3.—NEW CRUSTACEA FROM THE SWAN RIVER ESTUARY.

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INTRODUCTION.

The species with which this paper deals were collected during the period March to December, 1943, during an investigation of the fauna occurring amongst the algae of the estuary. The collections were taken almost entirely from the western side of Freshwater Bay, where the rocky nature of the bottom provides ample hold for the algae.

As a faunistic environment the Swan estuary presents some peculiar features. The estuary is a drowned river valley but owing to the negligible tidal influence on the coast outside its mouth, there is no tidal influence in the river. Nevertheless there is a marked variation in the salinity during the year. The salinity is practically that of the open ocean in summer; whereas in winter, at least in the shallow water near the banks where the investigation was carried out, the water became practically fresh after heavy downfalls of rain. Thus in summer the fauna tends to be made up of marine and estuarine forms, in winter of estuarine and freshwater forms.

This serves to explain the variation in ecologic type of Crustacea presented here, ranging from the marine *Mesochra*, through the estuarine *Corophium* to the practically freshwater *Gladioferens*.

The species here described include two Copepods, an Amphipod, and two Isopods.

DESCRIPTION OF NEW SPECIES.

Class: COPEPODA.

Order: CALANOIDA.

Family: **CENTROPAGIDAE.**

GLADIOFERENS, Henry (1919).

Gladiferens imparipes sp. nov.

OCCURRENCE.

Amongst algae, July to December. Large numbers.

FEMALE.

Ovigerous, 1·35-1·4 mm, non-ovigerous up to 1·5 mm. Body rather robust, cephalothorax oval, its greatest width a little behind the middle. Head narrowly rounded in front and projecting below in a rostral prominence. Last thoracic segment fairly short, expanded laterally into slight lobes each bearing a slender seta.

Urosome half as long as cephalothorax. Genital segment has rounded projections at about the middle of its length and widens again posteriorly. The projections bear a group of spinules, the posterior one of which is somewhat stouter than the rest. There is also a short spine on the posterior swelling. Ventrally on the genital segment, lateral to the genital aperture and immediately behind it, is a pair of short spines. At about the same distance apart and in front of the aperture occur another pair. On each side a row of minute spinules run inward and forward from the posterior pair. Second segment of urosome half as long as first; the third is longer and rectangular; the fourth is as long as the second. Caudal rami long and slender. They are divergent and ciliated along the whole length of the inner side, and in a cluster behind the lateral seta on the outer. The lateral seta is inserted two-thirds of the distance along the margin. The other four of equal length are inserted close together on the truncated end.

Appendages: Antennule has twenty-five segments, some of the proximal being very short. Second antenna biramous, rami subequal; exopod six-segmented with three terminal setae on the distal segment. Mandibles strong and expanded, with eight somewhat rounded denticles, the outermost the largest and separated from the rest by a sinus; a slender seta stands at the inner end. Maxillae and maxillules normal; maxillipeds long and slender, the distal segments with dense setae; four borne on the second segment.

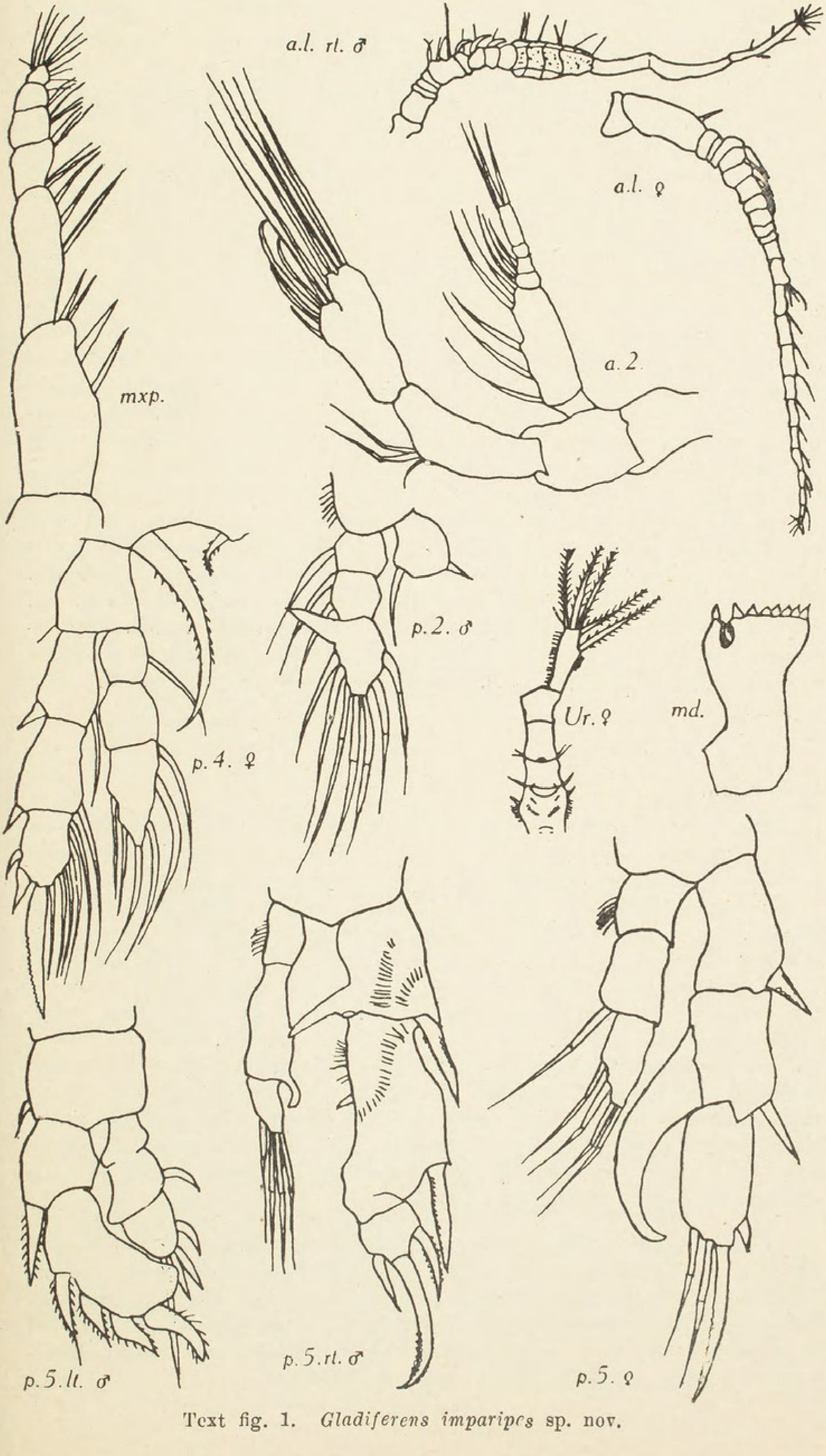
The natatory appendages are slender, with 3-segmented rami, the endopods somewhat shorter than the exopods. The second segment of the first exopod is without an external spine. The external spines are weakly denticulate. Distally each exopod bears a stouter denticulate spine and a seta. The fourth pair of appendages are asymmetrical in that the left bears a long curved coxal spine extending to the end of the middle segment of the endopod. The right coxa has a short curved sparsely ciliate spine. Coxae of all other natatory limbs have a slender straight seta. The fifth pair have the second and third segments of the exopods equal in length; a long curved spine arises from the inner side of the middle segment and reaches to the end of the third segment.

Ovisac rounded, and ventral in position.

MALE.

Length 1·26 mm. Metasome narrow compared with that of female. Urosome slender, five-segmented. Caudal rami of the same relative length as in the female but without external cilia below the outer seta, and with a fifth terminal seta, more slender and much shorter than the others, between and dorsal to the two innermost setae.

Appendages: Left antennule as in female; the right modified, divided into three sections, the first of nine segments, some of which are very short, the last three with sensory setae; the second section contains five swollen segments and a long slender sixth, followed by the third section, which consists of two long curved segments which show signs of at least four incipient segments which are not divided off. The other head apppendages, including the maxillipeds are similar to those of the female.



Text fig. 1. *Gladiferens imparipes* sp. nov.

