a small but sharp post-ocular tooth.

The antennules when folded are not visible in dorsal view; they are separated by a well-marked septum. The external maxillipedes resemble those of the preceding species.

The chelipedes of the female are stouter than the legs. The merus does not bear any distinct teeth. The chela is not com-

pressed and the fingers, which are longer than the palm, meet throughout their length when the claw is closed and bear a regular series of 5 or 6 teeth on their inner margins.

The walking legs are not very slender; those of the second pair are about twice the length of the carapace and rostrum. The anterior border of the merus in each pair ends in a prominent tooth. The dactylus of the first walking legs is unarmed; that of the three following pairs is provided with a stout recurved tooth close to the apex. The chelipedes bear scattered hairs; these also occur on the walking legs, which are, moreover, densely fringed on their posterior margins.

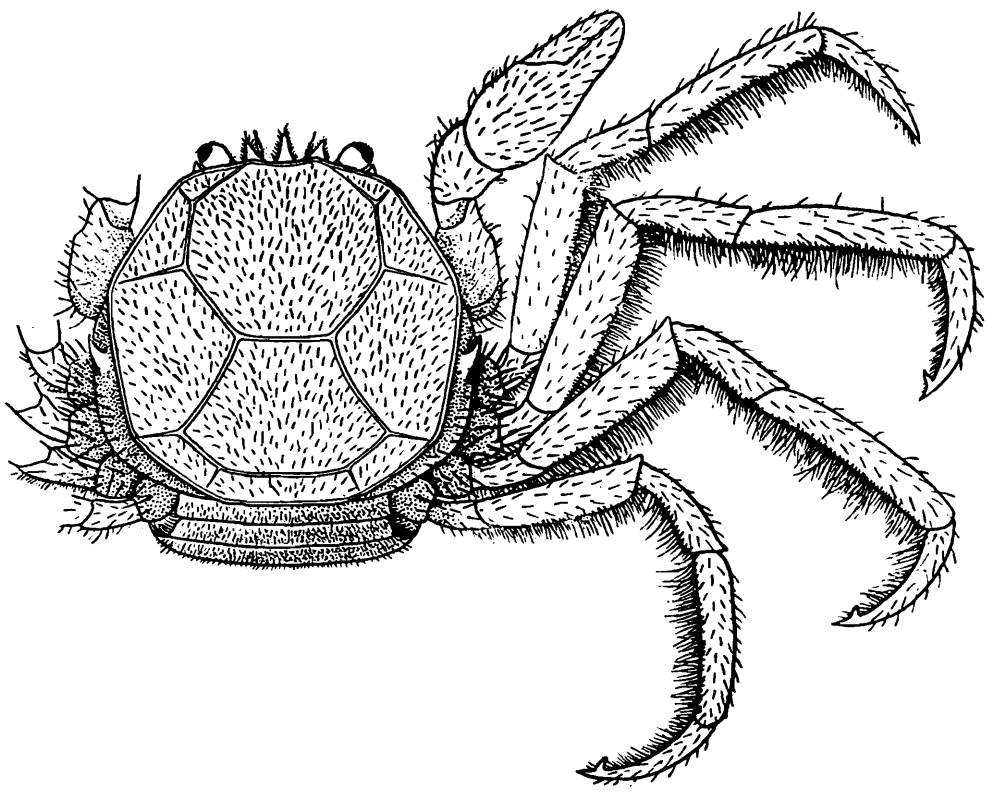

FIG. 5.—*Rhynchoplax octagonalis*, sp. nov.

The species is described from a single ovigerous female, with carapace about 3·9 mm. in length.

De Man's *Elamene filholi* [1], from Noordwachter I. near Batavia, is without doubt a species of *Rhynchoplax* and resembles *R. octagonalis* in the structure of the dactyli of the walking legs and in the position of the single tooth found on the lateral margin of the carapace. In the Javanese species, however, the eye is altogether concealed from above, the carapace and rostrum are quite different in form and the legs are much more slender. Miss Rathbun's *R. coralicola* [2] from Singapore also possesses a single tooth at the

[1] De Man, *Archiv. f. Naturgesch.*, LIII, i, p. 386, pl. xvii, fig. 3 (1887).

[2] Rathbun, *K. Danske Vid. Selsk. Skrift.* (7), *naturvid. og math.*, V, p. 316, text-fig. 5 (1910).

side of the carapace, but it is said to be antero-lateral in position In this species the dactyli are spinulous, thus differing conspicuously from those of *R. filholi* and *R. octagonalis*.

The specimen was obtained at low water under stones among mangroves on Vareeg Islet in Mormugao Bay, Portuguese India. It bears the number 9740/10 *Zool. Surv. Ind.*

Rhynchoplax demeloi, sp. nov.

The carapace is nearly circular; the breadth of its upper surface is about equal to its length, including the median rostral lobe.

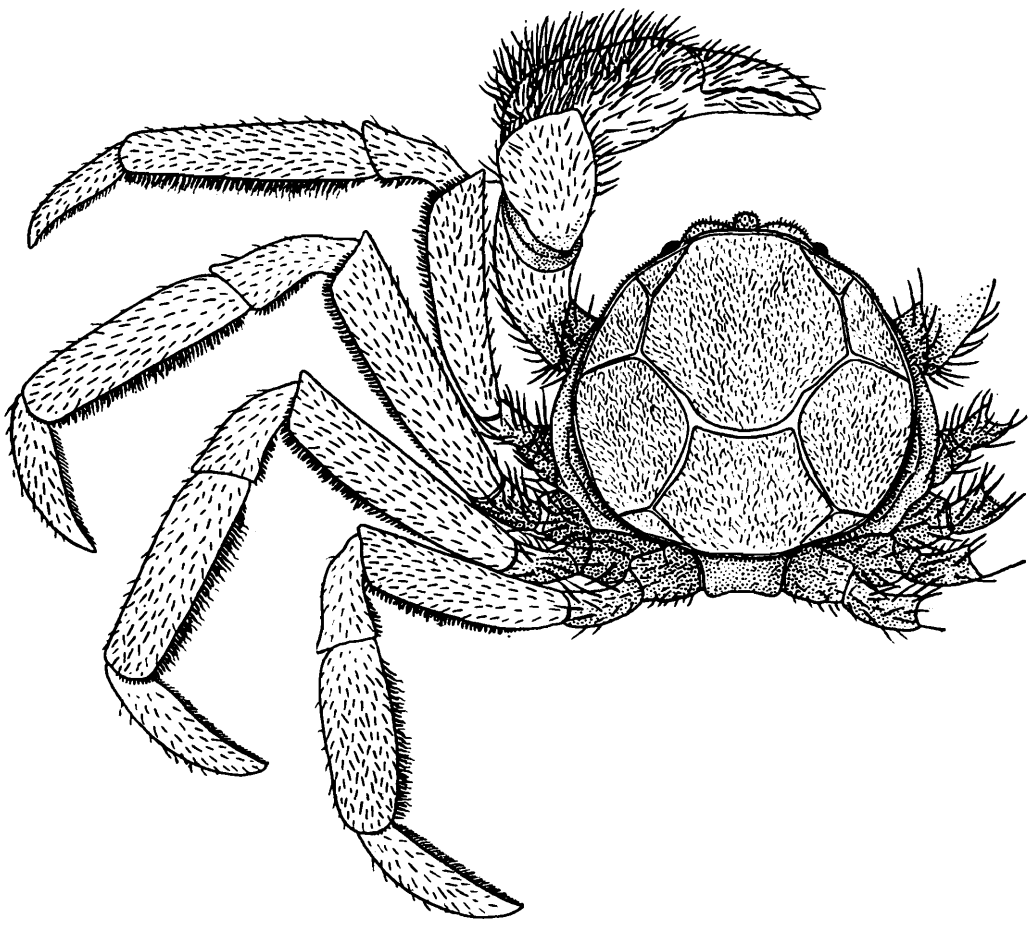

FIG. 6.—*Rhynchoplax demeloi*, sp. nov.

The surface is greatly sunken and is covered with fine hairs that retain a quantity of mud; the usual grooves are deeply cut. The lateral border is entire, upturned, and continuous anteriorly across the base of the three rostral prominences; it is obscurely angulate a short distance behind the eye. The tooth found in the three preceding species on the side wall of the carapace is absent.

The three rostral prominences are exceedingly short. The median one is almost square, a little longer than broad, and is abruptly deflexed; the other two are rounded, very much broader than long, and project straight forwards. The greater part of the cornea of the eye is visible in dorsal view.

When viewed from below the median rostral lobe is seen to be longitudinally carinate and behind the eye there is a small post-ocular tooth which is altogether invisible from above (text-fig. 7). The antennules when folded are completely concealed beneath the front; they are separated at their base by a strong septum. The epistome is rather short. The external maxillipedes are similar to those of *R. alcocki*.

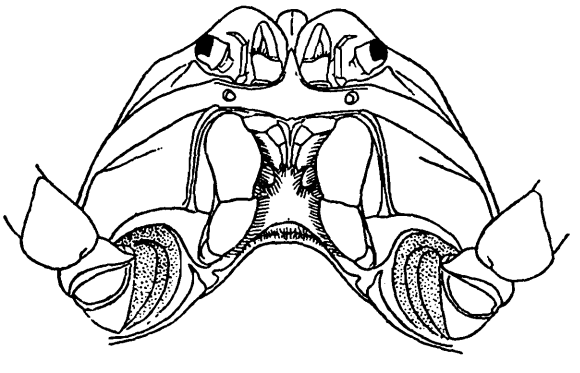

FIG. 7.—*Rhynchoplax demeloi*, sp. nov. Anterior part of carapace, seen from below.

The chelipedes in both sexes are stouter than the walking legs and the chelae are much larger in the male than in the female. The merus and carpus are without teeth. The chela of the adult male (text-fig. 8) is about twice as long as high and is not carinate on its upper or lower margins. Except for a gap close to the base the fingers meet throughout their length; they are armed on their inner margins with 5 or 6 broad interlocking teeth that diminish in size from behind forwards. The dactylus is nearly twice the length of the upper border of the palm. The chela of the female is similar, but more slender. In both sexes the chelipedes are covered with fine hairs; on the outer surface of the palm of the male they are very long and dense, each retaining a quantity of mud.

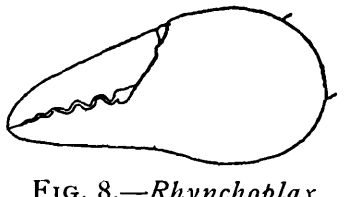

FIG. 8.—*Rhynchoplax demeloi*, sp. nov. Chela of male (denuded).

The second walking legs are slightly the longest and are a little more than two and a half times the length of the carapace. All the segments are exceptionally broad and the anterior border of the merus in each pair ends in a blunt tooth. The dactyli are quite flat, very broad, and only slightly curved; that of the last pair is only about four times as long as wide. The posterior margin is without any of the usual recurved teeth, in this respect differing from all other Indian species of the genus. The walking legs like all other parts of the body are covered with fine hairs which form a short but dense fringe on the posterior borders of the last four segments.

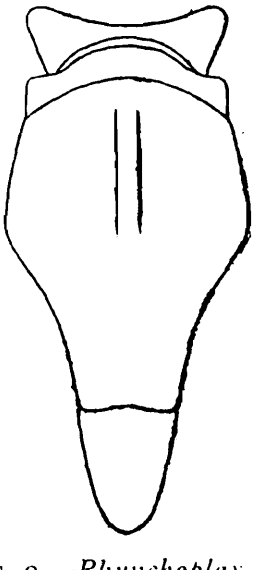

FIG. 9.—*Rhynchoplax demeloi*, sp. nov. Abdomen of male.

The abdomen of the male is similar to that of *R. alcocki* and *R. wood-masoni*, but is narrower. The ultimate segment is bluntly

pointed and is much longer than broad; the preceding portion, which, as in the other species, appears to comprise three fused segments, is obscurely grooved in the middle line; its lateral margin is angulate near the middle and in front of this point is distinctly concave.

The carapace of the largest specimen, an adult male, is about 4·4 mm. in length.

The species is described from fourteen specimens, including a number of ovigerous females, obtained on the shores of the Mandavi river at Nova Goa in Portuguese India. They were found at low water under stones on a muddy bank. At the time they were taken the water in the river was brackish, the specific gravity being about 1·0010.

With this species I have associated the name of Capt. Froilano de Melo, Director of the Bacteriological Laboratory of the Instituto de Análises e Vacina at Nova Goa. I am greatly indebted to Capt. de Melo for the assistance he gave me during my visit to Portuguese India, especially for facilities for the investigation of the very interesting fauna of the Mandavi river.

The types bear the number 9741/10 *Zool. Surv. Ind.*

Rhynchoplax exiguus, sp. nov.

The carapace is ovate and is widest a little behind the middle point; its upper surface, rostrum included, is a little longer than broad. In an adult female (text-fig. 10) the portions of the carapace above the bases of the first two pairs of walking legs are swollen, covered with stiff hairs and project beyond the upturned lateral margin of the carapace; in males these parts are not visible in dorsal view. There is no tooth or process above the base of the first walking legs or on the antero-lateral margin. The upper surface is a little sunken, covered with fine hairs, and with the usual grooves sharply defined. The rostrum is composed of three lobes set with stiff setae. The median lobe is depressed and longer than the other two; in the adult female it is narrow and parallel-sided, in males broader at the base and triangular.

The eye is unusually large; the entire cornea and a portion of the stalk is visible from above, together with a large and very conspicuous post-ocular tooth. The antennules when folded are completely concealed beneath the front; at their base they are separated by a well-marked septum.

The epistome is comparatively long. The buccal cavern is of the usual form and is not nearly closed by the external maxillipedes. The merus in the latter appendage is a little longer than the ischium and expanded antero-externally, partially concealing the exopod The stalk of the exopod, as in *R. naso*, is long and projects a little beyond the endopod when the segments are normally flexed.

The chelipedes of male specimens (which are perhaps not full grown) resemble those of the female, the chela being only a little

stouter than the walking legs. The merus is without teeth and the chela, though the palm is somewhat swollen, is comparatively long and slender. The fingers when closed meet throughout their length and are armed from base to apex with a regular series of 5 or 6 teeth.

The walking legs are slender; those of the second pair are about twice the length of the carapace and rostrum. The merus in each pair ends bluntly. The dactylus is long, slender and very strongly curved; the apex is finely pointed and on the posterior margin there are a number of exceptionally large recurved teeth. In the adult female there are 8 or 9 such teeth, distributed

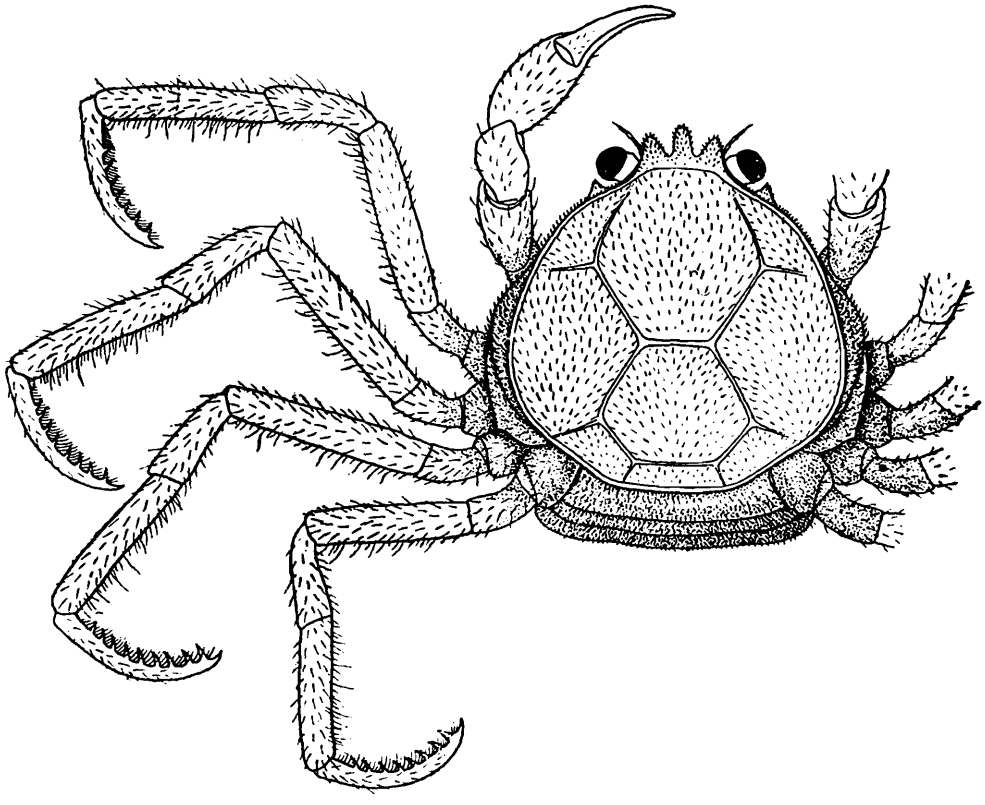

FIG. 10.—*Rhynchoplax exiguus*, sp. nov.

along the whole length of the dactylus; in smaller specimens they are less numerous—sometimes only 3—and occur only in the distal half.

The abdomen of the male is similar to that of *R. demeloi*. The 3rd, 4th and 5th segments form a single piece; the ultimate segment is triangular and a little broader than long.

The species is described from ten specimens, most of which are exceedingly small. The adult female, which appears to have been captured soon after the eggs were discharged, is only 3·4 mm. in length from the tip of the rostrum to the hinder part of the carapace. The largest male, similarly measured, is only 2·8 mm. in length.

Rhynchoplax exiguus appears to be related to *R. inachoides* (Alcock), but is distinguished by the broader carapace, shorter rostral lobes, much shorter walking legs and larger dactylar teeth.

The specimens were obtained by Dr. Annandale in the Tale Sap in Peninsular Siam. They were found on the mainland opposite the western end of Koh Yaw, living in lumps of turf that had fallen into the lake owing to the undermining of the bank. The water in the vicinity was brackish, the specific gravity being about 1·00625 (corrected).

