Intersexes in *Gammarus chevreuxi* and Related Forms.

By

E. W. Sexton, F.L.S.,

Ray Lankester Investigator,

AND

Julian S. Huxley, M.A.,

Fellow of New College, Oxford.

With Figures 1–6 in the Text and Plates I–IX at the end.

SINCE 1912 extensive investigations have been carried on in the Laboratory of the Marine Biological Association at Plymouth on the genetics of *Gammarus chevreuxi* Sexton, a brackish-water amphipod (Allen and Sexton '17 and '20, see also Sexton '13 and Sexton and Matthews '13).

During the course of the work, numerous individuals have appeared showing abnormalities in sexual behaviour or structure. In view of the interest attaching to such forms, especially after the work of Goldschmidt ('20), Banta ('16), Sturtevant ('20) and others, it was deemed advisable to collate and publish the available data in spite of their somewhat fragmentary character.

In normal circumstances, the males of *Gammarus chevreuxi* mate with the females some days (3 to 9 days) before fertilisation is due to take place. Unless the female is mated for the first time she will normally be carrying in her brood-pouch a brood of developing embryos. After hatching, the young are carried about 24 hours before extrusion, and during that time they come to the anterior end of the brood-pouch and feed on what the mother is eating. Finally they are extruded by a voluntary opening of the brood-pouch. Immediately afterwards the female moults, whereupon fertilisation occurs and a new batch of eggs is extruded into the pouch.

The pair have by now separated, and remain separated usually until the embryos have gone through about half their development in the pouch.

Cannibalism is of fairly frequent occurrence, the male eating the female immediately after she has moulted. It is extremely rare for the normal female to eat a male.

The following description of the normal male and female will show their distinctive characters, and the points in which the abnormal forms differ from them.

In *Gammarus chevreuxi*, the sexes are indistinguishable on hatching. The young animals moult every few days until sexual maturity is reached, at which period the secondary sexual characters are well developed, and it is then easy to distinguish male from female at a glance. The characteristic sensory hairs of the male, and the brood-plates of the female are represented one or two moults before maturity, and will be described later, but it requires microscopic examination to perceive them at this stage.

The size of male and female is similar until sexual maturity is reached; after this the male increases in size more rapidly than the female, but moults at less frequent intervals, taking generally from 4 to 6 days longer between moults. For adult females the period between moults (and normally between fertilisations) varies from about 10 days in summer to about 30 in winter in laboratory conditions.

The adult male is always larger than the female of the same age, and has the body more laterally compressed, and the colour much lighter. The locomotion also shows characteristic differences, the male swimming freely and swiftly with extended body, the female usually moving along the surface of the substratum with the body more curved.

In the female the ovaries are visible as dark green masses above and on either side of the intestine in the peræon, extending through more or fewer segments according to the state of maturity. In the male, nothing can be seen of the gonad in life.

The points by which the sexes can be definitely distinguished are as follows (see Plates I, II, and the description of these plates for the young male last immature moult and first mature moult; Plates III and IV, for the young female, moult before eggs were laid, and moult after young were hatched) :—

1. The setose armature of the second antennæ. These antennæ, in the male, are larger and much more setose than in the female, the setæ being longer as well as more numerous. In addition to the straight setæ common to both sexes, the adult male carries dense tufts of coiled sensory hairs on the inner surface of the 4th and 5th joints of the peduncle, and of most of the joints of the flagellum (Plate II, Fig. 13).

These sensory hairs are peculiar to the male. They are also developed on the inner surfaces of the two gnathopods, the first pair of peræopods, and the third pair of uropods, and are very striking in appearance. They are long, very fine and delicate, with the tips coiled round. It must be noted that the sensory hairs are not coiled until the male is fully mature. In the young male a few *curved* hairs are produced one or two moults before maturity, at first on the second antennæ only (Fig. 1); in the succeeding moults on the other appendages modified at maturity,

the second gnathopod appearing to be the last to develop them. The normal female never has any of them.

2. The gnathopods. In the male, the gnathopods are not only considerably larger, but differ greatly from those of the female in the shape, proportions, and sensory armature of the subterminal joint, or " hand," the differences increasing with age. The gnathopod hand is always much larger in the male, with the palm oblique (Figs. 14–19) ; in the female, the palm is transverse (Figs. 37–42). The palmar margin, in both sexes is crenulate, microscopically spinose, with a row on either side of tiny sensory setæ along its whole length, ending at the palmar angle.

The palmar angle is furnished with a graduated row of spines or setæ on the upper or outer side of the hand ; and on the under side with a pair of sensory spines, inset close together. Between these two groups, the tip of the claw closes down.

This angle-row, in gnathopod 2, is one of the best characters for distinguishing the sexes. In the normal female, it always consists of rigid, serrated sensory setæ, the number in the row increasing with age from 3 in the immature female, to 6 in the oldest adult, 679 days old. In the normal male the row is composed of large stout sensory spines, the type and number of spines varying according to the degree of maturity ; in the immature male the spines are pointed, in the adult there are some pointed, and some small broad and truncate. In addition to the row at the angle the male is provided with a large spine inset about the middle of the palmar margin, of the long pointed type in the immature animal (Figs. 3 and 7), and of the truncate type, very large and broad, in the adult (Figs. 15 and 18). This type of truncate spine is peculiar to the mature male. The normal female never has any spines in the angle-row, nor the one in mid-margin.

The sensory setæ, and the pointed sensory spines carry a long curving flagellum near the tip ; this flagellum can be seen in the small truncate spines, but is only rudimentary in the very large ones.

In gnathopod 1 the male develops the full number of spines at the second moult after maturity, i.e. 1 very large truncate spine in mid-margin, 1 long, pointed spine and 3 short truncate ones on each side of the palmar angle. The palm bends so far round to the under surface of the hand, that part of the upper group of spines at the palmar angle is turned completely over, and only 3 of the spines show when looked at from the upper side (see Fig. 15).

The coiled sensory, male hairs are, in both gnathopods, on the inner surface of the hands and the preceding joint (i.e. joint 5) of the appendages.

3. The first pair of peræopods. The coiled hairs are found on the inner surface of joints 4, 5, and 6 in the male, and are absent in the female.

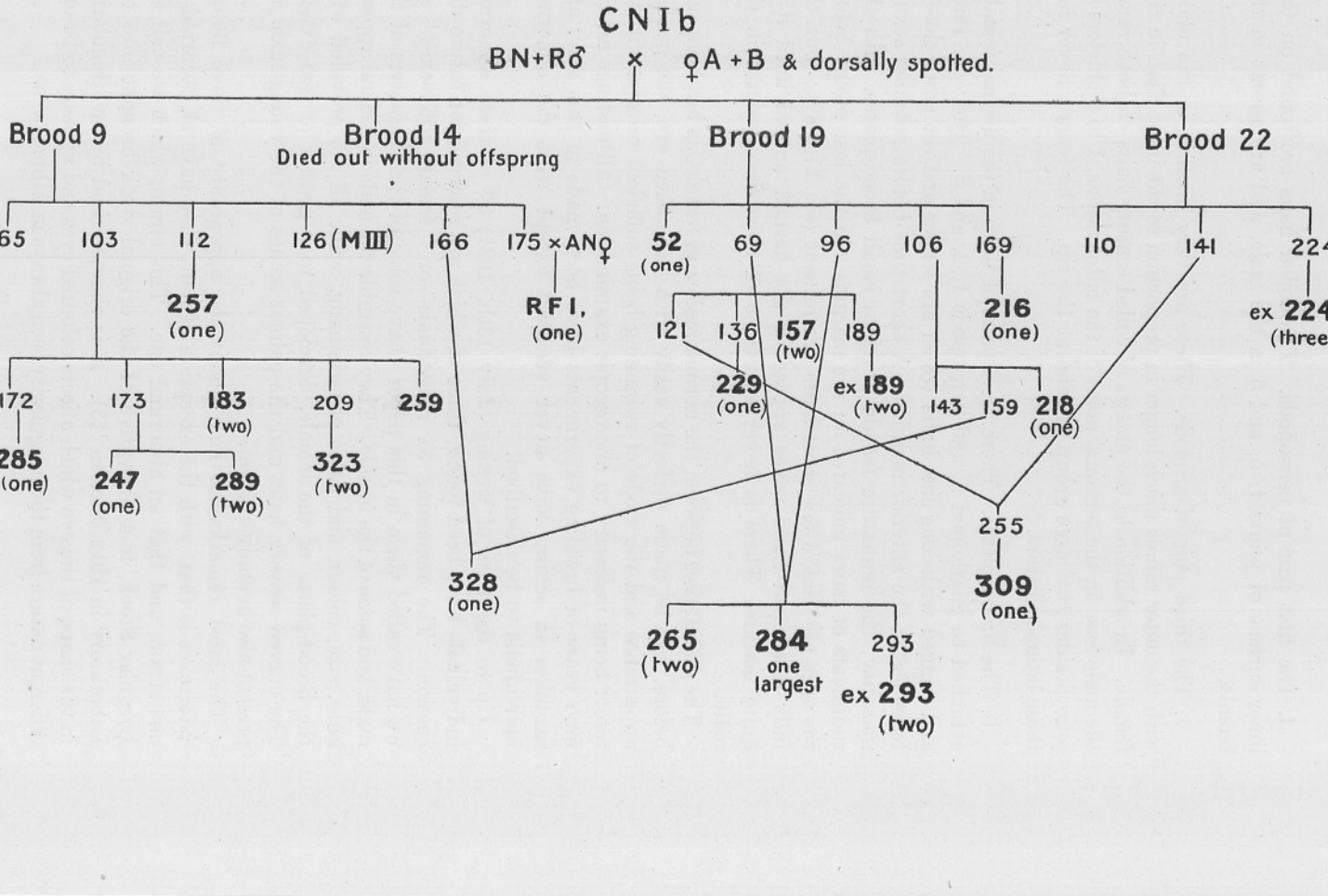
4. The third pair of uropods. These are very massive in the male, with the outer ramus much longer in proportion to the inner than in the female. In addition to the masses of coiled sensory hairs on both rami, the male has, on the terminal point of the outer ramus, 1 to 2 clusters of setæ besides the large group of setæ at the tip. The female never has these lateral clusters.

5. The brood-plates. There are 4 pairs of these in the normal female, attached to gnathopod 2, and peræopods 1, 2, and 3. They are large and fringed with long fine hairs which are longer and set more closely together on the anterior margins. A short time before reaching sexual maturity, the immature female develops small brood-plates, with the rudiments of hairs indicated on the margins ; in the last moult before the eggs are laid, a few short hairs are present (see Fig. 29) ; but the fully developed hairs never appear in the normal animal until it is quite mature. There is never any trace of these brood-plates in the male.

The distinction between the normal male and female, as has been said before, can be made perfectly easily with the naked eye, the general appearance and the mode of swimming being sufficient criteria without resort being necessary to microscopic examination. All matings for the nine years of breeding experiments have been made in this way, and mistakes in sexing have never occurred except with the abnormal individuals to be described.

Up to the time of writing (July 13th, 1921) 35 of these abnormal individuals have been found, three of which are reserved for future discussion. The remaining 31 individuals—or "female intersexes" as we have called them in this paper—have some of the characters of the male, and some of the female. They resemble the male in general appearance, size, colour, and habit of swimming, while all are provided with the brood-plates of the female, developed to a greater or less extent. The curved sensory hairs and the palmar spines of the young male are present also in many of them.

The most remarkable thing about the appearance of these female intersexes is that, with the exception of four, they have all occurred in one strain, and that an abnormal one. This strain, which we call the Irregular Stock, is a derivative of the original stock brought into the Laboratory in 1912 (Sexton '13). It is characterised by an irregularity in the shape of the eye which affects coloured eyes and appears to be of a different nature from the irregularity seen always in Albino eyes.


CNIb
BN+R♂ × ♀A+B & dorsally spotted.
Brood 9
Brood 14
Died out without offspring
Brood 19
Brood 22
65
103
112
126 (M III)
166
175 × AN♀
257 (one)
RF1, (one)
52 (one)
69
96
106
169
216 (one)
110
141
224
ex 224 (three
121
136
157 (two)
189
229 (one)
ex 189 (two)
143
159
218 (one)
172
173
183 (two)
209
259
285 (one)
247 (one)
289 (two)
323 (two)
328 (one)
255
309 (one)
265 (two)
284 one largest
293
ex 293 (two)

It originated from a mating (CN.I.b) of Black No-white male (BbCCww) with an Albino female carrying Black (BBccWW). This female had large dorsal patches and spots, and came of spotted ancestry for 4 generations. The pair gave four broods (see Chart, p. 510); the members of each brood were mated inter se. One brood died out without giving any descendants. A second brood has produced 572 descendants in 5 generations with practically no eye-irregularity (nine showing it in a slight degree) and with only three intersexes.

The 3684 descendants of the two remaining broods have given numerous irregular-eyed individuals, and many intersexes. Whether there is any correlation between the irregularity of eye and of sexual constitution cannot at present be stated.

In addition to the appearance of these intersexes, other variations from the normal have been noted:—e.g. the infertility discussed on page 544; and the cannibalism of the males, which is much worse than in any of the other strains. It is almost impossible to mate the males with the females of the Irregular Stock, and outside mates have to be provided. In consequence of this cannibal tendency, the descendants are comparatively few in number.

As a rule, the intersexes take much longer in reaching maturity than the normal animals, but attain a greater size. Text figure 1 gives a comparison of size of an intersex with the normal male and female—as nearly as possible of the same age.

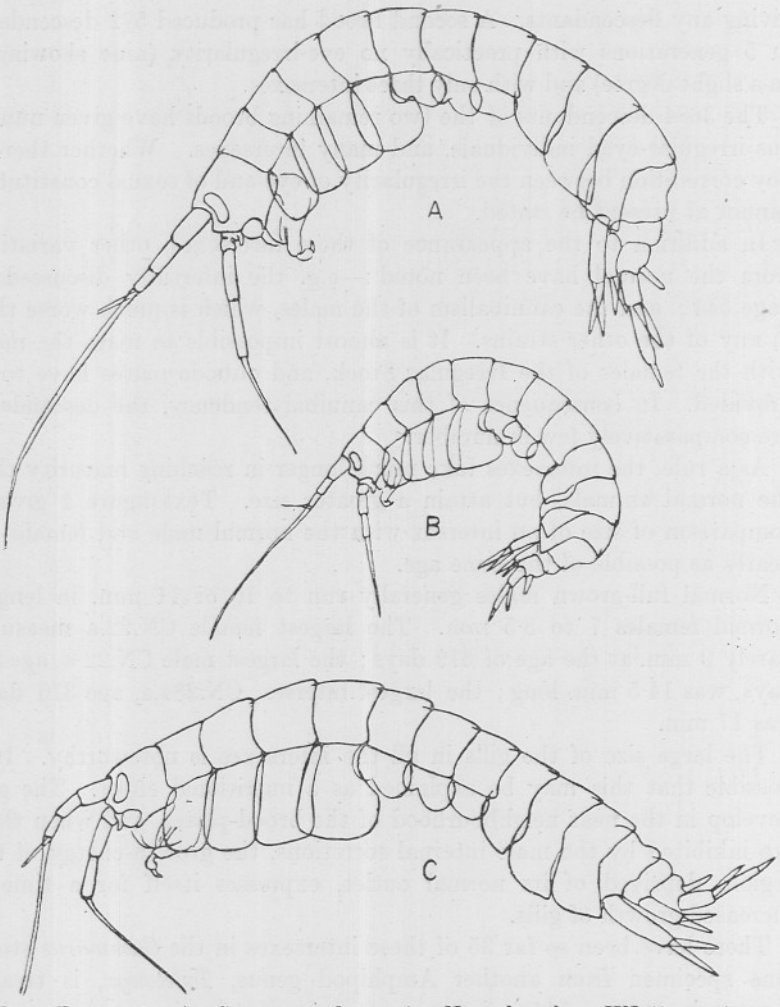
Normal full-grown males generally run to 10 or 11 mm. in length, normal females 7 to 8·5 mm. The largest female CN.22.a measured barely 9 mm. at the age of 679 days; the largest male CN.22·a, age 579 days, was 14·5 mm. long; the largest intersex, CN.284.a, age 310 days, was 17 mm.

The large size of the gills in all the intersexes is noteworthy. It is possible that this may be explained as a nutritional effect. The gills develop in the near neighbourhood of the brood-plates, and when these are inhibited by the male internal secretions, the growth-energy of this region, deprived of its normal outlet, expresses itself for a time in increased growth of gills.

There have been so far 35 of these intersexes in the *Gammarus* stock. One specimen from another Amphipod genus, *Tmetonyx*, is treated separately on page 544.

The *Gammarus* intersexes, while all resembling the male in general appearance, size, colour, and habit of swimming, fall into three groups according to the degree of development of the brood-plates. These groups each again divide into sub-groups according to the "more" or "less male" character of the second gnathopod hand. In some the palmar row is distinctively female, all the setæ being of the rigid serrated

type ; in others one hand, usually the right, is more male than the other, and carries one or more sensory spines with the serrated setæ in the row ; in others again both hands have these spines, and in one or two specimens, the most male of all the intersexes, there is a sensory spine in the middle



TEXT FIGURE 1.—A. *Gammarus chevreuxi*. Normal male. HN.50.a. Age 332 days. × 8. B. Normal female. CN.136. Age 355 days. × 8. C. Intersex. HN.50.a. Age 331 days. × 8.

of the palmar margin, as in the young immature male (cf. Fig. 3 with Fig. 103).

That it is possible for an animal to pass from one sub-group (" less male ") to another (" more male ") as its age increases, has been proved e.g. in the case of specimen 6, CN.229h., in Group II, p. 523.

Not much is known as to the possibility of the intersexes mating; as a rule they are so male in appearance at maturity that they are recorded as males with a query, and females have been put into their bowls to test them. The moults are usually too fragmentary for any evidence as to sex to be deduced from them, and by the time the animals are recognised as female intersexes they are too old to breed.

One specimen in Group I, HN.50.a., laid eggs three times, but none hatched. Another in Group II, CN.216.b., mated with a male, with no results, being probably too old; whilst a third one, CN.259.b., Group II, page 521, mated and hatched 2 very remarkable young, but there is some doubt as to whether this animal was an intersex at the time the eggs were laid, or whether it developed intersexuality later. It did not show any sign of an ovary after the young were extruded from the pouch, although it moulted and mated twice afterwards. At its death, three months later, its brood-plates were found to be of the partially developed type, and one hand was more male than the other.

The groups are as follows :—

Group I. Animals with fully developed brood-plates, with the fringing hairs of normal length, but with some male characters, notably the third uropods.

There are 2 specimens in this group, both of the " more male " type, one more so than the other.

1. HN.50.a. (text fig. 1). Gnath. 2, right hand more male than left, 1 sensory spine developed; gnath. 1, both hands with one spine extra below; third uropods of the male type, and with curved sensory hairs, 2 lateral clusters; mated and laid eggs.
2. CN.224.a_3. Gnath. 2, both hands with 1 sensory spine developed; gnath. 1, both hands with an extra spine below; third uropods of the male type, no lateral clusters; sectioned.

Group II. Animals with partially developed brood-plates, i.e. the brood-plates nearly normal in size, but with a greater or lesser number of the fringing hairs rudimentary, those that are developed being usually on the posterior margins. There are 14 specimens in this group, 2 in Sub-group A (the " less male " class) with serrated setæ on the second gnathopod; 1 which hatched young; 1 which passed from the " less male " class to the " more male," developing sensory spines; 10 in Sub-group B, the " more male " class, 1 of which mated; and 1 the most male of all the intersexes, CN.183.m., which had the spines of the immature male, and only 1 or 2 hairs on brood-plate 4.

