

Copepods from the Interstitial Fauna of a Sandy Beach.

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With 10 Figures in the Text.

ATTENTION was first drawn by Wilson (1932) to the large copepod fauna which can be found in an ordinary sandy beach. In his introduction he describes his method of collecting these copepods (p. 7) and in the course of the paper describes a number of new genera and species thus obtained.

Sand-dwelling animals, particularly crustacea and worms (excluding sessile forms), are usually regarded as burrowers, since in their migrations they displace the particles of their environment. The fauna opened up by Wilson's discovery is of a quite different type. In contrast to true sand-burrowing animals, these copepods do not displace the particles of the sand through which they move but crawl over the surface of the grains, which, by capillarity, always hold more or less water, even high up on the beach at low tide. Such copepods, together with nematodes, rotifers, protozoa and other animals sufficiently small, may be regarded as part of an "interstitial" fauna.

As pointed out by Wilson they are feeble swimmers and move with a wriggling motion resembling that of a worm. The wriggling motion, moreover, is incessant so that it is almost impossible to distinguish species while alive and, of course, quite impossible to obtain even approximate measurements of length. They become quiescent only when in a moribund condition or when crawling over sand grains when, owing to their transparency, they are almost invisible.

Copepods of this type, though members of different families, have a number of features in common. They are all elongate and cylindrical, with practically no demarcation between the metasome and urosome, and many bear, on one or more pairs of the swimming legs, modified setæ of a peculiar type (hastate setæ) not found in copepods from other habitats. This type of seta is common to two copepods which, from other considerations, must belong respectively to the Ectinosomidæ and Canthocamptidæ which suggests that this development is an environmental adaptation rather than an indication of morphological affinity.

The different species, moreover, show an almost specific distribution from low water to the highest part of the beach, which is submerged only by the highest tides and may receive large quantities of fresh water in the form of rain both directly and by drainage. The copepods of the interstitial fauna show, in some cases, specific vertical distribution, some species being restricted to the top two or three centimetres of sand while others may be found only below 3 cm., at least during the period of tidal exposure. Thus those species which inhabit the higher parts of the beach and are superficial may be subject to considerable changes in salinity. The ability to withstand such changes is probably the major factor controlling the distribution of species.

I have to thank Mr. R. Elmhirst for the series of sand samples from which this information on the horizontal distribution of species was obtained. It was from these samples that the discovery was made of the presence of copepods high up the beach and also of several of the new species herein recorded.

The beach in question is Kames Bay, Millport, an area of some 11 acres, bounded at the highest part by a concrete promenade and sea-wall, and at both ends by rocks. The linear extent of tidal range is about 150 yards and only occasionally does the sea reach the promenade.

Several of the copepods found in the Bay are new species referable to genera erected by Wilson. The others have to be placed in new genera. All appear to breed continuously though they are undoubtedly more numerous during the spring and summer than later in the year. The method of collecting did not differ materially from that described by Wilson.

Formalin-preserved material has been used throughout and lengths are given in millimetres. All measurements of total length are from the tip of the rostrum to the end of the caudal rami and do not include the caudal setæ. Measurements can, of course, have little or no specific value since they were, of necessity, on preserved material and a certain amount of alteration occurs on preservation, quite apart from the general unreliability of measurements of such animals as copepods, whose body segments are telescopic. The lengths are given because they give some idea of the relative difference between male and female or between species, such a difference being one which strikes the eye and helps in identification. They are given to two places of decimals because without the second place the majority would appear to have the same length. The scale shown with each figure applies only to the whole animal. The appendages, except where otherwise stated, are drawn to a scale equal to 1.8 times that shown. The drawings have all been made with the aid of a *camera lucida*.

Family **ECTINOSOMIDÆ**.

Wilson has already recorded one new genus, *Arenosetella*, from a similar habitat and belonging to this family. One of the copepods occurring here, while undoubtedly an Ectinosomid, does not belong to any of the known genera. In shape it most closely resembles *Arenosetella*, in which feature both depart from the fusiform shape typical of the family.

Genus *HASTIGERELLA* gen. n.

Body cylindrical, slender, without definite demarcation between metasome and urosome, but tapering somewhat posteriorly. Urosome 4-segmented in female, 5-segmented in male. Head fused with first segment; rostrum prominent and well defined at the base. Antennule 6-segmented in female, 7-segmented in male. Antenna with 2-segmented exopod attached to the distal end of the first segment of the 3-segmented endopod. Upper lip bearing a median palp. Mandibular palp well developed, with small 1-segmented exopod. Maxilla armed with two long powerful claws and three more slender setæ terminally; basal endites represented only by setæ. Maxilliped reduced. Both rami of legs one to four with three segments, the exopod in each case bearing one or more hastate setæ. Segments of the fifth legs almost entirely fused. Caudal rami short and tapering, each bearing one long apical seta. The choice of generic name was decided by the extensive development of the hastate setæ in this animal.

Remarks. In its general shape and in its habitat this genus resembles *Arenosetella*, but the two segments of the fifth legs are fused and the claws on the anal segment are lacking. As in *Pseudobradya* there are only two segments in the exopod of the antenna. The mandibles and maxillules are similar to those of *Microsetella* and the maxillæ and maxillipeds resemble those shown by T. and A. Scott (1896) for various *Ectinosoma* species but are more reduced than any figured by them. Thus it has many points in common with the several genera of the Ectinosomidæ but cannot be included in any one. The acute point on the upper lip in *Ectinosoma* appears in *Hastigerella* as a palp or filament, distinctly separated at the base and tipped with setæ.

Hastigerella palpilabra sp. n. (Figure 1).

Female. Body segments about equal in size except the anal segment which is about half the preceding one. Segments of the posterior region of the body, except the anal and pre-anal, fringed behind with fine denticles. Caudal rami short truncated cones with one long terminal seta as long as the urosome, a second about half as long and two short

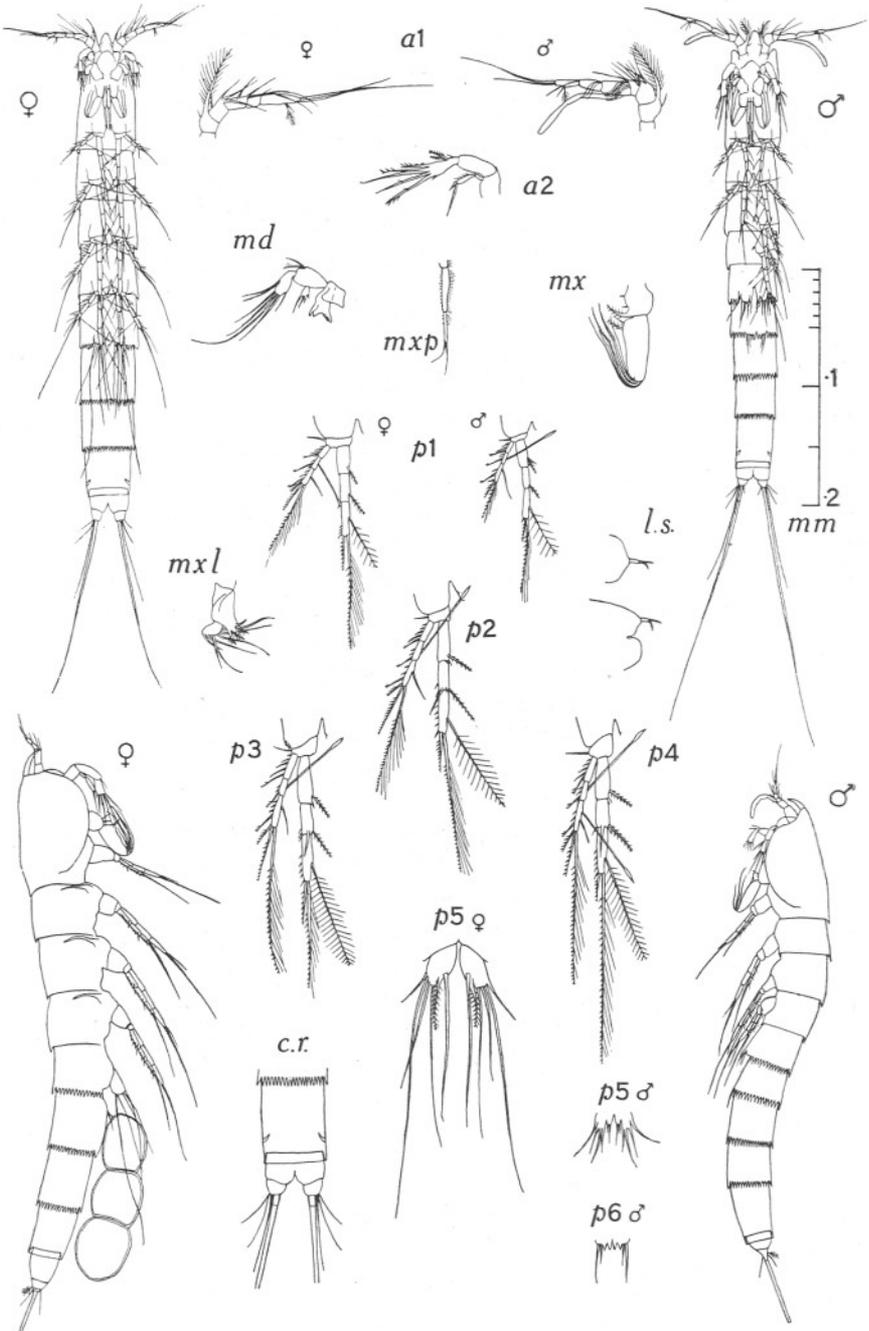


FIG. 1.—*Hastigerella palpilabra* gen. n., sp. n. *a1*, antennule; *a2*, antenna; *l.s.*, upper lip; *md*, mandible; *mxl*, maxillule; *mx*, maxilla; *mxp*, maxilliped; *p1*–*6*, legs 1–6; *c.r.*, caudal rami and posterior region of urosome. The caudal rami are those of the female.