The types bear the number 9743/10 *Zool. Surv. Ind.*

Rhynchoplax introversus, sp. nov.

The carapace is ovate and is widest behind its middle point; its greatest breadth slightly exceeds its length, rostrum included. The upper surface is much sunken; in addition to the usual grooves, which are sharply demarcated, the branchial regions are traversed by a fine oblique line. There is an obscure angulation on the antero-lateral margin midway between the eye and the chelipedes, but there are no teeth in this position and no tooth or process above the base of the first walking legs. At first sight the antero-lateral and postero-lateral borders on each side appear to be discontinuous (tex-fig. 11*a*). This, however, is due to the fact that the lateral walls of the branchial chamber project on either side and are reflected upwards, so as to form a crest which is actually higher than the true postero-lateral border. This border is continued as a low ridge within and parallel to the branchial crest. The posterior margin is short, with a slight emargination on either side opposite the last leg. The rostrum is composed of three blunt processes, the median horizontal, parallel-sided and about twice as long as broad, the two others shorter, and projecting obliquely upwards.

Almost the whole of the eye is visible from above, together with a small post-ocular tooth. The antennules fold beneath the front and are separated at the base by a blunt longitudinal ridge. The epistome is long. The external maxillipedes are of the usual form; they gape widely in the middle line and the merus is a little longer than the ischium. The exognath is almost entirely exposed (text-fig. 11*b*).

The chelipedes are stout and clothed with fine hairs. The merus is without teeth. The chela is stout in the male, about two and a half times as long as broad, with the palm slightly swollen. The fingers are fully one and a half times as long as the upper border of the palm; they meet throughout their length when the claw is closed and their inner margins bear five or six interlocking teeth.

The walking legs are slender; the second pair is about two and a third times as long as the carapace and rostrum. The merus in all four pairs bears a small tooth at the distal end of the upper border. The dactylus is moderately curved and is armed

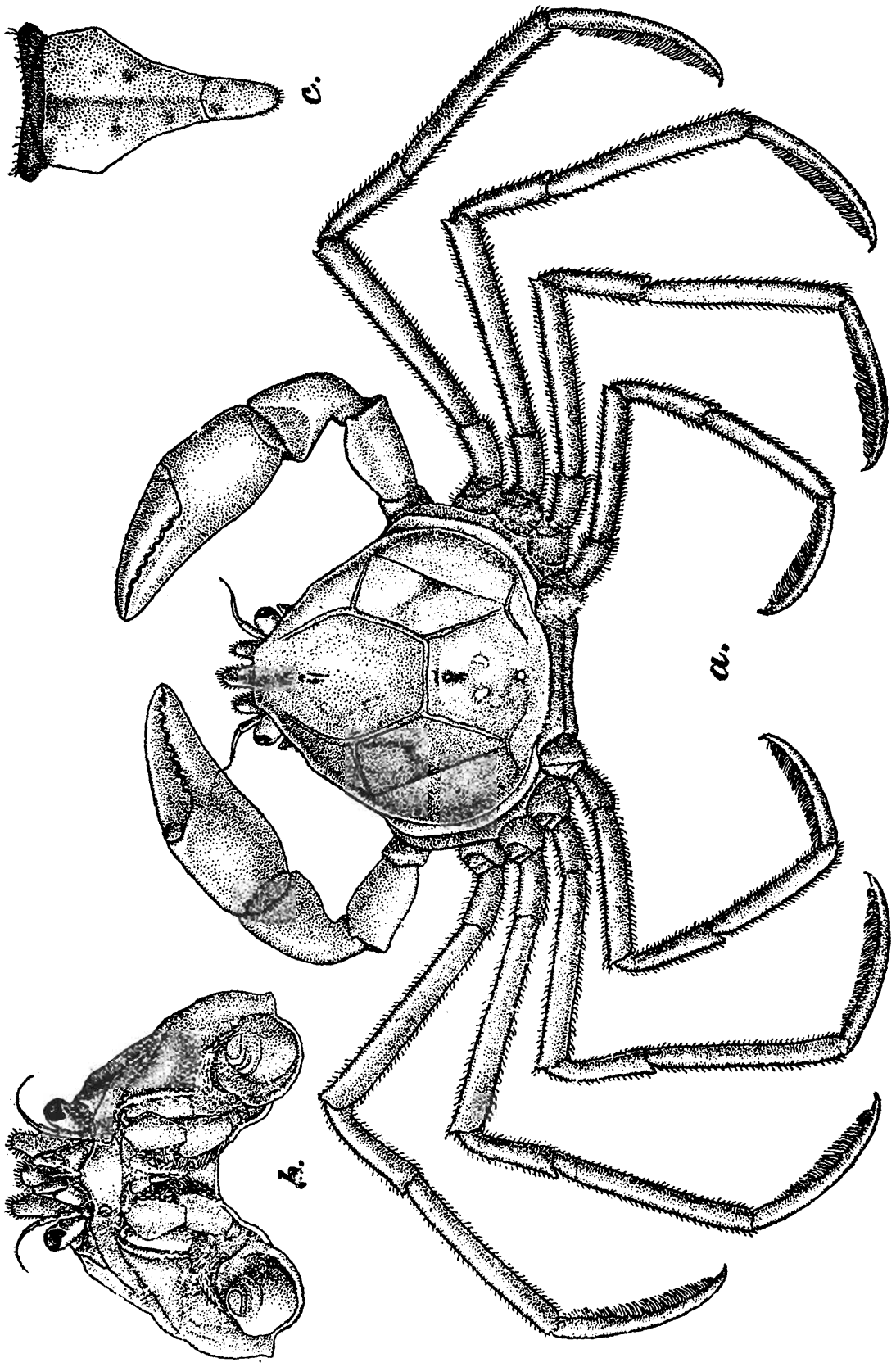

FIG. 11.—*Rhynchoplax intraversus*, sp. nov.
a. Large male in dorsal view. *b*. Anterior part of carapace of same specimen from below.
c. Abdomen of same specimen.

with 6 to 8 small rather widely separated teeth that occupy the greater part of the length of the posterior border.

In the abdomen of the male (text-fig. 11*c*) the penultimate piece is of the usual form, but is very strongly narrowed distally. The terminal segment is exceptionally long, its length being nearly twice its basal breadth.

The species is described from two males, in one of which—much the larger of the two—the carapace is 5·4 mm. in length.

In most respects *R. introversus* is intermediate between *R. exiguus* and *R. inachoides*, but differs from both in the form of the postero-lateral border of the carapace. It resembles *R. inachoides* in the character of the dactyli of the walking legs, but the legs themselves are shorter, the rostral lobes shorter and blunter and the carapace broader.

The specimens were found by Dr. Annandale in the Tai Hu Lake in the Kiangsu Province of China. The larger individual was found off the mouth of the Tong Dong Ding Creek and the smaller at the mouth of the Moo Too Creek. Both were dredged in water about 2 metres in depth. Dr. Annandale noted that the specimens were pale buff in colour with brown markings on the carapace somewhat like a *fleur-de-lys*.

The species is remarkable in that it was obtained in pure fresh water far beyond the reach of tidal influence. A considerable number of Hymenosomatidae have been found in localities where the salinity is low and some appear to be able to exist in water that is quite fresh during a portion of the year. But the only species hitherto recorded from permanently fresh water is *Halicarcinus lacustris* (Chilton),[1] which has even been found 3,000 ft. above sea-level.

The type specimen, the larger of the two individuals, bears the number 9730/10 *Zool. Surv. Ind.*

Rhynchoplax inachoides (Alcock).

1900. *Hymenicus inachoides*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 388, and (1902) *Illust. Zool. 'Investigator,'* pl. lxix, fig. 1.

I have little to add to Alcock's description of this species. The post-ocular denticle is clearly visible in dorsal view; the fingers of the chela of the male meet throughout their length and are armed with a regular series of teeth; the abdomen in the same sex is narrow and similar to that of *R. demeloi*.

The only known specimen is the male described by Alcock and found by Wood-Mason, along with *R. wood-masoni*, at Port Canning near Calcutta. On a recent tour in this locality I tried to obtain further specimens but was unable to find either species.

[1] For references see p. 247.

Rhynchoplax nasalis, sp. nov.

The carapace is almost exactly circular and is nearly or quite as broad as long, excluding the rostrum. The surface is sunken, covered with hair, and with the grooves sharply defined. The border is entire, upturned, and is continuous from side to side across the base of the rostrum.

The rostrum differs from that of all other species in the genus in the suppression of the lateral processes; it consists merely of a single horizontal plate, more than twice as long as wide, pointed at the apex and bordered with hairs (text-fig. 12).

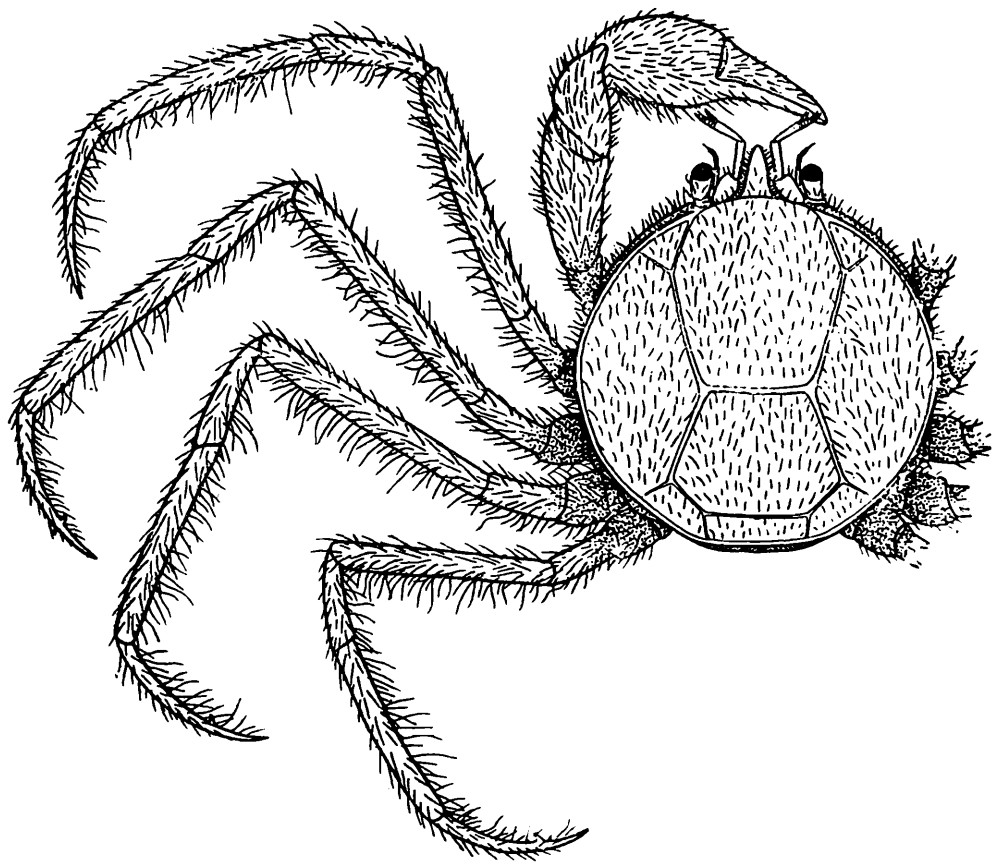

FIG. 12.—*Rhynchoplax nasalis*, sp. nov.

The basal segment of the antennular peduncle and the whole of the eye are visible in dorsal view. There is no post-ocular tooth and no trace of an inter-antennular septum. The epistome is of moderate length. The external maxillipedes are similar to those of the preceding species, but the merus is larger in proportion to the ischium and, when normally folded, the stalk of the exognath extends much beyond the distal end of the merus.

The chelae are swollen in both sexes and are much stouter than the walking legs; they are only a trifle larger in the male than in the female. The distal end of the lower border of the merus ends in a stout tooth, but the segment is not otherwise

armed. The carpus is smooth. The chela is not greatly compressed and is not carinate either above or below. In the male it is little more than twice as long as deep, the dactylus being about one and a half times the length of the upper border of the palm. When the claw is closed the fingers meet throughout their length; they are armed with a regular series of six blunt teeth which diminish in size from behind forwards (text-fig. 13).

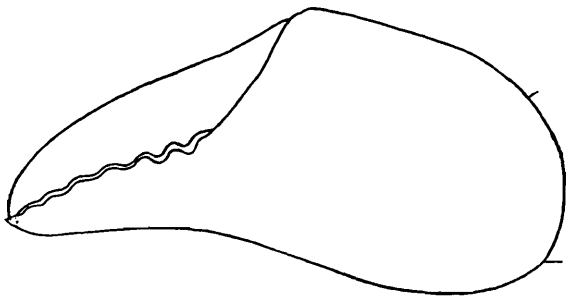

FIG. 13.—*Rhynchoplax nasalis*, sp. nov.
Chela of male (denuded).

The second pair of walking legs is about two and a half times the length of the carapace and rostrum, the last pair about twice the length. All the segments are very slender and there is no tooth at the end of the upper border of the merus. The dactyli are curved; that of the first pair is simple, while in the remaining three pairs there is a single small recurved tooth situated some distance behind the apex (text-fig. 14).

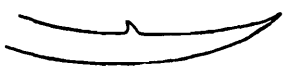

FIG. 14.—*Rhynchoplax nasalis*, sp. nov.
Tip of dactylus of penultimate walking leg.

The abdomen of the male (text-fig. 15) is abnormally broad, the length of the two ultimate pieces being equal to the breadth of the penultimate. The lateral margin of the latter is abruptly narrowed anteriorly and bears a large and curiously formed tubercle near its distal end. The ultimate segment is broader than long, broadly rounded apically and with elevated lateral margins. In the female the abdomen is broad, but the ultimate segment is rather more triangular than in other species.

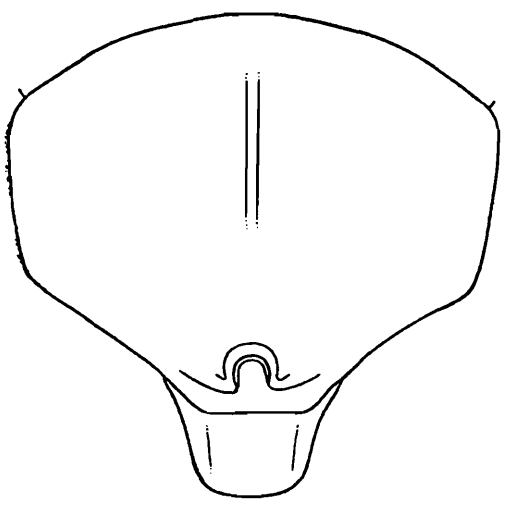

FIG. 15.—*Rhynchoplax nasalis*, sp. nov.
Abdomen of male.

The entire animal is covered with hairs, which are comparatively long on the chelipedes and legs. The specimens when caught were covered with a dense coating of mud which was only removed with great difficulty. When denuded the crabs were ivory white in colour, the eggs of the female being reddish orange.

The length of the carapace and rostrum in an adult male is 4·4 mm., an ovigerous female is exactly the same size.

The species is described from fifteen specimens, most of which are exceedingly small. They were dredged in the Bidyadhari river near Chingrighatta on the outskirts of Calcutta in October and December 1914. They were found in very foul water which gave specific gravities of 1·0045 and 1·0060 on the two occasions on which the locality was visited.

The types bear the number 9744/10 *Zool. Surv. Ind.*

Genus **Hymenicoides**, nov.

The carapace is nearly circular in outline, sunken, with the usual grooves sharply defined and the lateral margins upturned. The rostrum is altogether absent. The epistome is of moderate length and the buccal cavern is bounded anteriorly by a sharp ridge. The external maxillipedes are slender, gaping widely in the middle line and leaving visible parts of the underlying appendages.

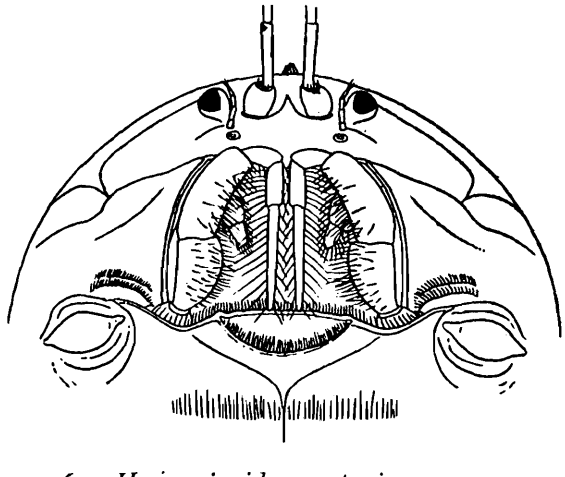

FIG. 16.—*Hymenicoides carteri*, gen. et sp. nov.
Anterior part of carapace, seen from below.

The merus is much longer than the ischium and is more than two and a half times as long as wide; the dactylus is styliform and of abnormal length, reaching the posterior limit of the buccal cavern when normally flexed (text-fig. 16). The chelipedes in both sexes are stouter than the legs. In the abdomen of the male the terminal segment is trilobate and the sutures of all the segments are distinct.

This genus is related to *Rhynchoplax* and *Halicarcinus*, but differs from both in the absence of the rostrum and in the great length of the dactylus of the external maxillipedes. It resembles *Rhynchoplax* in the slenderness of the basal segments of the external maxillipedes and *Halicarcinus* in having all the segments of the male abdomen distinct.

Type and only known species,—*Hymenicoides carteri*, sp. nov.

Hymenicoides carteri, sp. nov.

The carapace is almost circular, emarginate at the base of the last legs and with the posterior border short; it is broader than long in the proportion of 21 to 20. The upper surface is greatly depressed, with the grooves well defined, and is closely covered with minute hairs. The margin is entire and upturned; anteriorly and antero-laterally it forms an even curve and bears in the middle of the front a small tuft of hairs. The rostrum is entirely absent. The basal segment of the antennule and the greater part of the eye are visible in dorsal view.