The natatory legs, except for the second and fifth, are armed as in the female and the seta on the fourth right coxa is normal, not expanded as a spine. Second pair of legs are asymmetrical, being similar to the female except that the left endopod has the proximal inner seta of the terminal segment modified into a stout spur. Fifth legs are distinctly asymmetrical; the right exopod is three-segmented, the first segment bearing a stout, inwardly directed, pointed projection; the middle and proximal segments each bear a denticulated outer spine. The middle segment is prolonged beyond its spine, and its inner surface is concave with a small spine about mid-way along the margin and a cluster of spinules proximally, but no marked basal process. The smaller distal segment bears three spines, the middle being the largest and terminally denticulate and curved. The other two are smaller, the outer somewhat the larger and denticulate, the inner smooth and more slender. The right endopod is three-segmented. At outer distal corner of its middle segment is a short spine which curves inwards. Distal segment bears four ciliate setae. The left fifth leg is shorter than the right; both exopod and endopod are peculiar in that they appear three-segmented if viewed from in front, but only two segments can be made out from behind. In the exopod it is the terminal segment which is incompletely divided. The basal segment bears a ciliate spine distally. The terminal segment has four, one of which is proximal to the incomplete dividing line. The terminal spine is the largest and is peculiarly bent. The inner distal corner is extended laterally into a rounded bulge with a postero-lateral groove or sinus. In the endopod it is the basal segment which is incompletely divided. There is a curved inner spine on the middle segment and three short spines, and an elongate outer spine that could almost be termed a seta on the distal segment.

Discussion.

Five species have been definitely assigned to this genus, and Nicholls (1944) suggests that *Centropages pectinatus* Brady described in 1899 from a damaged specimen is really referable to this genus, possibly referable to *brevicornis*, Henry, or *subsalaria*, Percival. In his paper Nicholls deals briefly with the probability that *subsalaria* is synonymous with *brevicornis*. The figures given by Percival are certainly very similar to those for *brevicornis*, particularly as shown by Dakin and Colefax (1940). The females of this genus are very similar and significant specific features are hard to find in the somewhat incomplete descriptions of the species. However, Kiefer for *gracilis* shows the coxal segment of the right fourth leg of the female with a straight short "feathered" seta. For *subsalaria* Percival records "a short feathered seta as in *G. gracilis*." Dakin and Colefax figure it for *brevicornis* as a straight seta. Nicholls for *inermis* shows it curved distally and rather thickly ciliated. In *imparipes* it is distinctly curved and but sparsely ciliated.

In *spinosus* the fifth endopod in the female is shorter than the exopod and does not reach beyond the centre of the middle exopod segment; whereas in *gracilis* it reaches just to the end; in *brevicornis* it is figured as reaching half-way along the terminal exopod segment, and in *subsalaria* it is stated to reach one-sixth of the distance along. However, this may not be significant, only careful examination of material could tell.

The third urosome segment of *imparipes* is relatively short compared with that of *inermis*, resembling *gracilis* in this respect. It differs from *gracilis* and agrees with *inermis*, however, in being without most of the armature on the urosome and last thoracic segment figured for *gracilis*.

Males: The structure of the fifth legs of the male differs from all other species by the hooked projection or spine coming from the middle segment of the right endopod. The two subsidiary spines on the terminal segment of the right exopod are stronger than in other species. As figured for *inermis* and *spinosus* this segment bears only one subsidiary spine in the case of the former (externally), and none in the latter. However, as Dakin and Colefax point out for *brevicornis*, Henry's drawings and descriptions are sometimes incomplete, so they may be in the case of *spinosus*. The distal inner bulge of the terminal segment of the left exopod is not shown elsewhere except for a trace in *subsalaria*.

The spur on the end segment on the left second endopod points towards the base in *imparipes* and *inermis*, but the adjacent setae have not become spinose in *imparipes* as in *inermis*, though they are shorter and less densely ciliated than in *gracilis*.

KEY TO THE MALES.

(Adapted from Nicholls).

1. Both rami of left fifth leg 3-segmented .. .. .. *spinosus* Henry
   Both rami of left fifth leg 2-segmented 2
   Exopod 2-segmented, endopod 1-segmented 4
2. Middle segment right fifth endopod with spine *imparipes* sp nov.
   Middle segment fifth endopod without spine 3
3. End segment of left second endopod armed with spur at right angles to axis and 7 setae .. .. .. *gracilis* Kiefer
   End segment of left second endopod armed with spur directed to base, 2 spines, 5 setae .. .. .. *inermis* Nicholls
4. Right fifth endopod 3-segmented .. .. *subsalaria* Percival.
   Right fifth endopod 2-segmented .. .. .. *brevicornis* Henry.

Distribution of the Genus: Henry described *brevicornis* and *spinosus* from fresh water in New South Wales. Dakin and Colefax record *brevicornis* as common in the New South Wales coastal lakes and record a single specimen from Port Jackson; *gracilis* and *subsalaria* occur in fresh to brackish water in New Zealand; *inermis* at the head of Spencer Gulf. The present species *imparipes* was taken in the Swan Estuary, W.A.

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Order: HARPACTICOIDA.

Family: CANTHOCAMPTIDAE.

MESOCHRA Boeck 1864.

Mesochra parva sp. nov.

OCCURRENCE.

A few specimens were collected throughout the year, but they were extremely abundant in October and November, among shallow-water algae.

FEMALE.

Length 0.45 mm. Body with genital segment divided. Abdominal somites without spines on the dorsal surface, but each has a lateral row of spines which is continued on to the ventral surface for a short distance. On the anal segment these are particularly small and they are not markedly separated from the spines lining the margin of the anal incision. The anal operculum is spineless. Caudal rami broader than long; outer terminal seta less than half the length of the inner seta, which is less than half as long as the body.

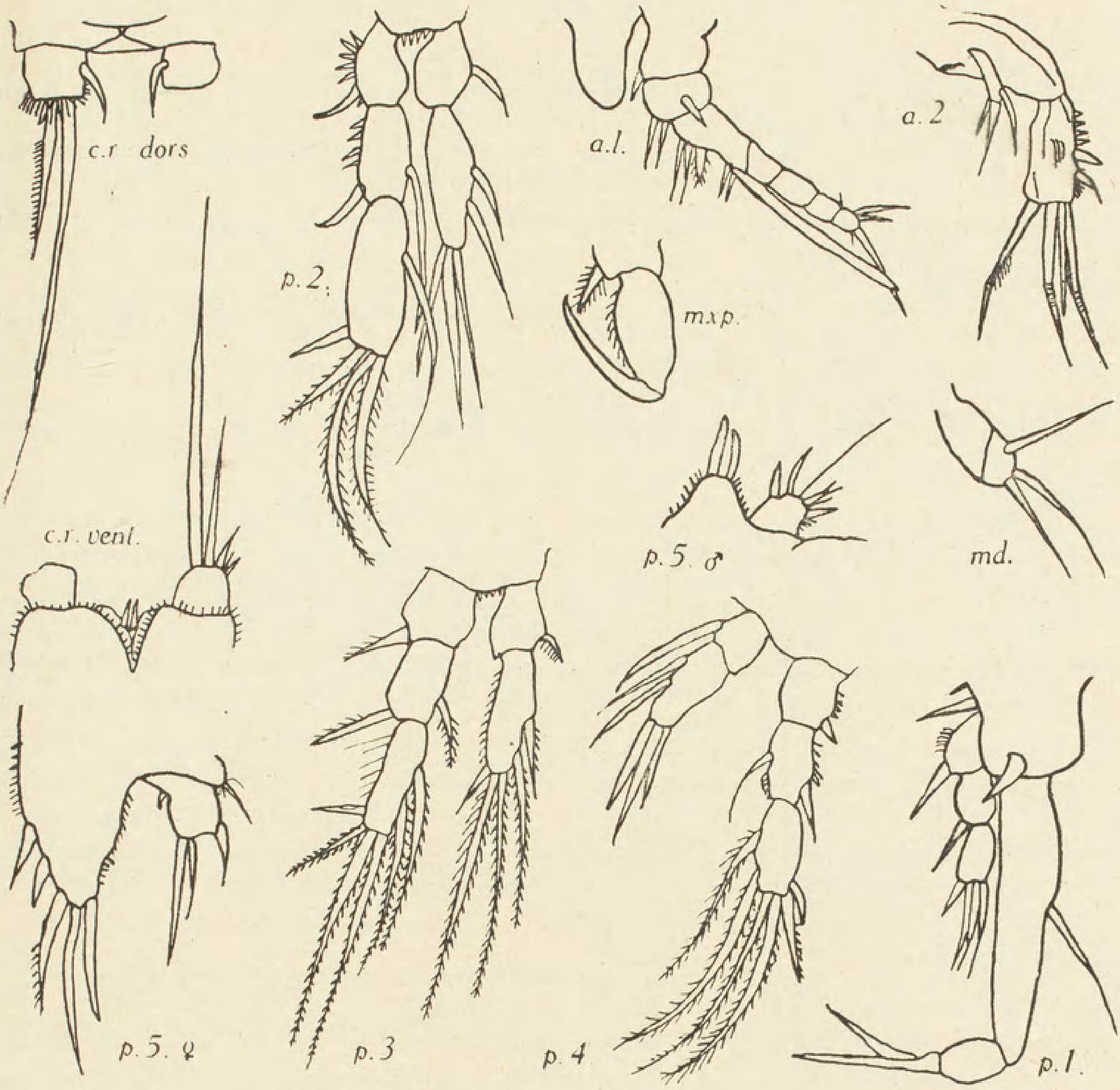
Appendages: First antenna. 7-segmented; third segment the largest, bearing a tufted spine. The aesthetasc is on the third segment and extends for a short distance beyond the end of the appendage. Second antenna has basal segment elongate and narrow, undivided; exopod 1-segmented with two apical and one lateral setae, of which the outermost is the shortest and stoutest; endopod large and expanded somewhat distally, with four terminal setae, one smaller than the others, and on the outer margin a row of four to six spinules. Mandible with palp two jointed and with three distal setae. The remaining mouth parts are characteristic of the genus. Maxillipeds, subcheliform, with a seta on the basal segment near the distal end.