In Sub-group A the 2 specimens are :—

3. CN.293.a_2 and 4 CN.157.a_1. Both were sectioned (text fig. 4). Both had, on the left hand of gnath. 2, a rigid seta inset, apart

from the angle-row; third uropods of large size, with latera clusters.

5. CN.259.b. (Plate V) which hatched two young.

6. CN.229.h. (Plates VI and VII) is figured in detail to show the development from the female type of hand to the more male type; sectioned.

In Sub-group B are:—

7. CN.189.a_1. Gnath. 2, both hands with 1 sensory spine developed; gnath. 1, no extra spines; brood-plates with a few small hairs on first two pairs; 1 lateral cluster on uropods.

8. CN.224.a_2. Gnath. 2, right hand more male than left, with 1 sensory spine developed; gnath. 1, right hand with 1 extra spine below; brood-plates with a few very small hairs on first two pairs; 1 lateral cluster on uropods; sectioned.

9. CN.265.b. Gnath. 2, both hands with 2 spines developed; gnath. 1, both hands with 1 extra spine below; a few very small hairs on fourth brood-plates only; 1 lateral cluster on uropods; 2 lateral clusters developed three months later.

10. CN.189.a_2. Gnath. 2, both hands with 2 sensory spines developed; gnath. 1, both with 1 extra spine below; brood-plates with a few small hairs, most on first two pairs; 2 lateral clusters on uropods.

11. CN.216.b. Gnath. 2, right hand with 3 sensory spines developed, left hand with 2 sensory spines, 1 of which is in mid-margin as in immature male; gnath. 1, both hands with 1 extra spine below; a few small hairs on the brood-plates; third uropods of the adult male type, 1 lateral cluster. Mated with a male; sectioned.

12. CN.289.a. Gnath. 2, right hand missing, left hand with 2 sensory spines developed, and 1 below the angle-row (the only instance of this, fig. 98); gnath. 1, both hands with 1 extra spine below; brood-plates with hairs all present but unequally developed; uropods very massive, of male type, 3 lateral clusters on one, 2 on the other.

13. CN.247.d. Gnath. 2, right hand with 2 sensory spines, left hand with 1 developed; gnath. 1, both hands with 1 sensory serrated seta extra on upper and under sides of palmar angle; brood-plates with numerous hairs; differs from the others in having the hairs of the last two pairs better developed than in the first and second pairs; uropods with 2 lateral clusters; sectioned.

14. CN.265.a. Right hand with 2 sensory spines developed, left hand

with 1, left hand also carries a stout seta inset in mid-margin ; gnath. 1, both hands with 1 spine extra below ; a very few small hairs on the brood-plates, most on the first two pairs ; uropods with 3 lateral clusters on one, 2 on the other.

15. CN.284.a. Right hand with 3 spines, and 1 spine inset in mid-margin, claw impinging against the under surface of palm ; left hand with 3 spines ; gnath. 1, both hands with 1 extra spine above and 2 below ; hairs on first two pairs of brood-plates ; uropods nearly as large as in oldest adult male, 4 lateral clusters, 1 plumose hair in 2 of the clusters, the only instance of this. The largest specimen of *G. chevreuxi* yet seen.

16. CN.183.m. The most male of all the intersexes ; curved hairs on second antenna ; gnath. 2, right hand 2 spines in angle-row, and 1 inset in mid-margin as in immature male ; left hand 2 in angle-row and 1 stout sensory seta in mid-margin ; right hand with 1 extra spine below ; gnath. 1, right hand with 1 sensory spine in mid-margin, 3 in angle-row, with 2 extra spines below ; left hand with 4 spines in angle-row, and 1 extra below. Only 2 or 3 very tiny hairs developed on fourth brood-plates ; third uropods of male type, more spinose than usual, with 2 lateral clusters on each.

Group III. Animals with the small brood-plates of the young immature female, the hairs quite rudimentary.

There are 15 specimens in this group, 7 in Sub-group A, 1 of which passed to Sub-group B, and 8 in Sub-group B.

Sub-group A, the " less male " type :—

17. R.F.1. Gnath 2, both hands with 4 serrated sensory setæ ; gnath. 1, not known, uropods comparatively small, 1 lateral cluster on each uropod.

18. CN.289.f_3. Gnath. 2, both hands with 5 serrated setæ ; gnath.1, both hands with 1 serrated seta extra below ; 1 lateral cluster on the right uropod.

19. CN.157.a_2. Gnath. 2, right hand with 5, left hand with 4 serrated setæ ; gnath. 1, no extra spines ; 1 lateral cluster on right uropod, left missing.

20. CN.257.d. Gnath. 2, both hands with 6 serrated setæ, 1 a little apart on left hand ; gnath. 1, both with 1 spine extra below ; no lateral clusters on uropods.

21. CN.309. Gnath. 2, both hands with 6 serrated setæ ; gnath. 1, no extra spine ; no lateral clusters on uropods.

22. CN.323.a_1. Gnath. 2, left hand with 6 serrated setæ; gnath. 1, both hands with 1 spine extra below, right hand with 1 extra spine above also; no lateral clusters on uropod.

23. CN.323.a_2. Gnath. 2, right hand with 6 serrated setæ, left hand with 8 setæ, 7 in the angle-row and 1 apart; gnath. 1, with 1 extra below (sensory seta on right hand, spine on left), left hand with 1 extra spine on upper surface also; 1 lateral cluster on left uropod, 2 on right. Two months later this specimen had passed from Sub-group A to Sub-group B.

Sub-group B, the " more male " type :—

24. Abn.Exp.3. Gnath. 2, right hand not known, left hand with 1 sensory spine developed; gnath. 1, right hand not known, left hand, no extra spine; uropods very large, 2 lateral clusters on each.

25. Abn.Exp.4.

26. CN.183.c. Gnath. 2, right hand with 1 sensory spine developed; gnath. 1, right hand with 1 extra spine below, left hands missing; antennæ of the immature male type, with curved sensory hairs; one uropod missing, no lateral clusters on other; sectioned (text fig. 5).

27. CN.224.b. Gnath. 2, both hands with 1 large sensory spine, a little apart from the angle-row; gnath. 1, both hands with 4 spines above, and 1 extra spine below; uropods regenerating, left one with 2 lateral clusters.

28. CN.52. Gnath. 2, right hand with 2 sensory spines, 1 in angle-row and 1 inset in mid-margin, left hand with 2 in angle-row, and 1 serrated seta in mid-margin; gnath. 1, not known; uropods, 1 lateral cluster on left, more spines than usual on right; sectioned (text fig. 6).

29. CN.293.a_1. Gnath. 2, right hand with 2 sensory spines developed, left hand with 3, i.e. 2 in angle-row and 1 inset apart in mid-margin; gnath. 1, left hand with 4 spines in angle-row and 1 extra below; uropods with 2 lateral clusters; sectioned.

30. CN.285.a. Gnath. 2, both hands with 3 sensory spines developed, left hand with 2 extra spine-like sensory setæ below; gnath. 1, both hands with 1 extra spine below, left hand with 1 extra spine above also; uropods with 2 lateral clusters.

31. CN.218.b. Gnath. 2, 3 sensory spines developed on each hand, 1 on right hand inset apart in mid-margin; right claw impinging against under surface of hand (the second instance of this, cf. spec. 15); gnath. 1, both hands with 1 spine extra below; uropods very spinose, with 2 large lateral clusters.

The life-history of the different specimens is given below :—

Group I, Sub-group B.

Specimen 1. HN.50.a. (see text fig. 1, p. 512).

The male parent of this specimen was a Black No-white (BBCCww) from the original stock (brought into the Laboratory June, 1912). Its female parent was derived from a pure wild stock (BBCCWW), brought into the Laboratory in 1915, in which the " Gradual No-white " strain developed. When hatched, her eyes were Black, with the normal white reticulation, and she had large white dorsal patches. Later she became almost completely No-white, the dorsal patches fading out also.

On 18 August, 1919, a brood of 20 was produced. Only 5 came to maturity, 1 male, 3 females, and 1 " intersex." The 3 females mated normally and produced normal young. The intersex was first entered as " female," but grew more male in appearance as time went on. It mated repeatedly with two mates, but only produced eggs three times ; these eggs were all infertile. The eggs were laid on 20 March ; 6 April ; and 12 June, 1920. On the first two occasions a normal number was produced ; but on the last occasion it was noted that only 2 or 3 eggs were extruded into the pouch. The specimen was then very large, and on examining it microscopically on 3 July, 1920, the entry was made " looks like a male, no ovary seen." It died on 14 July, age 331 days, length 11 mm., as compared with about 8 mm. for a normal female of such an age.

This intersex was as large as the male in the same brood (see text fig. 1) and indistinguishable from it except by microscopic examination. Although younger than the normal female, it was much larger and its brood-plates were even better developed. The first brood-plate, e.g. had 38 hairs fringing it, compared with the 33 of the normal animal (fig. 1. B). The brood-plate was as large, in fact, and had as many hairs as that of female CN.22.a. This, the oldest female we have had, died at the age of 679 days, after having hatched 227 young in 15 broods.

First antennæ broken. Second antennæ large and setose ; flagellum 17-jointed.

The gnathopods are as large as those of the young mature male (Plate II), and much more setose, but have no curved sensory hairs.

Gnath. 1. The hand as long as in the young male, but wider ; palm slightly oblique, with the usual row of 3 sensory spines, 1 long and 2 short, inset on the upper side of the palmar angle ; on the under side, an extra spine is developed on each hand, as in the immature male (cf. Fig. 51). The normal female never has more than the usual pair of spines on the under surface of the hand.

Gnath. 2. The hands are very large and wide; palm slightly oblique; the right hand more male than the left (cf. Figs. 54 and 56). The row at the palmar angle consists of 1 large pointed sensory spine, and 3 rigid serrated sensory setæ on the right hand; on the left is a graduated row of the rigid sensory setæ, as in the female, 5 in number, the fifth very small; both hands have the usual pair of sensory spines on the under side.

The gills are very large, longer, and wider than in the normal male of the same brood, extending to below the fourth joint in peræopod 2.

The third uropod on the left side is broken; that on the right side is very remarkable. It is nearly a third as long again as in the young mature male (Fig. 20), whilst, compared with the uropods of fully adult males, it is very nearly as long as and more massively built than that of its normal brother HN.50. at the same age, 331 days, though with fewer clusters of setæ; compared with that of the oldest male, CN.22.a., 579 days (Fig. 12), it is three-quarters its length, almost as wide, with the same number and position of spines, but with only half the number of setæ-clusters on the margins; on the other hand it has 2 lateral clusters of setæ on the terminal joint of both outer rami. It is densely setose, and carries a large number of very long, delicate, curved sensory hairs, as does the immature male.

Specimen 2. CN.ex.224.a_3. F_3 from CN.I.b. Irregular Stock.

Four survivors were found in the brood-bowl February 8, 1921—two normal females, one with a rudimentary ovary and very large gnathopods of the female type, and one with no ovary visible but with female characters (Spec. 8). These two were put in a separate bowl. By February 28 they were seen to be intersexes, and could not then be distinguished from each other, as the ovary before noted had completely disappeared. They increased rapidly in size. On May 14 they were preserved and examined.

This specimen measured 9 mm. Its brood-plates were large, of perfect form, with all the hairs present and of normal length; on the left side, 25 on the first brood-plate, 17 on the second, 12 on the third, and 9 on the fourth.

First antenna with 29–jointed primary, and 5-jointed accessory flagella. Second antenna, large, densely setose; flagellum 17-jointed.

Gnathopods very large, densely setose.

Gnath. 1. Both hands, as in the preceding specimen, carry an extra spine on the under side of the palmar angle.

Gnath. 2. The hands in this animal are more male than in Spec. 1, both having developed 1 large sensory spine in the angle-row in addition to the 3 serrated setæ. The right hand has the 2 sensory spines on the

under side, but in the left hand the second spine is not fully developed (cf. Fig. 39).

Third uropods very large and massive, as large as in Spec. 1, but with no curved hairs nor lateral clusters developed.

This animal was sectioned; the gonads showed asymmetrical differences in size, the smaller ovary about the same as in text fig. 6, the other one more developed.

It is not known if this animal could have mated, as did HN.50.a. It looked so male, after February 28, that it was kept under observation to see if the male hairs would develop, in order to try it with a female. The moults were eaten at once, and so the brood-plates were not seen until the animal was dissected.

Group II, Sub-group A, the "less male" type.

Specimen 3. ex CN.293.a_2. F_4 from the Cross CN.I.b. Irregular Stock.

On February 9, 1921, three survivors were found in the brood-bowl, 1 Black irregular-eyed male, and two others, this specimen and Spec. 29.

This one was entered as "normal eyes. Intersex? No ovary visible, but microscopic examination (1 inch) showed a transparent mass full of tiny dark specks lying on top of the intestine." By March 11 this had gone. On May 14, 1920, it was preserved; it then measured 10·5 mm.

The antennæ and gnathopods are large and very setose; second antenna with 19-jointed flagellum.

Gnath. 1. The left hand has the usual cluster of 3 spines at the angle, but in the right there are only 2 of the spines, and 1 rigid seta; both with the usual pair below.

Gnath. 2. The right one was broken at the 3rd joint. The left hand has the graduated angle-row of 4 rigid setæ, and, in addition, 1 by itself inset nearly in the middle of the palmar margin (Fig. 95). It is interesting to note that this same feature occurs in the other specimen of this class, CN.157.a_1.

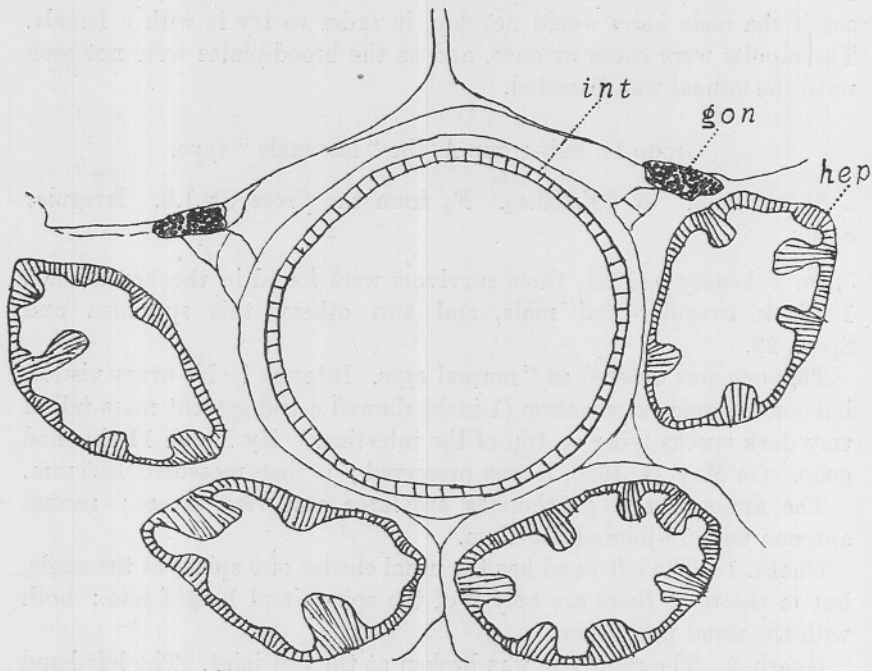
The first two pairs of brood-plates show all variations in the size of the hairs, from the quite rudimentary to the quite normal; on the third and fourth pairs the hairs are all rudimentary; 31 hairs on the first pair, 22 on the second, 12 and 13 on the third, and 8 on the fourth.

The third uropods are very large with 2 lateral clusters on the terminal joint, right side, 3 lateral clusters on the left.

Sections show gonads resembling those of the next specimen (CN.157.a_1.) in structure, not as large, with an occasional oocyte; larger than in its sister intersex, Specimen 29.

Specimen 4. CN.157.a_1. F_3 from the Cross CN.I.b. Irregular Stock.

One of a brood of 28, extruded December 15, 1919, of which two only came to maturity, this the larger one and Spec. 19, both intersexes and both irregular-eyed. On March 30, 1920, it was entered as "female." Placed with three different males it did not mate. It was examined on July 7 and again marked as "female," but it gradually grew more masculine in appearance and on August 24 the entry was made "no sign of ovary,



TEXT FIGURE 2.—Transverse section of normal male, where the gonad is of maximum size. The testes are very small and dense. *Int.* = intestine, *gon.* = gonad, *hep.* = hepatic cæcum. Reichert, $\frac{1}{12}$" objective, No. 4 ocular, drawing at table level. J.S.H. del.

looks like a male." It was preserved and sectioned on August 30, age 260 days.

First antenna with 31-jointed primary, and 5-jointed accessory flagella. Second antenna, large, massive and very setose; 15-jointed flagellum.

Gnathopods half as long again, as in its sister intersex, Spec. 19.

Gnath. 1. The right hand has, in the angle-row, 2 sensory spines and 1 small serrated seta, as in the preceding specimen; with 1 very stout serrated seta below. The left hand has the usual number, 3 sensory spines on the upper surface of the angle, and 2 below.

Gnath. 2 has on each hand 4 of the rigid serrated setæ of the female type ; those in the graduated row of the right hand larger and stouter than in the normal female ; on the left hand they are of the usual slender form, but the longest of the four is separate from the others, inset nearly in the middle of the palm, as in the preceding specimen (cf. Fig. 95) ; the usual pair of large sensory spines below.

The brood-plates show all variations in the length of the hairs, from the quite rudimentary to some of almost normal length ; first brood-plate with 31 hairs, most of them rudimentary, 5 of the posterior ones partly developed.

Third uropods large and massive, with 2 lateral clusters on the terminal joint, right side, 1 lateral cluster on the left.

The gonads are shown in text fig. 4. They are nearly as large as in a normal female. Ova with yolk grains are present, and an occasional oocyte is seen. The two ovaries differ from each other in size more than in a normal female. (Compare with text figures 2 and 3.)

Specimen 5. CN.259.b. F_3 from CN.I.b. Irregular Stock.

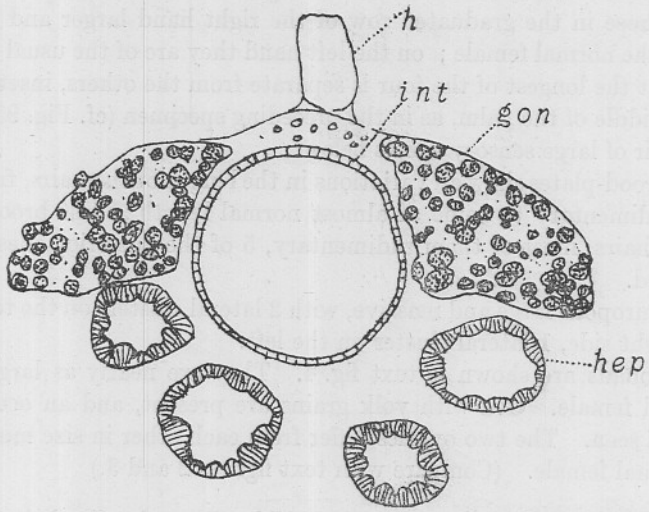
One of a brood of 16 Black-eyed young, extruded June 4 and 5, 1920, of which only 6 had normal eyes. This specimen had the left eye irregular. on September 6 it became mature, a female ; and a male from the same brood was added ; the male had both eyes irregular. The female moulted on September 21, mated, and laid eggs ; on October 6, 2 young were extruded from the pouch. Both of these were very remarkable, having very irregular eyes, and one with its head malformed also ; the right eye in each was black, the left eye white.