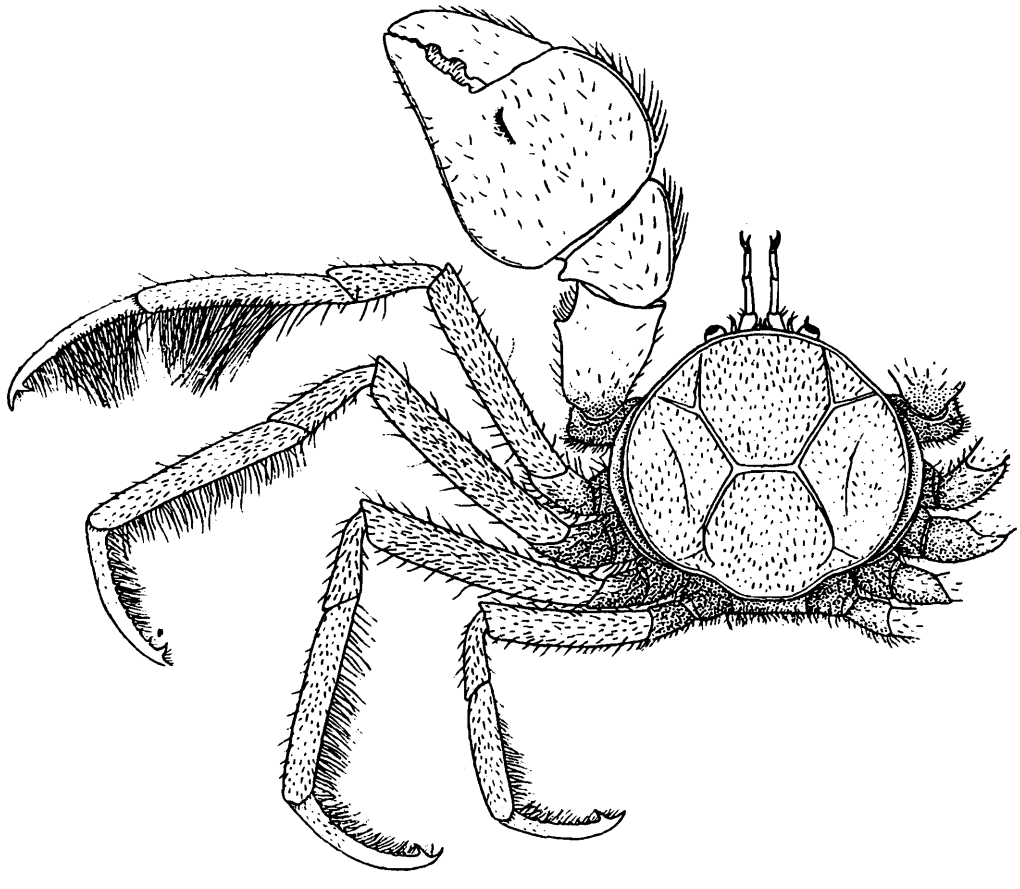

FIG. 17.—*Hymenicoides carteri*, sp. nov.

At their bases the antennules are separated by a sharp forwardly directed tooth: there is no post-ocular tooth. The epistome is of moderate length. The buccal cavern is somewhat narrowed anteriorly; its lateral borders are rather strongly curved and, as in the genus *Rhynchoplax*, its anterior and posterior edges are curved inwards (text-fig. 16). On the sternum behind the bases of the external maxillipedes there is a semicircular ridge, concave anteriorly, which bears a fringe of long hairs. The curious structure of the external maxillipedes has been referred to in the generic description. There are long hairs on the inner borders and outer surface of the ischium and merus and on both inner and outer borders of the dactylus. The exognath bears a long flagellum and,

except for a small portion at the base of the stalk, is entirely concealed from view.

The chelipedes are greatly swollen in both sexes; the chelae of the male are much larger than those of the female. The outer border of the merus bears a conspicuous tooth in front of its middle point. On the inner side of the carpus there is a longitudinal ridge which is furnished with a fringe of long hairs. The chela of the male (text-fig. 18) is less than one and a half times as long as high. There are sharp keels on both upper and lower borders of the palm, the latter being continued to the tip of the immobile finger. These keels like that on the carpus are fringed with long hairs. The inner surface of the palm is convex and the outer face bears a huge protuberance (text-fig. 19), only well developed in very large males, which culminates in a short crest not far form the finger cleft. The fingers are stout and in large individuals meet only at the tips. The dactylus bears two large blunt teeth in its basal half and the fixed finger two smaller ones placed just behind them; nearer the tip each finger bears four or five teeth. The dactylus is fully one and a half times the length of the upper border of the palm and is obscurely ridged dorsally. The chela of the female is similar to that of the male, but is more slender and shows practically no trace of the large protuberance on the palm. Except for the fringes of hair already mentioned the chelipede bears only a few fine and scattered setae.

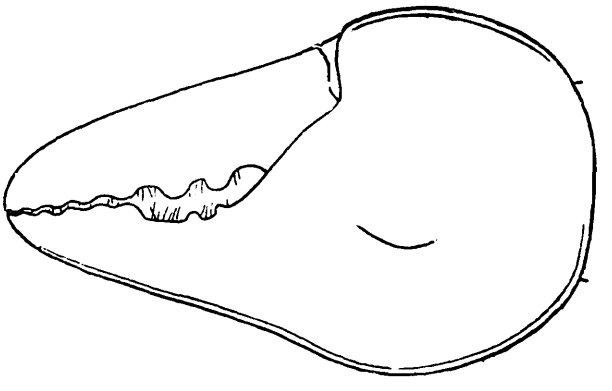

FIG. 18.—*Hymenicoides carteri*, sp. nov.
Chela of large male, external view.

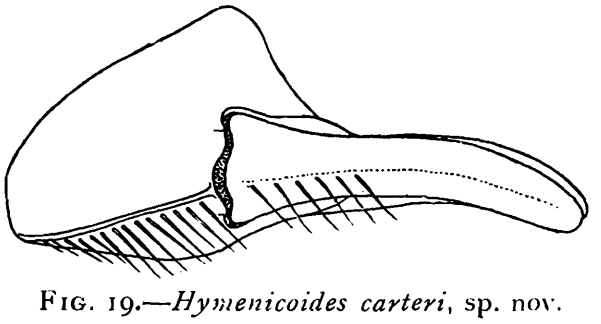

FIG. 19.—*Hymenicoides carteri*, sp. nov.
Chela of large male, dorsal view.

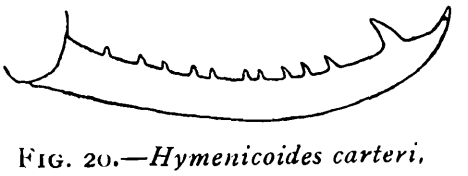

FIG. 20.—*Hymenicoides carteri*, sp. nov.
Dactylus of penultimate walking leg.

The second walking legs are a little longer than the first and third and are about three times the length of the carapace; the last pair is only two-thirds the length of the second. The anterior border of the merus in all four pairs terminates in a blunt tooth. The dactyli are slender and

curved. Close to the apex each bears a large recurved tooth, behind which a number of smaller teeth are usually found. On the first pair of legs there are generally not more than one or two such teeth; on the other legs they are more numerous (text-fig. 20) and often extend from the base to the large subterminal tooth; the maximum number observed is eleven. There are fine hairs on all the segments and a fringe on the posterior margins of the propodus and dactylus. In large males the hairs on the propodus and dactylus of the first legs are very long and numerous, forming dense tufts that retain a great quantity of mud.

The sternum and abdomen are thickly beset with hairs. In the abdomen of the male (text-fig. 21) all the sutures are distinct. The lateral margins are markedly sinuous, the widest point being at the junction of the fourth and fifth segments; the ultimate segment is trilobed terminally and is much broader than the distal width of the sixth.

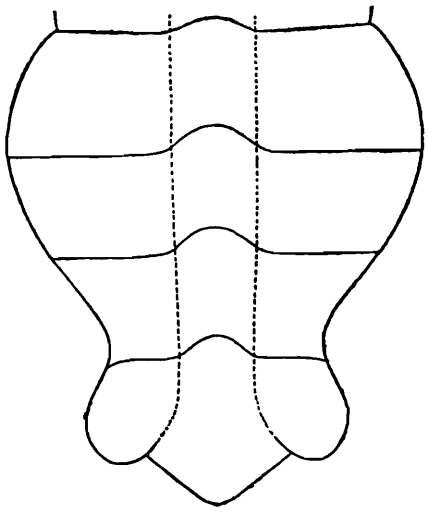

FIG. 21.—*Hymenicoides carteri*, sp. nov.
Abdomen of male.

The carapace of the largest specimen, a male, is 5·7 mm. in length.

The species is described from twenty-two specimens found on the banks of the R. Hughli at Sibpur, near Calcutta, in January 1917, by Dr. Annandale and myself. They were obtained in timber bored by Teredo (*Xylotria dunlopi*) lying between tide-marks. The water at the time they were found was almost or quite fresh at all states of the tide, but is doubtless brackish later in the year. There are also in the collection two specimens, both small, collected by Mr. T. Southwell near Khulna in the Gangetic delta in August 1915.

With this species I have associated the name of Dr. H. G. Carter, Officiating Director of the Botanical Survey of India, to whom I am indebted for facilities for collecting at Sibpur. The types, which are from this locality, bear the number 9746/10 *Zool. Surv. Ind.*

Genus **Elamena**, Milne-Edwards.

1837. *Elamena*, Milne-Edwards, *Hist. nat. Crust.*, II, p. 33. [Not *Elamene*, Milne-Edwards, *Ann. Sci. nat., Zool.* (3), XX, p. 223 (1853); nor *Elamene*, A. Milne-Edwards, *Nouv. Arch. Mus. Paris*, IX, p. 321 (1873).]

1900. *Elamena*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 385 (not the synonymy).

The carapace is oval, triangular or polygonal, greatly depressed, and sometimes lamellar. The upper surface is flat or concave, without the usual sharp-cut grooves, and the lateral margins

may or may not be upturned. The rostrum is broadly truncate or triangular, never tridentate or trilobate. The epistome is long, sometimes very long and is separated by a ridge from the floor of the buccal cavern. The external maxillipedes are broad and completely close the buccal cavern; the ischium is longer, sometimes much longer than the merus, and the dactylus is, as usual, short. The chelipedes of the male may or may not be stouter than the walking legs. In the abdomen of the male the 3rd, 4th and 5th segments are fused and the sutures between them obliterated.

Judging from the Indian species, this genus, here described *sensu lato*, differs from all other Hymenosomatidae in the absence of the customary grooves on the upper surface of the carapace. In the character of the male abdomen it resembles *Rhynchoplax*, but differs from that genus in the form of the rostrum and external maxillipedes. Milne-Edwards' *Trigonoplax* is, at most, a subgenus of *Elamena* (*v. infra*, p. 274).

Six species of *Elamena*, *s.l.* are now known from the Indian coasts, all being represented in the Indian Museum with the exception of *E. gracilis*, Borradaile. I have not been able to satisfy myself regarding the position of this species and have, in consequence, omitted it from the following key. It is perhaps intermediate between *Elamena*, *s.s.* and *Trigonoplax*.

I. Margin of carapace upturned; rostrum with a vertical keel on its lower surface and in frontal view T-shaped; chelipedes of male greatly swollen, much stouter than legs [dactylus of walking legs apically triunguiculate] = *Elamena s.s.*

A. Carapace as broad or broader than long[1]; rostrum broad and squarely truncate; a small post-ocular tooth present, but not visible from above ... ... *E. truncata* (Stimpson).

B. Carapace longer than broad[1]; rostrum prominent, triangular; no post-ocular tooth ... *E. sindensis*, Alcock.

II. Margin of carapace not upturned; rostrum at most with a small tooth at base of lower surface, not T-shaped in frontal view; chelipedes of male slender, not stouter than walking legs. = subgen. *Trigonoplax*.

A. Rostrum parallel-sided at base; a strong post-ocular tooth visible in dorsal view; dactyli of walking legs armed in their distal third with a series of small teeth [carapace about as long as broad] ... ... *E.* (*T.*) *cimex*, Kemp.

B. Rostrum strictly triangular, its sides convergent from base to apex; no post-ocular tooth visible in dorsal view; dactyli of walking legs triunguiculate at apex.

1. Carapace longer than broad,[1] its antero-lateral margins curved and not longer than postero-lateral; rostrum flat above; a post-ocular tooth visible only from

[1] Rostrum included.

below; 2nd walking legs less than $2\frac{1}{2}$ times length of carapace[1] ... ... *E.* (*T.*) *xavieri*, sp. nov.

2. Carapace broader than long,[1] its antero-lateral margins straight and very much longer than postero-lateral; rostrum hollowed above; no post-ocular tooth; 2nd walking legs more than 3 times length of carapace[1] ... ... *E.* (*T.*) *unguiformis*, de Haan.

Elamena truncata (Stimpson).

1858. *Trigonoplax truncata*, Stimpson, *Proc. Acad. Nat. Sci. Philadelphia*, X, p. 109 [55].
1873. *Elamene truncata*, A. Milne-Edwards, *Nouv. Arch. Mus. Paris*, IX, p. 323.
1893. *Elamene truncata*, Henderson, *Trans. Linn. Soc., Zool.* (2), V, p. 395.
1900. *Elamena truncata*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 386.
1906. *Elamena truncata*, Baker, *Trans. Roy. Soc. S. Australia*, XXX, p. 112, pl. ii, figs. 2, 2*a-d*.
1907. *Trigonoplax truncata*, Stimpson, *Smiths. Misc. Coll.*, XLIX, p. 146.

There does not appear to be any reason to doubt that the descriptions given by Stimpson and A. Milne-Edwards refer to the

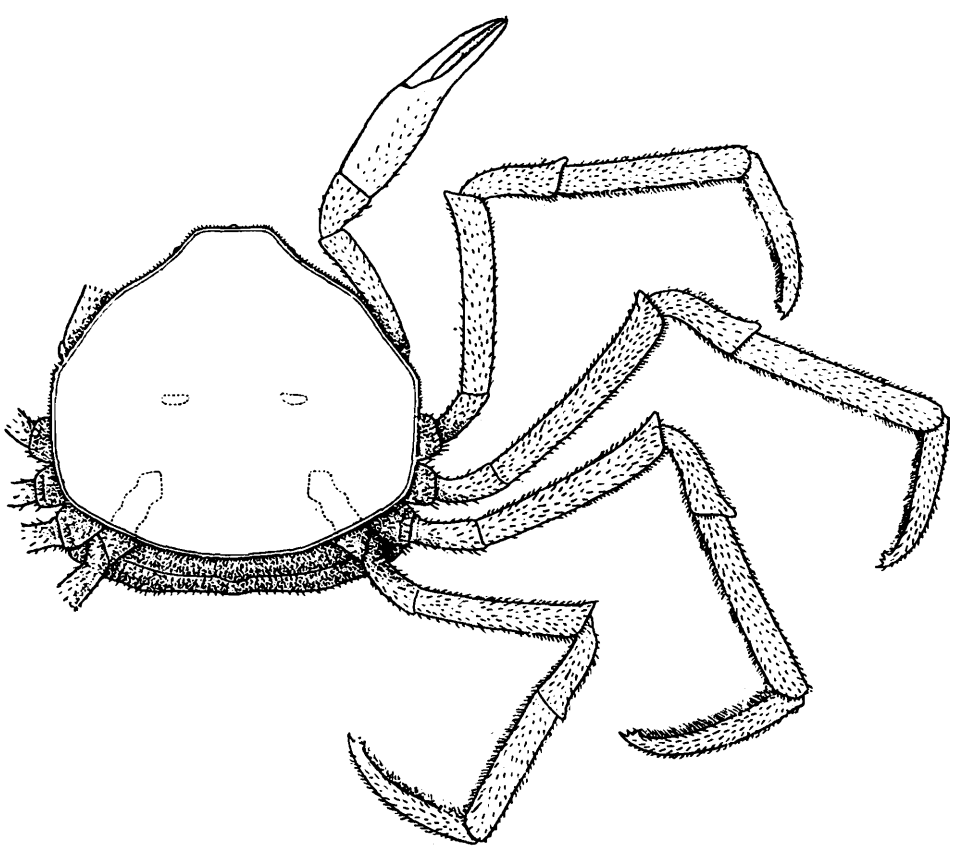

FIG. 22.—*Elamena truncata* (Stimpson) ♀

same species, though the specimens examined are from widely distant localities. A. Milne-Edwards, however, seems to have

[1] Rostrum included.

been unaware of the existence of Stimpson's account, for he makes no reference to it and his description is headed "*Elamene truncata* (nov. sp.)." That both authors have used the same specific name is presumably due to a remarkable coincidence.

Alcock was able to examine only a single example of this species, but two others have since been obtained; unfortunately all three specimens are females. Both Stimpson and A. Milne-Edwards note that the chelae of the male are inflated and there is consequently little doubt that the species belongs to *Elamena*, *sensu stricto*. As in *E. sindensis*, the margins of the carapace are upturned and the front, or rostrum, bears on its underside a deep vertical keel, giving it a T-shaped appearance in facial view.

The abdomen of the male, according to Baker's description and figure, consists of five pieces, whereas only four are to be found in all the males of other species of *Elamena* and *Trigonoplax* that I have seen. From the figure it looks as if only the 3rd and 4th segments were fused in *E. truncata*, in place of the 3rd, 4th and 5th. A fresh examination of males is desirable.

In the Indian specimens the carapace is proportionately broader than in those described by Baker, the breadth being decidedly greater than the length. The front, or rostrum is squarely truncate, not rounded as described by Henderson. Behind the base of the swollen eyestalk there is a small post-ocular tooth (not shown in Baker's figure) which is altogether invisible in dorsal view. The chela of the female is little stouter than the walking legs; the fingers gape slightly when closed and are armed on their inner margins with minute teeth and short hairs. The dactylus in all four pairs of walking legs is triunguiculate at the apex. The anterior border of the ultimate segment of the abdomen of the female is strongly sinuous (text-fig. 23).

