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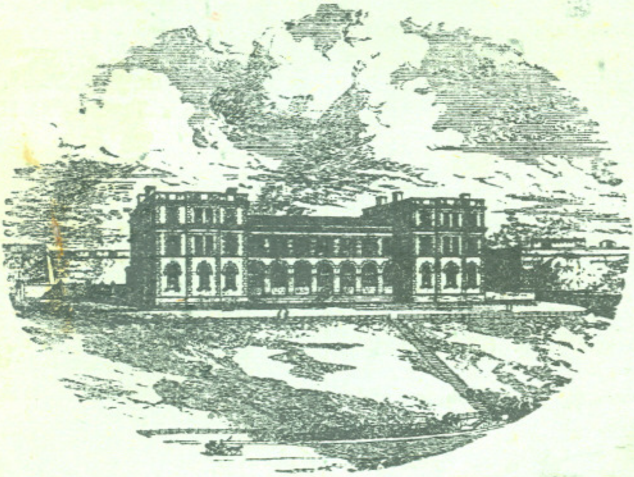

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A Contribution to the Quantitative Study of Plankton.

By

E. J. Allen, D.Sc., F.R.S.

Director of the Plymouth Laboratory.

THE well-known work of Hensen (1887) was the first serious attempt to determine the actual number of individual plankton organisms in sea-water. Hensen's method consisted in straining a vertical column of water through a net of fine-meshed bolting silk having 6,000 to 6,500 meshes per square centimetre, the average length of the side of a mesh being 50 μ. A carefully measured sample of the organisms retained by the net was taken and the number of organisms in it counted. From this, since the area of the mouth of the net and the distance through which it was drawn were known, the number of organisms in a unit volume (1 litre) of water could be calculated, with the help of a coefficient of filtration for the particular pattern of net employed, which was determined experimentally. Many small organisms, however, escaped through the meshes of the net, and Lohmann (1902, 1908) made a special study of these by filtering through hard filter paper or closely woven taffeta silk, by an examination of the filtering apparatus in the "houses" of Appendicularians, and finally, for the quantitative estimation of the smallest organisms of all, by subjecting samples of sea-water to the action of a centrifuge making 1,400 revolutions per minute for a period of 7 minutes. The use of the centrifuge has been continued by Gran (1915) and by Lebour (1917). For the full literature of the subject the reader is referred to Gran (1915) and Lohmann (1911).

In the course of my work on the cultivation of plankton diatoms (1910, 1911) I became convinced that even the quantitative method based on the use of the centrifuge fell very far short of giving the total number of organisms actually present in a sample of sea-water, and the results recorded in the present paper show that this is certainly the case. The figures now given, which are based on culture experiments, though very greatly exceeding those obtained by the use of the centrifuge, must still be regarded as minimal figures, and by no means represent the actual number of organisms present, even when we leave out of consideration the bacteria, which I have not attempted to enumerate.

The culture solution used was the modification of Miquel's solution recorded in the paper by Allen and Nelson (1910). Two solutions were made up :—

A.	Potassium nitrate	22·2 grams.
	Distilled water	100 grams.
B.	Sodium phosphate ($Na_2HPO_412H_2O$)	4 grams.
	Calcium chloride ($CaCl_26H_2O$)	4 grams.
	Ferric chloride (melted)	2 cc.
	Hydrochloric acid (pure concentrated)	2 cc.
	Distilled water	80 cc.

To 1 litre of sea-water 2 cc. of solution A and 1 cc. of solution B were added. After the addition of the two solutions, the sea-water was brought to the boil and then allowed to cool and stand for at least 24 hours, generally for some days, the precipitate which forms settling to the bottom. The clear liquid was poured off and used in the experiments. Long experience has shown that no growth of organisms (other than bacteria and possibly moulds introduced from the air) occurs in sea-water so prepared unless it is inoculated with sea-water containing such organisms. All flasks were thoroughly cleaned and baked in an oven before use, and pipettes were always both boiled and baked, a clean and sterile pipette being used each time a flask was examined.

On September 6th, 1918, a sample of sea-water was taken near the Knap Buoy, which is situated about ½ mile outside the Plymouth Breakwater. The sample was taken in a sterilised Winchester quart bottle, which was plunged, after the stopper had been taken out, one or two feet below the surface and allowed to fill. The sample was dealt with immediately it reached the Laboratory ; (1) by centrifuging 40 cc. of it twice, and counting the number of organisms under the microscope in the ordinary way and (2) by a culture method in which the organisms present in ½ cc. were allowed to grow.

1. EXAMINATION BY MEANS OF THE CENTRIFUGE.

This part of the experiment was carried out by Dr. Lebour, on the same plan as that usually followed by her in the quantitative determination of the microplankton of Plymouth Sound (Journal M.B.A., Vol. XI, p. 133, 1918).