Natatory limbs. Legs 1-4 with 3-segmented exopods and 2-segmented endopods. The first legs have the basal segment of the endopod considerably longer than the exopod. It bears an inner marginal seta slightly proximal to the middle of the segment. The distal segment of the endopod bears two stout setae. The basal segment of the exopod has an inner seta. The arrangements of spines and setae are shown in the figures.

Setae formula.

	Endopod		Exopod		
p2	1	221	0	1	122
p3	1	221	0	1	222
p4	1	221	0	1	222

Fifth leg with basal segment extending beyond the distal and bearing five setae. The distal segment is distinctive, almost quadrangular with two stout setae at the distal corners, the inner twice as long as the outer. Next to the inner spine is a very slender seta. Between the setae are minute spinules.



Text fig. 2. *Mesochra parva* sp. nov.

MALE.

Length 0·39 mm. The expansion of the basal segment of the fifth leg has only two setae and does not extend much beyond the distal segment. The distal segment is much more normal than in the female, having four stout spine-like setae and one slender seta around the margin.

Appendages: First antenna has the proximal segments somewhat swollen and the distal segments relatively shortened. The aesthetasc is more massive than in the female and extends beyond the end of the appendage for some distance.

Colour.—White with a yellowish-green tinge.

DISCUSSION.

Some fifteen species of *Mesochra* are known. The female of *M. parva* is clearly distinguished by the unusual shape and structure of the fifth leg. The lack of a spine on the anal operculum and the seta formula serve to distinguish it from at least some of the species. Many of the species are known from the female only, so it is impossible to note specific characters for the male.

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Class: MALACOSTRACA.
Subclass: PERACARIDA.
Order: AMPHIPODA.
Suborder: GAMMARIDEA.
Family: **COROPHIIDAE.**

COROPHIUM, Latreille 1806.

Corophium minor sp. nov.

OCCURRENCE.

March to early July; tubicolous on algae.

Female.

Ovigerous, length 2·55 mm. Body small, the urosome segments coalesced, rostrum small and pointed. Eye-lobes rounded and elongate. Eyes black and well developed.

Appendages: First antenna, about one third of the body length; first segment longer than second and third together (in figure appears slightly shorter, owing to bending of appendage). Lower edge of segment one with four straight spines of which the proximal is the smallest, and a little off the ventral line. There is a slight lateral bulge proximally on the first segment which bears three spines. A few long tufts of setae also occur on the segment. Segment 2 bears several tufts of setae and is cylindrical in section. Flagellum is seven segmented. Second antenna somewhat larger than antenna 1. There is a pair of spines ventrally on segment 3. Segment 4 has five well developed spines on the lower edge, a proximal pair a quarter of the distance from the proximal end, a median pair at half the distance and the fifth about an eighth of the distance from the distal end. A number of long setae also occur on this segment. Segment 5 has one median ventral spine and many long setae. Flagellum is 3-segmented. (The figure shows an abnormal appendage with a paired distal spine on the 4th segment.) Mandible with basal segment not extending beyond the base of the end segment; palp small, of two segments, each with a strong ciliated seta. Maxillae, typical. Maxillipeds sub-lamellar with basal lobes narrowly produced. The masticatory lobes are long, the inner edge fringed with slender spines; palp elongate, the last segment short but broad.

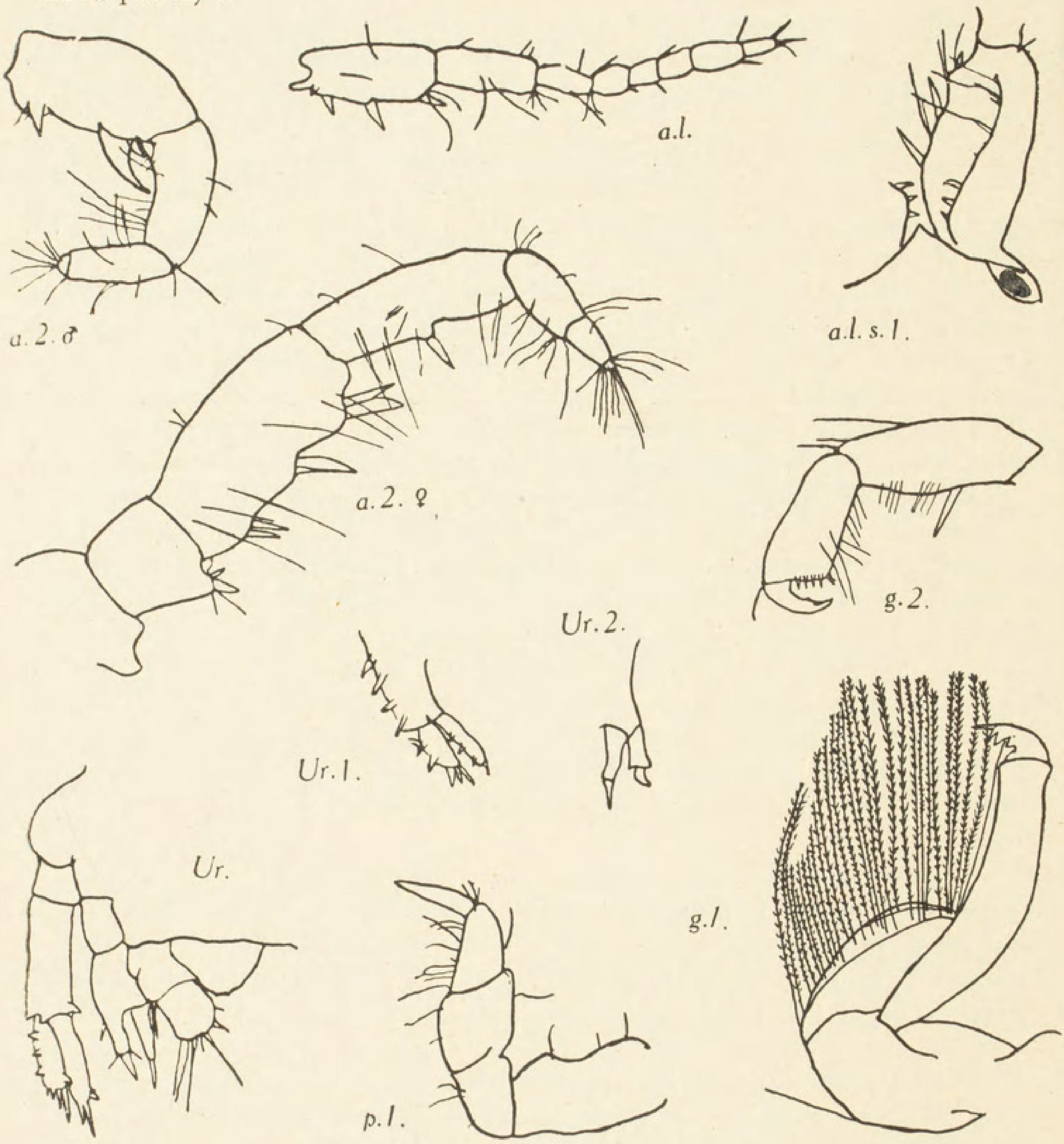
Gnathopod 1 with palm almost square with a row of four short stout spines, supplemented by short setae on the edge of the propod; dactyl with a slight accessory tooth. Gnathopod 2 larger than Gnathopod 1; not differentiated from other members of the genus. The fourth segment is closely attached to the hind margin of the fifth, and fringed with two rows of plumose setae. Propod sublinear, without a palm; dactyl with 4 accessory teeth. Pereiopods normal, the anterior two with basal segment large and broad and the merus greatly expanded, the carpus short and the dactyl considerably larger than the propod. Pereiopods 3 and 4 are comparatively stout and have two rows of spines on the outer side of the carpus. Pereiopod 5 is slender and elongate, the basal joint lamellarly expanded and fringed on both edges with long ciliate setae which however are not so dense as in other members of the group.