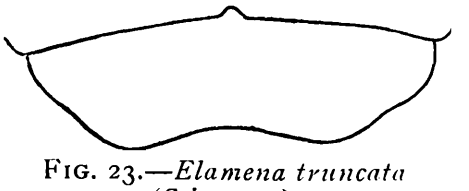

FIG. 23.—*Elamena truncata* (Stimpson).
Terminal segment of abdomen of female.

Alcock examined a single individual of this species, obtained at the Nicobars. The two additional specimens were found at Port Blair in the Andamans under a block of coral exposed at low water; the carapace of the larger is 4·8 mm. in length. When alive the carapace was brown in colour with four cream-coloured marks[1] as described by Stimpson.

There is also in the Indian Museum a female specimen of *E. truncata*, unfortunately with all the legs missing, received many years ago from the Godeffroy Museum under the name *Elamena quoyi*. It bears the label "Samoa and Viti Is."

The species appears to be one of wide Indo-pacific distribution. In addition to the above records it is known from the Ceylon coast (Henderson), the Loo Choo Is. (Stimpson), New Caledonia (A. Milne-

[1] Shown by dotted lines in text-fig. 22.

Edwards) and S. Australia (Baker). Lenz's record from Zanzibar[1] is erroneous, the specimens described belonging in all probability to Desmarest's *E. mathaei*.

Elamena sindensis, Alcock.

1900. *Elamena sindensis*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 386 and (1902) *Illust. Zool. 'Investigator,'* pl. lxiv, fig. 3.

This species is still represented in the Indian Museum only by the specimens described by Alcock from Karachi. In addition to particulars noted by Alcock, it may be mentioned that the dactylus of the male chela bears a low blunt tooth near the base, the margin of both fingers being otherwise finely serrate. The dactylus of the walking legs is apically triunguiculate. The abdomen of the male is rather broadly triangular, its sides being lightly sinuous, with the 3rd, 4th and 5th somites fused. The terminal segment of the abdomen of the female resembles that of *E. truncata*.

Subgenus Trigonoplax, Milne-Edwards.

1853. *Trigonoplax*, Milne-Edwards, *Ann. Sci. nat., Zool.* (3), XX, p. 224.
1900. *Trigonoplax* (subgenus of *Elamena*), Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 386.

I agree with Alcock that *Trigonoplax* can only be regarded as a subgenus of *Elamena*. *E.* (*Trigonoplax*) *xavieri*, which is described below, still further emphasizes the close relation between the two groups, the inter-antennular septum being a prominent plate, exactly as in *Elamena*, *s.s.*

In the subgenus the carapace is flatter than in *Elamena*, with its margins scarcely at all upturned, and the chelipedes are similar in the two sexes and not appreciably stouter than the walking legs. In the two species of *Elamena* that I have seen, the rostrum is T-shaped when viewed from in front, owing to the presence of a large vertical plate on its lower side; this structure, which is quite distinct from the septum between the bases of the antennules, is either absent in *Trigonoplax* or is represented by a tooth situated far behind the anterior margin.

These distinctions are slight and *Trigonoplax* in course of time will probably find a place in the synonymy of *Elamena*. Borradaile's *E. gracilis* appears from the description and figure to be intermediate between the two groups here recognised.

Elamena (Trigonoplax) cimex, Kemp.

1915. *Elamena* (*Trigonoplax*) *cimex*, Kemp, *Mem. Ind. Mus.*, V, p. 216, text-figs. 4, 5, pl. xii, fig. 3.

The species differs from all related forms in the areolation of the carapace; the gastric, cardiac and hepatic regions are each

[1] Lenz, *Abhandl. Senck. naturf. Ges. Frankfurt*, XXVII, p. 367, pl. xlviii, figs. 15 *a,b* (1902).

slightly tumid and are separated by broad and shallow furrows. In this respect there is perhaps some approach to the condition found in *Halicarcinus* and *Rhynchoplax*, but there is no trace of the finely cut grooves that are conspicuous in those genera. The tooth on the lower surface of the rostrum, which is well marked in *E.* (*T.*) *xavieri* and slightly indicated in *E.* (*T.*) *unguiformis*, is in this species altogether absent. The dactyli of the walking legs bear a series of small teeth and are not apically triunguiculate as in all other Indian species of *Elamena*.

Elamena (*Trigonoplax*) *cimex* has hitherto been found only in the Chilka Lake, on the Orissa coast of the Bay of Bengal. The specimens were dredged in fresh water, but in a situation subject to great seasonal variation in salinity.

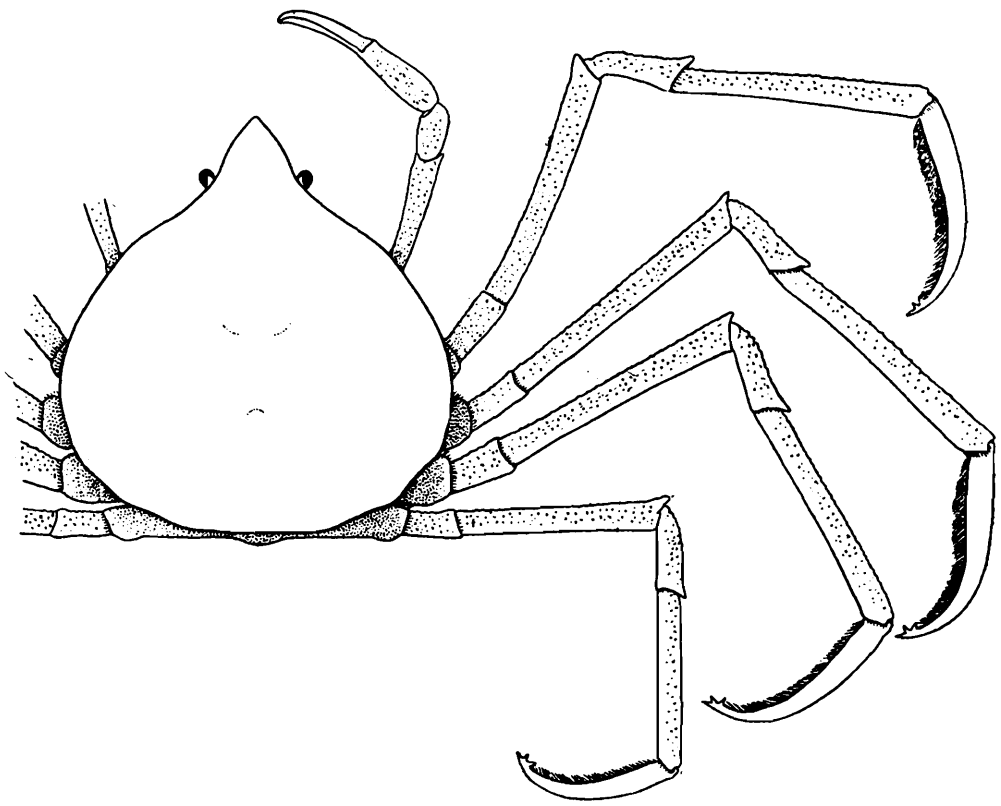

FIG. 24.—*Elamena* (*Trigonoplax*) *xavieri*, sp. nov.

Elamena (Trigonoplax) xavieri, sp. nov.

The carapace closely resembles that of *E.* (*T.*) *cimex* in outline, but the antero-lateral borders are more strongly arched; its length is to its breadth as 13 to 12. There are shallow emarginations opposite the bases of the last two legs. The surface is quite flat, the regions not being defined in any way, and is altogether devoid of hairs; the margins are not upturned. The rostrum is a large triangular plate and is flat above; its margins are slightly convex and converge regularly from the base to the apex; they are not parallel at the proximal end as in *E.* (*T.*) *cimex*. On the under side,

near the base, the rostrum bears a sharp forwardly directed tooth (text-fig. 25).

The eyes and a small portion of the eyestalks extend beyond the carapace. A small post-ocular tooth may be seen when the carapace is viewed from beneath, but in dorsal view is altogether invisible. The antennules are separated at the base by a well-defined septum, much more distinct than in *E.* (*T.*) *unguiformis*. The epistome is long. The anterior border of the buccal cavern is convex on either side of the middle line. In the outer maxillipedes the ischium is much longer than the merus and is separated from it by a very oblique suture. The exognath bears a long flagellum and its basal part, though largely overlapped by the endopod, is visible throughout its length.

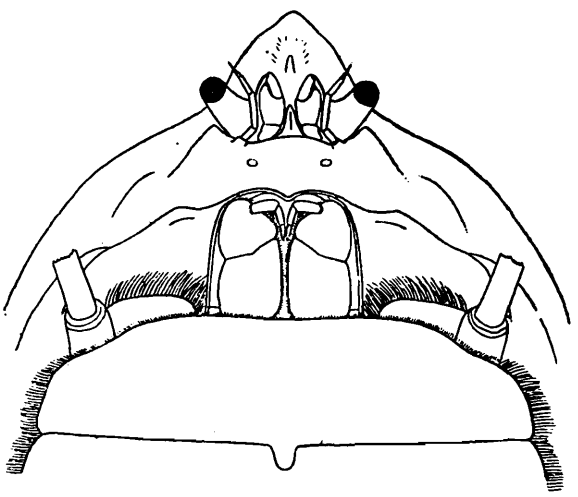

FIG. 25.—*Elamena* (*T.*) *xavieri*, sp. nov. Anterior part of carapace seen from below.

The chelipedes are alike in the two sexes and are not appreciably stouter than the walking legs; they are about as long as the carapace and rostrum. The merus is without teeth and the merus, carpus and palm are slightly roughened and bear very fine and exceedingly short hairs. The chela is about four and a half times as long as high and the fingers are equal in length with the palm. Towards their apices the fingers are slightly inturned and on the inner face of the chela are somewhat hollowed longitudinally. When the claw is closed the fingers meet throughout their length;

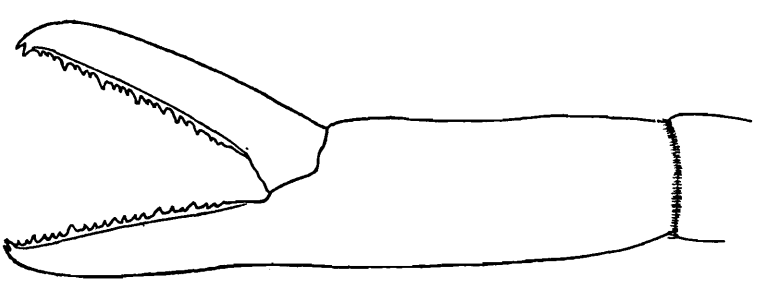

FIG. 26.—*Elamena* (*Trigonoplax*) *xavieri*, sp. nov. Chela of male.

each being provided with a series of small recurved teeth extending from the base to the apex (text-fig. 26).

The second pair of walking legs is slightly longer than the first or third, about two and a third times the length of the carapace; the fourth is much the shortest, about one and three quarter times the length of the carapace. All the segments except the dactylus

are roughened like the chelipedes and are thinly clothed with very fine hairs. In all four pairs the merus and carpus end in a strong tooth. The dactyli are slender and curved; the inner margin is densely fringed with hair and bears near the apex two stout recurved teeth, as in *E.* (*T.*) *unguiformis* (text-fig. 27).

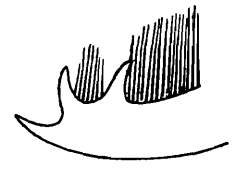

FIG. 27.—*Elamena* (*T.*) *xavieri*, sp. nov. Tip of dactylus of last walking leg.

The ultimate segment of the abdomen of the male is triangular, a little broader than long and with a pair of rather conspicuous pits near its base; proximally it is a little wider than the contracted distal end of the preceding portion. The distal margin of the abdomen of the female is slightly sinuous, as in *E.* (*T.*) *unguiformis*; in *E.* (*T.*) *cimex* it is more convex.

The carapace of a large female is 9·2 mm. in length; males are smaller, not exceeding 7·5 mm.

In living specimens the carapace is dark brown or slate-coloured, with pale antero-lateral margins and, as in *E. truncata*, a pair of elongated pale blotches project inwards and forwards from the bases of the last two pairs of legs.

In general appearance this species bears much resemblance to *E.* (*T.*) *cimex*; but it is in reality more closely allied to *E.* (*T.*) *unguiformis*. This is clearly shown by the presence of the inter-antennular septum and the tooth on the lower surface of the rostrum (both of which are in fact better defined than in *E.* (*T.*) *unguiformis*), and it is also evident in the structure of the dactylus of the walking legs.

The species is described from three males and three females obtained in the Mandavi river, opposite the town of Nova Goa in Portuguese India. They were dredged at a depth of about 10 feet on a muddy bottom in places where the current ran swiftly. The specific gravity of the water in which they were taken was very low, about 1·0010 (corrected).

In the specific name allusion is made to St. Francis Xavier, whose remains lie interred at Goa, not far from the place where the specimens were obtained.

The types bear the number 9750/10 *Zool. Surv. Ind.*

Elamena (Trigonoplax) unguiformis, de Haan.

1839. *Ocypode* (*Elamene*) *unguiformis*, de Haan, in Siebold's *Fauna Japonica, Crust.*, p. 75, pl. xxix, fig. 1; pl. H.
1900. *Elamena* (*Trigonoplax*) *unguiformis*, Alcock, *Journ. Asiat. Soc. Bengal*, LXIX, p. 387.
1907. *Trigonoplax unguiformis*, de Man, *Trans. Linn. Soc., Zool.* (2), IX, p. 396.
1915. *Trigonoplax unguiformis*, Parisi, *Atti Soc. Ital. Sci. nat.*, LIV p. 281.

Other references are given by Alcock.

This well-known species differs conspicuously from the two preceding forms in the shape of the carapace, the antero-lateral

borders being proportionately very much longer and quite straight (text-fig. 28). The rostrum is hollowed above and bears near the proximal end of its lower surface a low ridge in place of the tooth found in *E.* (*T.*) *xavieri*. The epistome is extremely large, almost as long as the external maxillipedes. The fingers of the chelae are

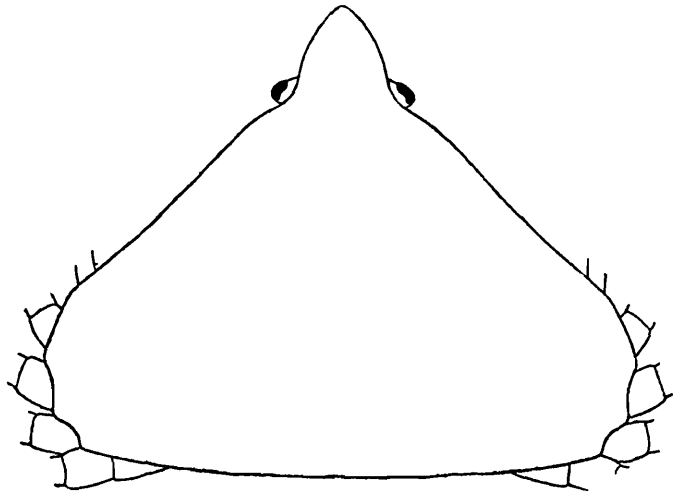

FIG. 28.—*Elamena* (*Trigonoplax*) *unguiformis*, de Haan.
Outline of carapace.

furnished with minute teeth and the dactylus of the walking legs is triunguiculate. The abdomen of the male is broad at the base and narrow at the apex, the lateral margins being concave; the 3rd, 4th and 5th segments are fused.

FIG. 29.—*Elamena* (*T.*) *unguiformis*, de Haan.
Dactylus of first walking leg.

McCulloch[1] appears to be right in regarding his South Australian specimens as a distinct variety of this species. In Indian specimens the rostrum is not nearly so long, nor the dactyli of the walking legs so broad as shown in his illustration. I give here, for comparison, outline figures of the carapace and dactylus of the first leg.

The species is not uncommon at Port Blair in the Andamans, living among weeds in pure sea water at depths of 2 to 8 fathoms. In life, specimens are of a dull semitransparent brownish or greenish tint, without any conspicuous markings.

The species is known from the Gulf of Martaban (Henderson) and from numerous localities in Japan (de Haan, Ortmann, de Man, Parisi).

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[1] *Trigonoplax unguiformis* var. *longirostris*, McCulloch, *Rec. Australian Mus.*, VII, p. 59, pl. xii, fig. 3 (1908).

Elamena gracilis, Borradaile.

1906. *Elamena gracilis*, Borradaile, in Gardiner's *Faun. Geog. Maldive and Laccadive Archipel.*, II, p. 684, text-fig. 122 *a*, *b*.
1911. *Elamena gracilis*, Rathbun, *Trans. Linn. Soc., Zool.* (2), XIV, p. 242.

I have seen no specimens of this species and do not know whether it should be referred to *Elamena*, *s.s.*, or to *Trigonoplax*. Judging from the figure the lateral margins of the carapace are upturned; but the chelae are described as slender and apparently do not show any sexual differences. There is no mention of a vertical keel on the lower face of the rostrum.

In the form of the carapace *E. gracilis* differs conspicuously from any Indian species of the genus that I have seen. It was described by Borradaile from Minikoi and Male Atoll and has since been recorded by Miss Rathbun from Coetivy.

XVI ON THE OCCURRENCE OF IRIDOCYTES IN THE LARVA OF *MICROHYLA ORNATA*, BOUL.

By C. R. NARAYAN RAO, *M.A., L.T., University of Mysore, Bangalore.*

(Plate XI).

INTRODUCTION.