Four glass tubes with pointed ends, each containing 10 cc. of the sea-water, were subjected for 10 minutes to the action of a centrifuge worked by a small water-motor and running at about 1,140 revolutions per minute.[1] The bulk of the water was then poured off from the tubes and

[1] The centrifuge was the same and worked at the same speed as that used by Dr. Lebour in her work on the microplankton of Plymouth Sound. The tubes were 65 mm. long (including the pointed ends) with an internal diameter of 18 mm. At a later date a careful comparison was made between the results given by this centrifuge and those given by a hand centrifuge driven at 1,680 revolutions per minute, with two tubes 95 mm. long (including the pointed ends) and 11 mm. diameter. The former, driven by the water-motor, proved to be distinctly more efficient.

the drop containing the organisms remaining in the pointed end of each tube was removed by means of a pipette and transferred to a ruled glass slide on which the number of organisms was counted under a microscope. The bulk of the water was then put back in the tubes, again centrifuged for 10 minutes and the organisms deposited, examined and counted.

Table I gives the result obtained by Dr. Lebour by using the centrifuge in this way.

Table I. Water Sample from near Knap Buoy, September 6th, 1918.
Four tubes of 10 *cc. each, centrifuged twice.*

AVERAGE NUMBER IN 10 CC.

× indicates that the organism was seen once only in the 40 cc.

Navicula sp.	10	Lithodesmium undulatum	1
,, membranacea	1	Pleurosigma sp.	2
Thalassiosira gravida	2	Hyalodiscus stellatus	×
,, sp.	×	Prorocentrum micans	6
Chætoceras sp.	16	Peridinium sp. juv.	7
Skeletonema costatum	26	Glenodinium bipes	3
Nitzschia closterium	8	Amphidinium crassum	×
,, delicatissima	7	Gymnodinium teredo	×
,, seriata	1	,, sp. juv.	3
Coscinodiscus radiatus	1	Spirodinium glaucum	×
,, excentricus	×	Cochlodinium sp.	×
,, sub-bulliens	×	Flagellata indet.	21
Rhizosolenia faerœensis	2	Tintinnopsis beroidea	1
Asterionella japonica	13	Infusoria indet.	×
Eucampia zoodiacus	3	Foraminifera indet.	×
Paralia sulcata	8	Algal spore	×
		Larval bivalve	×
		Larval crustacean	×

This gives **14·45 organisms per cubic centimeter or 14,450 per litre.**

2. EXAMINATION BY MEANS OF CULTURES.

The bottle containing the sea-water sample of September 6th, 1918, was shaken up and $\frac{1}{2}$ cc. was drawn out and measured off with a 2 cc. pipette graduated in 50ths of a cc. The $\frac{1}{2}$ cc. was added to 1,500 cc. of sea-water which had been treated with Miquel solutions as already described, boiled and allowed to cool and the precipitate to settle. After being well shaken up the solution was divided up into 70 very small flasks (capacity of flask 50 cc.), so that on the average there was a little over 20 cc. in each flask. These 70 flasks were placed in a north light and kept at room temperature without a fire (September and early October).

After ten days many of the flasks showed distinct signs of growth, and the first examination was commenced on September 16th and extended to September 19th. The different kinds of organisms found growing in each flask were recorded. A second examination was made between October 4th and October 15th, and a third examination between October 17th and October 23rd.

The organisms found were chiefly diatoms, flagellates and other protozoa. Bacteria were practically always present, but no attempt was made to distinguish them, and they are not included at all in the figures given below.

It must be understood clearly that the numbers given are *minimal* numbers. Closely allied species, where there was any possibility of their being merely varieties or " growth forms " of one species, were counted only as one organism when they occurred in the same flask. Thus *Nitzschia delicatissima* and *Nitzschia seriata* are not counted as distinct, and never more than one species of minute *Thalassiosira* is recorded from the same flask. In the case of *Chætoceras* never more than two were recorded in any one flask, and then only when the distinction between them was very marked. Flagellates were only regarded as distinct when their characters were very marked indeed.

The largest number of different kinds of organisms found in one flask was 7 ; in two flasks only one organism was distinguished, and there were no flasks in which no growth at all took place. The average number of different kinds of organisms per flask for the whole series was 3·3. Adding together the numbers found in each flask for all the 70 flasks we get a total of 232 different organisms. Now each of these must have been represented by at least one individual or unit, either as cell or spore, in the original $\frac{1}{2}$ cc. of sea-water from which the experiment was started. The sample of sea-water therefore must have contained **at least 464 organisms per cubic centimeter or 464,000 per litre.**

The real number must be very considerably greater than this. In the case of several of the minute diatoms, especially small *Thalassiosira*-like species, they form little patches of encrusted growth on the sides and bottom of the flask, and when the flasks are first examined, and before they have been disturbed in any way, two or three or more patches are frequently seen in the same flask, showing that the growth in that flask has probably started from more than one individual cell or spore. In the case of chain-forming diatoms such as *Chætoceras* it is practically certain that the chains are not all broken up into individual cells by the shaking given to the $1\frac{1}{2}$ litres of inoculated culture solution before it is distributed amongst the 70 small flasks. In many cases the growth of such species in a flask will have started from more than a single cell.