Branchial lamellae well-developed; none on gnathopod 2. Incubatory lamellae elongate and oval, edged with strong setae.

Pleopods with basal portion greatly expanded; rami narrow and densely setose.

Urosome, segments fused, sides hollowed out to receive insertions of uropods 1 and 2. Rami short, with stout spines on the margin externally on the first, but those of the second spineless except apically. Uropod 3 with peduncle short, ramus single and lamellar with a few long apical setae.

Telson, trapezoidal, with a terminal emargination. Number of eggs in brood pouch, 6.



Text fig. 3. *Corophium minor* sp. nov.

Male.

Length, 2·1 mm. Similar to the female except in the following points: —Antenna 1:The first segment has three spines on the lower keel and appears to be shorter than the second and third together. Length of the appendage about 45% that of the body. Antenna 2: Segment 4 twice as long as broad, with a large subterminal tooth, and a smaller tooth above it. The ventral spines found in the female are absent. Segment 5 has six tufts of setae. Gnathopod 1: Palm with a row of three spines and one large seta.

Ecology.

Builds tubes of muddy sand on algae and the rocky substratum in shallow water. They survive some degree of lowering of salinity but disappear with the onset of heavy rainfall.

DISCUSSION.

The genus *Corophium* was named by Latreille in 1806, with *C. longicorne* as the type species. Stebbing in Das Tierreich (1906) gives excellent descriptions and bibliography of the species known to him. Since his account the number of species described has been doubled and the best modern account of the group is that of Crawford (1937). He divides the genus into three sections on the character of the urosome and the insertion of the uropods. He includes useful keys to the species of each group. The present species falls into his section B, characterised by small size, fusion of the urosome segments and the lateral insertion of uropods 1 and 2, in notches on the urosome. Crawford assigned eight species to this section.

The female of *C. minor* is very like that of *C. insidiosum* (Crawford). It is however much smaller, 2·5 as compared with 4·5 mm. The relative lengths of the three basal segments of antenna 1 differ. Also both right and left dactyls of gnathopod 2 have four accessory teeth in *minor* whereas this is the case with the right only in *insidiosum*, the left having three.

The male of *minor* differs from that of *insidiosum* in the structure of antenna 1, and lesser features such as relative abundance of setae on various segments. Nor has the male of *minor* the very long rostrum of *insidiosum*. Like the female it is also much smaller than the other species.

The armature of the antennae is sufficient to distinguish *C. minor* from all other species.

Apart from the changes in armature associated with growth, normally occurring in this genus, two variations were noted. Some twenty-four females were examined. In two of these the proximal spine on the first segment of antenna 1, instead of being small, was quite large, and the second proximal was the smallest spine. In another specimen which did not differ from normal otherwise the distal spine on segment 4 of the second antenna was paired (as shown in figure) replacing in its position the more usual seta. Such variations in a small percentage of individuals was noted by Crawford. It is impossible to say without experimental breeding whether this is due to abnormal growth, or to a mutation.

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Order: ISOPODA.

Suborder: FLABELLIFERA.

Family: **ANTHURIDAE.**

CRURANTHURA gen. nov.

Cruranthura simplicia sp. nov.

OCCURRENCE.

June to September; twelve specimens being taken during this period. Among algae.

FEMALE.

Length 5·25 to 6 mm. (ovigerous). Body elongate, narrow, back broadly arched, surface smooth. Ratio of lengths of thoracic segments 9:11:10:12:12:9:4. The seventh thoracic segment is wider than the abdominal segments. Abdominal segments 2-5 fused dorsally, though the suture may still be distinguished laterally.

Head: Eyes large, situated in the prominent antero-lateral lobes. Anterior margin excavate for reception of antennae, with a conspicuous median rostral point. Dorsally there are scattered patches of dark pigment. The mouth parts are adapted for sucking.

Appendages: First antenna 4 segmented, basal segment long, widening distally. The fourth segment (flagellum) shows a distinct constriction at about two-thirds of its length, possibly indicative of a fused segment. It bears a thick bunch of setae on a slight prominence apically. Second antenna of five joints, the last densely setiferous, the basal segment the longest, penultimate the next longest.

Mouth Parts: Unfortunately only the maxilliped and second maxillae dissected out well, but as far as could be ascertained the mandible had no palp, or else a very reduced one. Second maxillae straight with short lateral teeth distally. Maxillipeds, two-segmented, the proximal portion fused to the head. The free segment is narrow distally, but much broader proximally, the two portions distinguished by a marked constriction of the inner margin.

Pereiopod 1, subchelate, propod with proximal tooth defining the palm which is only slightly oblique. There are two rows of setae on the inner side of the propod parallel to the palm, and one row on the outer side. The carpus is cup-shaped and under-rides the propod. The ischium and basis are slightly expanded, and the dactyl is smoothly curved. Pereiopod 2, subchelate, palm linear, propod smaller than in pereiopod 1, and armed with a row of six spines. "Tooth" of the dactyl marked off by a sudden narrowing on the palmer side. From the shelf so produced a number of setae spring. Carpus and merus are very much as in pereiopod 1. Pereiopod 3, similar to 2. Pereiopod 4, with dactyl bent at an angle to the propod, but scarcely subcheliform; propod armed with two spines, one distal, the other at mid-length. The terminal portion of the carpus bears two spines. The carpus is relatively larger than in the three anterior limbs. Merus with only a slight distal expansion and the carpus does not under-ride the propod. Pereiopods 5 and 6 similar to pereiopod 4, except that the carpus is armed with three spines. Pereiopod 7 absent.

Pleopod 1 operculiform, covering the other pleopods. The outer ramus is enlarged, distal and fringed with long setae except on the inner margin; the inner ramus narrow, fringed distally on both sides. Both rami loaded with dark pigment. In Pleopod, 2-5 inner ramus not quite as long as the outer, which is wider. Endopod simple without setae, distal portion bulbous. Exopod broad with fringing setae.

Uropod basis with a few terminal setae; the lower edge produced downwards in a keel. Exopod three times as long as broad, inner edge fringed with a few long setae, with still fewer inserted on the outer edge. Endopod less than twice as long as broad, inner margin almost straight, outer margin with long fine setae.

Telson: Broadly ovate-lanceolate, setiferous at the rounded apex, otherwise bare. Convexly arched dorsally.

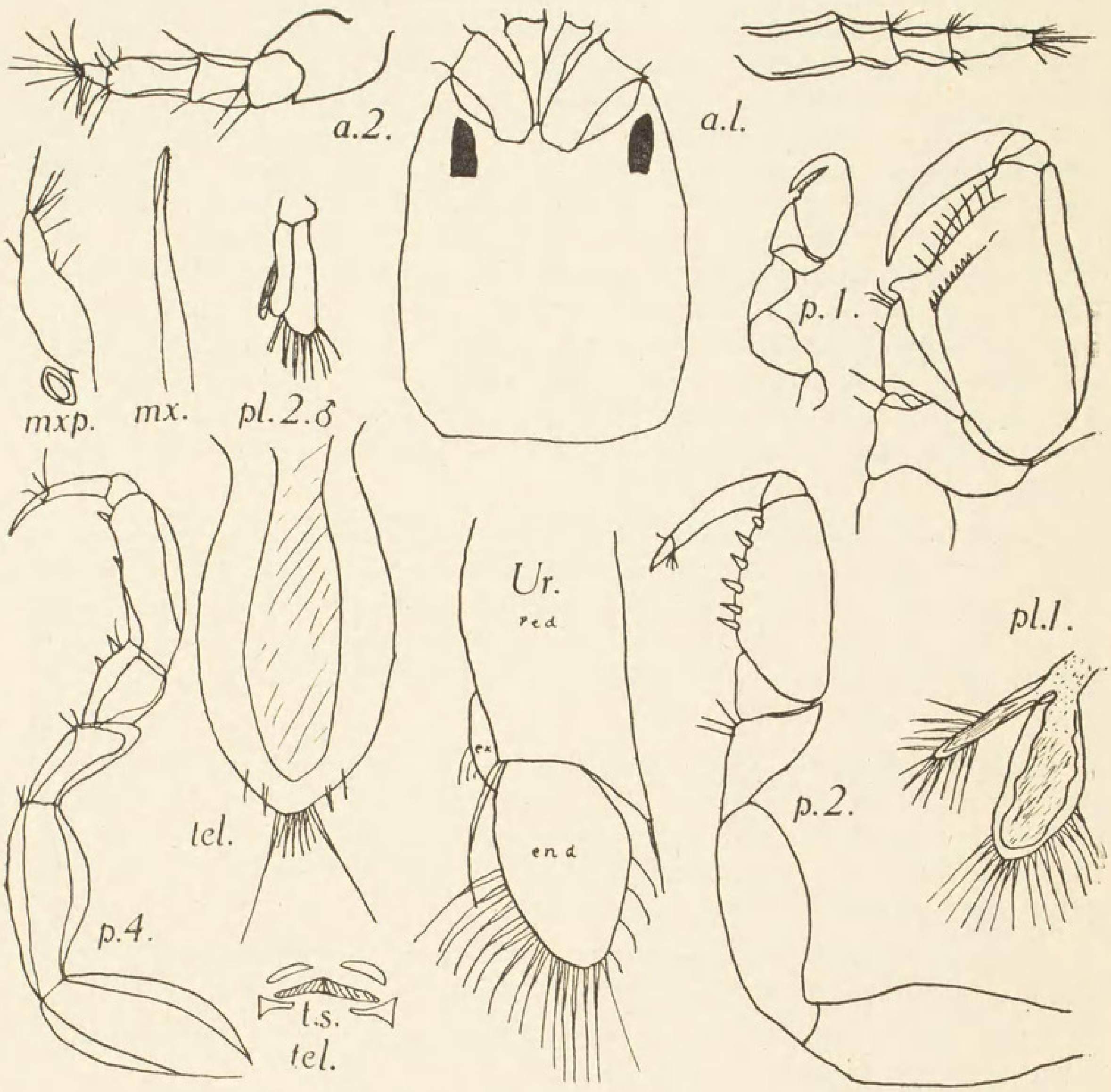
Tail fan: Ends of uropodal endopods coincide with the end of the telson. Exopod arches dorsally over the telson.