ones externally. None of these is armed. Rostrum large, curved and pointed, well defined at the base. Antennule 6-segmented, bearing one large plumose seta on the swollen inner side of the second segment; terminal segment with a small lateral plumose seta and two long terminal setæ, the longer equalling the length of the appendage. Antenna 3-segmented with a small 2-segmented exopod on the inner distal margin of the basal segment; exopod with one long and one short terminal seta and a row of fine hairs on the terminal segment. Upper lip with 1-segmented median palp tipped with two short setæ. Mandible with palp well developed; basal segment bearing two setæ, terminal segment with two marginal setæ, four long terminal setæ and one short seta; exopod consisting of one small segment with four terminal setæ. Maxillule with at least four short curved spines and a lobe bearing numerous long setæ. Maxilla 2-segmented; basal segment with endites reduced, represented by one short spinous seta and two small hairs; terminal segment with short spinous seta and small hairs basally, and tipped with two long curved denticulate spines and three slender curved setæ. Maxilliped a simple 3-segmented, linear appendage tipped with two short setæ, and fringed with fine hairs laterally. Both rami of legs one to four have three segments; the outer margins of the exopods have three to five spines on each segment and one long seta and two short spines terminally, the long seta being armed with spinules externally and with fine hairs internally. The second segment of the exopod in legs one to four bears one long hastate seta on its inner margin; the third segment has one short seta with an additional hastate seta in the fourth leg. The basal segment of the endopod bears one short spine distally, in legs one to four, on the inner margin; the second segment bears one in the first leg and two in legs two to four, distally; the third segment has a longer seta, coarsely plumose, on the inner margin with one long and one short seta terminally. The terminal setæ of both rami increase in length from first to fourth legs. The fifth legs show almost complete fusion of the two segments and are elongate and lamellar. There is a short seta outside, followed by one very long one, extending nearly to the end of the pre-anal segment, then two shorter setæ, one short plumose seta and a longer seta internally. The genital segment bears a pair of short setæ, one on either side of the genital aperture. A single egg-sac is carried containing usually three eggs, one behind the other. Length about 0.41 mm.

Male. Body similar to that of the female except that there are five segments in the urosome and the anal segment is about one-third of the length of the pre-anal. Caudal rami as in the female but the long setæ are about three-fifths of the length of the body; the other setæ are like those of the female with an additional small seta inside. Antennule

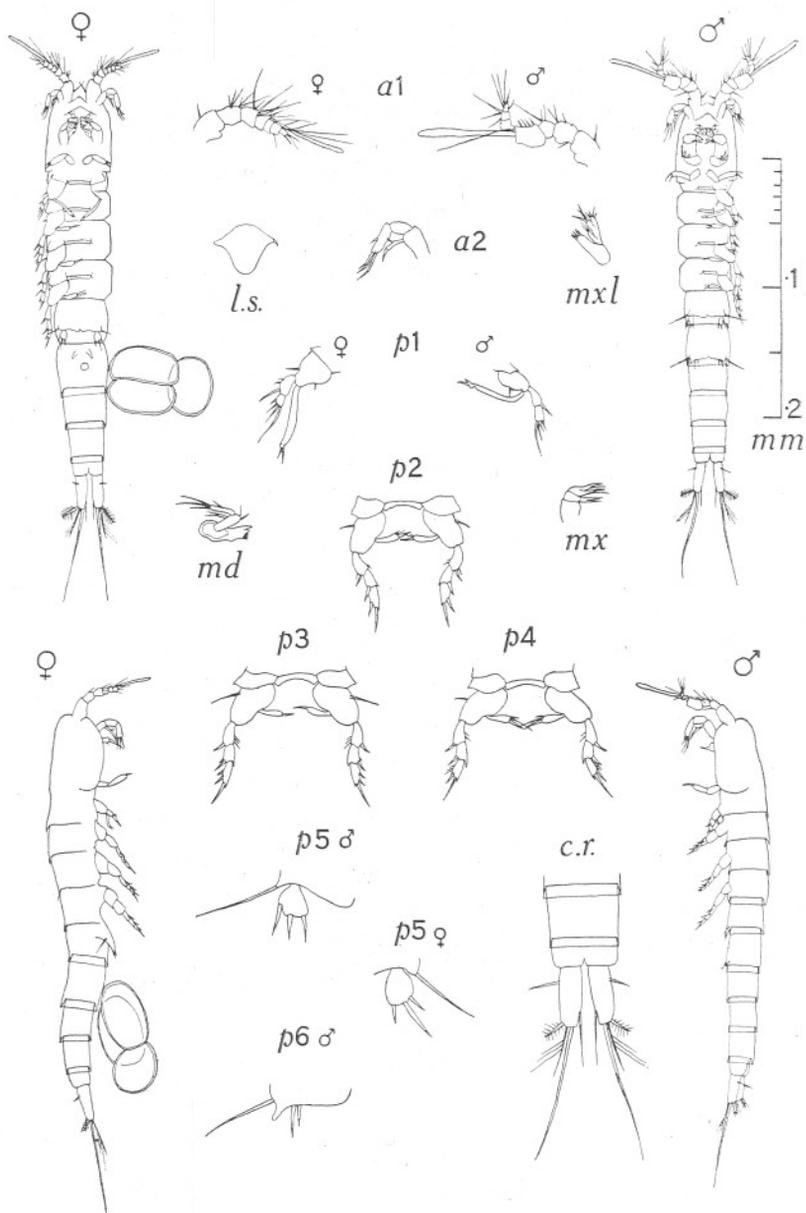


FIG. 2.—*Leptopsyllus constrictus* sp. n. Lettering as in Figure 1. Fifth and sixth legs drawn to a scale 2-3 times that of the other appendages.

7-segmented, distinctly geniculate between the third and fourth; a long plumose seta occurs on the second segment and a long curved aesthetasc is borne on the end of the fourth segment and extends beyond the end of the appendage; a bunch of setae occurs at the end of both fourth and fifth segments, otherwise the setae are much as in the female. The mouth parts and legs are like those of the female but the legs are much shorter and the setae not so strikingly long. The fifth legs are much smaller than those of the female which they resemble in showing only one lamellar segment, armed with six short setae. Length about 0.38 mm. No eye visible.

Occurrence. Washed from the sand of Kames Bay, Millport, September to December, 1934. Centre of abundance about half-tide level. Moderately common.

Remarks. The hastate setae on the exopods of legs one to four appear to project backwards on some legs and forwards on others. Probably in life they project in a plane more or less at right angles to that of the other setae and when flattened under the cover-slip fall either forwards or backwards. In a whole mount they appear to project backwards.

Family CANTHOCAMPTIDÆ.

The majority of the interstitial copepods belong to this heterogeneous family, the various attempts at classification of which have been reviewed by Gurney (1932) who suggests an arrangement in a number of evolutionary series. This arrangement has been followed in dealing with the remaining copepods all of which appear to belong to this family. The first is included in Gurney's "Tetragoniceps Series" and the rest in his "Evansula Series," to which must be added *Paraleptastacus* Wilson and the two new genera described below.

Genus LEPTOPSYLLUS T. Scott.

Syn. *Emertonia* Wilson, 1932. Bull. 158. U.S. Nat. Mus., p. 256.

Body somewhat depressed, last segment of the metasome narrower than the preceding segments. Urosome more or less tapering posteriorly; 4-segmented in the female, 5-segmented in the male. Metasome segments clearly marked off from one another by deep indentations (except in the female of *L. (Emertonia) gracilis*). Caudal rami elongate. Rostrum short and ill defined basally. Antennule 7- or 8-segmented, bearing a long aesthetasc on the fourth segment. Antenna 3-segmented; the first two unarmed, the third with a number of terminal geniculate spines and one or two short lateral spines; a 1-segmented exopod is attached distally to the basal segment and bears lateral and terminal setae. The upper lip is obtusely conical and unarmed. The mandible has a

well developed palp with a 1-segmented exopod. The maxillule, maxilla and maxilliped are normal. The basipod in legs one to four is large and expanded laterally, causing the whole of the exopod to project beyond the lateral margin of the metasome. Both rami of first legs 1- or 2-segmented. Exopods of legs two to four 3-segmented, endopods 1- or 2-segmented. Fifth legs 2-segmented. A single egg-sac is present.