The organisms recorded are only those that will grow in the particular culture medium employed, and under the conditions of light, temperature, etc., in which the experiment was carried out. It is certain that many species cannot be cultivated at all under these conditions. I have, for example, in the whole course of my work only once had a species of Peridinian in culture.

Taking all these points into consideration we should probably be within the mark in putting the number of organisms in the sample of sea-water examined at least one million per litre.

To what extent the number found represents individual cells and to what extent it represents "spores" it is impossible to say definitely. The organisms most frequently occurring in the cultures are small diatoms and flagellates of different kinds, the usual mode of reproduction in both cases being by binary fission, reproduction by spore formation being exceptional.

The following table gives the details of the experiment just described :—

Table II showing the minimum number of organisms (excluding bacteria) in ½ cc. of sea-water collected near the Knap Buoy, September 6th, 1918, *as determined by a culture experiment in which it was distributed amongst* 70 *small flasks.*

	Number of Occurrences in ½ cc.
Navicula sp.	4
Thalassiosira (large sp.)	9
,, (minute sp.)	59
Chætoceras sp. (not more than 2 recorded in one flask)	73
Skeletonema costatum	6
Nitzschia delicatissima	8
,, closterium	19
Coscinodiscus sp.	4
Detonula sp.	1
Rhizosolenia færœensis	2
Asterionella japonica	1
Eucampia zoodiacus	1
Minute diatom indet.	1
Chrysomonads	14
Cryptomonad	1
Peridinian	1
Coccolithophora	4
Tintinnids	2
Other Protozoa	22
Total	232

Notes on Table II.

Chætoceras sp. The most common species was a small one with cylindrical cells 11 μ long by 2·8 μ diameter. There was also a species with square cells, the side of the square being considerably less than the length of the cylindrical cells, probably about 5 μ, though no actual measurement was taken.

Thalassiosira sp. There were at least two minute species very frequent, one with diameter 4 μ and height 4 μ, the other with diameter 2·8 μ. These two were counted as one when occurring in the same flask. A larger species of *Thalassiosira* with diameter 8·3 μ was regarded as different.

Navicula sp. Two species occurred, a larger and a smaller one. The former had frustules 25 μ long by 5 μ broad at the widest part, and was the one usually found. The smaller one had frustules about 13 μ long.

The *Chrysomonads* were chiefly 3 μ to 7 μ in diameter, the *Cryptomonad* was 7 μ.

For comparison with the above experiment, a culture experiment started August 6th, 1918, and carried out in a similar way in 66 flasks, with ½ cc. of sea-water from a sample taken near the Knap Buoy, may be recorded. In this case the experiment was commenced for another purpose and no comparative examination of centrifuged samples was made.

The number of different organisms proved in the 66 flasks, that is the minimum number of individuals which must have been present in the original ½ cc. of sea-water, was 231, which is almost the same figure as that found from the experiment of September 6th.

The following table gives a list of the organisms. It will be noticed that the proportion of flagellates is larger in this sample than in the previous one.

Table III showing the minimum number of organisms (excluding bacteria) in ½ cc. of sea-water collected near the Knap Buoy August 6th, 1918, as determined by a culture experiment in which it was distributed amongst 66 small flasks.

	Number of Occurrences.
Navicula (2 species) . . .	60
Thalassiosira sp.	36
Chætoceras sp.	18
Skeletonema costatum . . .	6
Nitzschia delicatissima . . .	17
,, closterium . . .	7

	Number of Occurrences.
Lauderia borealis . . .	1
Flagellates (not more than 2 recorded in one flask)	73
Ciliates	10
Amœba	1
Coccolithophora	2
Total . . .	231

A comparison of the list of species and number of specimens recorded from the centrifuged sample (Table I) with that obtained from the culture (Table II) shows a considerably larger number of *species* revealed by the centrifuge, as we should expect from the larger sample examined (40 cc. as against $\frac{1}{2}$ cc.), whereas the number of *individuals* per cc. revealed by the culture is very much larger, more especially in the case of the smaller species.

In Table IV, which is compiled from Tables I, II, and III, the numbers given by the three experiments have been multiplied up to show the number of organisms per litre, so that the three can be more readily compared.

Table IV. Number of plankton organisms per litre shown by the three experiments.