On October 7 the female moulted and mated ; no eggs were laid ; the male moulted on October 8. The animal was examined microscopically on October 14, as no ovary had been seen since the extrusion of the young. None developed after this date, although it mated, and moulted again on October 26. As it looked ill on Nov. 9, it was removed to a separate pot ; moulted again on November 15 ; it was later marked as " intersex ? " and kept under daily observation till its death on March 10, 1921. Its last moult was on March 3, from which it did not recover. Length 11 mm., age 280 days.

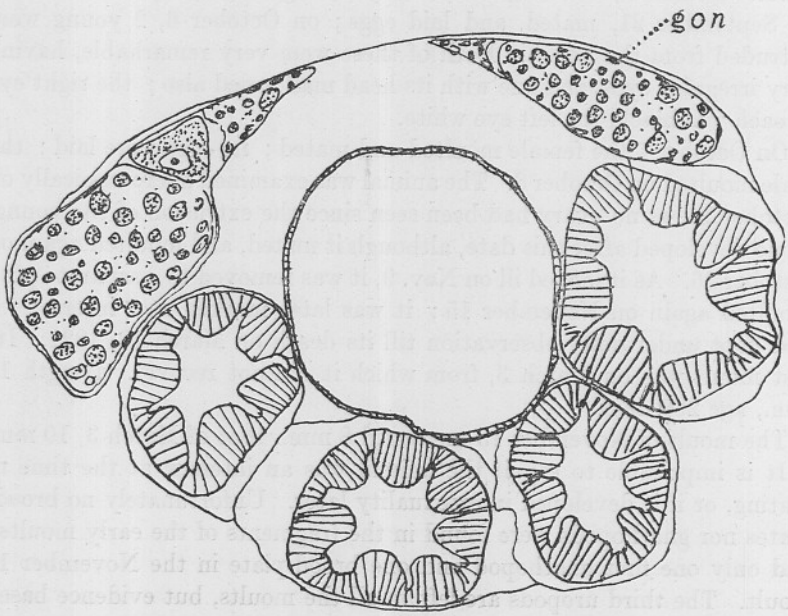
The moult of November 15 measured 8 mm., that of March 3, 10 mm.

It is impossible to say if the animal was an intersex at the time of mating, or if it developed intersexuality later. Unfortunately no brood-plates nor gnathopods were found in the fragments of the early moults ; and only one first gnathopod and one brood-plate in the November 15 moult. The third uropods are left in all the moults, but evidence based on these is not enough (Figs. 68 and 69).

First antennæ, both diseased in all the moults. Second antennæ very



TEXT FIGURE 3.—Transverse section of normal female, where the gonad is of maximum size. Large ovaries containing eggs loaded with yolk. Magnification, etc., as in text fig. 2; *h.* = heart. J.S.H. del.



TEXT FIGURE 4.—Transverse section of intersex. CN.157.a_1., where the gonad is of maximum size. Magnification, etc., as in text fig. 2. J.S.H. del.

large, about as large as Fig. 81, and densely setose, with a great number of long sensory hairs, one or two lightly curved ; tips of both flagella regenerating, 15 joints on left one.

Gnath. 1. Only the right hand was found in the moult of November 15, 1920 ; 2 spines on the upper surface of the palmar angle, 1 spine and 1 sensory serrated seta below. On March 3, 1921, 3 spines were found on the upper side, and, on both sides, 1 extra spine was developed below on the under surface, besides the usual pair.

Gnath. 2. March 3, 1921, right hand with the angle-row composed of 1 sensory spine, and 5 serrated setæ, the spine coming second in the row (Fig. 54) ; left hand with 5 stout serrated setæ in the row ; both hands with the usual pair below ; many long sensory hairs, but none curved.

Brood-plates. The fourth brood-plate, left side, from the moult of November 15, 1920, was the only one found in the early moults (Fig. 57) ; it may be compared with the same brood-plate in Figs. 62 and 67. The brood-plates of the March 3 moult, and of the dead animal March 10, are figured to show the curious changes in the length of the hairs at different moults.

Third uropods, Figs. 68 and 69 ; proportions are the same in all the moults ; the number and arrangement of the spines also (2 on the inner ramus margin, right side, and 3 on the left) ; the setæ-clusters have increased in number ; no lateral clusters.

Specimen 6. CN.229.h. F_4 from CN.I.b. Irregular Stock (Plates VI and VII).

This animal is very interesting, in that we have been able to trace its change from the typical " less male " Sub-group A to the typical " more male " Sub-group B.

One of a brood of 25, extruded May 12, 1920, many of them irregular-eyed ; 2 normal males and I female came to maturity besides this intersex. The males ate several females each ; the female mated and was eaten by her mate. The intersex developed slowly at first, but on August 26 it was very large, as large as its normal brother from the same pot and was marked " male." A female was added but no mating took place so, on October 13, it was examined microscopically, " no ovary ; looks exactly like a male, and swims in the characteristic manner, but the setæ and gnathopods are of the intersex type, no male hairs ; very large, 9·5 mm." It was then larger than its normal brother, which did not reach that size till November 12, 1920.

It moulted September 9 ; October 11 ; October 26 ; November 13, 1920 ; and small fragments of moults were found on March 16, 1921 ; April 8 ; and April 30. On May 14, 1921, it was preserved and sectioned, age 367 days, length 10·5 mm.

The moult of October 26, 1920, is perfect, 9·5 mm. long. It has been figured for comparison with the dead animal, about 6 months older (Plates VI and VII).

The first and second antennæ were attacked by disease, and although continually regenerating during the animal's life, they never reached the normal length.

First antennæ; on October 26, primary flagella 25-jointed, accessory 4-jointed. On May 14 primary flagella with 34-joints, and accessory flagella with 5.

Second antennæ, large, densely setose. On May 14, many sensory hairs were seen, but none curved; flagella broken or diseased in all the moults.

Gnath. 1. October 26, right hand with 3 sensory spines and 1 small serrated seta on the upper side, left hand with 4 spines; both with the usual pair below, right side having 1 small serrated seta extra. On May 14, both hands had 4 spines in the angle-row; the usual pair below, right hand with 1 seta extra, left hand with 1 spine extra. There is an extra hair on the back of the claw of the left hand.

Gnath. 2. The greatest change will be seen in this appendage. On October 26 both hands had 6 of the rigid sensory serrated setæ in the angle-row (the sixth very small); and the usual pair below. On May 14, the angle-row on the right hand consisted of 4 sensory spines (the first not fully metamorphosed), and 2 very stout spine-like serrated setæ, with 2 small ones a little behind the line. The left hand (Fig. 87, cf. also Fig. 54) had the same number in the row, but the first is a stout spine-like seta (not so far advanced as in the right hand), 2 large sensory spines, and 3 serrated setæ, with 1 small seta behind the line; the usual pair of spines below in both hands.

The delicate sensory hairs are well developed (October 26 and May 14), but none are curved. It will be seen, especially in Fig. 88, that the palmar row of hairs on May 14 is approaching the male type, the hairs massing together in a cluster, and not spreading out in a line as in the normal female.

Gills very large, extending, in peræopod 3, on October 26, to below the margin of the third joint.

Brood-plates (Figs. 78 and 79). The hairs are quite rudimentary on the first three pairs; a very few small hairs are developed on the fourth pair (cf. also CN.265.b., and CN.183.m.). The number of hairs was, on October 26, 30 and 28 on the first pair; 18 and 17 on the second; 10 and 9 on the third; 6 and 8 on the fourth. On May 14, there were 35 on the first pair; 20 on the second; 11 on the third; and 9 on the fourth.

Third uropods. On September 9, 1920, both of these were alike, with

1 spine on each side of the two inner rami ; on October 11, the right side had 2 spines on the outer margin of the inner ramus, the left had 1 ; on October 26, there was no increase in spines, nor in setæ-clusters, only in size, but 1 lateral cluster had developed on each terminal joint, outer rami ; November 13, no change except in size ; on March 16, 1921, the right side had 2 spines, the left, 3 ; 2 lateral clusters on each terminal joint ; great increase in size and in number of setæ ; on May 14, larger, but no other change.

Sections show very small gonads, with some rudimentary oocytes present.

Sub-group B, the " more male " type.

Specimen 7. ex CN.189.a_1. F_4 from CN.I.b. Irregular Stock.

On January 22, 1921, six animals were found in the brood-bowl, 3 normal females and 3 others larger, which were then marked as " male ? no sign of ovary." They were left together to mate. On January 28, on examining them again, the three were seen to be intersexes, but so male in appearance that two normal females from another family were put in to test them. No mating occurred, and the females were removed on March 4. By this date, one intersex was eaten, one was dead (this specimen), and one was left, described below as Specimen 10.

The animal was 9 mm. in length.

First antennæ, 29 joints in primary, 6 in accessory flagella. Second antennæ, setose ; 14-jointed flagellum.

Gnath. 1. Both hands with 3 sensory spines on the upper side of the palmar angle and 2 on the under side.

Gnath. 2. In both hands the angle-row consists of 1 sensory spine and 3 stout serrated sensory setæ ; with 1 sensory spine and 1 very stout spine-like seta below.

The brood-plates are barely two-thirds the normal length, the hairs on the first two pairs irregularly developed and short, those on the other pairs quite rudimentary ; 27 on the first brood-plate, 22 on the second, 11 on the third, and 7 on the fourth.

Third uropods of the young male type, but with no curved sensory hairs ; 1 lateral cluster on each terminal joint.

The gills, as is usual in the intersexes, are of great size, reaching, in the second peræopod, well below the third joint of the appendage.

Specimen 8. ex CN.224.a_2. F_3 from CN.I.b. Irregular Stock. Sister intersex of Specimen 2.

On February 8, 1921, it was noted as having " no ovary, but the female type of gnathopod." February 28, " Intersex." On May 14 it was preserved and sectioned ; length 10 mm.

First antennæ, 29 joints in primary, 5 in accessory flagella. Second antennæ large and very setose, with some fine, delicate sensory hairs, but none curved; 6 clusters of setæ on joints 4 and 5 of the peduncle; flagellum 16-jointed.

Gnath. 1. Right hand with a small extra spine developed on the under surface of the palmar angle (cf. Fig. 84).

Gnath. 2. Right hand, as in Specimen 1, has 1 sensory spine and 3 rigid serrated setæ in the angle-row; left hand has a graduated row of 5 rigid serrated setæ; the usual pair of sensory spines on the right hand below, 1 sensory spine and 1 very stout spine-like seta on the left hand (cf. Figs. 39 and 42).

The brood-plates are about three-quarters the normal length with only a few short hairs, mostly on the posterior margins of the first two pairs, those on the other pairs rudimentary; 22 hairs on the first brood-plate, 14 and 15 on the second pair, 9 on the third, and 6 and 8 on the fourth.

Third uropods large and setose, 1 lateral cluster on each terminal joint, larger on the right side.

Sections show the gonads very small, much resembling those of CN.183.c., text fig. 5.

Specimen 9. CN.265.b. F_3 from CN.I.b. Irregular Stock.

From the same brood as Specimen 14, hatched June 15, 1920. It was noted as "exceedingly small" on September 10, when the others in the bowl were mature. On October 4 it was recorded as "male," but on January 28, 1921, it was recognised as an intersex. Died July 12, 1921, age 393 days; length 12·5 mm.

First antennæ with 32 joints in the primary and 8 in the accessory flagella.

Second antennæ very large, with great masses of sensory hairs on the under surface, several of them curved; flagellum 21-jointed.

Gnath. 1. Both hands with 3 sensory spines on the upper side of the angle; 1 extra spine below, in addition to the usual pair.

Gnath. 2. Both hands have 2 large sensory spines and 3 serrated setæ in the angle-row; usual pair below.

The brood-plates are a little more than two-thirds the normal length; the hairs quite rudimentary on the first three pairs; 2 or 3 developed on the fourth pair (Figs. 96 and 97); 31 on the first brood-plate, 20 on the second, 11 on the third, and 6 and 7 on the fourth on March 11; increase in hairs but not in size, July 12th.

Third uropods very large and massive; 1 lateral cluster on each terminal joint March 11; 2 lateral clusters on July 12.

Specimen 10. ex CN.189.a_2. F_4 from CN.I.b. Irregular Stock.

This is a sister intersex of Specimen 7. It moulted on April 6, 1921, the same day as a normal female in the same brood; the moults were microscopically examined and compared. The intersex measured 9·5 mm.; the normal female, 8 mm. It died on May 11, 1921; length 11·5 mm.

First antennæ, both broken in the moult of April 6; on May 11, one had 39 joints, the other 37 joints in the primary, and 5 joints in the accessory flagella. Second antennæ large and very setose, with 3 or 4 rather short curved hairs on the peduncle; flagellum, 15 joints, April 6; 17 joints, May 11.

Gnath. 1. Both hands, with 3 spines in the angle-row; and the usual pair below, with 1 extra spine developed on each hand.

Gnath. 2. In both hands the angle-row consists of 2 large sensory spines, and 3 rigid serrated setæ; both have the usual pair of sensory spines below, but the right hand carries, in addition, a serrated sensory seta facing the second seta of the angle-row (cf. CN.183.m.).

The brood-plates are about three-quarters the normal length; the hairs very small and unequally developed, mostly on the posterior margins of the first two pairs. On April 6 there were 29 hairs on the first brood-plate; 19 on the second (the normal female had 21 very long hairs on this brood-plate); 11 on the third, most of them rudimentary, while the normal animal had 13 very long ones. On May 11, although the intersex had grown larger, the brood-plates were practically unchanged in size; the hairs, however, had increased in number and length, e.g. there were 35 hairs on the first brood-plate, the posterior 7 being all developed (cf. CN.259.b. Figs. 58 and 59).

Third uropods with 3 spines on the margin of the inner ramus right side, 2 on the left; 2 lateral clusters on the terminal joints.

Specimen 11. CN.216.b. F_3 from CN.I.b. Irregular Stock.

One of a brood of 14 Black-eyed, extruded April 24, 1920. Three came to maturity, normal male, normal female, and this intersex which was very slow in development. On October 2 it was marked "female," but two days later, when examined microscopically, it was noted as "male? or intersex? no male hairs on antennæ, but gnathopods look like young male." On October 20, "the gnathopods look more male, and the antennæ have 2 or 3 curved hairs; no ovary." It moulted on November 2 and a fertile female was added to test it. It did not mate; February 7, 1921, "female gone." The moult of April 25, 1921, was examined, and, as partially developed brood-plates were found, a male was put in, on May 2, to see if it would mate. There were no results till May 21, when

mating took place. By the next morning they were separate; no eggs were laid. The male died on May 26, the intersex on May 27, 1921.

On April 25 it measured 11 mm, age 366 days.

First antennæ, May 27, with 40 joints in the primary, 7 in the accessory flagella. Second antennæ as large as those of the adult male, densely setose, with many long fine sensory hairs, and 2 or 3 curved ones; flagellum 18-jointed.

Gnathopods very large and setose, the setæ exceedingly numerous and long with many of the fine sensory hairs on the under surface.

Gnath. 1. Both hands with 3 spines at the palmar angle, one unusually long, and two smaller, divergent; an extra spine below on each hand; this spine was also found in the moult of April 25.

Gnath. 2. The right hand, April 25, had in the angle-row 3 large sensory spines and 4 serrated setæ; with the usual pair of spines below. It was missing on May 27, the appendage having been broken at the third joint. In the left hand of this date, the angle-row consists of 1 large sensory spine, and 3 stout serrated setæ; in addition it has another large sensory spine, separate from the row, in the middle of the palmar margin as in the immature male (cf. also Fig. 106); the usual pair of sensory spines below.

Peræopod 1, very massive and setose with some long fine sensory hairs as in the gnathopods, but none curved.

The brood-plates are about two-thirds the normal length, all with a few short hairs developed, mostly on the posterior margins, the other hairs quite rudimentary. On April 25 the first brood-plate had 29 hairs, the second 17, the third 11, and the fourth 6; the number slightly increased May 27.

Third uropods exceptionally large and setose, of the adult male type and proportions, with a great number of long fine sensory hairs, a few lightly curved; 1 lateral cluster on each terminal joint.

Sections show the gonads, very small, loose and irregular in structure, very like text fig. 6.

Specimen 12. CN.289.a. F_4 from CN.I.b. Irregular Stock.

It was extruded on July 17, 1920; one of a brood of 13 Black-eyed young, of which only four were normal-eyed. Five reached maturity; 2 males, one reserved for future discussion grew very slowly, the other developed disease; 1 female, also with disease, and 2 intersexes, Spec. 18 and this specimen, very large and healthy.

On October 19 it was marked as "male," but on November 24 microscopic examination showed that it had none of the typical male hairs. It was therefore recorded as an intersex, and a female was added to see

if it would mate. In the pot it looked so exactly like a male that it was taken out at frequent intervals and examined for the male characters. It devoured its moults so quickly that it was not till April 7 and April 25 that enough fragments were found to prove that it was not a male.

The fragments consist of the second antennæ, the terminal joints of the two gnathopods, and first peræopod, some of the brood-plates and gills, and the third uropods.

Second antennæ large and very setose, long sensory hairs but none curved ; flagellum 19-jointed.

Gnathopods very large and setose.

Gnath. 1. With the usual 3 spines on the upper side of the palmar angle ; 1 extra spine developed below.

Gnath. 2. Right hand missing. Left hand with 8 clusters of setæ on the posterior margin (7 on the fifth joint) ; angle-row composed of 2 large sensory spines and 4 serrated setæ. It carries another spine on the upper surface, below the angle-row (Fig. 98), the only instance of a spine being found in such a position ; 1 extra spine developed below.

Peræopod 1 also resembles that of the immature male, with 3 or 4 long curving sensory hairs.

The gills are very large. The brood-plates are almost perfect, the fringing hairs all present, but unequally developed, those at the tips being very small.

Third uropods are about as large as in Specimen 1, much more setose, with more spines and with some long fine sensory hairs. They are very massive ; 3 lateral clusters on the terminal joint, right side, 2 on the left side.

This specimen is still alive (July 13, 1921) and has been placed with a male to see if it is capable of mating.

Specimen 13. CN.247.d. F_4 from CN.I.b. Irregular Stock.

One of a brood of 14 Black-eyed, extruded 26 May, 1920. It had both eyes irregular ; developed very slowly ; on September 11 marked "small male." It moulted on September 14 and a female was added. No mating occurred, and on the 15th it was examined microscopically and seen to be an intersex. By October 23 it had increased greatly in size, and looked exactly like a male ; no sign of ovary. A female, put in to test it, was eaten. On May 14, 1921, it was preserved, age 354 days, length 10 mm.

First antennæ, both broken ; longer primary flagellum 30-jointed, longer accessory, 6-jointed. Second antennæ very setose ; 8 clusters of setæ on joint 4, 9 on joint 5 of the peduncle, left side ; flagellum 17-jointed.

Gnathopods large and very setose, setæ of a great length.

Gnath. 1. Both hands have a stout serrated seta at the palmar angle in addition to the 3 spines, that on the right hand being more spine-like than the one on the left ; 1 slender serrated seta extra on the under side.