MALE.

Length: same range as female. Similar to the female except for absence of oostegites and the possession on the second pleopod of a male stylet, which is an elongated rod with a simple rounded apex.

DISCUSSION.

Barnard (1925) lists twenty-four genera of the Anthuridae and gives the specific distinctions of all species known to him. Since his paper eight further species have been described, one of which is ascribed to a new genus, *Notanthura* Monod (1927). The genus here described does not fit in to any of the genera described by Barnard, nor to *Notanthura*. Barnard pointed out that the important generic features were the arrangement of the tail fan, the shape of the telson and the form of the maxillipeds. Apart from the differences in these three features *Cruranthura* differs from all except *Hyssura* Norman and Stebbing 1886, *Colanthura* Richardson 1905 and *Cruregens* Chilton 1881 in the absence of the seventh pereiopod. However it is easily distinguished from the first of these genera. *Hyssura* has multiarticulate flagella on both antennae and the exopods of the uropods do not arch over the telson, the maxilliped is five-segmented, the pleopod is



Text fig 4. *Cruranthura simplicia* sp. nov.

not operculiform and the mouth parts are of the biting type. In all of which features it differs widely from *Cruranthura*. The general arrangement and structure of the antennae of *Cruranthura* are similar to those of *Colanthura*. But the latter genus is distinguished by the following points: the seventh thoracic segment is narrower than those in front and narrower than the abdominal segments; the abdominal segments show no sign of dorsal fusion; the telson is linguiform and appears to be without setae; no tooth defines the palm of the pereiopod in any described species of *Colanthura*. Unfortunately Richardson's description gives no account of the mouth parts. Of all the Anthurid genera *Cruranthura* undoubtedly comes nearest to *Cruregens* Chilton. The maxilliped structure is identical, except that some setae occur along its length in *Cruranthura*, not merely apically. It is possible however that such is the case with *Cruregens* though neither Chilton's nor Barnard's figures show this, and Chilton's description reads "The terminal portions are free, and the ends . . . . are tipped with setae." The structure of pereiopods and antennae are also similar. *Cruranthura* differs from *Cruregens* in the presence of eyes, the subterranean *Cruregens* being without them. The exopods of the uropods in *Cruregens* do not arch over the telson and they are long narrow filaments, whereas in *Cruranthura* they are shorter, broader and lamelliform. Also *Cruregens* shows no signs of dorsal fusion in the abdomen. The telson, to judge from Chilton's figure, differs also in that it is as wide proximally as more distally, whereas in *Cruranthura* it is a distinctly narrowed proximally.

Of the genera possessing a seventh pereiopod Cruranthura comes nearest to *Paranthura,* Bate and Westwood 1863, but differs in the form of the maxillipeds, the presence in the latter genus of the characteristic flat flagellum on antenna 2, and differences in the structure of antenna 1.

Generic features: *Cruranthura* is distinguished then, by the fact that it has eyes, the maxilliped is two-segmented, the uropodal exopod arches over the telson, the abdominal segments are fused dorsally, and the seventh pereiopod is absent.

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Suborder: VALVIFERA.

Family: **MUNNIDAE.**

MUNNA Boeck (1839).

Munna brevicornis sp. nov.

Occurrence.

July to December; sparingly on algae.

Female.

1·7 mm. in length. Body broad, rather flattened and oval; length twice the breadth. Head broad, its length: breadth ratio equals 1 : 1·5. The anterior margin of the head is straight, deeply notched on each side at insertion of the antennae. The eyes are large, situated on lateral projections of the head.

The first four pereion segments are subequal in length, the first slightly shorter than the others. Thorax wider than the head, each segment to the fourth being wider than the one in front. The last three thoracic segments are shorter and curve backwards at the sides. The lateral margins are all rounded. The pleon is much narrower, somewhat pear-shaped (ob-pyriform), extremity rounded, without denticles but with a few fringing setae.

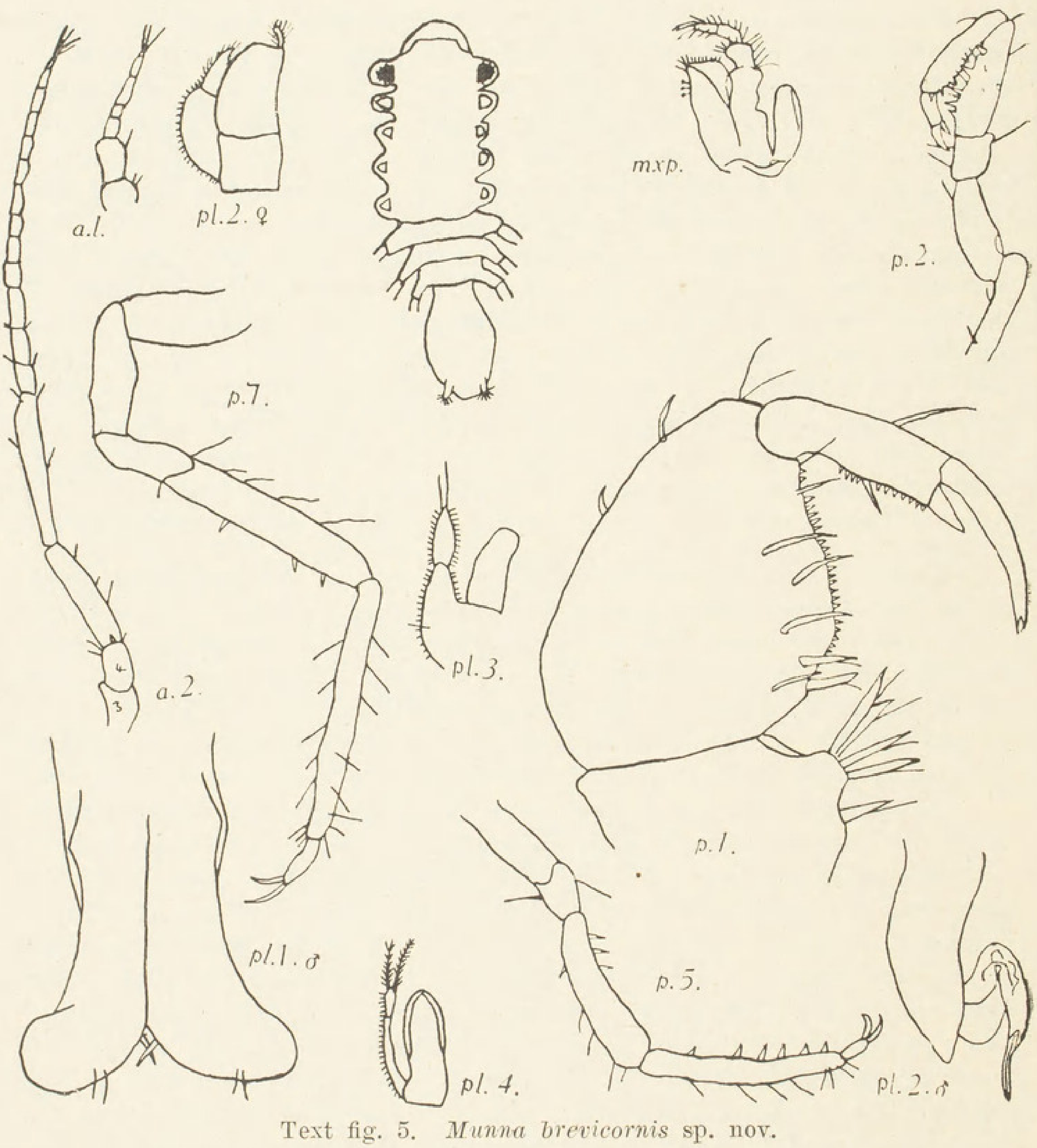
Appendages: Antennules reach about to the end of the 4th segment of the peduncle of the antennae. Basal segment the broadest, the second is only half as broad at the base, but expands slightly distally, and is covered with scattered setae. The next two segments are subequal and small. Following these are two long segments, the distal of which is the longer. At the extremity is a small segment. There are apical setae and "olfactory filaments."