	Centrifuge. Sample of Sept. 6th. Number per litre from Table I.	Culture. Sample of Sept. 6th. Number per litre from Table II.	Culture. Sample of Aug. 6th. Number per litre from Table III.
Navicula . . .	1,100	8,000	120,000
Thalassiosira . .	225	136,000	72,000
Chætoceras . .	1,600	146,000	36,000
Skeletonema costatum	2,600	12,000	12,000
Nitzschia delicatissima and seriata .	800	16,000	34,000
Nitzschia closterium	800	38,000	14,000
Coscinodiscus . .	150	8,000	—
Rhizosolenia færœensis .	200	4,000	—
Asterionella japonica .	1,300	2,000	—
Eucampia zoodiacus .	300	2,000	—
Other diatoms . .	1,125	4,000	2,000
Peridinidæ . .	2,000	2,000	—
Other Protozoa . .	2,250	86,000	172,000
Totals .	14,450	464,000	462,000

There is obviously at present no method that is capable of giving us a complete quantitative estimate of the total number of individual organisms in a sample of sea-water, but by combining a number of method we shall gradually get nearer to the solution of the problem. The present note it is hoped may carry the question a step forward.

My best thanks are due to Dr. M. V. Lebour, not only for carrying out the examination of the sample of sea-water by means of the centrifuge, but also for constant help in the determination of species.

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Feeding Habits of Some Young Fish.

By

Marie V. Lebour, D.Sc.

Naturalist at the Plymouth Laboratory.

With two figures in the text.

CONTENTS.

INTRODUCTION.

During the year 1918 several young fish brought in alive from the tow-nets were kept in small aërated aquaria at an even temperature and fed on plankton. In this way feeding habits were noted and some post-larval fish went through a metamorphosis into the adult form, notably *Labrus bergylta* the Ballan Wrasse, *Solea vulgaris* the Sole, *Solea lascaris* the Lemon Sole, and three species of *Lepadogaster*. Young Whiting and Pollack were also kept alive for some months and fed eagerly on most of the food that was given to them.

A great difference was seen in the way the various species of young fish feed. Some deliberately stalking certain selected food, others apparently eating the first thing that comes. Some feeding at all times, others only at night. Some eating very little at one time, others eating as much as they can get. Some very shy and only eating when apparently unobserved, others snapping immediately at the food. The Whiting, of all the young fish observed, is the greediest and very clever at recognizing the different foods and selecting the best first. The Pollack comes second. These stalk their food, usually Copepods, coming up behind and giving a sure sideways dart so that the Copepod is swallowed head first. Many times have Whiting and Pollack been captured with Copepods in their mouths, having probably swallowed these after being caught in the tow-nets when in a broad-mouthed bottle. The Copepods are always head first in the mouth, the advantage to the fish being obvious, as legs, antennæ and spines then fit close to the body and project as little as possible, whereas if the tail goes in first all would stick out, and a fish is easily choked by a spine. One small Whiting died from swallowing a crab megalopa whose dorsal spine stuck in its throat so that it was impossible to close the mouth. This particular fish took the megalopa very unwillingly and only because it was very hungry, but Whiting of a slightly larger size take crab megalopæ as part of their natural food, as is shown in this year's food records (see page 34 of this Journal).

Whiting being the cleverest of the young fish, the Ballan Wrasse, *Labrus bergylta*, is certainly the most stupid. Its movements are heavy and slow and food is not observed for a long time after having been put into the aquarium. When it does eat it does not stalk its food, but snaps up the small Copepods or other small Crustacea that cross its path. This slowness of perception of the food is curious, as the adult Ballan Wrasse in the aquarium tanks is very greedy and will if possible eat up all the other fishes' food.

The species of *Solea* were both very alert, but *Solea vulgaris*, although agitated by the presence of food, only ate it at night, *Solea lascaris*, on the other hand, would come a long way when food was put into the aquarium, and dashing in amongst it would snap quickly at it, not stalking anything, but selecting what it liked best.

Young Lump Suckers, *Cyclopterus lumpus*, were exceedingly intelligent. Fixed by their suckers to the glass sides of the aquarium or to the aërating tube they would know at once when food was near, instantly unfix and swim about, then selecting something specially attractive would chase it and quickly swallow it. They never snapped at food whilst they were fixed but always fed swimming. The little rock suckers, *Lepadogaster* spp., were the same in this way and always moved about when feeding.

Rockling *Onos mustela* were always shy when feeding, but would eat almost anything, *Callionymus lyra* the dragonet, and the gobies, *Gobius* spp., were also not at all particular as to the food they ate and snapped up most of what was given to them. Brill and Turbot are very dainty, but ate occasionally Copepods, larval Crustacea, Isopods or Amphipods. Various species of Blenny would dart after Copepods, using their long fins, but were difficult to keep alive in the small aquaria.