Gnath. 2. Angle-row on the right hand consists of 2 large sensory spines and 4 rigid serrated setæ ; on the left hand, of 1 sensory spine and 5 of the rigid setæ ; usual pair of spines below.

Gills of great size.

The brood-plates are interesting, varying from those previously described in having most of the hairs on the hinder pairs developed, many of normal length, while those on the first pair of brood-plates are nearly all rudimentary ; 34 on the first, 25 on the second, 14 on the third, and 10 on the fourth.

Third uropods with 2 lateral clusters on each terminal joint.

Sections show the gonads very little developed, about the same development as in text fig. 5.

Specimen 14. CN.265.a. F_3 from CN.I.b. Irregular Stock.

One of a brood of 26 Black-eyed, extruded on June 15, 1920 ; sister intersex of Specimen 9. It developed very slowly at first. On January 31, 1921, it was marked " Intersex ? No ovary seen." It is still alive, (July 13), and now very large ; the moult of May 11 measured 12 mm. A male has been added to see if it will mate.

Second antennæ large and setose ; flagellum 18-jointed.

The gnathopods are very interesting, showing the development of extra spines on all the hands.

Gnath. 1. Both hands with 4 spines in the row on the upper surface of the angle ; the usual pair below and 1 extra spine developed.

Gnath. 2. Right hand has the angle-row composed of 2 large spines and 3 stout serrated setæ, with an extra spine developed on the under side ; the left hand has in the angle-row 1 large spine and 4 stout setæ, but in addition it carries 1 long stout spine-like seta inset in mid-margin (cf. Fig. 108). In the moult of July 6 the left hand has 2 spines and 3 setæ in the angle-row.

The sensory hairs on the under surfaces of the joints are short but lightly curved.

The brood-plates have only a very few short hairs developed ; the rest quite rudimentary ; 35 and 36 on the first, 22 and 23 on the second, 11 and 12 on the third, and 9 on the fourth pair.

Third uropods large and massive, very setose with 3 lateral clusters on the terminal joint, right side, 2 on the left.

Specimen 15. CN.284.a. F_4 from CN.I.b. Irregular Stock. Figs. 99, 100 and 101.

One of a brood of 37 Black-eyed, extruded on July 9 and 10, 1920. On January 24, 1921, three animals were found in the brood-bowl, 2 normal females and this specimen marked " very large male ? " Two males were put into the bowl with the intersex, and at first it looked as if there would be a mating, the intersex and one of the males following each other about for several days, continually meeting and touching each other with their antennæ. However, no mating occurred. On February 7, it moulted and was then larger than the males. Another male was added on May 11, with no results. The intersex moulted on May 12, the moult measuring 14·5 mm. It died on May 25, 1921, length 17 mm., the largest specimen of *Gammarus chevreuxi* that we have seen.

All the appendages are very massive and densely setose, with numerous long fine sensory hairs, a few lightly curved.

The first antennæ are the longest yet recorded for this species, consisting of 47 joints in the primary, and 8 in the accessory flagella. Second antennæ each with a 21-jointed flagellum.

Gnath. 1. Both hands with 1 extra spine on the upper side of the angle, the usual pair and 2 extra sensory spines developed below.

Gnath. 2 is interesting as showing the development of spines in succeeding moults. On May 12, the angle-row of the right hand consisted of 2 large sensory spines and 3 rigid serrated setæ, with a long spine inset by itself in mid-margin ; claw impinging against the under surface of the hand (cf. CN.218.b. for the only other instance of this) ; palmar margin a little bent in under ; 1 extra spine was developed on the under side of the angle. On May 25, the angle-row had 3 large spines and 3 serrated setæ. The row on the left hand angle on May 12 contained 2 spines and 4 setæ, with the usual pair of spines below ; on May 25, it had 3 spines and 3 setæ. Both hands are furnished with a number of long, lightly curved sensory hairs ; 9 clusters of setæ on the posterior margin (8 on the 5th joint).

Brood-plates. The hairs on the brood-plates are most of them quite rudimentary, a few very small ones appearing on the first two pairs ; none on the 3rd and 4th pairs ; 38 and 40 on the first pair ; 28 on the second, 14 on the third, and 11 on the fourth.

The third uropods are of great size, almost the length of those of the oldest male, CN.22.a., and much more massively built ; densely setose, but with no curved sensory hairs ; no less than 4 large lateral clusters on each terminal joint, the largest number yet seen. These clusters are still more noteworthy for the presence of a plumose hair in the first two clusters never seen in the normal animals.

Specimen 16. CN.183.m. F_3 from CN.I.b. Irregular Stock (Figs. 102 to 110).

This is the most male of all the intersexes. Sister intersex of Specimen 26.

On April 10, 1920, it was entered as " male ; left eye irregular." As it had not mated with a normal female in the same bowl it was taken out on July 3, and microscopically examined, " sex doubtful." Another female and a male were placed with it, but no mating occurred. The " curved hairs on the second antennæ " were seen on July 20. It died on September 9, 1920, in the effort of moulting ; age 204 days ; length 10·5 mm.

First antennæ, all the flagella broken, 37 joints left in the primary, and 7 in the accessory flagella. Second antennæ, large, very setose, with many of the curved sensory hairs, such as are found in the immature male (cf. Fig. 1) ; in the intersexes, however, the curved hairs are shorter than in the normal animals ; flagellum 18-jointed.

Gnath. 1. The right hand is very remarkable. It has the long sensory spine in mid-margin, as in the immature male (Figs. 103 and 104 ; cf. Fig. 3) ; 3 sensory spines on the upper side of the palmar angle, and 4 spines below, all large. The left hand has the row at the angle, of 4 spines ; 1 extra spine developed below.

Gnath. 2. The right hand in this gnathopod also has the spine in mid-margin, as in the immature male (Figs. 106 and 107 ; cf. Fig. 7), 3 sensory spines and 4 stout serrated setæ in the angle-row, and 2 extra spines developed below. The left hand has 1 large serrated spine-like seta in mid-margin, 2 sensory spines, and 4 serrated setæ in the angle-row ; with the usual pair below.

Brood-plates. All the hairs are quite rudimentary except on the fourth pair, where 2 or 3 almost microscopic ones are found (Figs. 109 and 110). These tiny ones are evidently always developed, the new ones being plainly seen through the old cuticle. The hairs have been counted, but the number given for the first three pairs may not be exact. The animal had commenced moulting, and as the new brood-plates were partly withdrawn from the old cuticle which was crumpled, 1 or 2 may have been overlooked.

First brood-plate with 30, second with 20, third with 13, and fourth with 9 and 10.

Gills very large.

Third uropods very large, of the male type, densely setose, no curved hairs ; inner rami more spinose than is usual ; 2 lateral clusters on each terminal joint, outer rami.

Group III, Sub-group A, the " less male " type.

Specimen 17. R.F.1.

The male parent of this specimen was an F_2 from the Cross CN.I.b., Irregular Stock; the female parent was derived from the original stock (June, 1912).

One of a brood of 10, extruded on September 4, 1920. It was exceptionally slow in development, even for an intersex. On November 3, 1920, three males in the same bowl had reached maturity, but it was not till November 27 that this animal was marked as " male ? " It was examined several times, and on February 3, 1921, was recorded as an " intersex." On March 11 the gnathopods were noted as " female type." It did not recover from the moult of April 25, 1921.

It measured only 6·5 mm., although its age was 234 days, but the characters modified at sexual maturity, are very large for the size of the animal, as large as in Specimen 21, CN.309, which was 8·5 mm. in length, but they are not as well developed, nor furnished with as many setæ as specimens in Group I and Group II.

First antennæ, both diseased. Second antennæ, flagellum 13-jointed.

Gnath. 1. Hands missing.

Gnath. 2. Right hand has 4 rigid serrated setæ in the angle-row, and the pair below consisting of 1 large sensory spine, and 1 very stout spine-like serrated seta; the left hand also has 4 serrated setæ in the angle-row, but the under surface is too crumpled to see what is there.

The brood-plates are small, all the hairs quite rudimentary; 22 and 23 on the first, 15 on the second, 8 on the third, and 6 on the fourth.

The third uropods are much smaller than in the specimens previously described, and less male in appearance; 1 lateral cluster on each terminal joint.

Specimen 18. CN.289.f.3. F_4 from CN.I.b. Irregular Stock.

This is a sister intersex of Spec. 12. It was irregular-eyed, slow in development, but healthy; entered as " male ? " on October 19, 1920, and as " female ? or Intersex ? " on November 24. It died on November 27, aged 134 days.

The antennæ, gnathopods, and uropods are not as large as in the preceding group. They are all furnished with numerous very long setæ; the sensory hairs on the under surfaces are very short, none curved except on the left second antennæ, where 2 curving ones were found.

First antennæ, with 24 joints in the primary, and 3 in the accessory flagella. Second antennæ, one with 12 joints, the other with 14 in the flagellum.

Gnath. 1. Right hand has 2 spines on the upper side of the palmar

angle ; and the usual pair below, with 1 small but stout, serrated seta extra ; the left hand has 3 spines in the angle-row ; the pair below consisting of 1 large spine, and 1 spine-like seta, with 1 very small stout sensory seta extra.

Gnath. 2. Right hand has 5 serrated setæ in the angle-row, the setæ stouter than on the left side, one almost a spine ; usual pair of sensory spines below. The left hand has 5 serrated setæ in the angle-row ; the pair below consisting of 1 large sensory spine, and 1 stout spine-like serrated seta, with an extra similar seta behind the pair.

The brood-plates are very small, comparatively speaking, only about half the size of the normal animal's ; the hairs quite rudimentary, 23 on the first brood-plate, 16 on the second, 7 and 8 on the third brood-plates, and 7 and 6 on the fourth.

The third uropods have the proportions of the normal female's, but are larger ; 1 lateral cluster on the right side.

Specimen 19. CN.157.a_2. F_3 from CN.I.b. Irregular Stock.

Sister of Spec. 4 ; irregular-eyed ; entered as " male " on March 30, 1920. It was looked at daily, but as no mating occurred, on July 7 it was taken out and examined microscopically. It was then marked " Female ? doubtful. No male hairs, but the setæ are as long and as numerous as in a male ; gnathopods are of the female type, but in swimming and appearance it is male." July 24, " male ? " ; July 26, " Just moulted. Female, judging by the absence of male hairs ; no ovary visible." A male was added, but on August 27, 1920, the intersex moulted, and was eaten ; age 257 days ; the moult measured 8·5 mm.

First antennæ, August 27, flagella regenerating, longer primary with 32 joints, accessory with 6 joints. Second antennæ, very setose ; flagellum 15-jointed, regenerating.

Gnath. 1. Both hands with 2 sensory spines, and 1 stout serrated seta in the row on the upper side of the angle ; the usual pair below.

Gnath. 2. Right hand has 5 rigid serrated setæ in the angle-row, the left hand has 4 ; both with the usual pair of spines below.

The brood-plates are rather longer in proportion than in most intersexes ; the first pair with 28 hairs on the right one, 29 on the left.

The third uropods rather small ; 1 lateral cluster on right terminal joint ; left uropod missing.

Specimen 20. CN.257.d. F_3 from CN.I.b. Irregular Stock.

One of a brood of 19, extruded June 3 and 4, 1920, an albino, very irregular-eyed. Besides this intersex, 2 normal males and 2 normal females reached maturity. On August 5 a pair were mated, whilst this

one was marked " very small, male ? " Examined again on August 6 this entry was altered to " not mature ; " on August 14, " intersex. ? " It moulted August 31, September 9, September 20, and October 6, and died on October 8, 1920, age 128 days ; length 8·5 mm.

First antennæ, 29 joints in the primary, 6 in the accessory flagella. Second antennæ, great increase in the number of setæ noted, in the succeeding moults from August 31 ; the flagellum increased by 1 joint in each moult ; 17-jointed on October 8.

Gnath. 1. Right hand has 3 spines in the angle-row, the usual pair of large sensory spines below, and 1 smaller spine extra. The left hand has the same number, but the third spine below is larger than in the right, and the palm margin bends under the hand, as in the young male.

Gnath. 2. Right hand has 6 rigid serrated setæ in the angle-row, the second one stouter than the others ; the left hand also has 6 in the row, the second stouter than the others, the first one a little apart from the other five ; both have the usual pair below.

Gills are of very large size.

Brood-plates. The hairs are so rudimentary that it is difficult to count them ; first brood-plate on September 9, 1920, had 24 hairs, on October 8 it had 28 ; the third had 9 on September 9, 11 on October 8.

It is interesting to note that, while the other characters have increased regularly in setose armature and in size (the second antennæ, e.g. increased to a quarter as long again in 29 days), the brood-plates remained practically unchanged.

Third uropods with no lateral clusters.

Specimen 21. CN.309. F_5 from CN.I.b. Irregular Stock.

One of a brood of 7, extruded August 26, 1920. Two came to maturity, a normal female and this specimen. It was very slow in development, on October 15 being marked as " male ? " As no mating had taken place by February 9, 1921, it was examined microscopically and then recorded as " intersex ? Female characters (gnathopod hands, no male hairs) but no ovary." It died on February 22, 1921, in the effort of moulting ; age 181 days ; length 8·5 mm.

First antennæ broken. Second antennæ with some sensory hairs, but none curved ; 13-jointed flagellum.

Gnath. 1. Right hand has 3 spines in the angle-row ; the left hand has 2 spines and 1 sensory serrated seta ; usual pair below.

Gnath. 2. Both hands with 6 of the rigid serrated setæ in the angle-row ; on the under surface the right hand has 1 large spine and 1 very stout spine-like seta, the left hand appears to have 2 spines ; the second spine is larger than the stout seta on the right side, but it is difficult to see owing to the new spines below showing so plainly through the cuticle.

The gills are exceptionally large, extending, in gnathopod 2, beyond the fifth joint.

Brood-plates, with 22 and 24 rudimentary hairs on the first pair, 16 on the second.

Third uropods with no lateral clusters.

Specimen 22. CN.323.a_1. F_4 from CN.I.b. Irregular Stock.

One of two survivors of a brood of 21, extruded September 11, 1920, both intersexes, and both very slow in development, this one being the smaller. On January 17, 1921, it was marked as "male. ?" On February 22 the other was noted as looking like an intersex; March 11, "Smaller one also an intersex ?"; March 16, "Dead in the act of moulting; partly eaten. Intersex ?"; length 6·5 mm., age 187 days.

It very much resembles specimen 17 in its small size and large appendages. The proportion of the antennæ, gnathopods, first peræopods, and uropods are the same, but the appendages themselves are slightly larger, and the brood-plates are distinctly larger, the second one having the rudiments of 31 hairs as against the 23 of Specimen 17.

First antennæ broken. Second antennæ, 15-jointed flagellum.

Gnath. 1. Right hand with 4 spines on the upper surface, 1 of them very large, and nearly in mid-margin; usual pair of large spines, and 1 extra good-sized spine below. The left hand has 3 very large spines above, and 3 below, i.e. the usual pair and 1 imperfectly developed small spine extra; the palmar margin is slightly bent under the hand.

Gnath. 2. Left hand has 6 rigid serrated setæ in the angle-row, and the usual pair below; the cuticle of the right hand has been broken at the palmar angle, and it is not possible to distinguish the old setæ from the new ones, nor to count them.

Both gnathopods have fine sensory hairs, but none curved.

Third uropods; one left, no lateral cluster on the terminal joint.

Specimen 23. CN.323.a_2. F_4 from CN.I.b. Irregular Stock.

Extruded September 11, 1920, sister intersex of Specimen 22; very slow in development at first. On January 17, 1921, it was marked "male ?" on February 22 "Just moulted, looks intersex." On March 11 the entry was made "large intersex"; it then had gill-disease (a disease in which the gills turn black), but from this it recovered later. It moulted April 12, April 26, and May 11. The moult of May 11 measured 11 mm. It died July 9, 1921, age 302 days, length 12 mm.

The second antennæ and both gnathopods are very setose, with many long sensory hairs, some of them lightly curved (as in the immature male).

First antennæ, primary flagellum with 33 joints; accessory with 6. Second antennæ, flagella 15-jointed.

Gnath. 1. Right hand with 3 sensory spines in the angle-row ; pair of large spines below, with 1 serrated seta extra. The left hand is more developed than the right, having 4 spines on the upper surface, the pair of large spines below, and 1 good-sized spine extra.

Gnath. 2. Right hand with 6 serrated setæ in the angle-row ; left hand with 8 setæ, 7 in the angle-row and 1 apart ; usual pair below.

The first brood-plate had 38 rudimentary hairs on May 11, 2 more than in the moult of April 26, but was no larger.

Gills very large.

Third uropods, with 1 lateral cluster on the left side, 2 on the right.

By July 12, 1921, the change to the more male type had taken place.

Second antennæ had several curved hairs well developed.

Gnath. 1. Both hands with 4 spines in the angle-row, right hand with 1 stout seta extra below, left hand with 1 spine extra.

Gnath. 2. Densely setose, the 3 terminal joints bent at an angle to the rest of the appendage ; right hand with 1 sensory spine and 6 very large stout serrated setæ in the angle-row ; left hand with 2 spines and 6 setæ ; usual pair below.

Gills of extraordinary length.

First brood-plate with 40 rudimentary hairs.

Third uropods with 3 lateral clusters on the right side, 2 on the left.

Sub-group B, the " more male " type.

Specimen 24. Abn.Exp.3.

In 1915, two abnormal individuals were found in making the crosses to determine the Mendelian inheritance of eye colour, both in the F_2 from one brood of F_1, from the original cross Black-eye × Red-eye.

This specimen was one of a brood of 22 Black-eyed, hatched on June 9, 1915. Twenty-one came to maturity, 7 males, *13 females, and 1 marked " sex not known " on August 23. A male and a female were added to see if it would mate with either. The female was taken out again, but the male and another added later, were both eaten. It was examined microscopically on September 14 and marked " no ovary, but a mass of granular material can be seen lying on top of the intestine, in the position of the normal ovary." On examining it again a month later, October 14, this mass had apparently completely disappeared, and the gnathopods were noted as " intermediate in type, neither male nor female." Again examined, December 6, 1915, it is recorded " no coiled hairs on the antennæ, but the setæ are much more numerous than in a female ; gnathopods more male in appearance ; no sign of ovary ; no mating."

* One of these females was mated with four different males and laid five batches of eggs, but none hatched.

It was found macerating on December 29, 1915. Age 204 days ; length 9 mm.

The flagella of all the antennæ broken. Second antennæ very large and setose.

Only the gnathopods of the left side were found.

Gnath. 1 had 2 spines at the palmar angle, and 2 on the under surface.

Gnath. 2 had the row at the angle composed of 1 large sensory spine and 3 rigid serrated setæ, the usual pair of spines under, the second one not quite as well developed as the other.

The brood-plates were small, about two-thirds the normal size ; hairs quite rudimentary ; 26 on the first pair, 17 and 18 on the second, 13 on the third, fourth not found.

Gills large.

Third uropods very large, massive, setose, with 2 lateral clusters on each terminal joint.

Specimen 25. Abn.Exp.4.

Of the same origin as intersex Specimen 24. One of a brood of 12, hatched on February 3, 1915, of which 4 survived to maturity, 2 males, 1 female, and this specimen. On July 20 it was marked " not sure if male or female." It was examined microscopically on September 8, " many more setæ on antennæ than in normal female, and gnathopod hands a different shape, but not developed as in a typical male and with none of the male hairs." On September 14 it was again examined and the gonad was described as much resembling that of Abn.Exp.3, looking " almost like soft eggs much broken up." This had disappeared three weeks later, when it was noted as " looks more like a male." Several females were added at different times to test it ; two were eaten. No mating occurred, and on November 4, 1915, it died, probably in moulting ; the females in the pot were found eating it.