Antennae not as long as the body; the first three segments short and subequal, the succeeding ones long and slender, the more distal longer than the other. Flagellum longer than the peduncle. Mandibles with cutting edge divided from the molar expansion by a deep cleft; palp well-developed. Maxilla 1 of the usual shape, outer lobe the longer and relatively stout, bearing about ten denticulate spines. The inner lobe is almost as long but is more slender; it is widest at a third of the distance from its base, and is armed with three spines terminally. Maxilla 2 of the usual shape with pectinate setae along the margin. Maxillipeds protecting the remainder of the mouth part and being rather lamelliform. From the coxa spring an epipodite and a large basis which is produced at its extremity, the inner side of which is lined by short setae, three of which at the end are stout and spinelike. The ischium of the palp is short. The merus is longer and fringed with setae and expanded distally. Carpus broader than long, propod narrow, expanding slightly at its extremity and curving inward, and is setose. Dactyl two-thirds as long as propod and ends in two stout setae.

Pereiopod 1 with basis long, four times as long as broad; ischium about as long but narrower, merus expands antero-distally where it bears a single seta, a few others occurring on the anterior margin. The carpus is about the same size, but produced on the postero-distal angle which bears five spines, an apical cluster of four and one proximally on the margin. The propod is about as wide, its palmar margin with a convex expansion, fringed by small spinules. Two large spines occur at the base and several long setae over the surface. The dactyl bears a few fine setae and ends in two distinct spines, the outer of which is twice the length of the other. Pereiopod 2 about half as long as the body. The coxa is short but separate from the body; basis long and narrow, with setae on the hind margin and one anteriorly; ischium is similar in shape, not quite as long as the merus and narrower at the base though expanding somewhat at its middle length, with a few distal setae; carpus the same length as the ischium with a few scattered stout setae, mostly on the posterior border; propod shorter than the carpus and narrower, with four spines on the posterior border, and fine setae on the anterior; dactyl short and oblong, with two apical claws and two setae. Pereiopods 3 and 4 similar to the first except that the carpus and propod are elongated. Pereiopods 5-7 similar but considerably longer.

Pleopod 1 modified to form an anal operculum which widens abruptly from its base and is rounded apically where a few setae are present. Pleopod 2 with basal protopod bearing an inner flat branchial plate as the endopod; at its internal distal corner the branchial plate has a plumose seta. Exopod fused at its base with protopod. Its end segment is not quite as long as the basal, and both are fairly short and stout. The distal segment bears two stout apical setae. The whole exopod is fringed with delicate fine setae. Pleopod 3 very similar to pleopod 2 but has no apical seta on the branchial plate, and the exopod is longer and narrower. Pleopod 4 with an oblong branchial plate free from setae. Exopod longer and still more slender than in pleopod 3, fringed with fine setae, and the second segment tipped with two plumose setae. Pleopod 5. A branchial plate only.

Uropods small, conical with a few setae; inserted somewhat dorsally at the posterior margin of the pleon segments.



Text fig. 5. *Munna brevicornis* sp. nov.

MALE.

Length 1·4 mm. The body is distinctly narrower than in the female; length two and a half times the breadth. The first four pereion segments are subequal in length, the first slightly shorter than the others. The first thoracic segment is wider than the head, the second narrower; the third and fourth are wider than the first. The next three segments are shorter and turn back at the sides as in the female.

Pereiopod 1 similar to that of the female, equally massive, but longer.

Pleopod 1 modified as an accessory sex organ, consisting of two oblong plates fitting close together along the median line, narrow in the middle and wider again at the extremities, turning out and being rounded terminally. The upper surface is produced in a thin plate. A fold on each side distally produces a pair of ducts. On the distal rounded portion there are two setae apically on each side, and one medianly. Pleopod 2 curved and elongate, broader at the base with two apical setae; penial filament apparently two-jointed, one joint directed backwards, the other lying in the opposite direction, curved and ending in a long styliform extremity grooved along one side. A second short round projection lies distally from the penial filament. Otherwise the male is like the female.

From other species *brevicornis* may be distinguished by the relative shortness of the antennae, the shape and armament of the first thoracic appendages, the absence of denticles on the pleon. The posterior three thoracic segments are not so crowded relatively as in other species, the body being relatively elongate. Details of setation and armature on the other legs are also specific.

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4.—THE FAUNA OF THE ALGAL ZONE OF THE SWAN RIVER ESTUARY.

A PRELIMINARY SURVEY OF FRESHWATER BAY WITH NOTES ON THE CHIEF SPECIES.

By

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Read 14th March, 1944.

INTRODUCTION.

The primary aims of this investigation were, firstly to learn the nature of the fauna inhabiting the algae, and secondly to follow the seasonal change in this fauna. From the data gathered various other observations have been made, such as the species density and population density of various algal species.

Adequate ecological study requires a team of workers. A lone worker can hope only to make a general survey of the situation. Especially is this so when, besides collecting and the laborious and time-expending work of separation it is necessaray to identify species which are quite unfamiliar. As a result a number of species have only been identified as far as the genus, and some remain assigned only to the family. However, all those which can be described as dominant have been specifically identified except for an immature Gammarid which occurred at times.

Acknowledgment is due to Professor G. E. Nicholls and to Dr. A. G. Nicholls for advice on literature and aid in other ways; and to Miss A. M. Baird and Mr. G. G. Smith, of the Botany Department for aid in identification of the higher algae.

Collections were made somewhat irregularly, due either to the number of species requiring identification, or to other unavoidable circumstances.

PRELIMINARY SURVEY OF FRESHWATER BAY.

PHYSIOGRAPHY.

Accounts of the Swan River estuary have been given by Somerville (1919) and by Aurousseau and Budge (1921). It need only be added that the main area of investigation was situated in Freshwater Bay at the part marked "C" in the map given by Somerville (*op. cit.* p. 17). The rocky bottom under the high cliffs at this point provides an admirable substratum for the algae.

PHYSICAL CONDITIONS.

The Swan estuary differs in type from those upon which a fairly abundant literature exists (Alexander 1936; Bassindale 1938; Milne 1940, etc.). Along the coast in this region there is practically no tide; as a result there is no daily alteration of fresh and salt water in the estuary, nor are there areas of mudflats daily exposed as is the case in tidal estuaries. There is, however, a marked seasonal variation in salinity (Serventy 1938). In summer, conditions in the estuary are marine. In winter, the water is greatly diluted and after heavy rains becomes quite fresh at least in shallow water near the banks. This dilution is greatest during July and August.

During part of the year there is a regular daily rise and fall in the waters of the estuary, generally of about four to six inches. This appears to be due, not so much to tidal influence, but to the regular alternation of land and sea breezes. An easterly (land) breeze drives the waters of the adjacent ocean away from land, depressing the level of waters along the coast and consequently in the drowned valley of the estuary. A westerly (sea) breeze piles water against the coast and raises the water level. If the westerly continues for several days, as may happen during a storm, the level of water is raised several feet. Similarly when an easterly continues for an abnormal period, the water level may drop a few feet and as a result expose some of the algal beds which otherwise are not out of water.

The area under investigation is under direct illumination from the sun from early morning till late afternoon, when the high cliffs shut off the direct rays of the sun.

No measurements of temperature were taken, but, as was to be expected, in depths of only a few inches the water was considerably warmer than in deeper water, if there had been practically no water movement for some time and the sun was particularly hot.

The currents in the estuary are practically confined to the deeper channels. Shallow areas such as the one under consideration are more influenced by the surface drift produced by winds. Though normally inconsiderable, waves of up to two feet may be raised during strong winds, thus laying the shallows open to some battering.