LABRUS BERGYLTA. The Ballan Wrasse.

Three were kept alive, one of 6 mm. on June 12th, one of 7 mm. on July 16th, and one of 7 mm. on August 7th. All of these were similar to those recorded by Clark (1914) and Allen (1917) having the hind part of the tail quite free from pigment, which covers the rest of the body. Two completed their metamorphosis and showed themselves to be truly *Labrus bergylta*, thus proving that these authors were right in attributing the post-larval form to this species.

By June 25th the specimen of 6 mm. had grown to 11 mm. and had undergone its metamorphosis. On July 23rd it died, measuring 15 mm. The second specimen died the next day and contained no food. The third specimen metamorphosed at 11 mm. and lived until October 2nd measuring 13 mm. Both those that lived kept at the bottom of the aquarium all through the post-larval state and seemed to try to hide away as much as possible. After metamorphosis they would swim about more, especially if feeding. Their movements were always very slow, food being taken casually and without apparent selection although in the post-larval forms from the tow-nets taken from June to August and measuring from 4 to 10 mm. *Temora longicornis* was almost exclusively eaten even by the smallest, with *Podon intermedius* in July when it was common. In captivity *Labrus bergylta* would eat almost any small Copepod, *Temora* often being present, but also there were many *Acartia clausi*, *Oithona similis*, and Copepod nauplii of various species and *Balanus* nauplii which were always eaten. *Calanus finmarchicus* although often offered was never eaten even by the largest fish of 13 mm. It is possible that its movements are too quick for such a sluggish creature. It is an interesting fact that oyster spat was eaten, for most of the post-larval fish refused it. *Limacina retroversa* was, however, not liked and always left. After metamorphosis the food seemed to be the same as before.

TRACHINUS VIPERA. Lesser Weaver.

Four specimens were procured alive from the tow-nets in July and August, from 6 to 30 mm., but none lived more than a few days and they would not eat at all. One of 12 mm. caught August 2nd, died on August 8th, and in its stomach was an adult specimen of the trematode, *Derogenes varicus*, full of eggs. No food was found in any of them.

LOPHIUS PISCATORIUS. ANGLER.

A post-larval Angler occurred from the region of the Panther buoy on July 2nd, 1917. It measured 8·5 mm. in length and was alive when