Remarks. In 1894 T. Scott described a new copepod, taken from the shores of the Firth of Forth, which he named *Leptopsyllus typicus*. Three more species were described by T. and A. Scott in 1895, *L. intermedius* (1895a) from "pools near low-water on the shore at Musselburgh, Firth of Forth," and *L. robertsoni* and *L. minor* from the same situation and habitat (1895b). In 1900 Thompson and Scott described a fifth species, *L. herdmani*, obtained from "holes dug in the sand . . . at Port Erin," from which also they recorded *L. intermedius*. This latter species, it has been suggested by Sars (1911, p. 425), should be transferred to the genus *Paramesochra*. The two species of *Leptopsyllus* described below were at first thought to belong to *Emertonia* (Wilson, 1932) and they are undoubtedly congeneric with *E. gracilis* of that author. One of the species found here is, however, *L. minor* which, with *L. herdmani*, has previously been recorded from this district by T. Scott (1901). All of the seven species of *Leptopsyllus* grade one into the other and it is with some difficulty that *Paramesochra dubia* is separated.

Leptopsyllus constrictus sp. n. (Figure 2).

Female. In general structure it resembles *L. (Emertonia) gracilis* except that it is deeply constricted between the metasome segments. The antennule has only seven segments and the second segment is without a spine. The antenna is 3-segmented, with a 1-segmented exopod attached to the basal segment and bearing one lateral and one terminal spine. The upper lip is unarmed. The mandible palp shows two segments, the distal one with three terminal and one lateral seta, the basal segment having two lateral setae and bearing the 1-segmented exopod tipped with two setae. The maxillule shows a basal portion armed distally with teeth, and three lobes tipped with setae. The maxilla appears to have three segments. The maxilliped has a short basal segment, a longer second segment and a very short terminal segment bearing a short curved claw and two accessory setae. The exopod of the first leg has two segments and the endopod consists of one long slender segment bearing two small spines terminally. Both rami of the second, third and fourth legs show small differences from *L. (Emertonia) gracilis* in the number of spines and presence of hairs. The setae of the fifth legs are not plumose and have not the same relative length as in that species. A single egg-sac is carried,

with two eggs side by side and occasionally also a third placed transversely. The caudal rami are long, slightly tapering and bear each one long and one short terminal seta and a short plumose seta terminolaterally, with one inner and one outer marginal seta. The short terminal seta bears three or four long delicate hairs. Length about 0.32 mm.

Male. Resembles the female in the shape of the body but is more slender. The antennule is 7-segmented with an aesthetasc on the fourth. The exopod of the first leg has two segments and the endopod only one. The remaining legs resemble those of the female but are smaller. The anal segment is slightly smaller than in the female. Length about 0.30 mm.

Occurrence. Washed from the sand of Kames Bay, Millport. Very common just above low-water neaps.

Remarks. Though there is no doubt about there being two segments in the exopod of the first leg, in which it differs from *L. (Emertonia) gracilis*, it is possible that the endopod should be interpreted as having two segments in conformity with all the other species of the genus. There is a constriction at the end, particularly noticeable in the male, which may be true segmentation, but owing to its very small size it has not been possible to determine this with accuracy. An eye is present in this species and can be seen if the specimens are examined immediately after fixation. It disappears very rapidly.

Leptosyllus minor T. and A. Scott (Figure 3).

Female. Body very much as in *L. constrictus*, with a large cephalosome and 4-segmented urosome. The anal segment is about half the length of the pre-anal segment. The caudal rami are long and somewhat fusiform in shape, bearing each a single short terminal seta, swollen basally, with a short spine on either side and three other setæ. The rostrum is small and sharply pointed. Antennule 7-segmented, the basal segment unarmed and the remaining segments more or less setose; there is a slender aesthetasc on the fourth segment. The antenna consists of three segments; the basal segment bears a 1-segmented exopod which has two lateral and one terminal seta; the second segment has a single lateral seta and the terminal segment has one lateral seta and several setæ and geniculate spines terminally. The upper lip is like that of *L. constrictus*. The mandible palp consists of a large basal segment with two smaller segments terminally, armed with setæ, and a 1-segmented exopod tipped with two setæ. The maxillule has only two distal lobes. The maxilla has two small endites on the basal portion not present in *L. constrictus*. The maxilliped is typical. The rami of the first leg are 2-segmented;

the segments of the exopod are sub-equal, the first with two small spines and a long distal seta, the second with four unequal terminal setæ; the endopod has a long unarmed basal segment and a short terminal segment

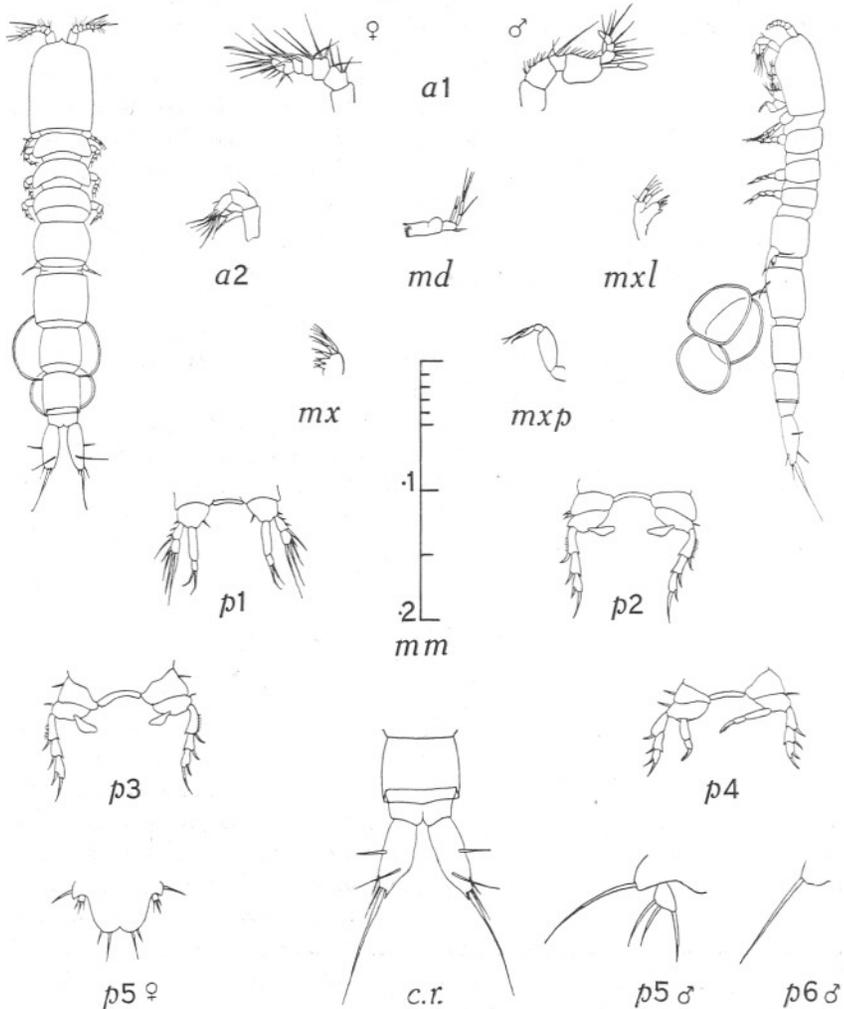


FIG. 3.—*Leptopsyllus minor* T. and A. Scott. Lettering as in Figure 1. Fifth and sixth legs of the male drawn to a scale 2.3 times that of the other appendages.

tipped with two unequal slightly clawed setæ. The second and third legs have 3-segmented exopods, and 1-segmented, unarmed, fusiform endopods. The exopods of the fourth legs are normal but the endopods are 2-segmented and well developed, the terminal segment bearing a curved spine. The basal segments of the fifth legs are considerably

elongated and completely fused in the midline, bearing the usual lateral seta, and two terminal setæ; the terminal segments are small and inconspicuous bearing three unequal setæ. The sixth legs are represented by a pair of short setæ. There is a single egg-sac, containing two or three eggs loosely held together and ovoid in shape.

Male. Resembles the female in general structure but has a 5-segmented urosome. Antennule 7-segmented, the fourth segment bearing a peculiar, apparently 2-segmented æsthetasc, the terminal portion of which is fusiform and the whole much shorter than is usual. The mouth parts and swimming legs are like those of the female. The fifth legs have a basal segment with one lateral seta, and the terminal segment has three setæ. The sixth legs consist of small lamellæ bearing each a single long seta.

Occurrence. Washed from the sand taken just above low-water neaps in Kames Bay, Millport, and found only between 3 and 10 cm. deep in the sand. Not very common.

Remarks. This species resembles *L. constrictus* in some features, but the two are easily separated on the structure of the caudal rami and by the extraordinary separation of the segments on fixation, such as has not been found with any other copepod from this fauna, although apparent in the drawings of *Leptosyllus* made by T. and A. Scott. It is presumed that this feature is unnatural and therefore no measurements are given, but the animals are approximately the same size as *L. constrictus* (0.3 mm.). The æsthetasc in the male is peculiar as are also the fifth legs of the female and the first and fourth legs in both sexes.

Genus PARALEPTASTACUS Wilson.

Paraleptastacus espinulatus sp. n. (Figure 4).