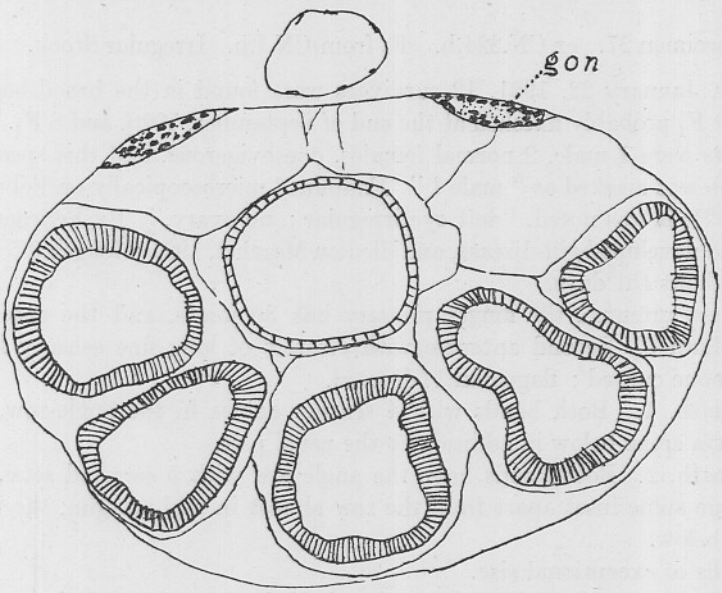
Its male parent was a brother of the female parent of the previous specimen Abn.Exp.3. The relationship of the two specimens is noted, in view of the fact that intersexuality appears to have some genetic basis. Three other examples in the same strain were found " resembling Abn.Exp.3," all of which were an exceptionally long time in developing. Their male parents were also brothers of the female parent of Abn.Exp.3. They were not kept under observation.

Specimen 26. CN.183, c. F_3 from CN.I.b. Irregular Stock.

One of a brood of 23, hatched on February 19, 1920. Only 4 survived to maturity, 2 females normal in appearance, and 2 intersexes, both irregular-eyed, this animal, and Specimen 16. One of the females mated, and was eaten by its mate ; the other died, after developing and recover-

ing from " antennal disease " (a disease in which the antennæ gradually rot off joint by joint).

This specimen developed very slowly. Another of the brood, a normal-eyed in the same bowl, became sexually mature on April 15, but this one was not recorded as " male ? " till May 3 ; on May 19, it was marked " male." Three females were added at different times to test it, but as no mating occurred it was taken out on July 7 and microscopically examined ; " no ovary ; a few young-male curved hairs on the second antennæ ; other hairs of the female type, but longer and nearly as



TEXT FIGURE 5.—Transverse section of intersex CN.183.c , where the gonad is of maximum size. Magnification, etc., as in text fig. 2.
J.S.H. del.

numerous as in the normal male ; male in appearance." It moulted on July 14, " the character of the hairs unchanged ; no ovary seen, but great masses of colourless globules in the third to the seventh peræon-segments, above the intestine, the seventh segment containing also a number of bright red globules." On July 26, 1920, it was preserved and sectioned, age 157 days.

The gonad (text fig. 5) was seen on sectioning to be extremely small. While in size and form it approached a testis, it was not so crowded with nuclei and showed occasional larger cells, perhaps representing aborted oocytes. It had 5 instead of 4 hepatic cæca.

Second antennæ (cf. Fig. 102), both very setose, and furnished with a number of long fine sensory hairs, many of them curved, as in the immature male ; flagellum 16-jointed.

Only the gnathopods of the right side are present.

Gnath. 1. Right hand with 3 sensory spines on the upper side of the palmar angle ; the usual pair below with 1 good-sized spine extra.

Gnath. 2. Right hand has 5 in the graduated row at the angle, 1 long rigid serrated seta, then 1 large sensory spine, and 3 more of the serrated setæ (cf. Fig. 54), the usual pair of spines below.

The brood-plates are small, only half the normal length, hairs quite rudimentary ; first brood-plate with 30.

Third uropods ; only one left, no lateral cluster on the terminal joint.

Specimen 27. ex CN.224.b. F_3 from CN.I.b. Irregular Stock.

On January 22, 1921, 12 survivors were found in the brood-bowl, 4 adult F_1 probably hatched at the end of September, 1920, and 8 F_2. The adults were 1 male, 2 normal females, one ovigerous, and this specimen which was marked as " male ? " Examined microscopically on February 7, 1921, it was noted, " left eye irregular ; no ovary." By February 28 it had developed gill-disease, and died on March 2, 1921 ; length 8·5 mm.. age about 151 days.

First antennæ, the longer primary has 35 joints, and the accessory flagellum 6. Second antennæ with clusters of long fine sensory hairs, but none curved ; flagellum 17-jointed.

Gnath. 1. Both hands with 4 sensory spines in the angle-row, and 1 extra spine below in addition to the usual pair.

Gnath. 2. Both hands have the angle-row with 5 serrated setæ, and 1 large spine inset apart from the row almost in mid-margin ; the usual pair below.

Gills of exceptional size.

Brood-plates small, little more than half the normal length, hairs quite rudimentary ; in the moult of February 28 there were 29 hairs on the first brood-plate, 16 on the second, 10 on the third, and 6 on the fourth.

Third uropods regenerating ; left one the larger, with 2 lateral clusters on the terminal joint ; other one very small.

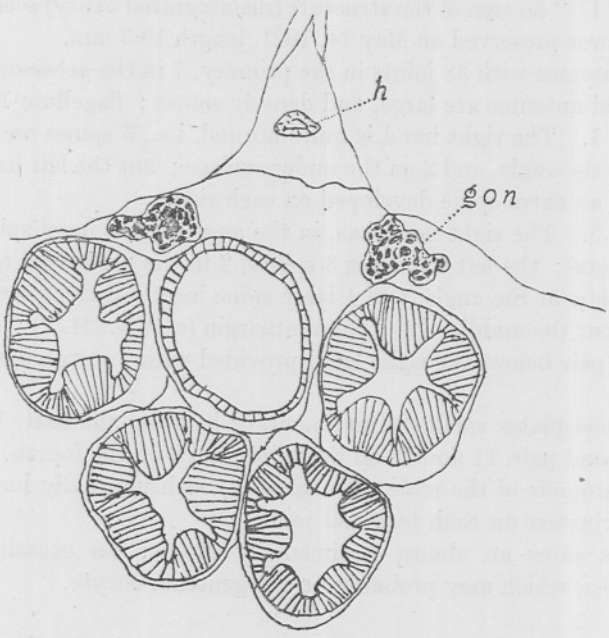
Specimen 28. CN.52. F_2 from CN.I.b. Irregular Stock.

The only survivor of a brood of 4, extruded March 14, 1919. It was exceedingly slow in development. July 30, 1919, marked " not yet mature." On March 26, 1920, it was recorded as " male—added a female " ; May 18, " male and female in pot, but no mating." July 1, " there are no coiled hairs, is it possibly a female ? " It was examined microscopically on July 27, and marked " intersex ? No ovary ; looks like a male but has no male hairs." Again on August 24, " hairs of the female type, but longer and more numerous ; no ovary ; added a male

to test it." As no mating had taken place by August 20 the animal was preserved and sectioned; age 536 days.

The gonad, see text figure 6, is interesting microscopically as showing the structure to be expected of an aborted ovary. It is larger than a testis, and irregularly lobulated. Nuclei do not occur in the smooth outer layer; occasional dark masses, apparently of degenerating nuclei, are to be found.

First antennæ, both broken; 33 joints remaining in the primary,



TEXT FIGURE 6.—Transverse section of intersex CN.52., where the gonad is of maximum size. Magnification, etc., as in text fig. 2.

J.S.H. del.

6 in the accessory flagella. Second antennæ, densely setose, with many long sensory hairs, but none curved; 23-jointed flagellum.

Gnath. 1. The hands missing.

Gnath. 2. (cf. CN.183.m., Specimen 16). The right hand has, in the angle-row, 1 large sensory spine, and 4 stout serrated setæ, and, in addition, 1 large spine inset in mid-margin as in the immature male; 1 extra spine developed below. The left hand has 2 large spines and 4 serrated setæ in the angle-row, and 1 stout serrated seta apart, in mid-margin; the usual pair below.

Brood-plates small, 27 rudimentary hairs on the first.

Third uropods of the male type with many long sensory hairs; 1

lateral cluster on the terminal joint of the left side ; 4 spines developed on the inner ramus, right side.

Specimen 29. CN.293.a_1. F_4 from CN.I.b. Irregular Stock.

Sister to Specimen 3. When found on February 9, 1921, it was entered as " Intersex ? ; no gonad visible to the naked eye, but under the microscope (1 inch) it looks as if there is a disintegrated ovary lying on the intestine ; eyes very irregular, the left eye twice the size of the right." On March 11 " no sign of the structure (disintegrated ovary) seen a month ago." It was preserved on May 14, 1921, length 10·5 mm.

First antennæ with 38 joints in the primary, 7 in the accessory flagella. The second antennæ are large, and densely setose ; flagellum 18-jointed.

Gnath. 1. The right hand is quite normal, i.e., 3 spines on the upper surface at the angle, and 2 on the under surface ; but the left hand differs in having an extra spine developed on each side.

Gnath. 2. The right hand has, in the angle-row, 2 large spines and 4 serrated setæ ; the left hand has 3 spines, 2 in the graduated row with 4 serrated setæ at the angle, and 1 large spine inset a little apart from the others about the middle of the palmar margin (cf. CN.224.b.) ; both have the usual pair below, the right hand provided with 1 serrated seta extra, also.

The brood-plates small, 32 rudimentary hairs on the first, 18 and 21 on the second pair, 11 and 12 on the third, and 8 on the fourth.

Third uropods of the male type massive, with unusually long spines ; 2 lateral clusters on each terminal joint.

Sections show an almost rudimentary ovary ; an occasional large mass is seen, which may probably be a degenerate oocyte.

Specimen 30. CN.285.a. F_4 from CN.I.b. Irregular Stock. Fig. 111.

One of a brood of 24, hatched July 10, 1920. It was noted as " intersex, large, with curved hairs on the second antennæ " on January 24, 1921.

It was preserved and sectioned on May 14 ; length 10 mm. ; age 309 days.

The appendages are large, and massive.

The first antennæ are unusually long ; 41 joints in the primary, and 7 in the accessory flagella of each. The second antennæ very setose, with several curved hairs on the 4th and 5th joints of the peduncle (cf. Fig. 102) ; flagellum 17-jointed.

Gnathopods densely setose, with many fine sensory hairs but none curved.

Gnath. 1. Left hand with an extra spine developed on each side of the

palmar angle; right hand with 3 spines in the angle-row and 1 extra below.

Gnath. 2 has 3 large sensory spines and 3 serrated setæ in the row at the angle, on both hands; right hand with the usual pair below; left hand with 2 very stout spine-like serrated setæ, in addition to the usual pair of spines below (Fig. 111).

The brood-plates have the hairs quite rudimentary, 36 on the first, 22 on the second, 13 on the third and 7 on the fourth.

The gills are very large.

Third uropods very massive, densely setose, with many long hairs but none curved; 2 lateral clusters on each terminal joint.

Specimen 31. CN.218.b. F_3 from CN.I.b. Irregular Stock. Figs. 112 and 113.

The only survivor of a brood of 36, extruded April 29, 1920.

On January 22, 1921, it was marked as "very large intersex." It was examined on February 8, and the note made, "three or four curved hairs on the second antennæ; intersex gnathopods; very large animal; eyes nearly normal, but with the reticulation irregular and the colour dilute." It died on February 28, 1921; length 11·5 mm.; age 306 days.

First antennæ, broken. Second antennæ very setose, with many sensory hairs, 9 or 10 of them curved as in the immature male; flagellum 19-jointed.

The gnathopods are exceedingly interesting in this specimen. They are densely setose, with many sensory hairs, several lightly curved.

Gnath. 1. Both hands with 3 spines in the angle-row; and 1 spine extra below.

Gnath. 2. Right hand with 3 spines, 2 in the angle-row with 3 serrated setæ, and 1 apart in mid-margin as in the immature male; the claw impinging against the under surface (Fig. 112). This and Fig. 100, CN.284.a, are the only instances of the claw in this position that we have found in the intersexes. The left hand is quite different; it has 3 large spines, and 4 serrated setæ on the upper side of the angle, the 3 spines and the 2 largest of the setæ, very stout and spine-like, in a row, the 2 smaller setæ behind, not in the same line; the claw is in the normal position (Fig. 113).

The brood-plates are very small for the animal's size, not half the normal length, 33 rudimentary hairs on the first.

Some of the gills are damaged, whether by injury or disease is not evident; the one attached to the second gnathopod on the right side is very small and bi-lobed, the anterior lobe differentiated, but not the larger posterior one. The gills that have developed are exceptionally large, even for an intersex.

Third uropods massive, of the adult male type, with more spines on the inner ramus than usual; 2 large lateral clusters on each terminal joint.

Specimen 32. CN.328 was of the Group III type. It was eaten by a male.

It may be of interest also to note the occurrence of a similar intersex in another Amphipod genus.

This, a *Tmetonyx similis* (G. O. Sars) has already been described by one of us (Sexton '11, p. 200; and see Sars '95), as "a very large, full-grown female, which has apparently developed the secondary sexual characters of the male." It was ovigerous, with a large brood-pouch, but with both antennæ of the length characteristic of the adult male, and provided with calceoli (which are not found in the normal female). Professor Sars most kindly sent us his type specimens from Sogne Fjord for comparison, and the interesting fact was established that the antennæ of the ovigerous specimen described above are exactly the same in every particular, even to the number of joints in the flagella, as those of his type male. The intersex was much larger than the normal animals; the length of the normal male was 14·25 mm.; of the two normal ovigerous females, 15 mm.; and of this ovigerous intersex, 18 mm.

Reference was also made (loc. cit.) to a similar case among Schizopoda, recorded by Tattersall ('11); where a full-grown ovigerous female of *Nematoscelis megalops*, Sars, had developed the rostrum characteristic of the adult male. Dr. Tattersall has informed us that his experience is, that it is not uncommon in *Nematoscelis* to find a female with a male rostrum. In this species the secondary sexual characters are well marked and these "intersexual" specimens are easily picked out.

Attention may be drawn to an account of an abnormal female appendage in *Asellus* which approached the male appendage in character (Journ. Linn. Soc. 34, 1920, p. 342). Mr. Unwin informs us that the eggs from this female hatched.

Another sexual abnormality in Gammarus also deserves mention. Seven pairs from the Irregular Stock which have been under observation since March, 1920, have shown remarkable behaviour. Mating occurs, lasts for much longer than normal (in one case, CN.110.a., up to 44 days), and then ceases. The female moults, but without laying eggs. Mating again follows after a few days. One pair has done this 8 times in less than three months; the periods of mating were as follows:—5 days; 7; 1; 10, ended by the male moulting; 8; 12; 10; 10, ended by the male moulting again. The length of time during which these pairs have been mated much exceeds that during which they have been separate, e.g., in CN.68.a. the periods of being paired between June 15 and August 27

were as follows :—10 days ; 12, female moulted, no eggs, mated again for another day ; 3 ; 3 ; 7 days, female moulted, no eggs, mated again for another day ; 13 ; and 4 days, the female died 3 days later.

The gonads appear normal in life. In two cases, a male was tested with another female and normal fertilisation resulted. The presumption here is, therefore, that the cause lies in the females. In one case, however, M.III, it was proved that the male was infertile. It mated with no less than 32 different ovigerous females in the usual way, carried them the usual time until the broods were extruded, and they moulted ; and it twice mated again for a day after the moult ; all, however, with no results. No eggs were ever laid, although all the females hatched broods with other males.

DISCUSSION.

Careful examination is necessary to reveal the sexual abnormalities considered in this paper, but once attention has been drawn to them, they are seen to be not uncommon.

In normal broods of Gammarus there is usually a considerable mortality before maturity is reached, and no means exist until then for telling the sex. It is therefore not possible to decide, as in Lymantria (Goldschmidt '20), from a study of the sex-ratio whether the abnormal individuals are to be regarded as modified males or modified females.

The evidence points strongly towards the specimens described in the present paper being modified females. Thus we have first the fact that in all these " intersexes " there has been a progressive increase of male characters with time. There are also all gradations between specimens which have ovaries capable of forming eggs, and possess normal brood-plates, and specimens in which the gonad is minute, the brood-plates extremely reduced, and marked male characters are shown in the hairs and gnathopods. In sections of the intersexes the gonad has usually been definitely recognizable as an ovary, reduced to a greater or lesser extent.

The suggestion may, of course, be made that all these abnormal individuals are simply unhealthy females in which the ovary is diseased or atrophied, and no longer produces the internal secretion necessary to maintain the female characters. For instance, one specimen showed an apparently normal ovary at maturity, and hatched two young. After the next two moults it became very unhealthy for some time. The ovary ceased to be visible after the two young were hatched. It then moulted several times, growing less female in appearance at each moult, until it finally looked a typical intersex—i.e. with general male appearance, and increase of hairs on antennæ, gnathopods and uropods, but no curvature of the hairs (CN.259.b. Plate V).

It would appear, however, that in most of the intersexes here described a typical full-sized ovary is never formed; and, although the animals take a longer time than usual to reach maturity, they are not unhealthy, eventually attain to a great size and are of normal vigour. The progressive increase in the degree of " maleness " fits well with Goldschmidt's theory of intersexuality (the moults allowing a progressive change which is impossible with Lepidoptera), and we may provisionally call these specimens *female intersexes* until more light is thrown upon their genesis.

An important fact in which our intersexes differ from those described by other observers is that whilst the new male characters increase in the direction of maleness,the female characters may continue to develop. For example, the number of hairs on the brood-plates may become even greater than in the normal mature female (e.g. Specimen 23, CN.323.a_2). The length of the hairs may also continue to increase. (Specimen 5, CN.259.b. Plate V.)

It is interesting to note the association of intersexes with the " irregular-eyed " condition. Further, the tendency for intersexes to appear repeatedly in the same strain is what we should expect after the work of Banta ('16), Goldschmidt ('20), and Sturtevant ('20).

It should be noted that perfectly normal males and females appear in the same broods with intersexes, so that the phenomenon is certainly not *identical* with that observed by Goldschmidt in Lymantria, whereas it *might* possibly be due to a single Mendelian factor, as in Drosophila (Sturtevant '20).

Another important point is that the female intersexes all took longer to reach maturity than their normal brothers and sisters. The extra time taken to mature is often very considerable.

This, in conjunction with the fact that the intersexes are not unhealthy, seems to point to a genetic basis for the condition.

It is impossible without further analysis to advance definite theories as to the nature and cause of the abnormalities here described. In view, however, of recent work on the subject, and of the success of Goldschmidt's explanation of his intersexes as individuals which have started their development as organisms of one sex but have been switched over at a given point of time to continue their development as organisms of the other sex, we may adopt the following provisional hypothesis. By means of this, the facts are accounted for, while they do not seem to be capable of explanation on any other hypothesis now current.