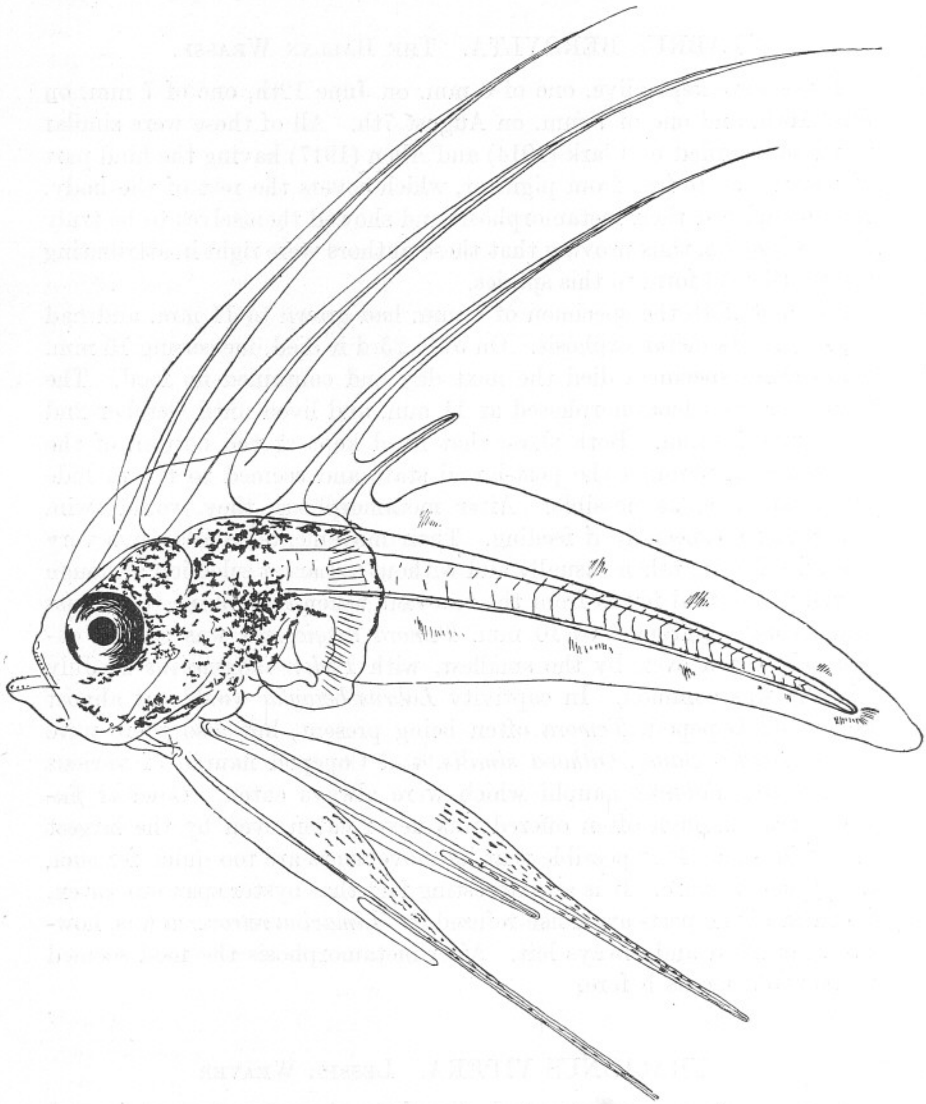

FIG. 1. Post-larval Angler, *Lophius piscatorius*, 8·5 mm. long.

brought into the Laboratory (Fig. 1). The most striking feature was its large and extremely brilliant blue eye, which glistened intensely. The yellow and black pigment of its head and fore part of the body and the distal portion of its pelvic fins was also conspicuous. The distribution of the pigment is peculiar, as it is entirely confined to the region from the head to the end of the alimentary canal and to the distal portions of the pelvic fins. A diffuse bright yellow pigment occurs over almost the whole of this anterior region with dense black dendritic chromatophores. The part of the head in front of the eye is almost destitute of pigment and the head crest is perfectly clear with no pigment at all. For rather more than half its length the distal end of the pelvic fin is a diffuse yellow with black chromatophores and the fringed edge of the pectoral fins are provided with small black chromatophores. Behind the anus the body is perfectly clear and hyaline.

This stage is very like the American form figured by Agassiz (1882) who, however, gives no measurements. It is older than those figured by Allen (1917) and Prince (1891), these two latter being at about the same stage and measuring over 6 mm., and it is at a much less advanced stage than the post-laɪval of 7 mm. figured by McIntosh and Prince (1890) although larger than this. The anterior portion of the dorsal fin is provided with four processes each with a supporting ray, the two front rays ending in extremely fine filaments. The pectoral fins are large with lobed edges and reach beyond the alimentary canal. The pelvic fins are much more developed than they are in the Plymouth specimen of 1917 (from 1914 tow-nets) being nearly as long as the body and having two distinct fin rays. Its shape approaches the more advanced stages figured by Agassiz (1882).

This stage follows on naturally from the younger stage from Plymouth and the oldest form figured by Prince from the Firth of Forth, the latter being 15 days old, so that probably the present specimen is a few days, older than that, perhaps three weeks old. It appears to be slightly older than Fig. 1, Pl. XVIII of Agassiz, but closely resembles this whilst the pelvic fins incline towards the shape in Fig. 2, and it exactly corresponds in colouring with Agassiz's description. There seems no reason to think, as Prince suggests, that the British *Lophius* is different from the American form in its post-larval stages. Danois (1913) figures a post-larval *Lophius* of 11 mm. in length which is at about the same stage as Allen's and Prince's, the pelvic filaments being rather longer.

On July 2nd from the Knap five young Anglers were obtained from 4 to 5 mm. long. These are rather younger than the Plymouth specimen recorded by Allen and figured by Mrs. Sexton (1917), having two head spines only and the clear space above the brain enormously developed. The pigment is almost entirely black with only a faint yellowish tinge, the eyes a very deep blue so that the anterior portion of the body alone is visible in the water, the little fish looking like small round masses of dark blue, the pigment being confined to the anterior portion of the body and the tips of the pelvic filaments. The head spines and the whole of the body behind the anus being transparent and colourless they are invisible in the water. No food was contained in any of these young Anglers and all died soon after they were brought in. The movements of these little Anglers are wonderfully beautiful and very quick, the long pelvic fins looking more like wings than anything else, and a quick darting movement being constantly kept up.

BLENNIUS OCELLARIS AND BLENNIUS GATTORUGINE.

One live *Blennius ocellaris*, the Butterfly Blenny, was caught on July 8th, measuring 18 mm. It fed on various Copepods, especially *Calanus* and *Temora*, but when these were not present it would eat *Acartia* and other small Crustacea including *Hyperia*. One *Blennius gattorugine* of 30 mm. caught August 12th ate similar food. Both would chase the food and dart at it with quick movements which have already been described by Garstang (1900) in the Butterfly Blenny. They both refused oyster spat.

GOBIUS MICROPS.