Female. Body elongate, cylindrical; segments more or less equal in size. Urosome 4-segmented, not clearly separated from the metasome. Rostrum small and fused with the cephalosome. Antennule 7-segmented, the second segment the longest and the fourth bearing a moderately long æsthetasc. The antenna is 3-segmented with a small 1-segmented exopod attached near the centre of the second segment. The mouth parts are like those of *P. spinicaudus* (Figure 5). Exopods of the swimming legs are 3-segmented, the endopods 2-segmented. The fifth legs are 2-segmented; the basal segment with the usual lateral seta and two short terminal setæ; the terminal segment with one terminal and three lateral setæ. Caudal rami short, tapering terminally to end in a spine, and bearing one long and one short terminal seta and two lateral setæ. Egg-sac single with two or three large eggs one behind the other. Length about 0.40 mm.

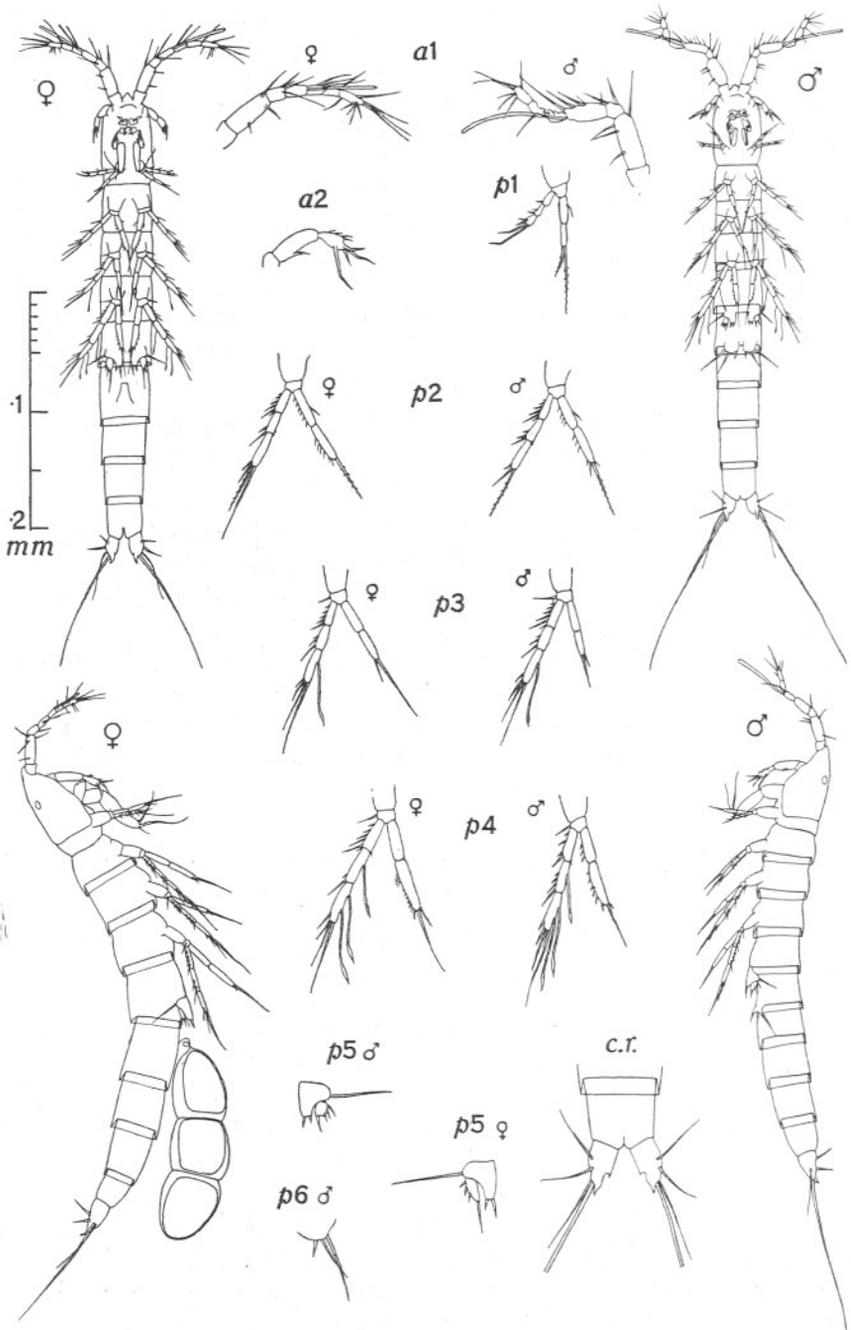


FIG. 4.—*Paraleptastacus espinulatus* sp. n. Lettering as in Figure 1.

Male. Body of similar shape to that of the female but slightly shorter and with 5-segmented urosome. Antennule 7-segmented, twice geniculate and bearing a long aesthetasc on the fourth segment. Mouth parts as in the female. The swimming legs, except for the first, show small differences in spinulation from those of the female. The terminal segment of the fifth legs is longer than in the female and bears a long terminal seta. The sixth legs are small lamellæ each bearing one lateral and two terminal setæ. Length about 0.37 mm.

Occurrence. Very abundant in the sand of Kames Bay, Millport; generally distributed in the lower half of the Bay. Breeding from January to December.

Remarks. In its main features this species differs little from those described by Wilson (pp. 248-252). The anal segment is, however, nearly as long as the penultimate segment and the caudal rami are as long as the anal segment. In the proportions of these parts and in the number and arrangement of the setæ on the caudal rami this species resembles the male of *P. katamensis*, lacking, however, the large inner distal spine. A single median reddish eye is present. The antennules show differences in the number and arrangement of the setæ and the aesthetasc extends slightly beyond the end of the appendage in the female and well beyond in the male. The second segment of the exopod of the first leg bears two spines and similar small differences in the number of spines are seen in the second, third and fourth legs. A notable difference is in the number of hastate setæ on the exopods of the third and fourth legs. The third leg bears one on the inner side of the terminal segment and the fourth legs bears one on the second segment and two on the terminal segment. Male and female are alike in this respect. The distal segment of the fifth legs in the female bears only three lateral setæ. The setæ of the legs of both sexes of this species are practically devoid of spinules and the setæ of the caudal rami entirely so, upon which fact depends the choice of specific name. This feature and the number of hastate setæ on the third and fourth legs serve to distinguish this species from those previously described.

Paraleptastacus spinicaudus (T. and A. Scott) (Figure 5).

Syn. *Mesochra spinicauda* T. and A. Scott, 1895. Ann. Mag. Nat. Hist., Ser. 6, Vol. XV, p. 52, pl. V, Figures 12-25.

Leptastacus spinicaudus Sars, 1911. Crustacea of Norway. Vol. V, Copepoda (Harpacticoida), p. 417.

Apart from the very clear-cut difference in distribution, the main structural difference between this and the preceding species lies in the caudal region. The rami are shorter and stouter than in *P. espinulatus*

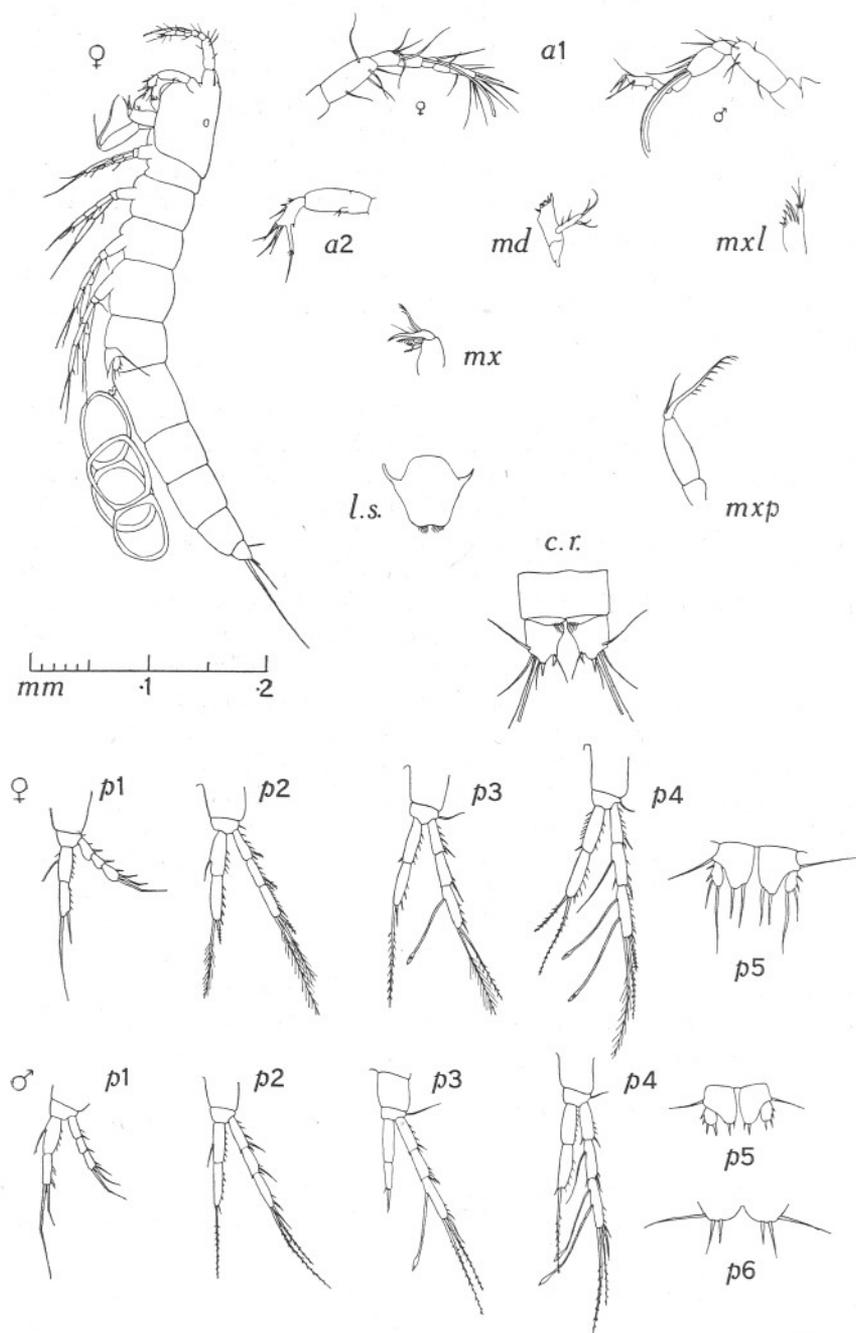


FIG. 5.—*Paraleptastacus spinicaudus* (T. and A. Scott). Lettering as in Figure 1.