The hypothesis is this :—that all the abnormal individuals described in this paper are true female intersexes; i.e. that they are genetically females, which during the course of their development have become, through some cause as yet not understood, switched over to maleness.

The difference between the various types described is due partly to the different moment of time at which the transformation from one type of metabolism to the other has been effected, partly to the length of time which has elapsed since this turning-point, and possibly also to the strength of the agency operating to produce maleness. If, for instance, a female has arrived at sexual maturity before the turning-point to maleness has been passed, she will possess all the female secondary sexual characters—e.g. fully developed brood-plates. After the turning-point, male characters will begin to appear, but since development seems to be very slow in all these intersexes, they will not reach any very full degree of development. If, on the other hand, the turning-point to maleness comes earlier, at a stage when only the first rudiments of brood-plates have formed, these, the female characters, will not develop much further, while the male characters, having started their development earlier, will attain a correspondingly higher degree of perfection. Any structure once chitinized appears to persist, as in Insects (cf. also the male copulatory appendages in Sacculinized crabs) ; this is shown, e.g. in the persistence of the brood-plates of the same size, in spite of progressive masculinization of male characters, e.g. in specimen CN.257.d. (p. 534). The soft parts, however, such as the gonads, cannot maintain themselves as either male or female when the metabolism is intermediate, are much degenerated during the change, and do not have time to become completely reconstituted as male after the turning-point. From this point of view, we must regard as female structural characters only the brood-plates, as male structural characters only the coiled sensory hairs, the special shape and spines of the gnathopods, and the size and shape of the uropods. The converse of all these characters, such as the absence of brood-plates in the male, or the shape and spines of the gnathopods in the female, is, physiologically at least, non-sexual or neutral, a basis common to both sexes, which is acted upon by the internal secretion of one sex only. Similar distinctions are to be found among the secondary sexual characters of Vertebrates (see Lipschütz, '19).

In support of this hypothesis, it is especially to be noted that of the two sub-groups into which our Group III falls, that with few and poor male characters has a smaller average size than that with numerous and better developed male characters. This of course indicates that although the turning-point came at the same period in the life-history in all individuals of Group III, those of the second sub-group had lived longer since the turning-point, and therefore show better male characters. This explanation presumably holds also for the sub-groups of the other two groups, although in all cases it is of course possible that different intensity of the tendency to maleness may enter as a third variable. This is strongly supported by specimen CN.229.h. (p. 523) and specimen

CN.323.a_2 (p. 536), which changed at successive moults from Sub-group A to Sub-group B.

We must emphasize that we only propose this as a hypothesis capable of explaining the facts in terms of our knowledge of the physiology of sex in other forms, not as proved by the facts here presented ; a demonstration of its truth for Gammarus is impossible until we get further information on the sex-ratio, and until we succeed in raising young from the end-terms of the intersexual series.

If this hypothesis is correct, it should be noted that our intersexes are unlike those recorded in other species in the slowness of their development of sexual characters.

The sterile females and males which indulged in abnormally long periods of pairing are of interest. It is *possible*, of course, that there are two tissues present in the gonad of Gammarus, as in that of Mammals, one concerned with gamete-production, the other with the control of sexual characters and instincts, and that in these specimens only the former was impaired. Whether this is so or not, only further research can decide.

In any case, the modification of female Crustacea towards the male type is of interest in view of the well-known fact that parasitic castration in the group modifies the males in the direction of femaleness, and not vice versa. This strongly supports the contention of Geoffrey Smith ('06) who insisted that, in the case of Sacculina, the parasite produced its effects, not by castrating its hosts, but by having a metabolism resembling that of the host's ovary. This interpretation is further strengthened by the fact that the presence of Sacculina caused immature Inachus to develop the full female characters prematurely (a fact which has not been sufficiently emphasized in subsequent discussion).

SUMMARY.

In stocks of *Gammarus chevreuxi* kept for genetic experiments 35 individuals have appeared with abnormalities of secondary sexual characters ; three of these have been reserved for future discussion. The remaining 32 we have described in the paper as female intersexes. These female intersexes on reaching maturity usually resemble normal females more or less closely, but gradually come to resemble males more and more nearly. Finally, in size, general appearance, and mode of swimming they resemble males, while the structural characters (brood-plates, gnathopods, and sensory hairs) are intermediate between male and female, but to a varying extent. Characters which are never present in normal males, such as brood-plates, are present, together with others

never present in normal females, such as gnathopod-size and shape, sensory spines, excessive hairiness of antennæ, etc., and, in extreme cases, curvature of the sensory hairs. On analysis, the individuals are found to fall into three groups :

I. With the hairs of the brood-plates fully developed, brood-plates of normal size ;

II. With the hairs of the brood-plates partially developed, brood-plates of moderate size ;

III. With the hairs of the brood-plates rudimentary, brood-plates smaller than normal.

All show some development of male characters (particularly in size, mode of swimming, and sensory hairs). Each of the 3 groups falls into 2 sub-groups :—(A) with the gnathopod setæ of female type ; (B) with the gnathopod spines of the type found in males immediately before maturity : but individuals may pass at successive moults from sub-group (A) to sub-group (B), though apparently not vice versa.

One specimen (CN.259.b.) has produced fertile eggs. One (HN.50.a.) has mated and produced infertile eggs, one (CN.216.b.) mated with no results, the rest have never mated, either with males or females. The ovary in those which have not mated never assumes the normal appearance or size. It appears often to decrease in size after maturity. Microscopically it presents the appearance of a reduced ovary ; the degree of reduction varies very considerably.

There can be but little doubt that these individuals are modified females, and can be called female intersexes.

They have occurred in three separate strains, but the majority have appeared in one particular strain, and mostly in the two families of that stock which have given irregular-eyed forms. Cannibalism is marked in all the strains which have given intersexes.

A very slow attainment of maturity characterizes these forms, and usually a final size which is abnormally large, even for a male.

The continuance of the development of the female characters after the male characters have appeared is to be remarked.

As a provisional hypothesis, all the above types may be regarded as genetically females which have been converted to a male type of metabolism during their life history. The degree of development of brood-plates will depend chiefly upon the stage at which conversion from female to male metabolism occurred, while the degree of development of male characters will depend upon the length of time which has elapsed since this stage.

Individuals which are normal in structure and appearance but are infertile and show abnormality in their mating habits have also appeared.

Reference is made to an intersexual condition in a wild individual of the Amphipod *Tmetonyx similis* (Sars).

Our thanks are due to Professor G. O. Sars for kindly sending us his type specimens of Tmetonyx for comparison, and to Dr. E. J. Allen for constant advice and help.

LITERATURE.

1917. Allen, E. J., and Sexton, E. W.—The Loss of the Eye-pigment in *Gammarus chevreuxi;* a Mendelian Study. J. Mar. Biol. Assn., 11, 1917, pp. 273–353.

1920. Allen, E. J., and Sexton, E. W.—Eye-colour in Gammarus. Journ. Genet. 9, 1920, pp. 347–366.

1916. Banta, A. M.—Sex-intergrades in a species of Crustacea. Proc. Nat. Ac. Sci., Washington, 1916.

1921. Crew, F. A. E.—A description of certain abnormalities of the reproductive system found in frogs, etc. Proc. R. Phys. Soc., Edinburgh, 20, 1921.

1920. Goldschmidt, R.—Untersuchungen über Intersexualitat (contains reference to previous work). Leitschrf. ind. Abst. 23, 1920.

1919. Lipschutz, A.—Die Pubertätsdrüse und ihre Wirkungen. Bern, 1919.

1895. Sars, G. O.—Crustacea of Norway. Christiania, 1895. I. Amphipoda. Pl. 33.

1911. Sexton, E. W.—The Amphipoda collected by the "Huxley" from the North Side of the Bay of Biscay in August, 1906. J. Mar. Biol. Assn., 9, 1911, p. 199.

1913. Sexton, E. W.—Description of a new species of Brackish-water, Gammarus (*G. chevreuxi* n. sp.). J. Mar. Biol. Assn., 9, No. 4, 1913.

1913. Sexton, E. W., and Matthews, A.—Notes on the Life History of *Gammarus chevreuxi*. J. Mar. Biol. Assn., 9, No. 4, 1913.

1906. Smith, G. W.—Rhizocephala. Fauna u. Flora Neapel. Mon. 29.

1920. Sturtevant, A. H.—Intersexes in *Drosophila simulans*. Science 51, 1920, pp. 325–7.

1911. Tattersall, W. M.—Fisheries, Ireland, Sci. Invest., 1910, II (1911), p. 16.

EXPLANATION OF PLATES I TO IX.

ALL the drawings were made with the camera lucida, and pains have been taken to make the details exact, all the hairs having been counted and figured, except in Fig. 12.

The abbreviations used are as follows :—

R.S.	right side.
L.S.	left side.
ad.sp.	adult spines.
ap.	aperture of the oviduct.
a.r.	angle row.
g.	gill.
p.m.	palmar margin.
p.r.	palmar row.
s.	side plate.
s.sp.	sensory pointed spine with flagellum.
s.s.	sensory serrated seta.
t.sp.	truncate spine.

PLATE I.

IMMATURE NORMAL MALE.

The last moult before sexual maturity, showing the mature characters through the cuticle.

The specimen figured was from the first generation hatched in the Laboratory. It died on August 31, 1912, in the effort of delayed moulting ; age 59 days. (Others of the brood were breeding at 52 days.)

Fig. 1. Part of second antenna, R.S., showing the curved hairs characteristic of the immature male ; the left antenna has 1 more joint in the flagellum, and 2 more clusters of setæ on joints 4 and 5 of the peduncle.
(First antennæ with 22 joints in the primary flagella ; in the accessory flagella, there are 4 joints R.S., 3 joints L.S.) ×39

,, 2. First gnathopod, R.S. ×39

,, 3. First gnathopod, R.S. ; palm and claw enlarged, showing the sensory pointed spine characteristic of the immature male in mid-margin, with the truncate spines (*ad.sp.*) of the adult animal visible through the cuticle. ×97

,, 4. First gnathopod, R.S. ; under surface of the palmar angle, showing through the cuticle the mature characters which will be established at the next moult. ×97

,, 5. First gnathopod, L.S. ; under surface of the palmar angle. ×97

,, 6. Second gnathopod, R.S., showing gill (*g.*). ×39

,, 7. Second gnathopod, R.S. ; palm and claw enlarged, showing the sensory pointed spine in mid-margin. The mature characters are visible through the cuticle. ×97

,, 8. Second gnathopod, R.S. ; under surface of the palmar angle, with 1 sensory spine of the pair below well developed, the other still a modified sensory seta not yet developed into a spine. ×97

,, 9. First peraeopod, R.S., showing the curved hairs and gill. ×39

Fig. 10. Third uropod, R.S., showing the curved hairs, and a lateral cluster commencing on the terminal joint of the outer ramus, represented by 1 seta. ×39

„ 11. Third uropod, L.S. ×39

„ 12. Third uropod, R.S., of the oldest male, C.N.22a., age 579 days, in which the development of the coiled hairs reached a maximum. The coiled hairs were so numerous that only a few of them could be represented in the figure. There were 2 lateral clusters of setæ on the terminal joint of the outer ramus of the right side. On the left side there was only one lateral cluster. ×39

PLATE II.

Mature Normal Male.

The specimen figured was the first male to mature of the second generation hatched in the Laboratory; hatched August 8, 1912; moult September 30, 1912; length 8 mm.

Fig. 13. Part of second antenna, L.S., showing the coiled sensory hairs of the mature animal. (First antennæ with 25 joints in the primary flagella; 5 joints in the accessory flagella.) ×39

„ 14. First gnathopod, R.S.; the 3 terminal joints. ×39

„ 15. First gnathopod, R.S.; palm and claw enlarged, showing the truncate spine peculiar to the adult male, in mid-margin (*t.sp.*). The palmar marginal setæ and those of the palmar row are omitted for the sake of clearness. ×97

„ 16. First gnathopod, L.S.; palm enlarged, showing the torsion of the palmar margin (*p.m.*). Setæ omitted as in Fig. 15. ×97

„ 17. Second gnathopod, R.S., with gill (*g.*). ×39

„ 18. Second gnathopod, R.S.; palm and claw enlarged, showing the characteristic truncate spine in mid-margin. Setæ omitted as in Fig. 15. ×97

„ 19. Second gnathopod, R.S.; under surface of the palm. Setæ omitted as in Fig. 15. ×97

„ 20. Third uropod, L.S., with 1 lateral cluster developed on the terminal joint of the outer ramus. ×39

PLATE III.

Immature Normal Female.

The last moult before eggs were laid.

The specimen figured was from the first generation hatched in the Laboratory. Moult 25 July, 1912; age 36 days; length 6·5 mm.

Fig. 21. Second antenna, R.S. (First antennæ with 16 joints in the primary; 4 joints in the accessory flagella.) ×39

„ 22. First gnathopod, R.S.; the 3 terminal joints. ×39

„ 23. First gnathopod, R.S.; palm and claw enlarged, showing 2 modified serrated setæ in the angle-row, developing into spines. ×97

„ 24. First gnathopod, R.S.; under surface of the palmar angle. ×97

„ 25. First gnathopod, L.S.; upper surface of the palmar angle, 1 spine of the angle-row well developed, the other imperfectly so. ×97

„ 26. Second gnathopod, R.S., showing the partially developed broodplate and gill. ×39

Fig. 27. Second gnathopod, R.S.; palm and claw enlarged, showing 3 of the sensory serrated setæ in the angle-row. The left gnathopod has 1 seta less in the palmar row (the small one, crossing the others). ×97

„ 28. Second gnathopod, R.S.; under surface of the palmar angle. ×97

„ 29. First broodplate, L.S., showing difference from the one on the right side (Fig. 26). ×39

„ 30. First peræopod, R.S., with broodplate and gill. ×39

„ 31. Second broodplate, L.S. ×39

„ 32. Third broodplate, R.S.; under surface. ×39

„ 33. Fourth broodplate, R.S., showing the aperture of the oviduct (*ap.*) under surface. ×39

„ 34. Third uropod, R.S. ×39

„ 35. Third uropod, L.S. ×39

PLATE IV.

Mature Normal Female.

The first moult after sexual maturity.

The specimen figured is the same female as in Plate III, after the first brood of eggs was hatched; moult 7 August, 1912; age 49 days; length 7·5 mm.

Fig. 36. Second antenna, R.S. (First antennæ with 20 joints in the primary, 4 joints in the accessory flagella.) ×39

„ 37. First gnathopod, R.S.; the 3 terminal joints. ×39

„ 38. First gnathopod, R.S.; palm and claw enlarged, showing 1 spine of the angle-row well developed (small palmar marginal setæ omitted). In the left gnathopod both spines are well developed. ×97

„ 39. First gnathopod, R.S.; under surface of the palm, showing the usual pair of spines, only one of which is fully developed. On the left gnathopod, both spines are well developed. ×97

„ 40. Second gnathopod, R.S., broken at the fourth joint in moulting; showing the first broodplate. Left gnathopod exactly the same. ×39

„ 41. Second gnathopod, R.S.; palm and claw enlarged, showing 4 of the sensory serrated setæ in the angle-row. The left gnathopod has one seta less in the palmar row (the small one crossing the others). Small palmar marginal setæ omitted. ×97

„ 42. Second gnathopod, R.S.; under surface of the palm. ×97

„ 43. First peræopod, R.S.; under surface, showing broodplate. The broodplate on the left side has 21 fringing hairs. ×39

„ 44. Second peræopod, R.S.; under surface, showing portion of sideplate, joint 2, broodplate, and gill, for comparison of the relative proportions. Left peræopod has 2 notches in the sideplate posterior margin and 13 hairs on the broodplate. ×39

„ 45. Fourth broodplate, L.S., showing the aperture of the oviduct (*ap.*). ×39

„ 46. Third uropod, R.S. ×39

„ 47. Third uropod, L.S. ×39

PLATE V.

C.N.259.b. Intersex. (*See* p. 521.)

Fig. 48. First gnathopod, R.S.; palm and claw enlarged (the palmar marginal setæ and those of the palmar row are omitted for the sake of clearness). November 15, 1920. ×97

Fig. 49. First gnathopod, R.S. ; under surface of the palmar angle. November 15, 1920. ×97

„ 50. First gnathopod, R.S. ; palm and claw enlarged. Setæ omitted as in Fig. 48. March 3, 1921. ×97

„ 51. First gnathopod, R.S. ; under surface of the palmar angle, showing extra spine developed in addition to the usual pair. March 3, 1921. ×97

„ 52. First gnathopod, R.S. ; the 3 terminal joints. March 3, 1921. ×39

„ 53. Second gnathopod, R.S. ; the 3 terminal joints. March 3, 1921. ×39

„ 54. Second gnathopod, R.S. ; palm and claw enlarged ; more male than the left gnathopod. Setæ omitted as in Fig. 48. March 3, 1921. ×97

„ 55. Second gnathopod, R.S. ; under surface of the palmar angle. March 3, 1921. ×97

„ 56. Second gnathopod, L.S. ; upper surface of the palmar angle, no spines developed. March 3, 1921. ×97

„ 57. Fourth broodplate, L.S. ; under surface. November 15, 1920. ×39

„ 58. First broodplate, R.S. ; upper surface. March 3, 1921. ×39

„ 59. First broodplate, L.S. ; upper surface. March 3, 1921. ×39

„ 60. Second broodplate, L.S. ; upper surface. March 3, 1921. ×39

„ 61. Third broodplate, R.S. ; upper surface ; with part of the sideplate of peraeopod 2. March 3, 1921. ×39

„ 62. Fourth broodplate, L.S. ; under surface, showing the aperture of the oviduct (*ap.*). March 3, 1921. ×39

„ 63. First broodplate, R.S. ; upper surface, showing the greater development of the fringing hairs than in the last moult. March 10, 1921. ×39

„ 64. First broodplate, L.S. ; under surface. March 10, 1921. ×39

„ 65. Second broodplate, L.S. ; upper surface. March 10, 1921. ×39

„ 66. Third broodplate, R.S. ; upper surface. March 10, 1921. ×39

„ 67. Fourth broodplate, L.S. ; upper surface. March 10, 1921. ×39

„ 68. Third uropod, L.S. ; moult before eggs were laid. September 21, 1920. ×39

„ 69. Third uropod, L.S. ; last moult, large intersex. March 3, 1921. ×39

PLATE VI.

C.N.229.h. (Sub-Group A.)

Showing the development of the intersex from Sub-group A, the "less male" type, to Sub-group B, the "more male" type. Moult of October 26, 1920.

Fig. 70. Second antenna, L.S. ; tip of flagellum diseased. ×39

„ 71. First gnathopod, R.S. ; palm and claw enlarged (small palmar-margin setæ omitted, and setæ of the palmar row indicated). ×97

„ 72. First gnathopod, R.S. ; under surface of the palmar angle, showing the usual pair of spines, and 1 extra serrated sensory seta developed. ×97

„ 73. Second gnathopod, L.S. ; broken at the fourth joint in moulting, showing broodplate, and gill, slightly crumpled. ×39

„ 74. Second gnathopod, L.S. ; palm and claw enlarged, showing 5 of the sensory serrated setæ (characteristic of the normal female) in the angle-row. Setæ omitted as in Fig. 71. ×97

„ 75. Second gnathopod, L.S. ; under surface of the palmar angle. ×97

„ 76. Second broodplate, R.S. ; upper surface. ×39

Fig. 77. Third broodplate, R.S.; under surface. ×39
„ 78. Fourth broodplate, R.S.; upper surface, showing a few minutely developed fringing hairs. ×39
„ 79. Fourth broodplate, L.S.; upper surface. ×39
„ 80. Third uropod, L.S., showing 1 lateral cluster commencing on the terminal joint, represented by one seta. ×39

PLATE VII.