There are some good observations recorded as regards the colour of batrachian larvae in life, but in most cases the descriptions refer to preserved specimens. Such descriptions must necessarily differ, for the material sent to leading authorities for examination generally arrives in a state in which the colour is somewhat different from what occurs in living forms, the usual methods of preservation, either in alcohol or formalin, greatly affecting the pigments. Moreover, the colouration of specimens of the same species of batrachian is not uniform as a rule, inasmuch as it depends in a great measure on the character of the surroundings from which they are taken and the conditions under which they live. For example, if the olive green tadpoles of the genus *Rana* or *Rhacophorus* should be transferred, from the green weeds amidst which they live, to a more exposed area of another pond, they turn grey; and if the same larvae should be retransferred to a third pond with a black clayey bottom, they become brown. Similarly dearth or abundance of food will greatly influence the colour. Starvation nearly causes the absorption of the yellow pigments with the consequence that the melanin chromatophores show through to some extent, the tadpole looking more or less darker. On the other hand, generous feeding favours the deposit of more than one kind of lipochrome pigment, and accordingly the larvae appear beautiful with a variety of colours.

The tadpole of *M. ornata* has been described by Capt. S. Flower (*Proc. Zool. Soc. London*, 1899, p. 902), and there is a short note on the same subject by Mr. H. S. Ferguson (*Journ. Bombay Nat. Hist. Soc.*, XV, p. 506). No allusion is made by either of these writers to the occurrence of the bright metallic dorsal band or the silver brilliancy on the sides of this beautiful tadpole. It is perhaps worthy of mention that this tadpole and its congener that of *M. rubra* are probably most singular in the possession at once of golden and silvery brilliance, of all the Anuran larvae that have been studied up till now.

The scope of this paper is to record the results of the investigations commenced with a view to discover the nature of the substance which produces this interesting phenomenon, which has also been observed in fishes, and further to trace the relation of it to the other histological elements. Incidentally, reference will be made to the colouring matter of other tadpoles, chiefly Indian forms known to me,—in all those particulars in which they approach the general scheme of pigmentation occurring in the two species of *Microhyla* which form the subject of this paper. The literature referring to this section of the paper is given below in a foot-note.[1]

The head of the tadpole of *M. ornata*, which is nearly two-thirds of the size of the body, is perfectly transparent, but this is not so in *M. rubra*. Behind the eyes, in the former species, there is a characteristic diamond-shaped black mark just above the cranium. Usually a yellow line runs fore and aft of this mark behind which is a glandular area. Over the vertebral column is the characteristic golden streak which may also extend in front over the diamond-shaped mark already referred to. Sometimes the lungs show through the transparent skin on either side of the vertebral band; more often, however, the skin may be yellowish green. The sides and ventral surface of the abdomen glitter with silvery brightness, while the throat is colourless. The ventral lobe of the tail is more or less pale copper coloured. When the dorsal metallic streak is absent, due to absorption, the underlying black band can then be seen.

The other Engystomatid larvae known to me are uninteresting in regard to their colouration. The tadpole of one species of *Kaloula* (*K. triangularis*) is absolutely transparent without any colour markings except on the head; and another (*K. variegata*) has a transparent head, but the body and tail are blotched, besides two blue spots in the region of the groin The tadpoles of *K. pulchra*, *K. obscura*, and *Cacopus systoma* are densely pigmented.

The points of interest that call for remark, in regard to the colouration of the larvae of the Ranid family, are the occurrence of bright orange red in the posterior third of the tail in *R. breviceps* and *Rhacophorus maculatus*,[2] which as metamorphosis

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[1] For an account of the colouration of Indian tadpoles the following literature, though not complete, may be consulted:—

Annandale, *Rec. Ind. Mus.*, VIII, p. 21 (1912).

Boulenger, *Ann. Mus. Genova*, (2) V, p. 420 (1887-88); *Proc. Zool. Soc. London*, 1893, pp. 526-527.

Flower, *Proc. Zool. Soc. London*, 1896, p. 911 and 1899, pp. 892, 902.

Anderson, *Proc. Zool. Soc. London*, 1895, p. 660.

Butler, *Journ Bombay Nat. Hist. Soc.*, XV, pp. 193, 387 (1903-04).

Ferguson, *Journ. Bombay Nat. Hist. Soc.*, XV, p. 499 (1903-04).

Narayan Rao, *Rec. Ind. Mus.*, X, p. 265 (1914); XI, pp. 31, 349 (1915).

Boulenger, *Proc. Zool. Soc. London*, 1891, pp. 606-607, mentions the occurrence of metallic dots in the larvae of *Rana arvalis* and *R. temporaria*.

[2] Flower, in his account of the tadpole of the Malay race of this species, describes the colour as pinkish (*Proc. Zool. Soc. London*, 1896, p. 906).

progresses is changed into intense black. The ventral surface of all these larvae is dead chalky white, more or less speckled on the throat and the sides. On the dorsal surface one meets with every shade of colouration, ranging from bright yellow to dark brown, with or without spots. A few exceptions may be cited to this prevailing scheme of colouration For instance, the perfectly grey larvae of *Rh. plurostictus*, which bear numerous round black spots, and are perhaps the biggest tadpoles yet discovered in India.[1] The yellow dorsal streak of the larvae of *R. breviceps* and *R. tigrina* is only a premature appearance of an adult character, and the round red spots on the back and thighs of the same tadpoles are mainly larval features. In a few cases like *R. alticola* and *R. liebigii* the tail may be diversified by ocelli or vertical bars.

The tadpoles of *Bufo* are all uniformally brown. Occasionally there are metallic dots on the dorsal surface, the ventral side being dirty white as in *B. microtympanum.*

After this brief survey, it need only be mentioned that the outstanding character of the larvae of *M. ornata* and *M rubra* is the possession of metallic bands and surfaces which make the colouration as a whole markedly striking.

Biological Significance.

The larvae of *M ornata* and *M. rubra* float on the surface in comparatively large shoals chiefly in the middle of the pond. In the aquarium the same habits are exhibited by these tadpoles.

Other tadpoles of the Ranid group, which I have reared and kept under observation, are unable to remain at the surface for any length of time being without the provision of a special structure like a float, as in *Megalophrys montana.* The ability to remain at the surface throughout metamorphosis is a feature that has some structural bearing. When the animal remains stationary at the top it is really occupying a plane of least effort, which it can do only when the body is for the time being lighter than the water, bulk for bulk. The gill chambers of the larvae of the two species of *Microhyla* possess large cavities filled with air, which can be easily seen through the transparent skin. These air spaces account for the enormous size of the cephalic region. On pressing the bulging portion of the throat, large bubbles of air may be driven out through the spiracle. An examination of the transverse and longitudinal sections of the larvae reveal these air cavities, situated between the first and the second and the second and the third gill arches on each side of the pharynx. This structural peculiarity, absent in the Ranid group (as revealed by sections), which bears some resemblance to the secondary air sacs of *Clarias*, accounts

[1] In my experience the dimensions quoted by Anderson for *R. cyanophlyctis* (*Proc. Zool. Soc. London*, 1895, p. 660) are not of the normal tadpole. If metamorphosis, however, is hindered through any cause the larvae attain such a size.

for the floating habit of the tadpole and like the fish it blows out a few bubbles of air through the mouth or the spiracle before sinking to the bottom.

While floating, the tadpole must be peculiarly exposed to attacks from enemies who may have some difficulty in hunting for other forms which lead a concealed mode of life. It is obvious that unless there is some special provision which to a greater or less extent secures immunity, the larvae of *Microhyla* will utterly perish.

Observation shows that in the aquarium these larvae are avoided by both fish and snakes, like *Clarias*, *Saccobranchus*, *Ophiocephalous* and *Tropidonotus*, and in ponds ducks and geese also do not touch them. They, however, greedily seize and devour other amphibian larvae. Reference has already been made to the occurrence of a cephalic gland and it is clear that the offensive matter, by which the larvae are protected, is situated in this gland. When a scraping from this gland was introduced into the conjunctiva of a dog, the eye was kept closed and at the same time it became blood-shot with a watery discharge. If an entire larva be placed in the mouth, nothing will induce the dog to swallow it; those of *Rana* are, however, swallowed. The fish *Opiocephalus* was tried. Forcible feeding of the fish was found to be futile, for as often as the larvae were introduced into the mouth, they were thrown out with considerable force. The secretion is acid in reaction, as may be tested with blue litmus paper. The colouration may have a warning effect.

THE COLOUR ELEMENTS.

For convenience of treatment, the colour elements of the larvae of *M. ornata* may be considered under the following heads:—

1. Black chromatophores of the melanin group.
2. Coloured pigments of the lipochrome group.
3. Iridocytes which are guanin crystals, occurring chiefly in the form of plates.
4. Argenteum or reflecting tissue, on the sides and the ventral regions of the abdomen.

The first two elements combine in various proportions or individually produce the several colours referred to already in the foregoing paragraphs, while the latter elements account for the metallic brilliance. The dead chalky white on the ventral surface of Ranid larvae is due to the argenteum being impregnated more or less with calcium, the compound thus produced being known as guaninkalk.

1. BLACK CHROMATOPHORES.

These elements occur in chiefly two forms, as mere dots and as dendritic structures. The former are confined to regions that are more or less transparent, such as the head and the caudal

membranes, while the latter are aggregated on the dorsal surface. A third variety—the stellate type—accounts for the dark pigmentation of the peritoneum.

2. COLOURED PIGMENT.

The true chromatophores which give colour to the skin are either yellow or orange and the degree of colouration depends on two factors. Firstly the number of coloured chromatophores present and the manner of their distribution, and secondly the extent to which they are diluted by the black chromatophores. The lipochrome pigment occurs in the form of scales or minute granules, the latter when present give the effect of colour suffusion. Only very fine granules of chromatophores produce the blue and orange, such as occur in *K. variegata* and *R. breviceps*, and in the yellow and scarlet red spots found in *Rh. maculatus* and *R. tigrina* respectively only large scaly chromatophores are met with. Green is simply the effect of the fusion of yellow and black, while purple or brown is caused by mixing red and black in various proportions. As will be shown in subsequent paragraphs, orange red is simply intensified yellow and is not a separate pigment at all.

3. IRIDOCYTES.

As has been stated already, the bright metallic band in the mid-dorsal line is formed by an opaque plate of iridocytes. Each is scaly and is irregular in outline, and when numbers of them form a thick band, they acquire strongly reflecting powers. The band is sunk in a groove in the spinal region covered over by the dermal tissue and bounded laterally by the nine pairs of dorsal muscles. Where this band occurs, the melanin chromatophores are absent. Iridocytes occur in the iris, the peritoneum, the lungs and subcutaneous tissue of the tail membranes. They are absent from the skin.

In two important respects the iridocytes of the batrachian larvae differ from those of fishes. In the first place they are irregular in outline, and are formed of minute spherical granules. The chief characters of these bodies in fishes are that they are regular, laminated structures with a clear nuclear spot, with divisions showing common origin. In the second place the crystals are most unstable in the tadpoles, falling almost to powder on removal from the subcutaneous setting; whereas in fishes they occur in the majority of cases in the skin and the crystals can be easily examined.

The iridescent phenomenon caused by this dorsal band in the *Microhyla* larva is simply the effect of light being reflected from the numerous surfaces and sides of these crystalline structures. But the golden colour is, however, due to a thin layer of yellow lipochrome spread over this band, and the occurrence of similar pigment produces the coppery hue of the tail lobes.

THE ARGENTEUM.

The argenteum is a thick, opaque, continuous layer of reflecting subcutaneous tissue in which the iridocytes no longer retain their individual character but are broken up so minutely that it is by no means possible to make out any definite structure with the microscope. This layer is covered over by the transparent epidermis which here is singularly free from all chromatophores. The silver brilliance of the argenteum is simply due to the powdering of the iridocytes which are thickly impregnated into the subcutaneous tissue; the same cause accounts for all absence of iridescence in this region. Thus the abdominal wall has a bright silver lustre on the outer surface and a spangle-like appearance on the peritoneal wall. As has been said already, the pericardium—the parietal layer—is also an argenteum and the visceral layer bears only chromatophores.

The only organs that contain iridocytes and black chromatophores are the lungs; all the other organs are perfectly devoid of them. The occurrence of argenteum in the air-bladder of fishes has been noticed, and the homology of the lungs of air-breathing Craniates with the air-bladder of fishes here receives fresh corroboration from the chemical side.

RELATION OF COLOUR AND HISTOLOGICAL ELEMENTS.

It is not possible to demonstrate the presence of connective tissue corpuscles in the dermis or epidermis of grown tadpoles, though gold chloride staining of the skin of very young tadpoles sometimes reveals the presence of a few corpuscles. The chromatophores occur in between the epidermal cells, and their cellular origin can be explained on the hypothesis that after formation in the deeper tissues they migrate bodily to the surface region. In sections of the skin two kinds of dots are noticeable, the smaller ones belong to the granular chromatophores and the larger ones represent the cut ends of the dendritic forms.

The coloured elements are absent from these sections and stained preparations, for they are most susceptible to the action of even mild solvents like rectified spirit. In the fresh specimens, the scale-like coloured chromatophores lie partly in the dermis and partly below, only a few occurring in the epidermis. Even in regard to them, their connective tissue origin can only be inferentially gathered.

The iridocytes are $\frac{1}{10}$ mm. *in situ*, while the coloured chromatophores are $\frac{3}{10}$ mm. and the granules of the former are less than 10 μ. The spinal groove in which the metallic band lies is quite open in young specimens; the epidermal tissue growing over as metamorphosis advances. If the iridocytes from these young specimens are examined, under a high power of the microscope, their cellular origin can be made out. It is probable that when they leave their place of origin, they become lightly held together

by some organic matrix, too feeble, however, to bind them together when mounted

The argenteum is so opaque and dense that the nature of the relation of the reflecting particles and histological elements of the subcutaneous tissue cannot be made out.

TIME OF APPEARANCE OF COLOUR ELEMENTS.

Such of the batrachian anuran larvae as are known to me are either dark or brown at the time of hatching, and the formation of coloured chromatophores is not complete till after the larvae come under the influence of sunlight. The time of appearance of colour varies in different families, mainly depending upon the environmental circumstances under which development progresses.

In *Microhyla ornata* the large cephalic region remains transparent throughout the metamorphosis, and the diamond-shaped mark appears as soon as the larvae adopt habits of floating on the surface of the water, when they measure about 10 to 12 mm. The other characters, such as the metallic band and the reflecting surfaces, gradually emerge into view as the tadpole increases in size (16 to 18 mm.). It may be mentioned that at this stage the peritoneum bears more numerous iridocytes than at later stages, so much so that they form a continuous metallic surface over a dark background formed by the melanin chromatophores. Perhaps the most important feature in the development of the argenteum at this stage is the fact that when a piece of fresh subcutaneous tissue is examined under the microscope, before it has become too opaque for such treatment, two kinds of metal elements can be noticed. The larger crystals are fairly regular in their outline, unlike those of the mid-dorsal band, and the smaller ones are irregular. As no broken pieces of these larger plates have yet been examined, the view that they contribute towards the formation of the argenteum is only tentatively put forward. When the tadpoles develop the front limbs, the dorsal golden streak and the argenteum are absorbed and the normal colouration of the adult begins to appear.

THE CHEMISTRY OF IRIDOCYTES AND ARGENTEUM.

In the sixties, Barreswil[1] and Voit[2] demonstrated the presence of guanin in the reflecting tissues and the air-bladder of fishes, and about 1845 this substance was isolated by Bodo Unger from guano. Some time later, Ewald and Krükenberg[3] found the occurrence of this substance in reptiles and amphibians as well, and their investigations go to show that the dead chalky white found on the ventral surface of the adult members of the Ranid family is really caused by a lime compound of guanin, which

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1 *Comptes Rendus*, LIII, p. 246 ; 1861 (*Phil. Trans. Roy. Soc. London*, CLXXXIV B, p. 781 ; 1893).

2 *Zeitsch. f. wiss. Zool.*, XV (*Phil. Trans.*, p. 782).

3 *Zeitschr. f. Biologie*, XIX, p. 1 : 1883 (*Phil. Trans.*, p. 785).

they called "Guaninkalk." About 1893 Cunningham and MacMunn,[1] as a result of extensive observations on fishes, established the fact that the iridescent effect produced in the skin of all fishes is due to the presence of iridocytes, and the silver brilliancy is caused by the reflecting tissue,—the argenteum. Guanin is the chemical substance present in both these structures.

It may be mentioned that guanin in the tissues of the body is the end product of the metabolic activity of the organism, and the utilisation of this waste matter for certain physiological ends is a feature of wide-spread occurrence in animals. As has been said in the foregoing paragraphs, the presence of guaninkalk and its chemical nature have already been worked out in the skin of adult batrachians, but so far the occurrence of the iridocytes and argenteum has not been determined either in the adult or the larvae. On chemical analysis of these substances it is established that they are guanin compounds identical with those worked out in the fishes, and the course of the chemical enquiry adopted for such a determination may now be proceeded with. I must mention here that in all stages of the work I have received considerable help from my colleague Mr. A. Subba Rao.

The tissues were thoroughly washed in distilled water till all albuminous matter was removed and then solutions of iridocytes and argenteum were obtained in nitric and hydrochloric acids.

I. A quantity of nitric acid solution was evaporated in a watch glass over a hot air bath. The residue formed is a yellow substance (guanin nitrate) which turned red on the addition of caustic potash. This is Barreswil's reaction.

II. A quantity of hydrochloric acid solution was evaporated similarly and the residue was treated with strong nitric acid. A yellow compound is obtained by reheating the solution to dryness which on the addition of caustic soda turned red, and purple on heating. This is Cunningham and MacMunn's test.

III. If to the yellow compound (nitrate of guanin), obtained in the first two cases, ammonia is added and heated the same colour changes are noticed. This test is given in Watt's chemical dictionary (p. 656).

It may be mentioned here that there is essentially no difference between Barreswil, Cunningham and MacMunn and Watt's reactions. In all the three cases the neutralising agent, a base, is added to the nitrate of guanin which on heating becomes purple.

IV. If silver nitrate is added to the nitrate of guanin a reddish-brown precipitate results, which on heating turns purple.