and bear more setæ and spines, and there are two well defined opercular tufts of setæ. There are also differences in the spinulation of the legs. The hastate seta on the second exopod segment of the fourth leg in *P. espinulatus* is replaced in this species by a long unarmed seta. The remaining setæ on the legs of this species are strongly denticulate or plumose. Length of female about 0.43 mm., of the male about 0.40 mm.

Occurrence. Washed from the sand of Kames Bay, Millport. Distribution very local, just below high-water neaps; also in sand from the head of Loch Fyne.

Remarks. The genus *Paraleptastacus* was established by Wilson (1932) to include two forms obtained by him from sand washings. As pointed out by him it differs from *Leptastacus* in the structure of the antennules, the maxillæ, the fifth legs and the caudal rami. The species described above conform to the generic diagnosis given by Wilson in all but the maxillæ, in which they resemble *Leptastacus*. This difference, though noticeable, does not seem to warrant a new genus.

P. spinicaudus, originally described as *Mesochra spinicauda*, by T. and A. Scott (1895a) and later removed to the genus *Leptastacus* by Sars (1911, p. 417), was at first thought to be a new species. Specimens obtained from sand at the head of Loch Fyne in September, 1934, in relatively the same position above low-water as those in Kames Bay, while showing no important structural difference from the latter, were larger (0.5 mm.), had larger egg-sacs containing six or seven eggs, and appeared to be identical with *M. spinicauda* of T. and A. Scott.

The sand in which these specimens were found was of a coarser texture than that of Kames Bay and possibly the larger size and larger egg-sac may be correlated with the larger sand grains which would provide greater interstitial space. T. and A. Scott give no data upon which their measurements were based, and if the extended antennules are included in the measurements, the size of the Loch Fyne specimens agrees exactly with that given by them. Moreover their specimens were "in pools near low-water on the shore" and it appears almost certain that the copepods are identical.

Genus LEPTASTACUS Scott.

Leptastacus laticaudatus sp. n. (Figure 6).

Female. Body cylindrical, metasome and urosome not clearly demarcated. Antennule 7-segmented, with a long æsthetasc on the fourth segment. Antenna 2-segmented, with a 1-segmented exopod attached near the base of the basal segment. The upper lip bears two spines and six setæ. The mouth parts resemble those of *L. macronyx*, except for the maxillule, the structure of which was not clearly determined. Legs one to

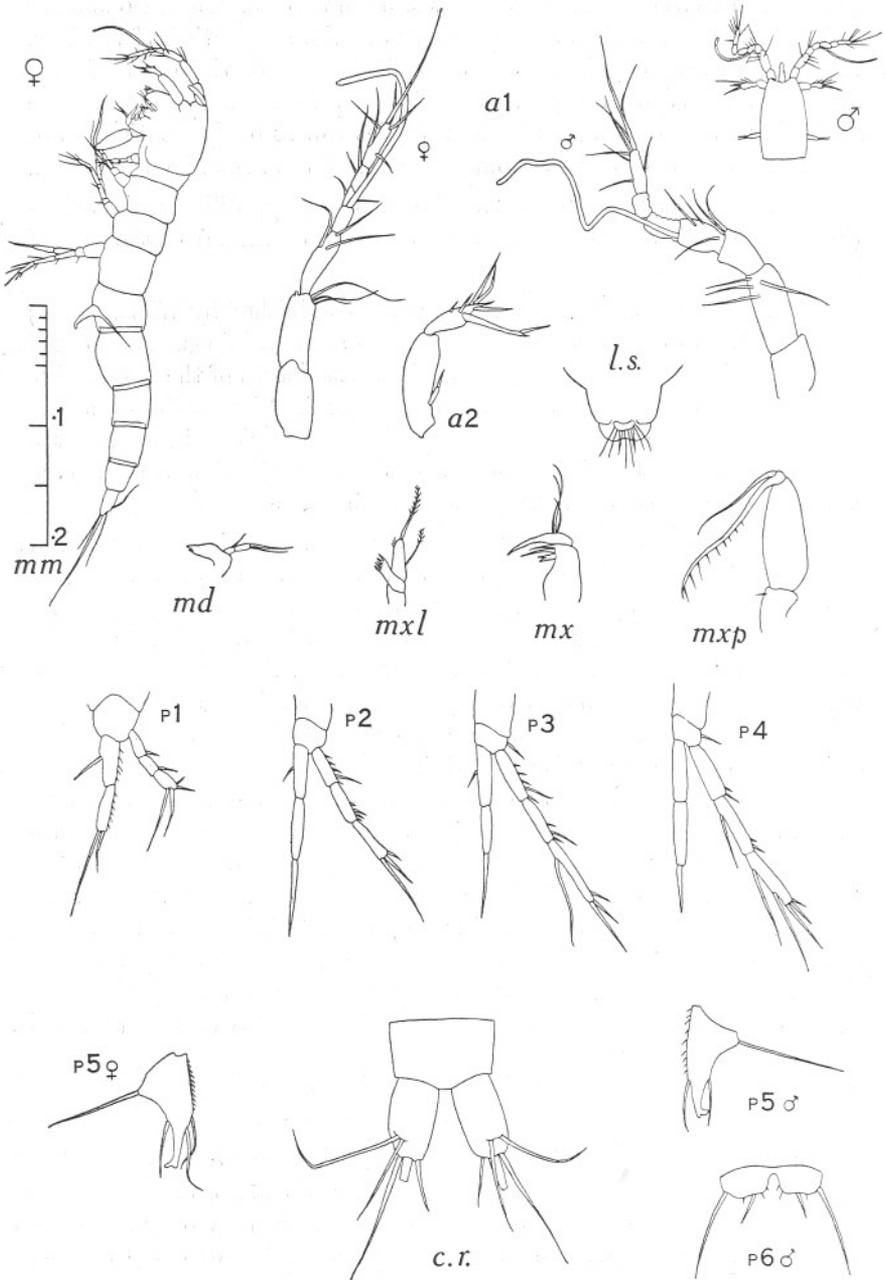


FIG. 6.—*Leptastacus laticaudata* sp. n. Lettering as in Figure 1. Appendages drawn to a scale 2.8 times that of the adult.

four are as in *L. macronyx*, with minor differences in the arrangement of setæ and relative lengths of segments, particularly in the first leg. The fifth legs are of the same general shape as in the type but are expanded terminally, somewhat resembling a human foot. The caudal rami are short, scarcely exceeding the length of the anal segment and about half as wide as long; each bears one long terminal seta with a shorter seta on either side, and two setæ on the upper surface. There is a single egg-sac containing two or three eggs. Length about 0.36 mm.

Male. This is shorter and more slightly built than the female and shows the usual modification of the antennules. The fifth legs are like those of the female but lack one seta, and a pair of lamellar sixth legs occurs armed laterally with one long seta and terminally with one short seta and three small spines. Length about 0.33 mm.

Occurrence. Thirty-six specimens were washed from sand at about half-tide in Balloch Bay, Isle of Cumbrae, in March, 1935. The majority occurred above 2.5 cm. and none was found below 5 cm.

Remarks. This species differs from *L. macronyx* mainly in the fifth legs and the caudal rami. These features, supported by the difference in distribution, appear to warrant a new species. *L. macronyx* was dredged from 14 fathoms on a clean sandy bottom, whereas *L. laticaudatus* occurs at about half-tide in somewhat muddy sand.

Genus PSAMMASTACUS gen. n.

Body elongate, cylindrical, widest at the second metasome segment, and gradually tapering posteriorly. Cephalosome about equal to the first two metasome segments. No definite demarcation between metasome and urosome. Caudal rami about half as long as the anal segment and little longer than wide. Rostrum prominent, curved and well defined. Antennule 6- or 7-segmented, twice geniculate in the male, and bearing a long slender æsthetasc on the fourth segment. Antenna 3-segmented, the second segment showing no sign of division but bearing the rudimentary exopod near the middle. Upper lip prominent. Mandible with simple 2-segmented palp. Maxillule armed with numerous spines and setæ. Maxilla and maxilliped similar to those of *Paraleptastacus*. First leg with 1-segmented exopod and 2-segmented endopod. Remaining swimming legs with 3-segmented exopods and 2-segmented endopods. Fifth legs in both sexes reduced to simple lamellæ. Sixth legs present in both sexes and of similar structure to the fifth pair. Egg-sac single, with two or three eggs one behind the other.