C.N.229h. (Sub-Group B.)

Preserved May 14, 1921.

Fig. 81. Second antenna, L.S. ×39
„ 82. First gnathopod, L.S.; the 3 terminal joints. ×39
„ 83. First gnathopod, L.S.; palm and claw enlarged (palmar row indicated, small palmar-margin setæ omitted), showing extra spine in angle-row; 2 setæ developed on the claw, the only case in which more than one has been seen. The right gnathopod claw has one only, as is normal. ×97
„ 84. First gnathopod, L.S.; under surface of the palmar angle, showing extra spine developed, besides the usual pair. ×97
„ 85. First gnathopod, R.S.; under surface of the palmar angle, showing a slender seta developed, besides the usual pair of spines. ×97
„ 86. Second gnathopod, L.S., showing broodplate. The right gnathopod is exactly similar. ×39
„ 87. Second gnathopod, L.S.; palm and claw enlarged, showing the development of sensory spines in the angle-row in addition to the sensory serrated setæ. Setæ omitted as in Fig. 83. ×97
„ 88. Second gnathopod, R.S.; upper surface of the palmar angle, showing greater "male" development of the angle-row than in the left gnathopod. ×97
„ 89. Second gnathopod, R.S.; under surface of the palmar angle, with the usual pair of spines. ×97
„ 90. First peraeopod, R.S.; the 4 terminal joints. ×39
„ 91. Second broodplate, R.S.; upper surface. ×39
„ 92. Second peraeopod, R.S., with third broodplate and portion of sideplate (*s.*). (The left peraeopod 2, sideplate and broodplate exactly similar.) ×39
„ 93. Fourth broodplate, L.S.; upper surface, showing the few partially developed hairs. ×39
„ 94. Third uropod, L.S.; 2 lateral clusters present. ×39

PLATE VIII.

Intersexes.

Fig. 95. Spec. 3. C.N.293a$_2$. Second gnathopod, L.S.; palmar angle, showing one sensory seta inset apart from the angle-row. ×97
„ 96. Spec. 9. C.N.265b. Fourth broodplate, R.S.; under surface. ×39
„ 97. „ „ Fourth broodplate, L.S.; under surface. ×39
„ 98. Spec. 12. C.N.289a. Second gnathopod, L.S., showing extra spine developed below the angle-row, the only instance of this. ×97

Fig. 99. Spec. 15. C.N.284a. First gnathopod, L.S.; under surface of palm Palmar-marginal setæ omitted. ×97

„ 100. „ „ Second gnathopod, R.S., showing claw impinging against the under surface of the palm (cf. Fig. 112, the only other instance of this). Palmar margin a little bent. Setæ omitted as in Fig. 99. ×97

„ 101. „ „ Third uropod, R.S., showing its great development, and the 4 lateral clusters on the terminal joint of the outer ramus. In two of these clusters a plumose hair is present, the only instance of this. Plumose hairs are never seen on the terminal joint in normal animals. ×39

„ 102. Spec. 16. C.N.183m. Second antenna, R.S., showing the curved hairs (as in the immature male). ×39

„ 103. „ „ First gnathopod, R.S.; palm and claw enlarged, showing sensory spine inset in mid-margin. ×97

„ 104. „ „ First gnathopod, R.S.; under surface of the palmar angle, showing the 2 extra spines. ×97

„ 105. „ „ First gnathopod, L.S.; under surface of the palmar angle, showing the 1 extra spine. ×97

„ 106. „ „ Second gnathopod, R.S.; palm and claw enlarged, showing sensory spine inset in mid-margin. ×97

„ 107. „ „ Second gnathopod, R.S.; under surface of the palmar angle. ×97

„ 108. „ „ Second gnathopod, L.S.; upper surface of the palmar angle. ×97

„ 109. „ „ Fourth broodplate, R.S.; under surface. ×39

„ 110. „ „ Fourth broodplate, L.S.; under surface. ×39

„ 111. Spec. 30. C.N.285a. Second gnathopod, L.S.; under surface of the palm with 2 extra spines developed. ×97

„ 112 Spec. 31. C.N.218b. Second gnathopod, R.S.; palm, showing claw impinging against the under surface (cf. Fig. 100). (The hand has been flattened a little, under a cover-glass. In life the whole palm was bent at an angle to the rest of the hand.) ×97

„ 113. „ „ Second gnathopod, L.S.; under surface; position of the claw normal. ×97

PLATE IX.

Tmetonyx similis (G. O. Sars).

Fig. 114. First antenna, R.S.; under surface; normal ovigerous female. ×42

„ 115. Second antenna, R.S.; under surface; normal ovigerous female. ×42

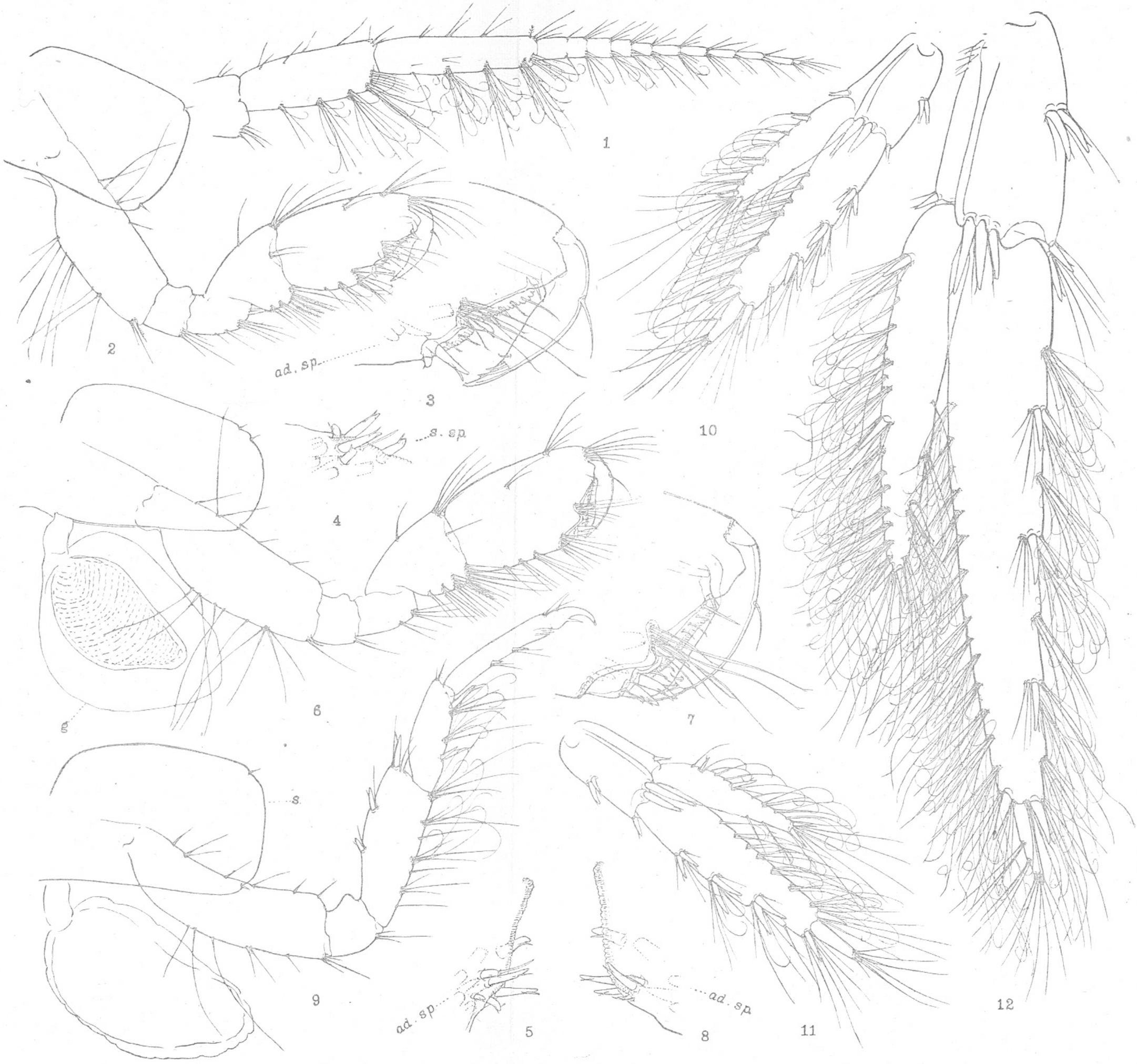
„ 116. First peræopod, R.S.; under surface, showing broodplate and gill; normal ovigerous female. ×42

„ 117. First antenna, R.S.; under surface; ovigerous intersex. ×42

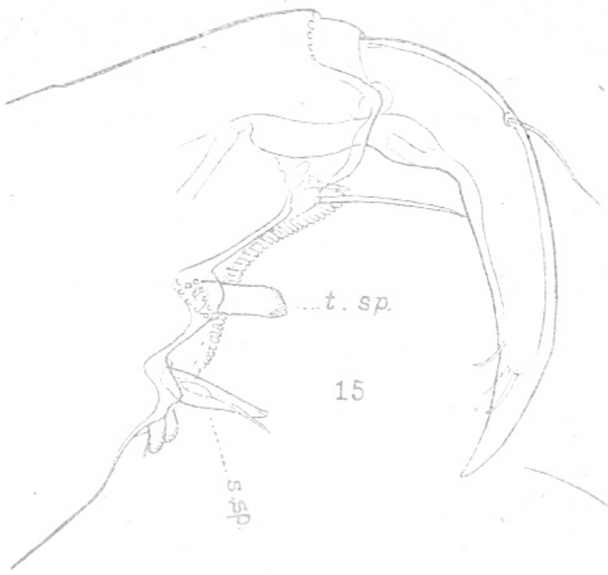
„ 118. Second antenna, R.S.; under surface; ovigerous intersex. ×42

„ 119. One of the calceoli enlarged. ×265

„ 120. First peræopod, R.S.; under surface, showing broodplate and gill; ovigerous intersex. ×42

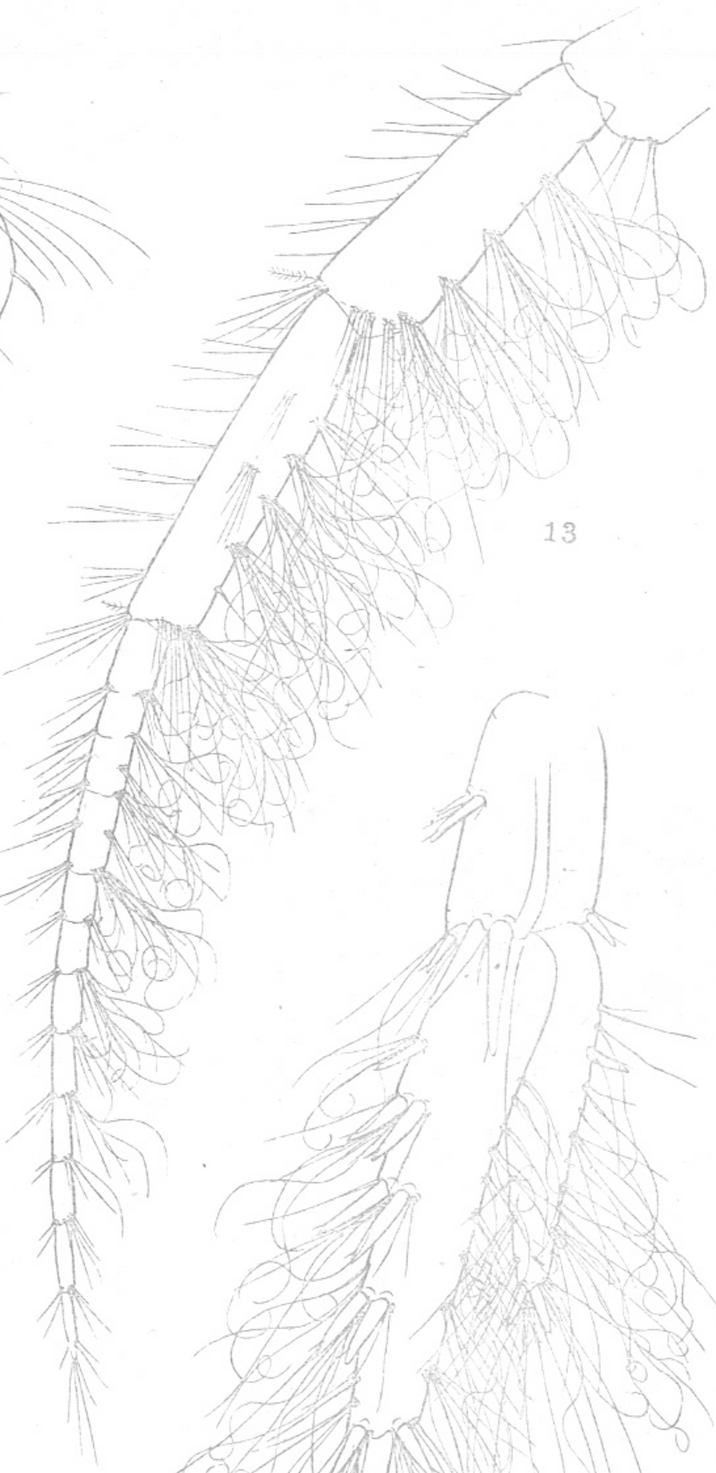


E. W. SEXTON del.

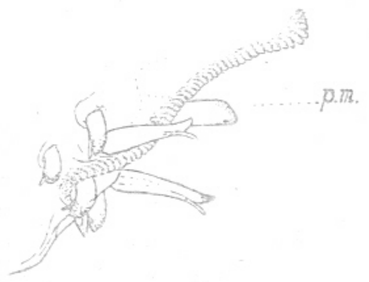


15

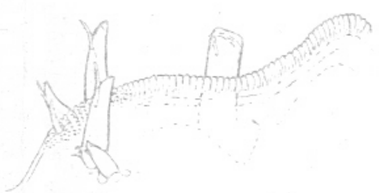
14



13

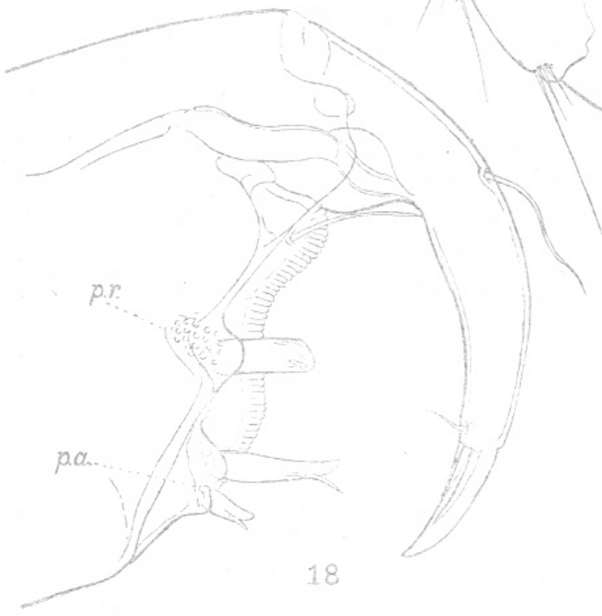


16

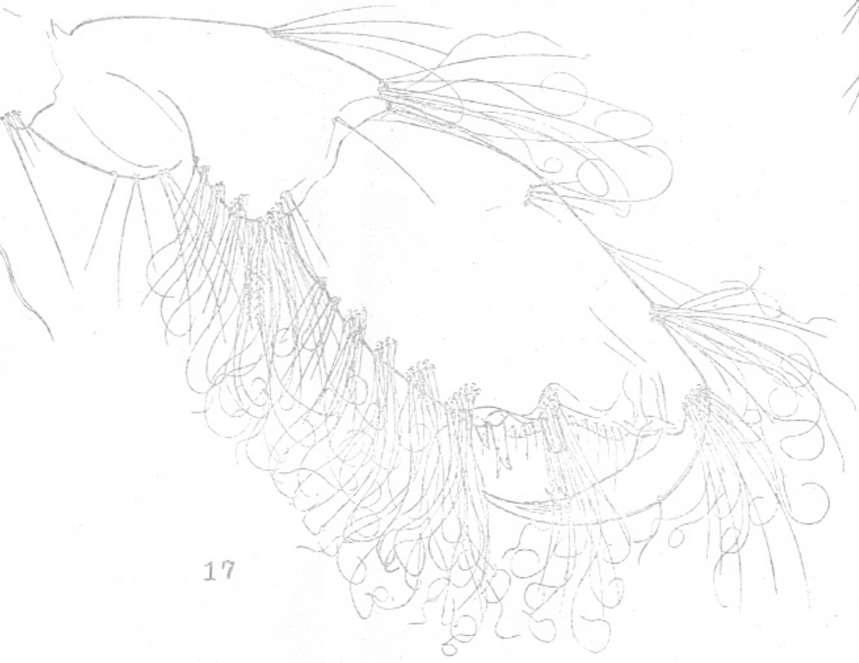


19

20



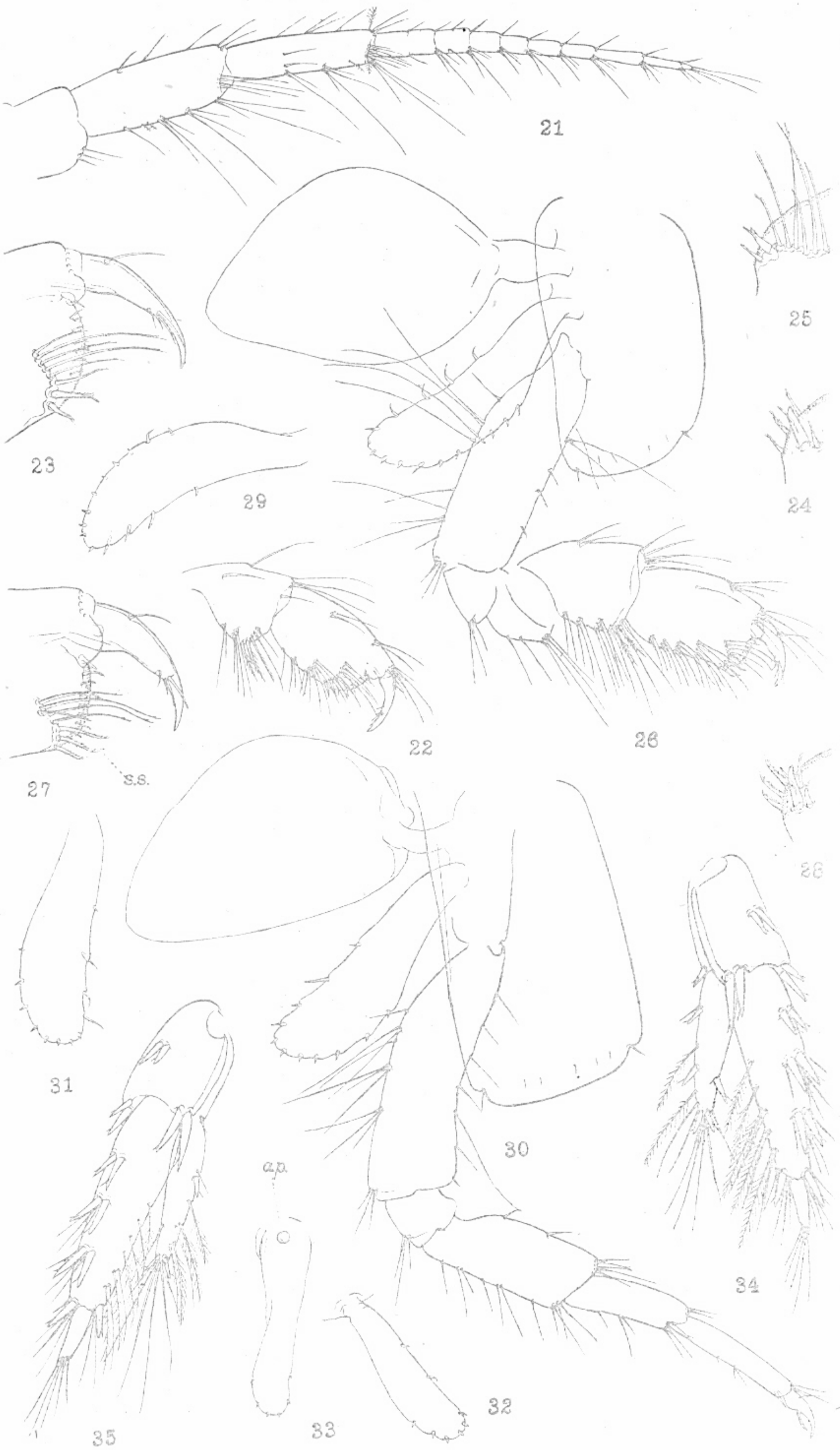
18



17

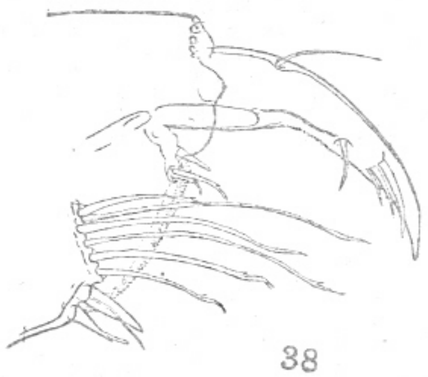
E. W. SEXTON del.