V. Potassium chromate gives an orange red precipitate on the addition of the nitrate of guanin (Watt).

VI. Potassium ferricyanide yields a brown precipitate with the same substance (Watt).

VII. Concentrated picric acid gives a bright red solution when treated with nitrate of guanin (Watt).

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[1] *Phil. Trans. Roy. Soc. London*, CLXXXIV B, p. 765 (1893).

VIII. Hydrochloric acid solution of guanin on heating turns red and the guanin hydrochloride—the ash obtained after boiling —is slightly reddish, which treated as in experiments V, VI and VII gives similar reactions.

IX. Potassium permanganate solution treated with nitrate of guanin, with a touch of caustic soda. The green solution (green being due to the formation of K_2Mno_4) on heating gives an albuminous flocculent red precipitate (oxyguanin) which is insoluble in water, rectified spirit and weak acids (Watt).

X. The same reactions are obtained with the hydrochloric acid solution of guanin.

If any of these precipitates obtained with silver nitrate in the above experiments should be treated with oxyguanin obtained in experiment X, the silver chloride is precipitated in the form of a white stuff.

The iridocytes are insoluble in water, ether, chloroform, glycerine[1] and acetic acid, but soluble both in acids (Nitric, Hydrochloric and Sulphuric) and bases like caustic potash, soda and ammonia. Formalin and alcohol are also solvents.

With the alkaline (NaOH) solution of iridocytes and argenteum the following additional reactions and properties were obtained.

XI. The solution was treated with strong picric acid and boiled for a few minutes. The whole turned into orange red on being allowed to stand for 18 hours.

XII. With potassium permanganate solution the usual green reaction results. On boiling, the red flocculent precipitate is obtained even without the addition of any acid.

XIII. To the alkaline solution of iridocytes, potassium ferricyanide ($K_3fe(CN)_6$) was added and boiled for about 15 minutes. Silver nitrate being added gives a white precipitate. Reboiled the precipitate is transformed into bright red.

XIV. NaOH solution of iridocytes ($C_5H_5N_5O$) on boiling slowly turns reddish and the addition of another base like NH_3 and reboiling turns the red into purple.

XV A white ash is deposited on the sides of the test tube when the above solution (KOH or NaOH $C_5H_5N_5O$) is boiled to dryness. The calcified substance is refractory to concentrated acids and aqua regia; it dissolves, however, on heating, setting up a vigorous chemical action.

The next point which is worthy of notice is the fact that calcium in any form is absent from the argenteum of the larvae of *M. ornata* and *M. rubra* which has therefore nothing to do with the guaninkalk of Ewald and Krükenberg. Solutions of the subcutaneous tissue from the abdominal surface of the Ranid larvae react to the calcium tests and the dead white of the skin is due to guaninkalk in these cases. Guanin is silvery white, and the golden

[1] Iridocytes mounted in glycerine broke up and crystals were found at the end of a fortnight.

brightness of the mid-dorsal streak is caused by a layer of yellow lipochrome superimposed over the crystals. On the removal of the colouring matter by alcohol or glycerine, the band is transformed into a silver brilliancy. The following crystals were obtained and examined:

1. Strong solution of iridocytes and argenteum of the tadpole in hydrochloric acid, on being boiled, is precipitated in the form of delicate pointed needles, which on standing unite to form irregular plates. These are not hygroscopic (fig. 3).

2. Nitric acid solution gives broad plate-like crystals, somewhat prismatic, truncated at both ends. They arrange themselves in pectinate groups while hot, and break into spherical granules on cooling (fig. 4).

3. Sulphuric acid solution, which chars on boiling, produce blunt delicate needles that are bent in parallel rows. They straighten on cooling (fig. 2).

4. In caustic soda iridocytes crystallise in the form of pyramidal needles, often aggregated in wisps. The crystals are hygroscopic (fig. 1).

5. Hydrochloric solution of argenteum treated with $MGCL_2$ and precipitated gives three forms of crystals:—(1) Long silky fibres; long spindle-shaped pointed or blunt needles (aggregations of the first); (2) small delicate needles arranged in the form of brushes, and (3) smaller needles either isolated or forming rounded plates. The crystals are not hygroscopic (fig. 5).

6. If $ZNCL_2$ should be substituted for $MGCL_2$ in the above, the crystalline forms are rounded with jagged edges. They decompose into very delicate yellow needles (fig. 6).

7. Hydrochloric acid solution of iridocytes treated with strong picric acid will yield tall cylindrical coloured crystals truncated at both ends. They are hygroscopic (fig. 7).

8. If nitric acid solution is used instead of hydrochloric acid in the above, radiating coloured plates more or less oblong are obtained. They are also hygroscopic (fig. 8).

9. The silver derivative of oxyguanin also crystallises in the form of short delicate needles. They arrange themselves like wheels with a number of spoke-like structures radiating from the centre and very minute concentric circles. Between any two of such aggregations the silver oxide, which is also formed, is deposited. The crystals are hygroscopic and unstable (fig. 9).

There is only one primary form of crystals of iridocytes and argenteum obtained from all these sources which, under the influence of different substances, assumes widely divergent shapes.

The lipochromes are easily soluble in alcohol and solutions of yellow and red pigments were employed for wave length measurements of the absorption band with negative results. It is possible that the red in the tail of the forms mentioned above and other larvae is only a concentrated form of the yellow pigment. As a solution of any degree of concentration could not be obtained of

the blue of *K. variegata* nothing can be said about the absorption band of this pigment.

SYNTHESIS OF IRIDOCYTES AND ARGENTEUM.

The iridocytes are most unstable and are easily affected and a few observations made in the aquarium may be here set forth.

1. If light should be absolutely cut off from the specimens, the iridocytes are absorbed in about 4 or 5 days but not the argenteum.

2. Starvation produces the same effect, and the time (4 or 5 days) depends on the condition of the larva previous to the commencement of the experiment.

3. Exposure to sunlight and liberal feeding produce two effects. The larvae become absolutely transparent, head and body included, and the metallic dorsal band extends over the cranium, at the same time becoming most brilliant.

4. If specimens used in experiments (1) and (2) are restored to normal conditions, the water (preferably tank water being used) in the aquarium being renewed every day, nearly 70 per cent of them acquire the dorsal band, appearing first in the anterior region of the vertebral column.

SUMMARY.

The leading facts discussed in this paper may be now summarised.

The first set of facts relate to the floating habits of the larvae of *M. ornata* and *M rubra* co-related with the presence of air-chambers between the branchial plates, which function more or less as hydrostatic organs. The danger of exposure to the attacks of enemies incidental to such habits is warded off by the presence of an acid offensive matter in the cephalic gland. This circumstance is probably advertised by the bright colouration.

The second set of facts deal with the unique occurrence of iridocytes and argenteum in the same larvae. Both from the morphological and evolutionary points of view the presence of iridocytes and black chromatophores on the lungs and peritoneum is full of significance, for their occurrence in the air-bladder of fishes and the peritoneum of embryonic fishes has been reported. It is established that the iridocytes of the mid-dorsal band, and the ventral argenteum of the subcutaneous tissue on the sides and the ventral surface of the abdomen of these tadpoles, are entirely free from calcium in any form, and, while both are in some respects identical with those of fishes, are entirely different from the *Guaninkalk* of Ewald and Krükenberg. The substance composing the iridocytes occurs in the form of irregular plates consisting of spherical granules, identical with those obtained by the breaking down of the guanin nitrate crystals, while the argenteum is a dense opaque reflecting subcutaneous tissue in which no structure can be made out. The dead chalky white on the ventral surface of the larvae of the genus *Rana* is due to guaninkalk.

The yellow and red lipochromes occurring in the tadpoles are not essentially different, though alcoholic solutions of them may appear quite separate.

Like the black chromatophores, the coloured ones are modifications of special connective tissue cells in which the pigments are deposited. Cells which have undergone such a change appear scaly and if the scale should break, as sometimes happens in the course of preparing tissues for mounting, the pigment occurs in the form of granules. Such a process must naturally take place in the subcutaneous tissues. Similarly the cells which develop guanin granules in the protoplasmic contents become transformed into iridocytes. They are easily marked off from the other tissue cells by their shape,—more or less flask-like, and the fact that they are not stained. As metamorphosis progresses, large amoebacytes make their appearance wherever iridocytes and argenteum occur (fig. 13).

EXPLANATION OF PLATE XI.

FIG. 1.—Hygroscopic crystals of iridocytes obtained from NaOH solution.

FIGS. 2, 3, 4.—Crystals obtained from Sulphuric, Hydrochloric and Nitric acids respectively.

(FIG. 4 Hygroscopic).

FIG. 5.—Crystals obtained after treatment of HCl. sol. of iridocytes with $HgCl_2$.

,, 6.—Crystals obtained after treating HCl. sol. of iridocytes with $ZnCl_2$.

FIGS. 7, 8.—HCl and HNO_3 sol. of iridocytes treated with Picric acid.

FIG. 9.—Silver derivation of oxyguanin.

(FIGS. 6-9 Hygroscopic).

FIG. 10.—Lateral view of the tadpole (*Microhyla ornata*).

,, 11.—Dorsal view.

,, 12.—Metallic band *in situ*.

,, 13.—Colour and histological elements from dermis.

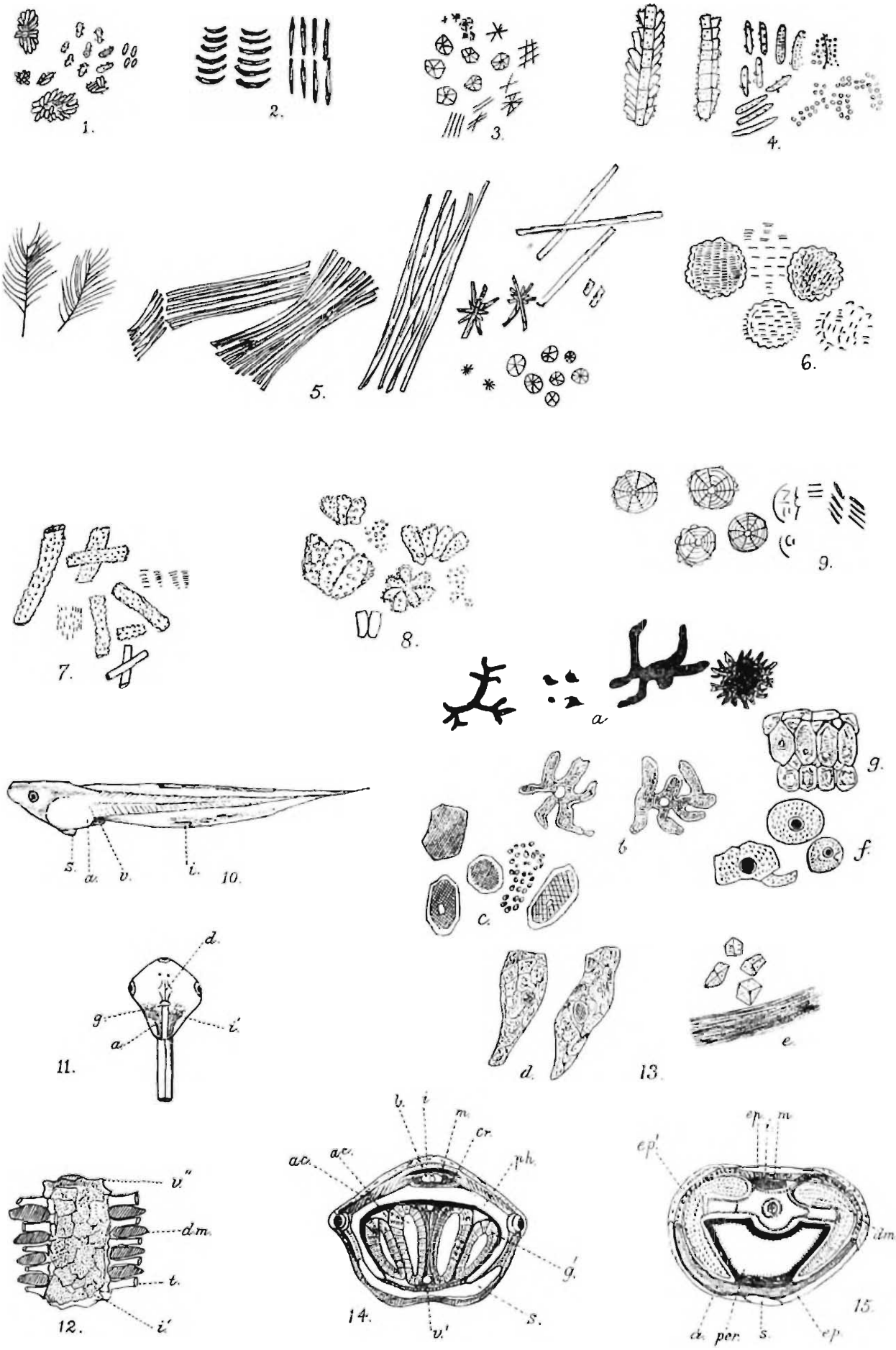
a, b. black chromatophores and connective tissue corpuscles; c. coloured chromatophores, scales, granules and connective tissue corpuscles; d. argenteoblarts; e. argenteum and plate-like iridocytes; f. phagocytes; g. elements of the dermis.

FIG. 14.—Transverse section across the eye.

,, 15.—Transverse section at about the fourth vertebra.

LETTERING IN FIGS. 10—12 & 14, 15.

a. argenteum; *ac*. air cavities; *b*. brain; *cr*. cranium; *d*. diamond-shaped mark; *d.m*. dorsal muscle; *ep*. epidermis free from chromatophores; *ep'*. with chromatophores; *g*. glandular area; *g'*. gills; *i*. iridocytes; *m*. black chromatophores. *per*. peritoneum; *ph*. pharynx; *s*. spuach; *t*. transverse process; *v*. vent; *v'*. ventral vessel; *v''*. vertebra.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XVII NOTES ON CRUSTACEA DECAPODA IN THE INDIAN MUSEUM.

XI. ATYIDAE OF THE GENUS *PARATYA* (=*XIPHOCARIDINA*).

By STANLEY KEMP, *B.A., Superintendent, Zoological Survey of India.*

Bouvier has shown that the West Indian *Xiphocaris elongata* (Guérin) differs in several important structural characters from the species, previously referred to the same genus, found in Eastern Asia, Australia and New Zealand and has proposed for the latter the generic name *Xiphocaridina*. But Miers in 1882, when recording certain Japanese Atyids as *Atyephyra? compressa*, noted that the species was probably to be distinguished generically from Brito-Capello's *Atyaëphyra* by the presence of exopods on all five thoracic legs[1]; and he suggested for the Japanese form the generic name *Paratya*. There can be no doubt that Miers' specimens are generically identical with those on which Bouvier based his *Xiphocaridina* with the result that the latter name, by far the more appropriate of the two, must lapse.

Genus **Paratya**, Miers.

1868. *Atyephyra*, von Martens, *Arch. f. Naturgesch.*, XXXIV, p. 51 (in part: not *Atyaëphyra*, Brito-Capello).
1880. *Miersia*, Kingsley, *Proc. Acad. Sci. Philadelphia*, 1879, p. 416 (in part).[2]
1882. *Paratya*, Miers, *Ann. Mag. Nat. Hist.* (5) IX, p. 194.
1895. *Xiphocaris*, Ortmann, *Proc. Acad. Sci. Philadelphia*, 1894, p. 400 (in part).
1905. *Xiphocaris*, Bouvier, *Ann. Sci. France Belgique*, XXXIX, p. 60 (in part).
1909. *Xiphocaridina*, Bouvier, *Comptes Rendus Acad. Sci., Paris*, p. 1729.
1912. *Xiphocaridina*, Kemp, *Rec. Ind. Mus.*, VII, p. 113.

Only two species which can be referred to the genus *Paratya* have hitherto been recognised, *viz. Paratya compressa* (de Haan), described from Japan and since recorded from Korea, Flores, Australia and Norfolk I. and *P. curvirostris* (Heller) from New Zealand, Chatham I. and Upper Assam.

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[1] Miers was evidently unaware that von Martens in 1872 (*Arch. f. Naturgesch.*, XXXVIII, i, p. 139) had founded the genus *Xiphocaris* on this very character. *Xiphocaris*, however, was based on specimens from the West Indies and, as Bouvier has shown, is distinguished from the Pacific genus by the greater number of branchiae and other important characters.

[2] The type of this genus is Risso's *Ephyra pelagica*, probably a Hoplophorid.

In the collection recently made by Dr. Annandale in the Far East there are series of *P. compressa* from several localities in Japan. On examination, the specimens were found to fall into two well-marked races, one inhabiting the north-eastern portions of the main island, while the other is apparently restricted to the south-western parts, the upper limit of its distribution being Lake Biwa and its vicinity. This rather unexpected discovery led me to make an examination of all the *Paratya* preserved in the Indian Museum, and I find as a result that there has been a great deal of misapprehension regarding the taxonomy and distribution of the species. The Indian Museum is fortunately well supplied with material: including Dr. Annandale's collection, specimens are available from seven localities in Japan, from Sydney in New South Wales, from Lake Torrens in S. Australia (as well as a sample from "S. Australian waters"), from both east and west sides of Norfolk I., from two localities in New Zealand and from two in Upper Assam.

Examination of this extensive material leads me to conclude (i) that the true *Paratya compressa* is restricted to Japan, possibly extending into Korea; in the main island of the former country it is represented by two well-marked races; (ii) that the Australian form is to be distingusihed specifically from the Japanese and is represented in Norfolk I. by a race which differs from it in characters of at least subspecific value; and (iii) that the form recorded from New Zealand and Upper Assam is distinct from any of the others.

The five forms examined may be distinguished by the following characteristics:—

Key to the species and subspecies of *Paratya*.

I. Propodus of 3rd and 5th peraeopods, in both sexes, less than three times as long as dactylus,[1] dactylus of 3rd pair with 19 to 30 spines,[2] the number very rarely falling to 18 [propodus of 3rd and 4th pairs expanded distally in male, the dilated portion bearing numerous spines].