Remarks. This genus is distinctive in its upper lip, but the remaining mouth parts all resemble those of copepods of the *Evansula* Series

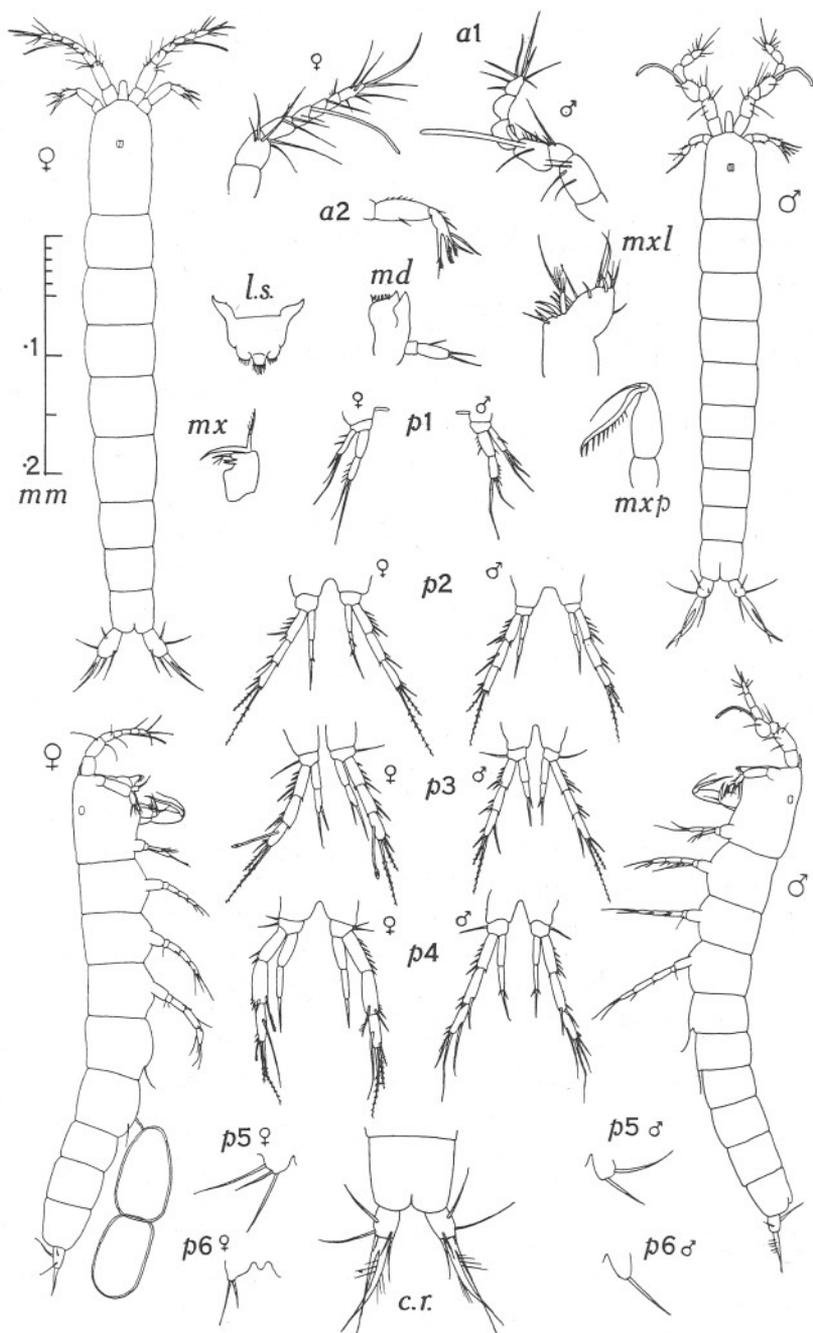


FIG. 7.—*Psammastacus confluens* gen. n., sp. n. Lettering as in Figure 1. Mandible and maxillule drawn to a scale 2.3 times that of the other appendages.

(Gurney, 1932). The first legs are peculiar but the others, including the fifth pair, are similar to those of the copepods of this Series.

Psammastacus confluens sp. n. (Figure 7).

Female. Cephalosome about equal to first two metasome segments. Rostrum longer than the first segment of the antennule. Reddish eye present in fresh specimens. Antennule 7-segmented, the second segment the longest. Antenna with exopod represented by a single seta attached about the middle of the second segment which has a fringe of fine hairs on the opposite margin; terminal segment with three denticulate spines and two setæ terminally, and three short spines laterally. Upper lip trilobed, each lobe with a tuft of fine hairs. Mandible with 2-segmented palp, the second segment having two terminal and one lateral seta. Maxillule consisting of a basal portion bearing spines and setæ and a distal lobe similarly armed. Maxilla normal. Maxilliped 2-segmented, the basal segment unarmed; the terminal segment with one long curved claw, bearing a number of long spines and an accessory curved seta. First leg with 1-segmented exopod bearing two short spines externally, and tipped with three unequal setæ. Endopod 2-segmented, the end segment tipped with two long unequal setæ and with a fringe of short hairs on the inner margin. Second, third and fourth legs with 3-segmented exopods and 2-segmented endopods. The first two segments of the exopod with a varying number of hairs and spines on the outer margin and, in the fourth leg, one inner seta bearing a fringe of fine hairs, on the second segment. End segments of exopods with two long denticulate setæ terminally and a spine and hairs on the outer margin. In the third leg the end segment bears one short hastate seta inside, replaced in the fourth leg by a long unplumed seta. The fifth and sixth legs are simple lamellæ bearing three setæ in the fifth pair and two in the sixth. The caudal rami are short, stout structures attached to the ventral part of the anal segment, making a break in the continuous line of the dorsal surface. Each ramus is armed with two apical setæ, fused for a short distance proximally, with one short seta inside and a longer one projecting laterally; there are also two dorsal setæ. Length about 0.48 mm.

Male. Similar to the female in general shape of the body but slightly shorter and more slender. Cephalosome shorter than the first two segments of the metasome. Antennule 7-segmented and twice geniculate, with a stout æsthetasc on the fourth segment; inner surface of the fifth segment with a rugosity for gripping. Mouth parts as in the female. The swimming legs are segmented like those of the female but show slight differences in spinulation. The fifth and sixth legs resemble those of the

female but have only two and one seta respectively. The caudal rami are similar to those of the female. Length about 0.40 mm.

Occurrence. Washed from the sand of Kames Bay, Millport, at about high-water springs. Also found in the sand from the bed of the stream flowing through the Bay. Very common.

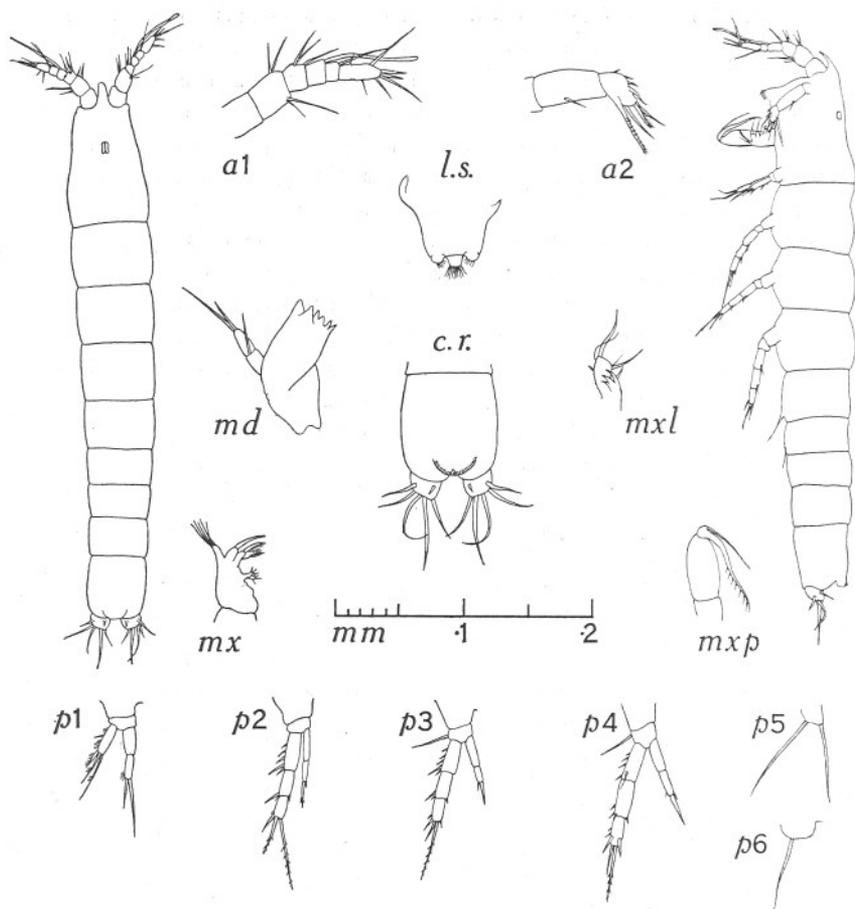


FIG. 8.—*Psammastacus brevicaudatus* sp. n. Lettering as in Figure 1. Mandible drawn to a scale 2.3 times that of the other appendages.