There is always a considerable amount of organic matter and soil in the water, but usually the bottom can be seen at several feet depth. However, after heavy rains greatly increased quantities of material occur suspended in the water and it may be impossible to see the bottom even at a depth of 1 ft. 6in. Photosynthesis in the algal zone must be considerably impeded during such periods.

Algal Zone.

The rock bottom on which the algae occurs is a ledge of shallow depth along the bank, extending outwards for a width of 7ft. to 16ft. Most of the algae occurs from surface level to a depth of 5ft., though ocasionally patches were found at 7ft.

Methods.

The method of collection consisted simply of plucking the algae from the substratum and transferring to a collecting jar. In the case of larger algae, such as *Cystophyllum muricatum* it was sometimes necessary to cut off only part of the stem or only branches. At first the transference of material was made under water with a control jar of water to ascertain whether there was any free-swimming population to influence results. Later trials, however, showed that no significant loss occurred if the algae were lifted out of the water and then transferred. As this method was more rapid and more easily accomplished it was adopted.

ESTIMATION OF POPULATION.

Although the importance of the algal fauna has long been recognised and such phrases as "among sea-weed" frequently occur in records, few studies of the fauna of aquatic vegetation have been made. Those that have been made are concerned almost entirely with fresh water plants (Ward, 1896; Moore, 1913; Richardson, 1921; Percival & Whitehead, 1929; Krecker, 1939), usually with flowering plants. Descriptions of the algal zones of the sea have rarely been accompanied by data as to the small members of the communities on and among the algae. The record is mostly of the dominant animals, usually Molluscs, occurring on the same substratum as the algae and sometimes passing on to the vegetation. (Flattely & Walton 1922; Colman, 1933; Kitching, 1935; Bright, 1938; Stephenson & Bright, 1938; Bokenham, 1938; Eyre, 1939; Stephenson & Day, 1940). A method for the quantitative analysis of the fauna of aquatic vegetation is wanting. Moore (1913) used the general terms "abundant" and "scarce." Bokenham (1938) used "Dominant," "Plentiful" and "Present." Richardson (1921) made a quantitative count of the upper nine inches of aquatic plants. The count was based on the animals washed off the plants collected from a definite area. Other workers (Needham, 1928, 1929; Pate, 1932) have failed to differentiate between the animals of the plants and those of the underlying substratum, except in the case of the two authors mentioned next.

Krecker (1939) working on fresh-water phanerogams took as a basis the population per ten linear feet of plant. He conducted a plant to plant examination. The only alga investigated in the Swan estuary which lends itself to such treatment is *Cystophyllum muricatum*, which attains lengths of up to seven feet. But the majority of the algae are relatively short, occurring as more or less branching filaments or intertwining strands densely crowded together. The broad flat *Ulva lactuca* provides a third type.

Colman (1940) working on the fauna of the intertidal sea-weeds, used the number of animals per unit weight of sea-weed. The method adopted in the present research was to calculate the fauna per 100 c.c. of the alga measured by displacement of water. As few, if any, of the animals present used the algae as food, but rather as a substratum it was considered that the space occupied by the alga was of more significance than the weight, since the volume bears a constant relationship to the surface of the plant (though admittedly the relationship varies to a degree from plant to plant according to irregularities of shape) whereas the weight is not a function of the surface, since it varies with the density. The displacement method adopted is also advantageous in being rapid.

By this means a picture was gained not only of the algal fauna as a whole, but enabled comparison between different algae.

Algae.

The dominant species of algae in the estuary are:—

Cystophyllum muricatum	*Enteromorpha compressa*
Chaetomorpha aera	*Ectocarpus confervoides*
Cladophora penicillata	*Ulva lactuca*

Besides these, others occur, usually as isolated clumps amongst the others and may sometimes have been included amongst collections. (For example. other species of *Enteromorpha* may have been included amongst *E. compressa.*) These secondary species include:—

Asperococcus sp.	*Chaetomorpha nitidula*
Calothamnium sp.	*Caulerpa cylindracea*
Enteromorpha prolifera.	*Gracilaria confervoides*
Enteromorpha intestinalis	*Monospora australis*
Enteromorpha claphrata	*Polysiphonia mollis*
Enteromorpha plumosa	*Zoobotrium pelucides*

Some of these are abundant elsewhere in the estuary (*G. confervoides*) but do not occur in quantity in the area investigated.

Diatoms.

Some colonial diatoms were present on the algae throughout the year. Three periods of particular abundance were noted. These occurred in March, May and October. From the nature of their surfaces *Cystophyllum* and *Cladophora* provided the best substratum for these, while *Ulva* was practically free from diatoms. From May to late July diatoms were fairly abundant but were very scarce in August and September.

No identification was attempted beyond the genus. The following are the genera present at the three peak periods. Except from May to July the amount of diatoms rather rapidly fell away from the peak.

March.	May.	October.
Frustulia (*Navicula*)	*Coscinodiscus*	*Synedra*
Pleurosigma	*Rhizosolenia*	*Bacillaria*
Gammatophora	*Gammatophora*	*Melosira*
Lycmophora	*Melosira*	
Melosira	*Nitzschia*	
Striatella	*Lycmophora*	
Asterionella (?)		

The genera are listed in order of relative abundance. It is notable that the October increase was due almost entirely to *Synedra*. By November *Bacillaria* and *Melosira* had disappeared and *Coscinodiscus* was sparingly present.

FAUNA.

Here is given a list of the fauna as identified for the purpose of this investigation. Thus Gammarid spp. includes two or three species of which one representative only was found and cannot be regarded as a true member of the algal fauna.

Protozoa
- No record kept. Maximum abundance in April.

Hydrozoa
- *Campanularia verticillata* (?) (Linn).

Turbellaria
- *Leptoplana* spp.

Nemathelminthes
- *Nematoda* spp.

Polychaeta
- *Nereis oxypoda* Marenzeller
- *Nereis albanyensis* Augener
- *Ceratonereis erythraeensis* Fauvel.
- Small Nereids
- *Odontosyllis fulgarans* Claparede
- Spionid. sp.

Oligochaeta
- Microdrilids.

Polyzoa
- Polyzoan sp.

Tanaidacea
- *Tanais cavolinii* Milne-Edwards.
- *Paratanais* sp.

Harpacticoida
- *Ameira minor* Thompson & Scott.
- *Amphiascoides intermixtus* (Willey).
- *Amphiascopsis sexsetatus* (Monard).
- *Amphiascus* sp.
- *Dactylopusia tisboides* Claus
- *Ectinsosoma propinquum* T. & Scott.
- *Harpacticus gracilis* Claus
- *Idyella exigua* Sars
- *Mesamphiascus normani* (Sars)
- *Mesochra parva* J. M. Thomson
- *Parathalestris* sp.
- *Perissocope* sp. (?)
- *Pseudothalestris pygmaea* T. Scott.
- *Tegastes* sp.
- *Tisbe furcata* Baird
- *Tisbe graciloides* Sars
- *Tisbe tenera* Sars
- *Zaus* sp. (?)

Calanoidea
- *Gladioferens imparipes* J. M. Thomson.

Ostracoda
- *Xestolebris aurantia* Baird.
- *Cytherid* spp.

Isopoda
- *Cruranthura simplicia* J. M. Thomson.
- *Munna brevicornis* J. M. Thomson.

Amphipoda
- *Caprella penantis* Leach
- *Caprella scaura* Templeton
- *Corophium minor* J. M. Thomson
- *Corophium* sp.
- *Erichthonius pugnax* Dana
- Gammarid spp.
- *Melita* sp.
- *Pallasea* sp. (?)
- *Talorchestia* sp.

Caridea
- *Leander intermedius* Stimpson

Brachyura
- *Cyclograpsus audouinii* Milne-Edwards.
- *Halicarcinus australis* (Haswell)

Arachnida
- *Litarachna* sp.

Insecta
- Chironomid (?) larvae

Mollusca
- *Modiolus* sp.
- *Rissoa* sp.

Ascidacea
- *Ascidea malaca* (Traust.)

Chaetognatha
- *Sagitta* sp.

Analysis of Collections.

Appended at the end of this paper is a table (Table 1) setting out the monthly mean results. The quantities are expressed, as explained under "Estimation of population," in terms of the number of animals per amount of algae displacing 100 c.c. of water. The total number of animals in any column then represents the population density per 100 c.c. for that type of algae.

From the table it is evident that no species of alga was present during all 10 months, although *Enteromorpha* was completely absent only in August. The following list shows the species of alga present from month to month and their relative abundance.

(a)—abundant; (b)—well distributed; (c)—isolated stands.