One *Gobius microps* measuring 10 mm. was caught alive from inside the Breakwater on July 24th. On December 18th it was still alive measuring 16 mm., and having the adult shape and colouring. It eats any small Crustacea, darting at them quickly, but not stalking them at all. At first it swam near the surface, but very soon retired to the bottom, where it stays. It usually eats up directly any Copepods given to it. When food was scarce it ate the young *Limnoria*, a wood-boring Isopod, oyster spat and *Limacina* were refused, also chopped worm.

GOBIUS RUTHENSPARRI.

One of 10 mm. was captured on June 7th; on December 5th it died measuring 25 mm. and was then in all respects like the adult, having changed from the larval and very transparent condition when it was only slightly pigmented, very soon after it was put into the aquarium. The black tail spot so characteristic of the species reached its ordinary condition at about 12 mm. Unlike *Gobius microps* this species does not live at the bottom but near the surface. It would eat almost anything that was given to it even including chopped worm, but the food was chiefly Copepods. Isopods 5 or 6 mm. long were eaten, but oyster spat and *Limacina* were refused.

CALLIONYMUS LYRA. Dragonet.

Two live specimens in May and July were obtained, one 10 mm. on May 21st, the other 7 mm. on July 7th. The first died July 15th at 21 mm., the other died October 6th at 17 mm. At 7 mm. it was still a surface swimming form, but underwent metamorphosis at 9 mm. and lived on the bottom. At the bottom they are almost invisible, looking as much like the background as possible and when food was put into the aquarium they did not come up for it, but when it went near the bottom they darted at it quickly. *Calanus*, *Temora*, *Acartia* and *Anomolocera* it took readily, also small worms, but oyster spat was, as in most cases, refused.

CYCLOPTERUS LUMPUS. Lump Sucker.

Five specimens were kept alive from the tow-nets in June and July measuring 10 to 25 mm. One of 23 mm. was caught on December 9th. All were caught among *Zostera*, where they feed on the small animals among the weed. They were always very alert and instantly perceived food given to them. With their large mouths they were able to catch quite large Crustacea larvæ, such as *Leander* nearly as long as themselves; *Crangon* and *Gebia* larvæ, crab zoeæ and megalopæ, Isopods and Amphipods, as well as Copepods were all eagerly eaten. The Decapod larvæ were caught from the side and bitten so that they were quite incapacitated, and then swallowed. *Leander* is a specially difficult animal to catch because it can see all round with its long-stalked eyes, and on account of its great agility requires a specially clever fish to catch it, but the young Lump Sucker never fails and will gaily continue to catch one after the other as they are put into the aquarium. The little Lump Sucker will go for quite large *Idotea*, sometimes, however, attempting to eat one that is too large. It then gives it a bite and leaves it and the *Idotea* pretends to be dead. The fish will not go for the food unless it is actually moving, so the *Idotea* is safe until it has recovered and swims about again, when the fish will again chase it, and seems to enjoy its races after its food.

LEPADOGASTER CANDOLLI.

One specimen of 6 mm. from the tow-nets on July 29th was kept alive for a few days, but died on August 2nd, measuring 6·5 mm. When caught it was bright red and yellow, the red predominating and spreading all over the ventral surface. It is one of the most brilliant of the post-larval fish. At this stage it tried to fix itself by its fins although no proper sucker was developed and the larval fin was still present round the tail. In the four days it underwent a metamorphosis so that the adult fins with fin rays were formed, the ventral sucker present in a rudimentary state, the colouring entirely different from the post-larval form (Fig. 2). The pigment in this later stage is arranged all over the body in irregular stripes running dorso-ventrally, the stripes themselves

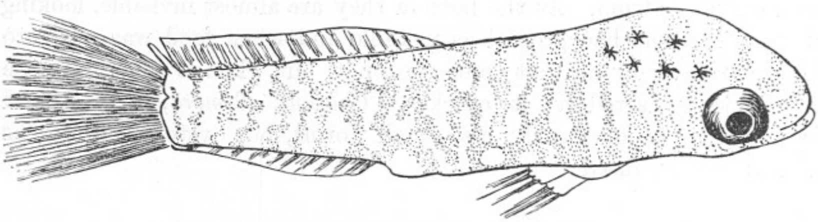

FIG. 2. *Lepadogaster Candolli.* Length 6·5 mm.

formed of spots of a dull purple colour and anastomosing here and there. The characteristic starry black chromatophores on the top of the head still persist. This colouring is totally unlike the adult fish and approximates more to that of its relative *Lepadogaster bimaculata*, but the form of the fins shows it to belong to the present species. Its food in captivity consisted of small plankton, chiefly Copepods and *Balanus* nauplii, which it pursued when they came near the bottom, but it never approached the surface to feed.

LEPADOGASTER BIMACULATUS.