Remarks. The caudal rami are distinctive and resemble the description given in Monard's key (1927) for *Marshia* (now *Cletocamptus*). Herrick's (1895) figure of *M. albuquerqueensis* also shows the apical setae fused basally.

Psammastacus brevicaudatus sp. n. (Figure 8).

Female. Cephalosome about equal to the first two metasome segments. Rostrum large and curved. Eye conspicuous, reddish. Antennule 6-

segmented, the first two segments about equal and larger than the others ; a short slender æsthetasc borne on the fourth segment. Upper lip prominent, trilobed. Mandible with 2-segmented palp ; the first segment with one seta and the distal segment with two unequal terminal setæ. Remaining mouth parts as in *P. confluens*. Legs one to four with similar segmentation to those of *P. confluens* but with slight differences in setation (cf. Figures 7 and 8). Fifth and sixth legs simple lamellæ with two and one seta respectively. Anal segment large, with distinct crescentic operculum, fringed with fine hairs. Caudal rami very short, rounded, each bearing four short terminal setæ and two dorsal setæ. Egg-sac single, containing two or three eggs. Length about 0.43 mm.

Male. Unknown.

Occurrence. Washed from the sand of Kames Bay, Millport, at about high-water springs in association with *P. confluens*. Not very common.

Remarks. The caudal rami serve immediately to distinguish this species from the only other species so far described.

Genus ARENOCARIS gen. n.

Body long, cylindrical, widest in the middle. Cephalosome short ; rostrum large, curved. Urosome 4-segmented in the female, 5-segmented in the male. Caudal rami elongate. Antennule 7-segmented, with long æsthetasc on the fourth segment, and twice geniculate in the male. Antenna 3-segmented, basal segment short ; second segment with a suggestion of segmentation at the point of attachment of the short, 1-segmented exopod ; third segment with one large spine and a number of shorter, geniculate spines terminally, and several short spines on the lateral margin. Upper lip fringed with hairs. Mandible with a small 2-segmented palp. Maxillule with a group of short curved spines and a lobe bearing spines and setæ. Maxilla of the usual Canthocamptid type. Maxilliped 3-segmented ; basal segment with short inner spine ; second segment unarmed ; terminal segment with a long curved claw and a single seta. Both rami of first legs 2-segmented. Legs two and three with 3-segmented exopods and 1-segmented endopods. Fourth legs with 3-segmented exopods and stout, 2-segmented endopods, slightly modified in the male. Fifth legs 2-segmented, the terminal segment greatly reduced in the male. Sixth legs present in the male. Genital area in the female well developed and noticeably sculptured. Caudal rami about as long as the anal segment and each bearing one short, stout, apical seta and one similar lateral seta which projects at right angles to the body, giving a characteristic appearance. Eye invisible. Egg-sac single.

Remarks. This genus appears to fit naturally into the Evansula Series (Gurney, 1932, p. 49) and to link up with *Stenocaris*, supporting Gurney's

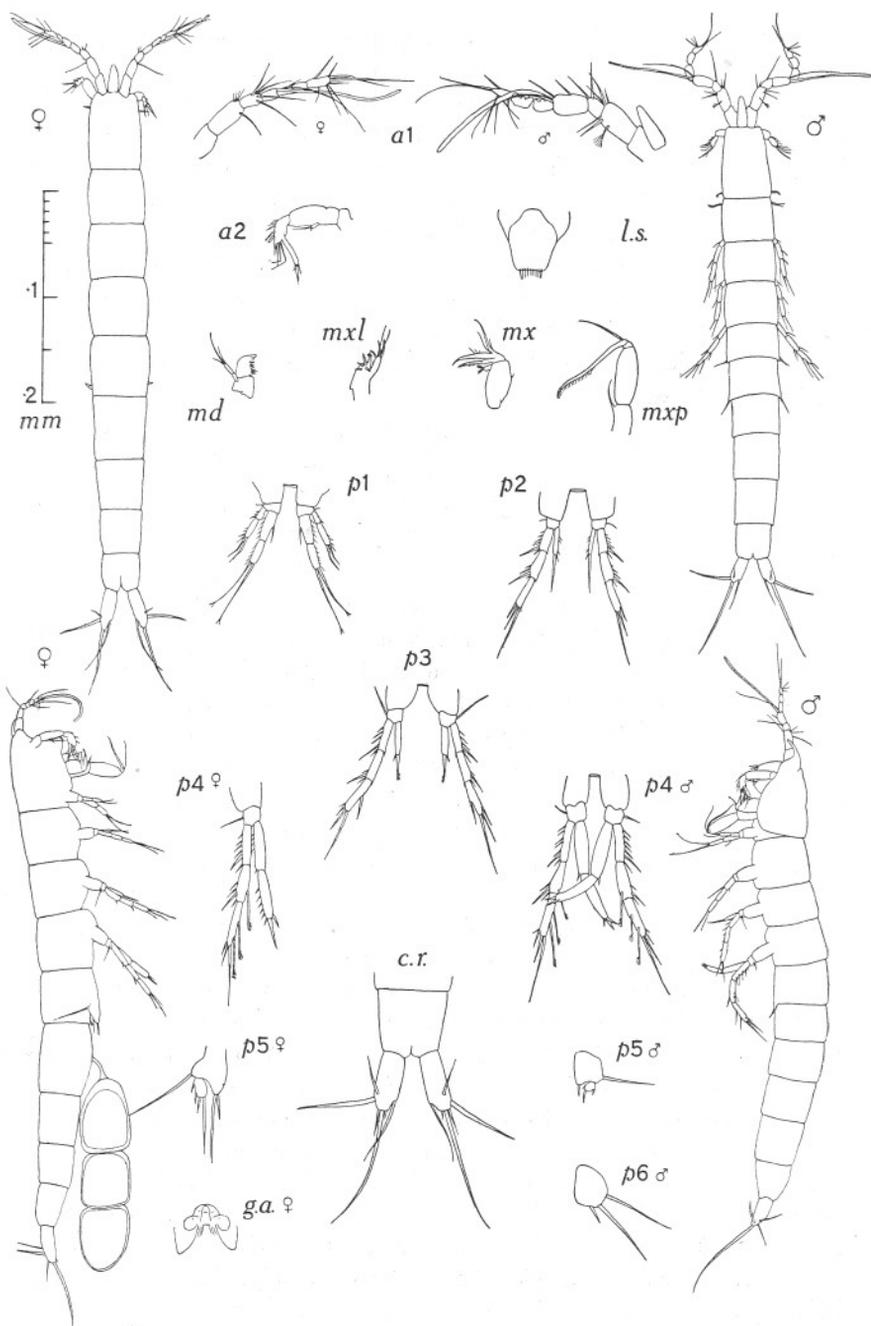


FIG. 9.—*Arenocaris bifida* gen. n., sp. n. *g.a.*, genital area; other lettering as in Figure 1. The caudal rami are those of the male.

suggested inclusion of that genus within this Series. In the general elongate shape of the body this genus resembles *Stenocaris*; in the structure of the antennules, antennæ, upper lip and other mouth parts it resembles *Paraleptastacus*. In the reduction of the endopods of the swimming legs it resembles *Stenocaris*, but in the structure of the first legs it is peculiar. The fifth legs do not show the reduction found in *Stenocaris* and *Leptastacus*, but resemble those of *Paraleptastacus*. The rostrum, however, is much larger and more clearly defined than in that genus.

Arenocaris bifida sp. n. (Figure 9).

Female. The body is widest in the fourth and fifth segments, tapers slightly anteriorly and somewhat more noticeably posteriorly. The large rostrum is well defined and ventrally curved. Antennule 7-segmented, the fourth bearing a long æsthetasc. The upper lip is prominent in lateral view. The exopods of the first legs bear lateral spines and two slightly bent terminal setæ. The endopods are fringed with hairs externally and the first segment bears a single seta about the middle of the inner margin; the second segment has two long setæ, distinctly bifid distally. This feature has given rise to the specific name. In legs two to four the first two segments of the exopods have each one long spine and a number of shorter spines and hairs on the outer margin; the third segment bears one long and two short terminal spines and in the third legs one short spine on the inner margin; in the fourth legs there are two modified setæ on the inner margin with a similar seta on the inner margin of the second segment. These setæ, which are relatively short and bear each a tuft of fine hairs distally, occupy positions similar to those of the hastate setæ in *Paraleptastacus* and *Hastigerella*, and both probably have a sensory function associated with the habitat. The endopods of legs two and three are 1-segmented and tipped with a single, more or less stout, spine which in the third leg also bears a tuft of fine hairs. The endopod of the fourth leg is 2-segmented, both segments being larger and more strongly built than the corresponding exopod segments; the terminal segment is tipped with one large strong spine and a smaller one; both segments are fringed with hairs externally. The fifth legs are of the usual 2-segmented type, the basal segment bearing two setæ terminally and a single long seta laterally; the terminal segment has one long and one short terminal seta and two short lateral setæ. The genital area is prominent and ornately sculptured. The caudal rami are almost as long as the anal segment; there is a single stout terminal seta and a second, equally stout, projecting laterally; a third seta occupies a dorsal position, while a fourth is situated internal to the main apical seta. There is a single egg-sac with two or three eggs carried one behind the other. Length about 0.53 mm.