A. Rostrum with 16 to 25 dorsal teeth; hindmost tooth situated on carapace or immediately above orbital notch ... ... *P. compressa* (de Haan).

B. Rostrum with 7 to 18 dorsal teeth; proximal part of rostrum unarmed, no tooth on carapace or above orbital notch ... ... *P. compressa*, subsp. *improvisa*, nov.

II. Propodus of 3rd and 5th peraeopods, in females,[3] more than three times as long as dactylus; dactylus of 3rd pair usually with 6 to 13 spines, the number occasionally rising, in males only, to 18.

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[1] The extreme length of the dactylus, terminal spine included.

[2] Including the terminal spine.

[3] The character is also valid for males of *P. australiensis* and its subspecies; in males of *P. curvirostris* the proportion occasionally falls as low as 2·5.

A. Upper border of rostrum with 10 to 17 irregularly disposed teeth, forming at least three distinct groups; propodus of 3rd and 4th legs expanded distally in males, the dilated portion bearing numerous spines ... ... *P. curvirostris* (Heller).

B. Upper border of rostrum with 19 to 32 teeth, forming an uninterrupted series; 3rd and 4th legs of male not modified.

1. Carpus of 1st peraeopods twice or more than twice as long as broad; propodus of 5th peraeopods less than four times as long as dactylus; dactyli of 3rd and 5th peraeopods at least three times as long as broad,[1] dactylus of 3rd peraeopod with 9 to 13 spines ... *P. australiensis*, sp. nov.

2. Carpus of 1st peraeopods less than twice as long as broad; propodus of 5th peraeopods, at least in females, more than four times as long as dactylus; dactyli of 3rd and 5th peraeopods less than three times as long as broad; dactylus of 3rd peraeopod with 6 to 8, rarely 9 spines ... ... *P. australiensis*, subsp. *norfolkensis*, nov.

It is probable that the size of the eggs will afford a valuable criterion in specific and subspecific differentiation; but unfortunately the collection contains ovigerous females only of *P. curvirostris* and of *P. compressa* subsp. *improvisa*.

It will be noticed that in three of the five recognised forms the third and fourth peraeopods of the male are modified, the propodus being conspicuously dilated towards its distal end and armed on the posterior margin of the expanded part with a great number of short spines. Very similar sexual differences are met with in *Atyaëphyra*, a genus that has a circum-Mediterranean distribution and is also one of the more primitive genera of the family. In males of *Atyaëphyra desmaresti*, as Barrois has shown,[2] the third and fourth legs are modified on precisely the same lines as in *Paratya*; but, strangely enough, the segment concerned is not the propodus, but the merus.

That sexual modifications of the third and fourth legs should be entirely absent in the forms of *Paratya* from Australia and Norfolk I. is very curious. Males are unfortunately scarce in my material from these localities and examination of further specimens is therefore desirable. In no case, however, have I found the slightest trace of modification, though the character is well marked in much smaller specimens from Japan.

Calman[3] has noticed sexual differences in the length of the spines on the third and fourth legs in *Limnocaridina similis* and *L. socius* from Lake Tanganyika, while in other species of the same

[1] Excluding all spines, both terminal and lateral.
[2] Barrois, *Rev. Biol. Nord. France*, V, p. 124, fig. 2 (1892).
[3] Calman, *Proc. Zool. Soc. London*, 1906, p. 195.

genus no such distinction was to be found. It seems probable, therefore, that in this genus, as in *Paratya*, the existence of sexual modifications in the thoracic legs is a specific character. In *Xiphocaris*, the most primitive of all the Atyidae, these sexual differences do not exist.[1]

Bouvier,[2] in his account of the races of *Atyaephyra desmaresti*, found that distinctive characters were afforded by the structure of the endopodite of the first pleopod of the male. In the genus *Paratya* the appendage is similar in outline in all the forms and the differences that exist in the spinulation appear to be of less importance than those derived from other parts.

All the species and subspecies examined agree in the possession of a supraorbital spine. The carpus of the first peraeopod is deeply excavate in front, that of the second pair less markedly so. Exopods are found on all the thoracic legs, but there are no arthrobranchs above the bases of any of these limbs. The outer uropod agrees with that of *Xiphocaris* in bearing only a single movable spinule in place of the series found in most genera of the family. The telson bears two, less commonly three pairs of dorsal spines and is provided at the apex with eight or ten spinules

A synopsis of the numbers of rostral teeth in the different forms is given on p. 297.

In the descriptions which follow I have referred only to the characters that show racial or specific differences.

Paratya compressa (de Haan) *sensu stricto.*

1849. ? *Ephyra compressa*, de Haan, in Siebold's *Fauna Japonica, Crust.*, p. 186, pl. xlvi, fig. 7.
1880. *Miersia compressa*, Kingsley, *Proc. Acad. Sci. Philadelphia*, 1879, p. 416.
1902. *Xiphocaris compressa*, Rathbun, *Proc. U.S. Nat. Mus.*, XXVI, p. 49 (? part only).
1905. *Xiphocaris compressa*, Bouvier, *Bull. Sci. France Belgique*, XXXIX, p. 62 (part only; not fig. 1, p. 61).
1914. *Xiphocaridina compressa*, Balss., *Abhandl. math.-phys. Klasse K. Bayer. Akad. Wiss.*, Suppl. Bd. II, Abt. 10, p. 23 (part only).

In this form the rostrum always reaches beyond the antennular peduncle, extending almost to, or a little beyond the apex of the antennal scale. On its upper border it is armed with 16 to 25 (usually 17 to 24) teeth, forming an uninterrupted series from the base to the apex. The hindmost dorsal tooth is either situated on the carapace or is placed immediately above the posterior limit of the orbit; in a few cases two posterior teeth are on the carapace. The lower border bears in the middle of its length from 1 to 6 teeth, most commonly 1 to 3.

The lateral process of the antennular peduncle extends a little beyond the end of the basal segment.

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[1] This statement is based on an examination of a few specimens from Havana in Cuba, preserved in the Indian Museum.

[2] Bouvier, *Bull. Mus. d'Hist. nat. Paris*, 1913, p. 65.

DORSAL TEETH.

Number of teeth.	Number of specimens.				
	P. compressa.		*P. curvirostris.*	*P. australiensis.*	
	typical form.	subsp. *improvisa.*		typical form.	subsp. *norfolkensis.*
7	...	1			
8	...	5			
9	...	4			
10	...	5	2		
11	...	11	5		
12	..	1	8		
13	...	10	9		
14	...	3	2		
15	...	3	1		
16	2	2	3		
17	5	...	1		
18	6	1			
19	14	...	...	1	
20	7	...	...	...	
21	19	...	...	...	1
22	8	...	...	3	1
23	2	...	...	1	...
24	2	...	...	2	1
25	1	...	...	2	2
26	...	...	...	1	1
27	...	...	...	2	1
28	...	...	...	1	1
29	...	...	...	4	...
30	...	...	...	3	...
31	..	...	...	2	...
32	...	...	...	1	2

VENTRAL TEETH.

Number of teeth.	Number of specimens.				
	P. compressa.		*P. curvirostris.*	*P. australiensis.*	
	typical form.	subsp. *improvisa.*		typical form.	subsp. *norfolkensis.*
1	13	3	...	1	
2	21	25	...	2	
3	22	14	5	1	1
4	4	4	17	3	2
5	3	...	7	3	3
6	3	...	1	3	2
7	...	...	...	1	1
8	...	...	1	3	1
9	...	...	...	1	
10	...	...	...	1	
11	...	...	...	1	
12	...	...	...	1	
13	...	...	...	...	
14	...	...	...	1	

In the first peraeopods (text fig. 1*a*) the carpus is comparatively slender, from 2·2 to 2·5 times as long as its greatest breadth; rarely in young specimens the proportion falls as low as 1·8. The chela is about a third longer than the carpus and its length is usually about one-third the width of the palm. The carpus of the second pair (text fig. 1*b*) is from 6·0 to 7·1 times as long as broad. The dactylus of the third peraeopods (text-figs. 1*c*, *d*) is long and slender; the propodus is only from 2·1 to 2·5 times its length. Excluding the spines its length is from 3·7 to 4·5 times its breadth. The dactylar spines vary in number from 19 to 22, very rarely 18. In the fifth peraeopods (text figs. 1*e*, *f*) the propodus is also from 2·1 to 2·5 times as long as the dactylus; the latter segment bears from 43 to 69 spinules, excluding which it is from 4·2 to 4·8 times as long as broad.

In the male the propodus of the third and fourth peraeopods is a little dilated towards the distal end and the terminal third of

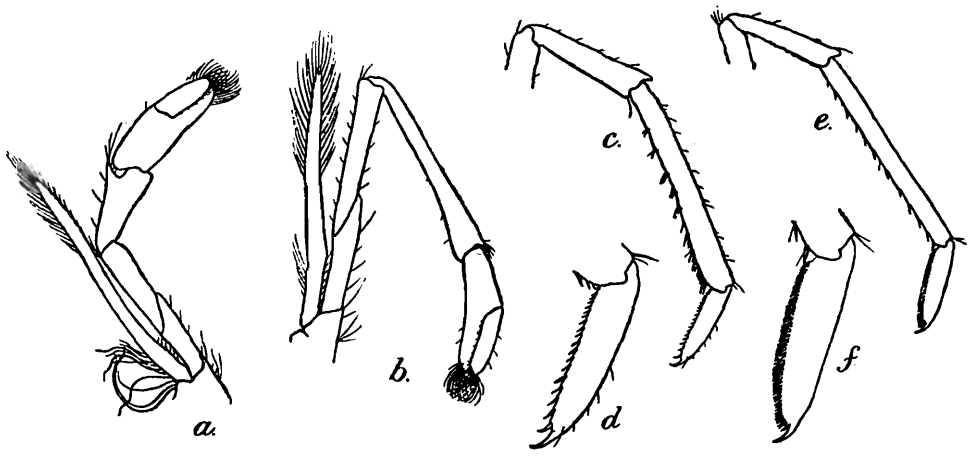

FIG. 1.—*Paratya compressa* (de Haan).

a. First peraeopod.
b. Second peraeopod.
c. Third peraeopod of male.
d. Dactylus of third peraeopod.
e. Fifth peraeopod.
f. Dactylus of fifth peraeopod.

the posterior margin is armed with numerous close-set spines (text-fig. 1*c*). In the specimens I have seen these sexual modifications are much less conspicuous than in the larger individuals belonging to the subsp *improvisa*.

None of the specimens examined bear eggs; the largest is 23 mm. in total length.

De Haan's figure of this species is unusually poor, but except for the fact that the carpus of the second legs is stated to be indistinctly annulate, the description agrees very well with the specimens I have examined. According to de Haan there are 20 to 24 teeth on the upper border of the rostrum.

The typical form of *P. compressa* is represented in the Indian Museum by a great number of specimens collected by Dr. Annandale in Komatsu Lake near the eastern shore of Lake Biwa and from the Ogura and Yodo ponds near Kyoto: there are also a few examples from L. Biwa itself. All specimens from localities situ-

ated further to the north-east belong to the subspecies *improvisa* and it appears, therefore, that the northern distributional limit of the typical form is somewhere in the vicinity of Lake Biwa. The specimens recorded by Miss Rathbun from the latter locality undoubtedly belong to the typical form and this is perhaps also the case with the solitary individuals which she examined from Tsushima I. and from Fusan in Korea. If my views on the distribution are correct, Balss' examples from Koitogawa in Kadzuza prov. are to be referred to the subsp. *improvisa*, while those recorded from Okayama belong to the typical race. Balss notes that in the latter individuals the eggs are 0·63 mm. in length and 0·40 mm. in breadth.

Dr. Annandale noted that the species was abundant among weeds or dense vegetation at Komatsu and in pools and backwaters round Lake Biwa; in the lake itself it was much scarcer. Living specimens showed no definite markings, but were dotted more or less profusely with small pigment cells. The fingers of the chelae were tinged with orange brown. The Temnocephaloid worm *Caridinicola* was present in the gill-chambers of a large proportion of the individuals examined at Komatsu.

subsp. **improvisa**, nov.

1868. *Atyephyra compressa*, von Martens, *Arch. f. Naturgesch.*, XXXIV i, p. 51, pl. i, figs. 4 *a-c*.
1882. *Atyephyra ? compressa*, Miers, *Ann. Mag. Nat. Hist.* (5), IX, p. 193.
? 1890. *Miersia compressa*, Ortmann, *Zool. Jahrb., Syst.*, V, p. 464.
? 1902. *Xiphocaris compressa*, Doflein, *Abhandl. math.-phys. Klasse K. Bayer. Akad. Wiss.*, XXI, p. 632.

This subspecies is distinguished from the typical form almost entirely by the dentition of the rostrum. The rostrum reaches to,

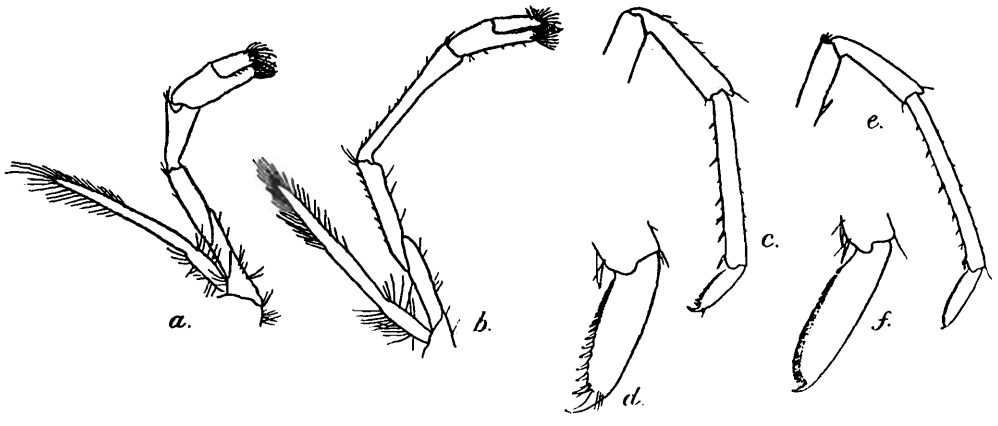

FIG. 2.—*Paratya compressa* subsp. *improvisa* nov.

a. First peraeopod.
b. Second peraeopod.
c. Third peraeopod of female.
d. Dactylus of third peraeopod of female.
e. Fifth peraeopod.
f. Dactylus of fifth peraeopod.

or a little beyond the antennal scale and bears on its upper margin an uninterrupted series of 7 to 18 (usually 8 to 15) teeth. The

proximal part of the rostrum is altogether unarmed; the hindmost tooth of the series is placed above the cornea, when the eye is directed straight forwards, or is in advance of this point. On the lower border there are from 1 to 4 teeth, usually 2 or 3.

The proportionate measurements of the legs are much the same as in the typical form. In the first pair (text-fig. 2*a*) the carpus is from 2·1 to 2·7 times as long as broad and in the second (text-fig. 2*b*) from 5·6 to 6·3 times. The propodus of the third pair (text-figs. 2*c*, *d*) is from 2·4 to 2·7 times the length of the dactylus, the length of the latter segment, spines excluded, being from 3·3 to 4·0 times its breadth. In the fifth pair (text-figs. 2*e*, *f*) the propodus is from 2·4 to (in one instance only) 2·9 times as long as the dactylus, the latter segment, spines excluded, being from 4·0 to 4·7 times as long as broad. The dactylar spines seem to be rather more numerous than in the typical form; in the third pair there are from 24 to 30 and in the fifth from 71 to 92.

In large males the third and fourth peraeopods show an extreme degree of sexual modification (text-fig. 3). The propodus is very strongly expanded distally, so much so that the segment is less than 5 times as long as broad, whereas it is nearly 9 times as long as broad in females. The anterior margin is concave, while the posterior is convex and is furnished with numerous spinules in the distal two thirds of its length. The dactylus is also modified; it is more than 5 times as long as wide and is widest near the distal end; the spines are distinctly recurved and the terminal one is not larger than the others.

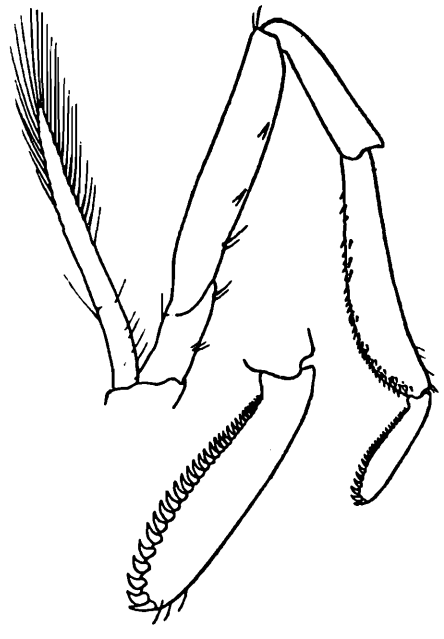

FIG. 3.—*Paratya compressa* subsp. *improvisa*, nov.

Third peraeopod of adult male with dactylus further enlarged.

The subspecies appears to be rather larger than the typical form, reaching a maximum length of 36 mm. The eggs vary from 0·63 to 0·70 mm. in length and from 0·43 to 0·46 mm. in breadth.

In this case I believe that the character of the rostrum affords a valid basis for racial distinction; among fifty specimens of the subspecies I have not been able to find a single individual that resembles the typical form. The specimens examined are from the lagoon Kasumi-ga-ura in Hikachi province, collected by Dr. N. Annandale; from Tokio, collected by Hilgendorf (Berlin Mus.); from Lake Haruna, near Ikao, at an altitude of about 3000 ft., collected by Dr. K. Nakazawa and from Lake Suwa, in the Shinano province, at an altitude of 2660 ft., collected by Dr. T Kawamura.