PLATE III.



E. W. SEXTON del.

PLATE IV.



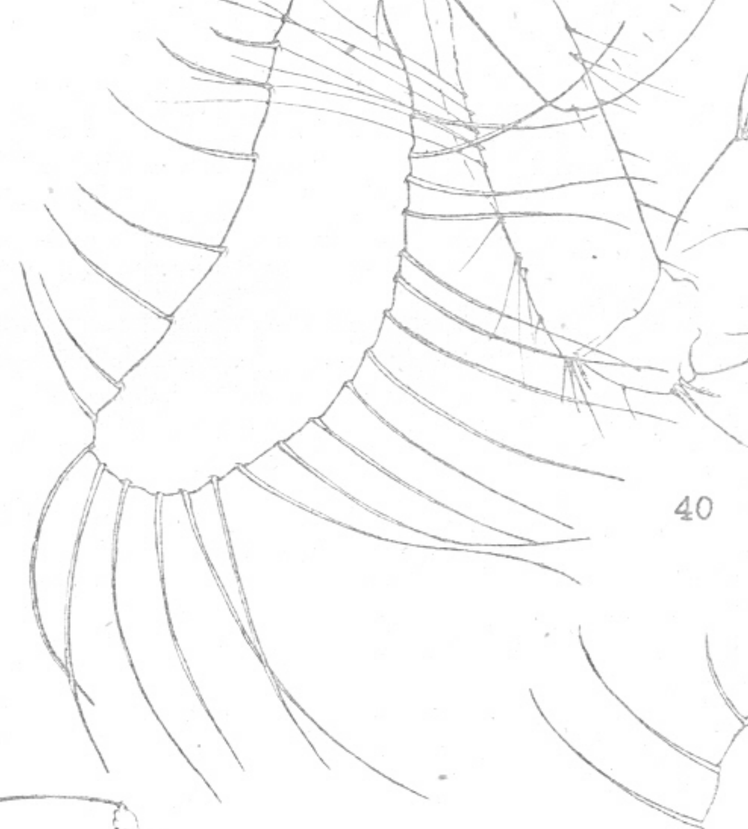
38

36

39

37

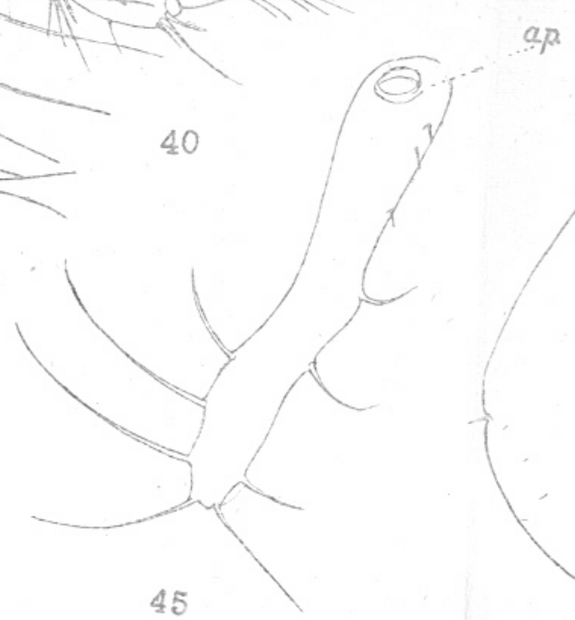
44



40

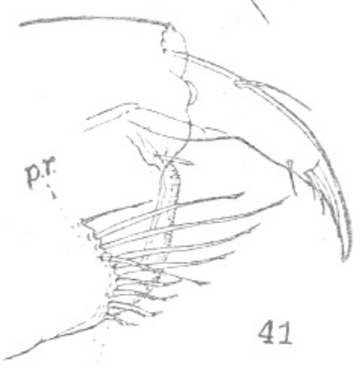
46

47



45

43



41

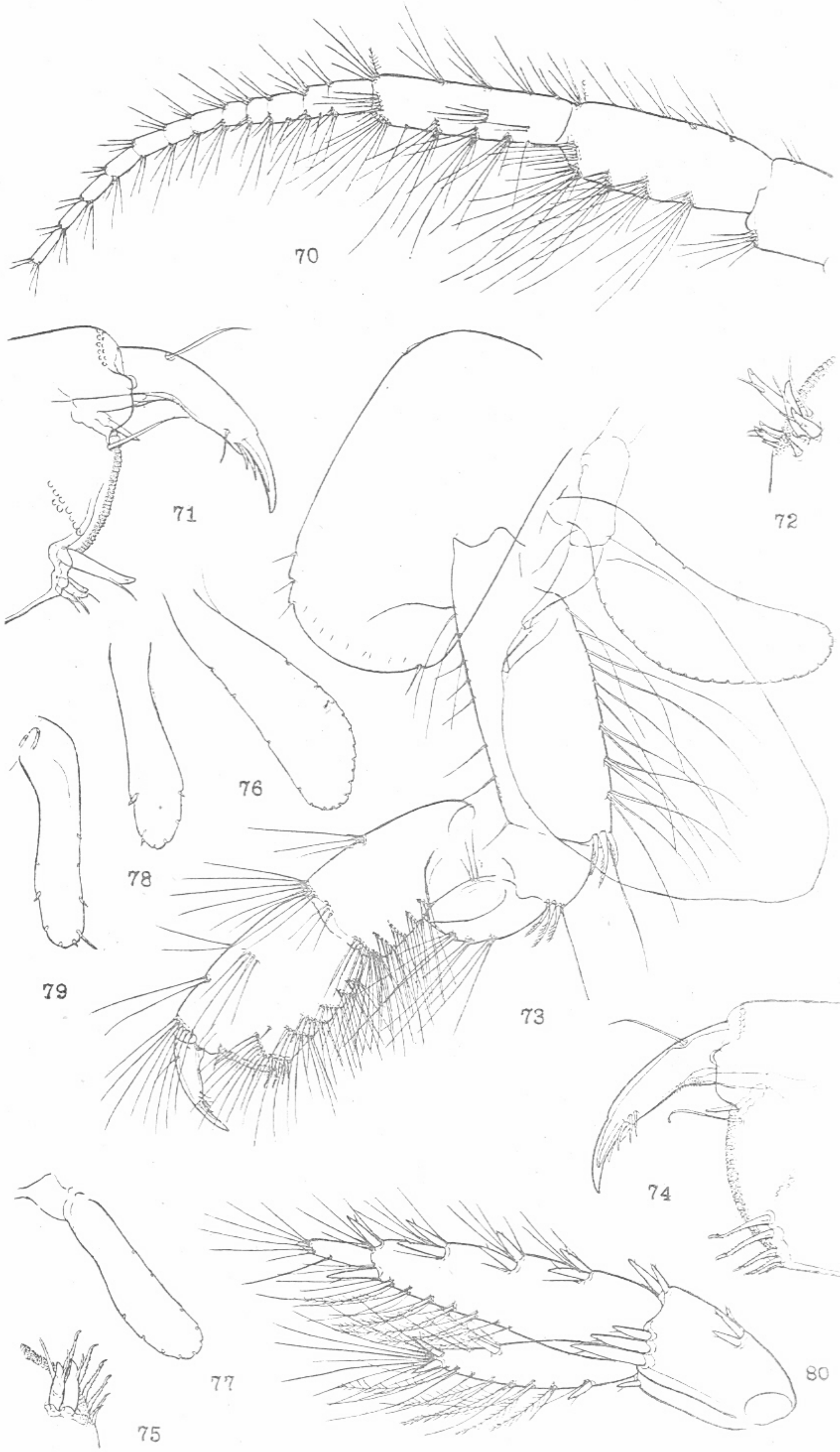
42

E. W. SEXTON del.

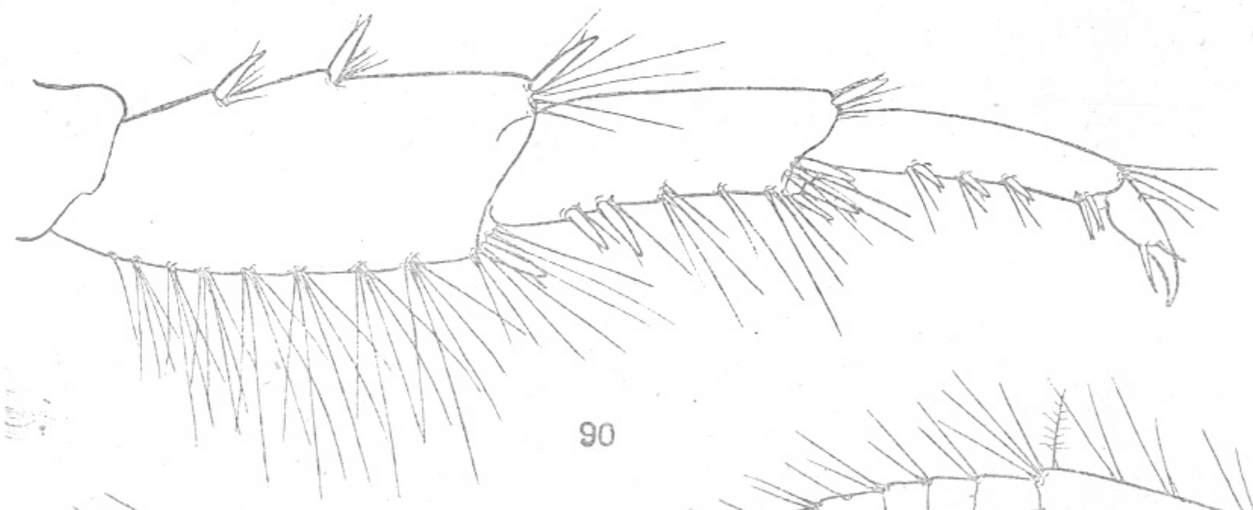
PLATE V.

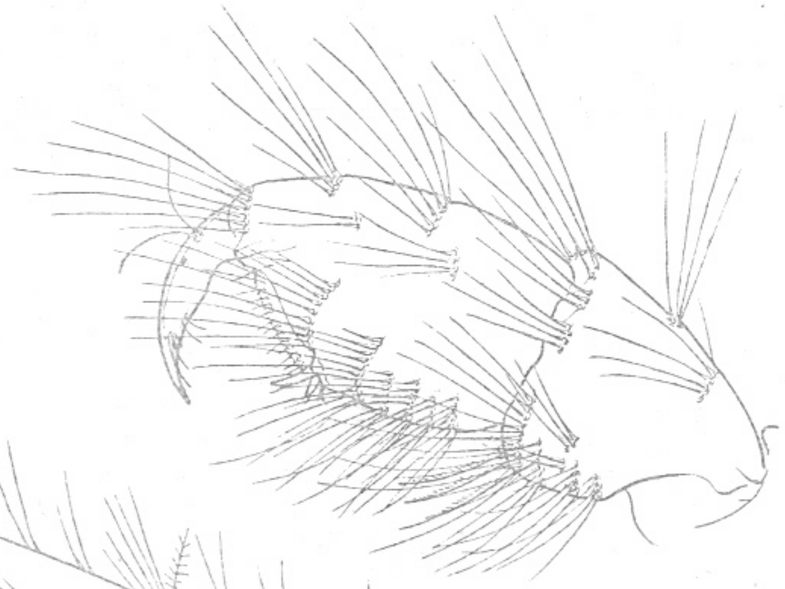
E. W. SEXTON del.

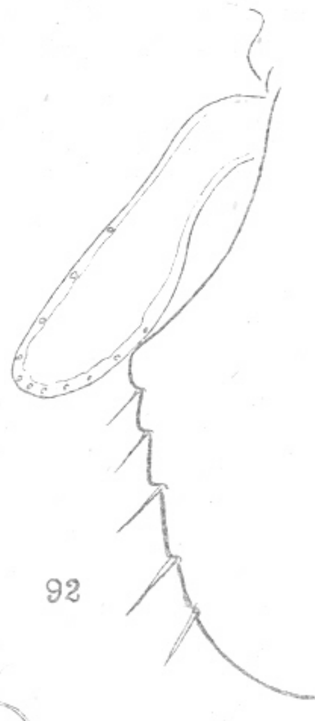
PLATE VI.

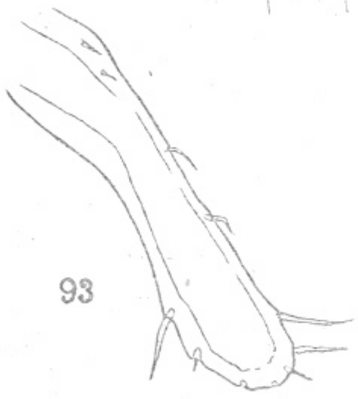


E. W. SEXTON del.

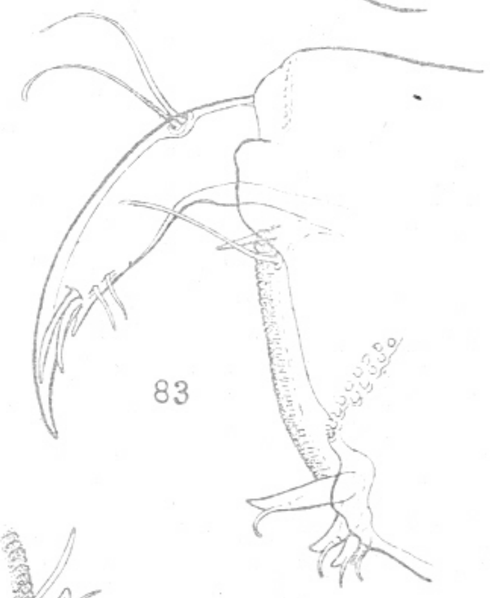

90

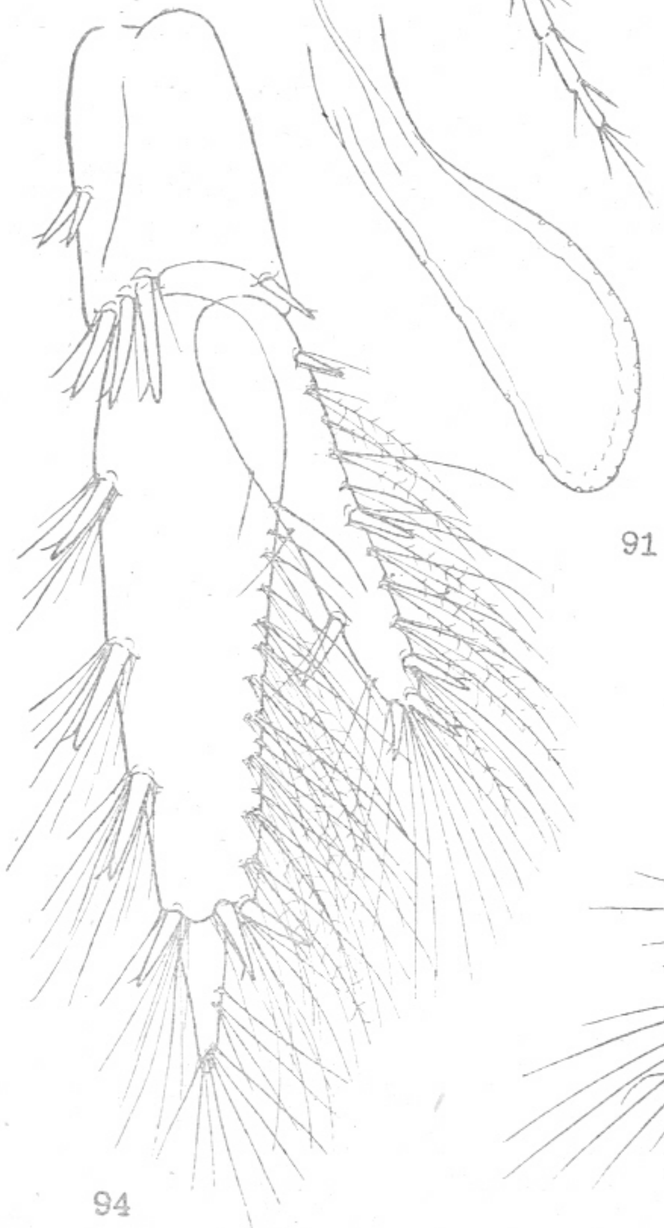

82


92


93


81

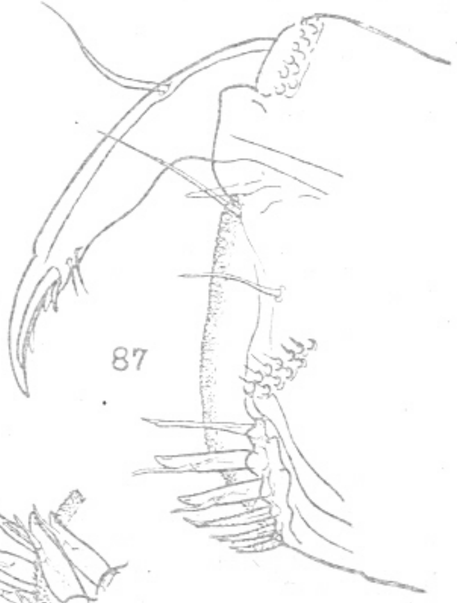

83


94

91 86


84


85


87

88


89

PLATE VIII.

E. W. SEXTON del.

PLATE IX.