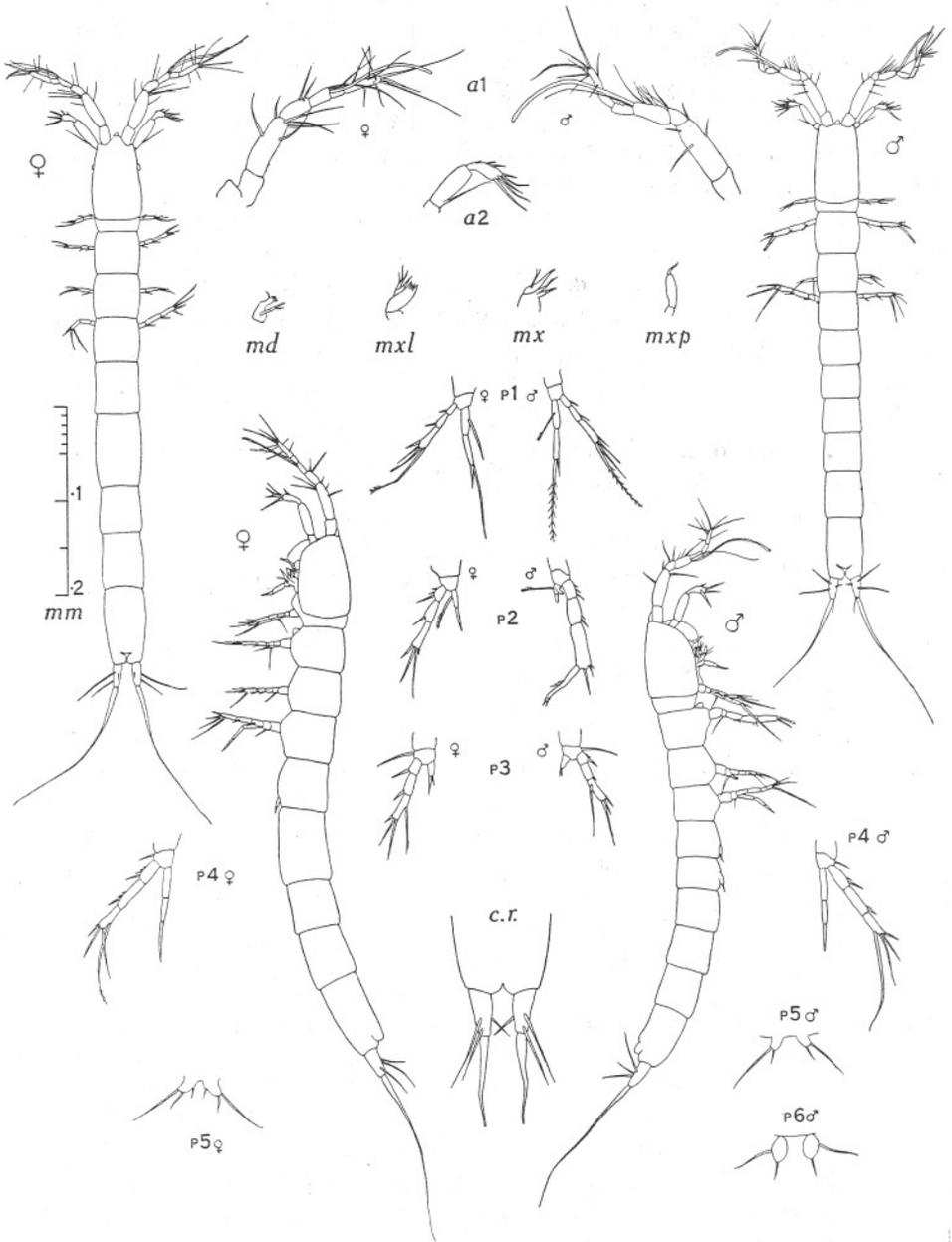


FIG. 10.—*Stenocaris minuta* sp. n. Lettering as in Figure 1.

Male. Body similar to that of the female but more slender and with 5-segmented urosome. Antennules 7-segmented, twice geniculate, with a long æsthetasc, stouter than that of the female, on the fourth segment; the fifth and sixth segments are corrugated on their inner margins and presumably provide a gripping surface when closed. Mouth parts as in the female. First three pairs of legs like those of the female with slight differences in the number of small spines and hairs, but these are of little importance since similar differences are seen in the two members of any one pair of legs. The fourth legs have endopods of similar structure to those of the female but they are even more stoutly built and have two short spines terminally, with one smaller spine; there is a single short spine distally on the outer margin of the second segment; the whole ramus is somewhat curved. The fifth legs are smaller than those of the female and the terminal segment is very small with only three short setæ. The sixth legs are represented by lamellar plates each bearing the usual long lateral seta and two terminal setæ. The caudal rami are as in the female but have in addition two small setæ situated one on either side of the apical seta. Length about 0.46 mm.

Occurrence. Washed from the sand of Kames Bay, Millport, and found only in a restricted area at about half-tide level. Not very common.

Genus STENOCARIS Sars.

Stenocaris minuta sp. n. (Figure 10).

Female. Body cylindrical, the 4-segmented urosome showing no demarcation from the metasome. The genital and anal segments are about equal, longer than any other segment but slightly shorter than the cephalosome. Rostrum small, well defined basally. Antennule 6-segmented, with an æsthetasc on the fourth. Antenna 3-segmented, the 1-segmented exopod attached basally to the second segment and bearing a single long seta. Mouth parts typical. Exopods of first four pairs of legs 3-segmented; endopods of first and fourth pairs 2-segmented, of second and third pairs 1-segmented. Fifth legs small lamellæ bearing three unequal setæ. Caudal rami equal to one-third of the length of the anal segment, narrow and tapering, armed with one long slender terminal seta and three lateral setæ. No specimens were obtained with egg-sacs which are presumably paired as in other members of the genus. Length about 0.60 mm.

Male. Body shorter and narrower than that of the female, with 5-segmented urosome. Antennule 7-segmented, geniculate between the fifth and sixth, and bearing a relatively long æsthetasc on the fourth. Mouth parts as in the female. The first and fourth legs resemble those of

the female. The exopod of the second leg is 3-segmented and stoutly built, the terminal segment bearing a long stout seta; the endopod is 2-segmented, the basal segment armed with one lateral seta internally and a short hook externally; the terminal segment is rounded and unarmed. The third leg has a 3-segmented exopod and a 1-segmented endopod, conical in shape and slightly constricted in the middle and armed terminally with two short spines. The fifth and sixth legs are simple lamellæ bearing each two setæ. Length about 0.50 mm.

Occurrence. A small number of specimens of this copepod was obtained from a sample of coarse sand collected at the head of Loch Fyne in September, 1934.

Remarks. This species differs from *S. gracilis* Sars in having the basal segment of the antenna distinctly divided, and in the relative lengths of the rami and segments of the swimming legs. The fifth leg is also much reduced. It differs from *S. minor* (Scott) in having only six segments in the antennule of the female, and in the structure of the caudal rami. It is, moreover, considerably smaller than either of these species.

It is a pleasure to acknowledge here my indebtedness to Dr. R. Gurney for advice on the systematic position of some of the species herein described.

REFERENCES.

- GURNEY, R. 1932. British Fresh-Water Copepoda. II. Ray Society. London.
- HERRICK, C. L. 1895. Microcrustacea from New Mexico. Zool. Anz., XVIII, pp. 40-47.
- MONARD, A. 1927. *Synopsis universalis generum Harpacticoidarum*. Zool. Jahrb., 54, pp. 139-176.
- SARS, G. O. 1911. An Account of the Crustacea of Norway. V. Copepoda (Harpacticoida). Bergen.
- SCOTT, T. 1894. Additions to the fauna of the Firth of Forth. 12th Ann. Rep. Fish. Board Scot., pp. 231-271.
- 1901. Land, Fresh-Water, and Marine Crustacea. Clyde Fauna List, pp. 328-358, Glasgow.

- SCOTT, T., and SCOTT, A. 1895a. On some new and rare Crustacea from Scotland. *Ann. Mag. Nat. Hist.*, (6), XV, pp. 50-59.
- 1895b. On new and rare species of Copepoda from Scotland. *Ann. Scot. Nat. Hist.*, pp. 28-35.
- 1896. A Revision of the British Copepoda belonging to the Genera *Bradya* Boeck, and *Ectinosoma* Boeck. *Trans. Linn. Soc. Lond.*, VI (5), pp. 419-446.
- THOMPSON, I. C., and SCOTT, A. 1900. Some Recent Additions to the Copepoda of Liverpool Bay. *Trans. L'pool. Biol. Soc.*, XIV, pp. 139-144.
- WILSON, C. B. 1932. The Copepoda of the Woods Hole Region, Massachusetts. Bull. 158, U.S. Nat. Mus., Smithsonian Institution, Washington.