The specimens from Yokohama described by von Martens belong, as is clearly shown by the figure, to the subspecies *improvisa* and this is also true of those from Tokio examined by Miers, the rostrum bearing only from 7 to 14 dorsal teeth.

From these facts it may be concluded that the subspecies is found only in the north-eastern parts of the main island of Japan and, if this is true, the specimens recorded by Ortmann from Tokio, by Doflein from Yokohama and by Balss from Koitcgawa in Kadzuza province are probably to be referred to the subspecies. This is no doubt also the case with the material used by Ishikawa in his account of the development of the species.[1]

The types are from Lake Haruna and bear the number 9679/10 in the register of the Zoological Survey of India.

Paratya curvirostris (Heller).

1862. *Caridina curvirostris*, Heller, *Verhandl. zool.-bot. Ges. Wien*, XII, p. 525.
1865. *Caridina curvirostris*, Heller, *Voy. 'Novara,' Crust.*, p. 105.
1876. *Caridina curvirostris*, Miers, *Cat. N. Zealand Crust.*, p. 78.
1879. *Leander fluviatilis*, Thomson, *Trans. N.Z. Inst.* XI, 1878, p. 231, pl. x, fig. A 2.
1903. *Xiphocaris curvirostris*, Thomson, *Trans. Linn. Soc., Zool.* (2), VIII, p. 447, pl. xxix, figs. 2-13.
1906. *Xiphocaris curvirostris*, Chilton, *Proc. Zool. Soc. London*, p. 703.
1909. *Xiphocaridina fluviatilis*, Bouvier, *Comptes rendus Acad. Sci. Paris*, p. 1728.
1912. *Xiphocaridina curvirostris*, Kemp, *Rec. Ind. Mus.*, VII, p. 113.

In this species[2] the rostrum reaches to or a little beyond the apex of the antennal scale and is armed above with from 10 to 17 teeth. These teeth do not form an uninterrupted series, as in all other species of *Paratya*, but are separated, usually quite distinctly, into three groups. The hindmost group consists of 2 or 3 teeth, all of which are on the carapace behind the orbital notch; the second group is composed of 4 to 8 teeth, situated in the basal half of the rostral length; the third group is placed just behind the apex and comprises 3 to 7 teeth. In most cases 1 or 2 solitary teeth are to be found between the second and third groups. On the lower margin there are from 3 to 8 teeth, usually 4 to 6. The teeth are larger than is customary and are rather widely separated, extending on to the distal third of the rostral length.

The lateral process of the antennular peduncle reaches to the middle of the second segment.

The carpus of the first peraeopods (text-fig. 4*a*) is from 1·7 to 2·4 times as long as broad; it is decidedly more slender in males than in females. That of the second peraeopods (text-fig. 4*b*) is from 5·0 to 6·7 times as long as broad. The propodus of the third peraeopods (text-figs. 4*c*, *f*) is from 2·5 to 3·9 times the length of

[1] Ishikawa, *Quart. Journ. Microsc. Sci.*, XXV, p. 391 (1885).

[2] The information here given is mostly abstracted from my paper of 1912, supplemented by a number of fresh observations.

the dactylus, the former segment being proportionately shorter in males. Excluding the spines the dactylus is 3·4 or 3·5 times as long as broad in females, rather narrower in males. In females the spines (the terminal one included) are from 9 to 11 in number, very rarely 8; in males they are more numerous, from 13 to 17, rarely 18. In the fifth peraeopods (text-figs. 4*g*, *h*) the propodus is from 3·1 to 3·7 times the length of the dactylus. The latter segment bears from 46 to 71 spinules, excluding which it is from 3·2 to 3·7 times as long as broad.

In males the propodus of the third and fourth peraeopods is modified much as in *P. compressa* (text-figs. 4*e*, *f*). The dactylus is slightly abnormal in form, but is without recurved spines and the propodus does not seem to attain as extreme a development as in large males of *P. compressa* subsp. *improvisa*. In very old females additional spinules are sometimes found on the propodi of

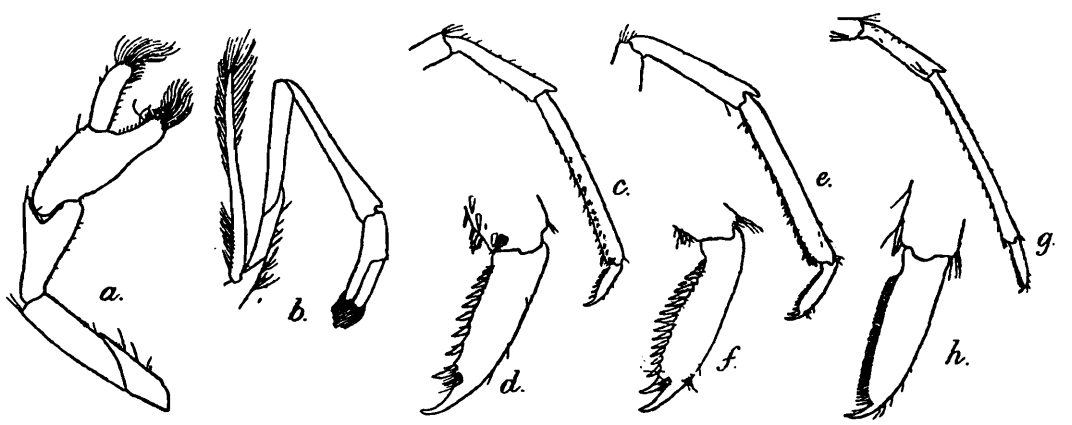

FIG. 4.—*Paratya curvirostris* (Heller).

a. First peraeopod.
b. Second peraeopod.
c. Third peraeopod of old female.
d. Dactylus further enlarged.
e. Third peraeopod of adult male.
f. Dactylus further enlarged.
g. Fifth peraeopod.
h. Dactylus further enlarged.

the third and fourth peraeopods (text-fig. 4*c*), thus resembling adult males.

The eggs are from 0·40 to 0·45 mm. in length and from 0·25 to 0·26 mm. in breadth. Large specimens reach a total length of 42 mm.

P. curvirostris is known from both north and south islands of New Zealand and from Upper Assam. It has been recorded by Chilton from the Chatham Is. In the Indian Museum it is represented by a number of specimens from the River Avon at Christchurch (Chas. Chilton coll.) and by one from the Shag River (Paris Mus.), both localities being in the southern island. There are also twenty-four specimens from Tezpur, in the Darrang district of Assam, and three from the Manipur Hills, all collected by Col. H. H. Godwin-Austen.

The views here advanced on the taxonomy of the species of *Paratya*, make it more than ever difficult to offer any explanation of the curious distribution of this species; the new observations

indicate that the methods I adopted in 1912, in comparing the specimens from Assam with those from New Zealand were reliable and that had specific differences existed they would infallibly have been detected. If the record from Assam were based on specimens from one locality I would have rejected it as untrustworthy, but the fact that samples exist from two distinct places renders it improbable that any mistake can have arisen.

Paratya australiensis, sp. nov.

1894. *Miersia compressa*, Ortmann, *Jenaische Denkschrift*, VIII (=Semon's *Zool. Forschungsreis. in Australien* etc., V), p. 10.
1903. *Xiphocaris compressa*, Thomson, *Trans. Linn. Soc. Zool.* (2) VIII, p. 449 (part).
1905. *Xiphocaris compressa*, Bouvier, *Ann. Sci. France Belgique*, XXXIX, fig. 1, p. 61.

Hitherto the Australian representative of the genus *Paratya* has been considered to be specifically identical with that from

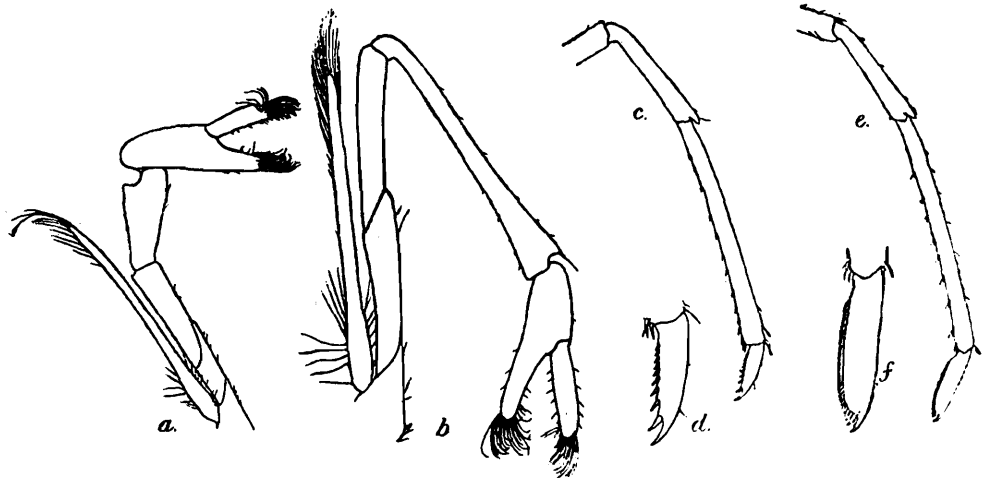

FIG. 5.—*Paratya australiensis*, sp. nov.

a. First peraeopod.
b. Second peraeopod.
c. Third peraeopod.
d. Dactylus of third peraeopod.
e. Fifth peraeopod.
f. Dactylus of fifth peraeopod.

Japan, but judging from the specimens in the Indian Museum it is undoubtedly distinct. Three samples of Australian specimens have been examined, all of which differ in certain well-marked features from the Japanese examples. They also differ rather considerably *inter se* and it appears not unlikely that recognisable races exist in different parts of the Australian continent. As types of *P. australiensis* I have selected a number of specimens from Clyde, near Sydney in New South Wales.

The rostrum in *P. australiensis* varies considerably in length, extending to the end of the antennular peduncle or far beyond the apex of the antennal scale, sometimes (in specimens from Sydney) reaching beyond the latter point by as much as one quarter its length. On its upper border it bears an uninterrupted series of

19 to 32 teeth[1] (usually 22 to 31) of which 1 or 2, rarely 3, are placed on the carapace behind the orbital notch. On the lower border there are from 1 to 14 teeth (usually 2 to 9); the distal third of the lower margin is in most cases unarmed.

The lateral process of the antennular peduncle sometimes reaches only to the end of the basal segment, in other cases to about one-third the length of the second segment.

The carpus of the first peraeopods is comparatively slender, from 2·0 (Lake Torrens) to 2·9 times as long as broad and is sometimes, as shown in text-fig. 5*a*, much less deeply excavate than in other species. The carpus of the second pair (text-fig. 5*b*) is from 5·8 to 7·5 times as long as broad. The propodus of the third pair (text-fig. 5*c*) is from 3·5 to 4·0[2] times as long as the dactylus (terminal spine included). The dactylus (text-fig. 5*d*) bears from 9 to 13 spines, usually 9 to 11; excluding these its length is from 3·0 to 3·6 times its breadth. In the fifth peraeopods (text-figs. 5*e*, *f*) the propodus is from 3·0 to (rarely) 3·8 times the length of the dactylus. The latter segment, spinules excluded, is very variable in form, from 3·3 to nearly 5[3] times as long as wide. The spinules vary in number from 28 to 82.[4]

The third and fourth legs of the male show no signs of sexual modification.

No ovigerous females are present in the material examined. The largest of the Sydney specimens is 27 mm. in length; an individual from "S. Australian waters" is rather larger, about 31 mm.

The specimens examined are from Clyde, near Sydney, from Lake Torrens in S. Australia and from "S. Australian waters." The first of these samples includes the type specimens[5] which bear the number 7590-2/10 in the Zoological Survey register. The specimens recorded by Ortmann from Burnett in Queensland, by Bouvier from Melbourne and by Thomson from Victoria and New South Wales are presumably to be referred to this species. The identity of von Martens' examples from Adenare near Flores is quite uncertain.

The material I have examined shows an unusually great range of variation and it is possible, as noted above, that more than one definable race of the species exists in Australia; the specimens in my hands are, however, not sufficiently numerous to afford evidence that this is really the case.

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[1] The rostral formulae in the three samples are as follows:—In 12 specs. from Sydney $\frac{25\text{-}32}{5\text{-}14}$: in 6 specs. from Lake Torrens $\frac{22\text{-}29}{3\text{-}8}$: in 5 specs. from "S. Australian waters" $\frac{19\text{-}30}{1\text{-}5}$.

[2] In a female from Lake Torrens.

[3] 3·3 to 4·0 in most cases. The specimen with a proportion of nearly 5 is perhaps an abnormality.

[4] From 28 to 65 in the Sydney specimens.

[5] Owing to a very unfortunate accident the types have been destroyed since the description was drawn up. The only portions of them that remain are certain appendages mounted on slides for microscopic examination.

subsp. **norfolkensis,** nov.

1903. *Xiphocaris compressa*, Thomson, *Trans. Linn. Soc. Zool.* (2) VIII, p. 449 (part).
1907. *Xiphocaris compressa*, Grant and McCulloch, *Proc. Linn. Soc. N.S.W.*, XXXII, p. 156.

Specimens from both sides of Norfolk I., collected by Messrs. Laing, are in the Indian Museum. Examples from the east side of the island are smaller than those from the west, but do not appear to be distinguished by any other constant character. The material examined does not bear out Grant and McCulloch's statement that the rostrum is proportionately shorter in specimens from the east side.

The rostrum varies greatly in length and is frequently very

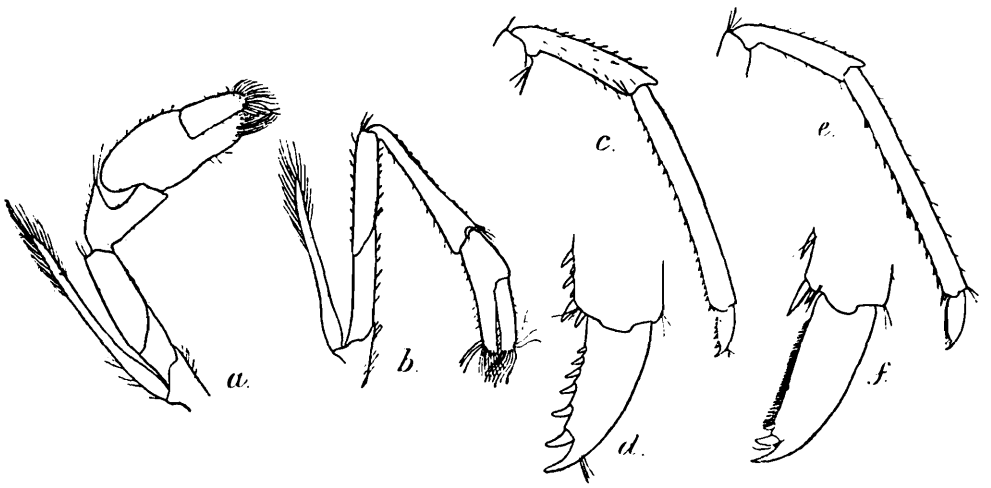

FIG. 6.—*Paratya australiensis* subsp. *norfolkensis*, nov.

a. First peraeopod.
b. Second peraeopod.
c. Third peraeopod.
d. Dactylus of third peraeopod.
e. Fifth peraeopod.
f. Dactylus of fifth peraeopod.

much shorter than in any other race of *Paratya*. In specimens from the west side it reaches, in one instance, only to the end of the second antennular segment, in others almost or quite to the end of the peduncle and in one individual a little beyond the apex of the scale. Among those from the east side the rostrum in one case reaches barely beyond the end of the first antennular segment, in others to the end of the second segment, to the end of the peduncle or a trifle beyond the apex of the scale. The upper border bears from 21 to 32 teeth,[1] forming an uninterrupted series from the base to the apex. The hindmost 2 to 5 teeth[2] are placed on the carapace. On the lower border there are from 3 to 8 teeth[1] which almost always extend on to the distal third of the rostral length and not infrequently reach almost to the apex.

[1] According to Thomson's observations the teeth vary from 17 to 34 above and from 2 to 9 below.

[2] 2 or 3, rarely 4, in specimens from the east side; 4, rarely 5, in those from the west.

The lateral process of the antennular peduncle reaches to the end of the basal segment, or as far as the middle of the second segment.

The carpus of the first peraeopods (text-fig. 6*a*) is much broader than in any other race or species of *Paratya* that I have seen; in females it is only from 1·3 to 1·6 times as long as broad and in males from 1·7 to 1·9 times. It is very deeply excavate anteriorly. The carpus of the second peraeopods (text-fig. 6*b*) is from 4·2 to 4·9 times as long as broad. In the third peraeopods (text-figs. 6*c*, *d*) the propodus, in females, is from 4·3 to 5·2 times as long as the dactylus, from 3·7 to 3·9 times in males. Excluding the spines the dactylus is only from 2·1 to 2·7 times as long as broad, being rather more slender in males than in females. The spines are less numerous than in the typical form; they vary from 6 to 8, the number occasionally rising to 9 in males. In the fifth peraeopods (text-figs. 6*e*, *f*) the propodus is from 4·2 to 4·4 times as long as the dactylus, the proportion in males rarely falling to 3·9. The dactylus, excluding the spinules, is from 2·4 to 2·8 times as long as broad. The spinules are from 35 to 43 in number and differ conspicuously from those of the typical form in one particular. In the Australian race, as in all other members of the genus save the present one, the spinules towards the apex increase successively in size by even gradations. In the Norfolk I. form the spinules are fine and regular throughout the greater part of the dactylar length, but close behind the tip there is a sudden break in continuity, the three, less commonly two terminal teeth being vastly larger than the adjacent members of the series (text-fig. 6*f*).

As in the typical form the third and fourth legs of the male show no signs of sexual modification.

There are no ovigerous females among the specimens examined. Examples from the west side of the island reach a length of 32 mm.; those from the east side do not exceed 18 mm.

It appears to me not improbable that the Norfolk I. form deserves rank as a full species, but further work on the Australian races is necessary before its precise position can be determined.

The types are from the west side of the island and bear the number 8500/10 in the register of the Zoological Survey of India.

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