March—*Cystophyllum* (a), *Enteromorpha* (a), *Ulva* (b).

April—*Cystophyllum* (a), *Enteromorpha* (a).

May—*Cystophyllum* (a), *Enteromorpha* (a).

June—*Cystophyllum* (b), *Enteromorpha* (a), *Ulva* (a).

July—*Cystophyllum* (c), *Enteromorpha* (b), *Ulva* (a), *Chaetomorpha* (c).

August—*Ulva* (a), *Chaetomorpha* (b).

September—*Cystophyllum* (c), *Enteromorpha* (b), *Cladophora* (c).

October—*Enteromorpha* (c), *Cladophora* (c), *Ectocarpus* (a).

November—*Enteromorpha* (a), *Cladophora* (a), *Ectocarpus* (a).

December—*Enteromorpha* (c), *Cladophora* (a), *Ectocarpus* (c), *Ulva* (c).

Animal Distribution.

From March to September *Cystophyllum muricatum* provided the most favoured habitat for the algal fauna. From October to December *Ectocarpus confervoides* was favoured as long as it was thriving, but in December when it was decaying *Cladophora penicillata* became the chief habitat. *Ulva* at all times provided the least utilised substratum, being most densely inhabited in March when the fronds were of great size and much convoluted. There can be little doubt but that it is the character of the plant that causes the differences rather than environmental conditions. It is noticeable that *Cystophyllum muricatum, Cladophora penicillata* and *Ectocarpus confervoides* provided the best substrata for the colonial diatoms.

Seasonal Changes.

Almost assuredly associated with the change in salinity is the change in the species making up the algal communities. No species was recorded in all ten months. *Tanais cavolinii,* while absent only in October, was represented by immature specimens only during August, September and November. The following were the dominant species (numerically) from month to month:—

March—*Tanais cavolinii. Caprella penantis.*

April—*Caprella penantis; Tanais cavolinii.*

May—*Harpacticus gracilis.*

June.—*Erichthonius pugnax; Melita* sp. (Immature).

July—*Caprella scaura; Tanais cavolinii.*

August—*Gladioferens imparipes.*

September—*Gladioferens imparipes.*

October—*Mesochra parva; Gladioferens imparipes.*

November—*Mesochra parva; Gladioferens imparipes.*

December.—*Harpacticus gracilis; Tisbe tenera.*

The population density of the algal zone fell from March to August and then rose again. (See text fig. 1.)

The number of species present also dropped from 33 in March to six in September, rising again to 25 in December.

SPECIES DENSITY.

Following Hesse, Allee, Schmidt (1937), "Species Density" is taken to mean the number of species present in unit area or unit volume. The figures are given at the bottom of Tables 1 and 2. It will be seen that although *Cystophyllum* had the greatest population density, in March and June its species density was not as great as that of *Enteromorpha,* and in April and May there was no significant difference between the two. The highest species density is 25, recorded for *Cladophora* in December. *Enteromorpha* follows with 22 in March. Like the population density, the species density fell from March to August and September and then rose again. The lowest species density recorded was 1 (*Ulva* in August, and *Enteromorpha* in September). Species density does not necessarily correspond with the population density. Thus in March *Cystophyllum* had the greatest population density, but the lowest species density.

Again, although two species of alga may have similar species densities, the species making up the community are not necessarily the same. Thus in July *Enteromorpha* and *Ulva* had species densities of 13 and 12 respectively but had only five species in common. The apparent preference for one alga or another is doubtless extremely complex in its causation; all the factors that influence environmental distribution probably play a part, food, competition with other species, vulnerability to attack and so on.

VARIATIONS WITH DEPTH.

Apart from the collections summarised in Table 1, on three occasions separate collections were made to gain an idea of distribution by depth. The results are shown in Table 2. The four inches nearest the surface are least densely inhabited, particularly where open to buffeting by the wind-driven waves. In positions sheltered by large rocks the top few inches are more thickly populated. Most species were taken between four inches and two feet depth. But the population density varied in its maximum from deeper than two feet to shallower, probably according to the physical conditions at the particular time. A point to be noted is that in November, *Gladiofe-rens imparipes* was present in large numbers below a depth of two feet, but absent entirely above; whereas *Mesochra parva* was present in large numbers in the surface layers, but few in numbers below two feet.

BIOTIC INFLUENCE FROM OUTSIDE THE COMMUNITY.

It has been mentioned earlier that certain of the species recorded in these collections are more properly regarded as only occasional intruders into the algal association. Such are Gammarid spp. *Cyclograpsus audouinii, Modiolus sp., Sagitta sp.* Besides these there are occasional intruders which are not recorded in collections but whose presence was noted. This group includes both aquatic and non-aquatic creatures.

Aquatic intruders.

Trochus sp. Abundant on rocks above and below water level, and occasionally found amongst the algae. Also on the rocks occur *Balanus nigrescens* and *Balanus amphitrite* which possibly influence the abundance of the algae. *Sphaeroma quoyana* with its attendant commensal *Iais pubescens* (var. *longistylis*) burrows into the sandstone which forms the substratum for the algae. Whether it has any influence on the algal fauna above is unknown. Similar remarks apply to various Gammarids, Polychaets and Turbellarians found on the rock, together with various Isopods.

Hippocampus tuberculatus Castelnau has been taken in this weed area. Dunker (1910) reports *Trachyrramphus brevicaudis* Castelnau from the Swan estuary also, and this species may also occur amongst the algae.

The blue Serrated Swimming crab *Scylla serrata* has also been observed amongst the algae. Swarms of little fish periodically appear, and these were particularly abundant during September-October. The common "jelly-fish," *Aurelia aurita* is sometimes driven in large numbers among the algae, with what effect, if any, upon the algal fauna is problematical.

Extra-aquatic intruders.

These generally appear when the water is particularly low, exposing the algal beds to the air. Some of the birds also pick through the weeds in shallow water. The following have been observed apparently feeding on or among the algae or the Molluscs on the rocks beneath.

Phalacrocorax atra.
Phalacrocorax varius.
Phalacrocorax carbo.
Microcarbo melanoleucus.
Pisobia minuta
Tringoides hypoleucus.
Larus novae-hollandiae.

When the algae are exposed, numbers of ants, flies, wasps, spiders, land isopods and beetles (e.g., *Ophodinus* sp.) make their way thither, retreating again as the water rises. Most of the algal fauna doubtless retreats as the water level falls, but some at least remain in the damp weed.

NOTES ON THE CHIEF SPECIES.

The notes presented below are mainly of an ecologic and systematic nature. No detailed account of any species is given.

Leptoplana spp.

A few specimens were definitely identified as *Leptoplana*, but it is possible that other genera are included under this heading. These animals were much more common on the rocky substratum, and occurred on the algae mostly when they were covered in diatoms and were in an old and semi-decaying state.

Ceratonereis erythraeensis Fauvel 1919 and *Nereis oxypoda* Marenzeller 1879.

Monro (1938) has recorded these species from the Swan estuary, and Augener (1913) named ? *Nereis* (*Ceratonereis*) *aequisetis* which Monro says may be the former species. These were the largest and most common of the nereids found on the algae.

Nereis albanyensis Augener 1913.

A few specimens were obtained in August. The species has been recorded by Augener from Albany and Fremantle. Except for an occasional small specimen, Nereids were absent from March to October.

Tanais cavolinii Milne-Edwards, 1828.

This is probably a cosmopolitan species. It has been recorded from the Atlantic Coast of North America, Bermuda, Greenland, West Coast of Norway, British Isles, Western France, Azores, Mediterranean. It usually occurs in shallow water (1ft. to 6ft.) among algae. It has also been recorded from oysters, on *Balanus*, on *Pinna*, and sponges.

T. cavolinii is tubicolous, though it leaves its tube quite regularly in search of food and crawls slowly over the algae. The tube is of mucin, to which little bits of algae and other detritus are joined. On several occasions Nematodes were found in the same tube. The tubes are usually twice as long as the animal, but may be smaller or larger.

Although as far as ascertained not previously recorded from the southern hemisphere, there is little doubt that the species recorded is *T. cavolinii*. It agrees perfectly with Sars' (1899) description of *tomentosus* (synonymy, see Dollfuss, 1897) and with Richardson's (1905) description.

The numbers of *T. cavolinii* were greatest in March, and the proportion of ovigerous females was also greatest at this time (33%). Numbers fell off rapidly till June, presumably as a result of the lowering of salinity. A temporary increase occurred in early June, ovigerous females being taken for the first time since the end of April. However, by the middle of July the species was again very scarce and was not recorded at all in October. No females were found from the middle of July to the beginning of September. The few specimens found in November were all immature.