Two live specimens were caught in the tow-nets. The first on August 19th, measuring 6 mm., almost immediately metamorphosed, fixing itself by its pelvic fins and the characteristic unpaired fins appearing. The colouring was at first pinkish, but after a few days it turned to a purple which was much more like that of the young *Lepadogaster Candolli* just described, but the blue spots are very conspicuous in the present species. It may thus be the light of the aquarium in the tank that induces this sombre colouration.

On December 4th this specimen measured 17 mm. and was in the form of body and fins like the adult. It lives clinging to the glass either at the sides or bottom of the aquarium, but leaves its hold for feeding and darts gently after its food, which consists of small Copepods, chiefly nauplii, and the adults of *Temora*, *Pseudocalanus* and *Acartia*. It also ate small Isopods.

Another specimen 18 mm. long was captured on November 30th. When first brought in it was bright red, but after living in a small aquarium on December 3rd it had changed to a dull greenish purple, somewhat approaching the colouring of the two above-mentioned specimens of *L. bimaculatus* and *L. Candolli*. It is evident that the colouring can change very easily.

LEPADOGASTER GOUANI.

One specimen of 6 mm. was caught in the tow-nets on August 19th. This is the common shore form and seldom occurs in the tow-nets. It was already fixing itself and its adult fins were formed. It unfortunately died the next day.

These notes on young *Lepadogaster* show that the time of metamorphosis of all three species is at about 6 mm., the permanent fins at that time being formed and fixation taking place.

SOLEA VULGARIS. Common Sole.

A Sole of 11 mm. was kept alive from the tow-nets on April 12th and is still alive and well. When captured it had not quite completed its metamorphosis, and although inclined to settle on the bottom it sometimes swam about near the surface. Very soon, however, it settled down at the bottom of the aquarium for good. *Temora* was given to it for food exclusively for nearly two months. This Copepod was chosen as it was found last year to be its commonest food. It throve very well on this although never seen to eat, as it always fed at night, all the Copepods having disappeared by the next day. About 30 *Temora* a day were given to it, but on some days none at all. By June 3rd it was more than double the size, now measuring 25 mm., and lying at the bottom of a flat glass aquarium with the upper part of its body a spotty sand colour. At this time as no *Temora* was obtainable *Calanus* was substituted, which was readily eaten, but, as before, always at night. On June 10th it measured 30 mm., having grown 5 mm. in 7 days, a few other Copepods, including *Acartia clausi* and *Anomalocera Petersoni*, being mixed with the *Calanus* and also eaten. After this it was given Decapod larvæ, *Crangon*, *Leander*, *Gebia*, *Hippolyte*, crab zoëæ and megalopæ, all of which it ate except the *Leander*, which apparently was difficult to catch. It even ate *Porcellana* larvæ, which are avoided by most young fish on account of the long spines. Young *Hyperia* and other Amphipods and young Isopods were also eaten and small live worms, but chopped worm at this stage was refused. Oyster spat was apparently uneaten. At 35 mm. in July it jumped out of the small aquarium and was seen in the larger tank in which this was standing. As this tank was fitted with a false bottom it was difficult to reach the Sole which was seen from time to time, pieces of chopped worm being periodically put into the water for it. On December 4th the false bottom was removed and the Sole rescued. It then measured 50 mm. As the normal growth is about 5 inches in the first year this is rather below normal, but is easily accounted for as the fish had little food. It will now eat chopped worm and is perfectly well.

SOLEA LASCARIS. Lemon Sole.

A specimen 9 mm. long was kept alive from the tow-nets on July 15th. The eyes were still quite symmetrical and the fish completely in the post-larval condition, swimming vertically and pigmented on both sides. Unlike *Solea vulgaris* it fed in the daytime, eagerly eating *Acartia clausi*, *Pseudocalanus* and Copepod nauplii. Directly the food was put into the aquarium it would come up to it and apparently selecting what it liked best it would retire backwards, make one dart at it and swallow it. It seemed to like the nauplii best, but would eat the smaller adult Copepods. *Calanus* and even *Temora* seemed at first too big for it. On July 20th it showed signs of settling at the bottom, and by August 1st it had completely metamorphosed. It still would come up to feed, getting agitated as soon as food was put into the aquarium. As it got bigger it ate *Temora* and *Calanus* and the smaller Decapod larvæ, but could not manage *Leander*, *Porcellana* nor crab larvæ. It also refused oyster spat and *Limacina*. In the autumn when plankton was scarce it took small Isopods, but like *Solea vulgaris* it refused chopped worm. It died on November 19th measuring 23 mm., having grown 14 mm. in four months.

RHOMBUS LÆVIS. Brill.

One Brill of 27 mm. on July 1st and one of 15 mm. on July 24th were kept alive from the tow-nets. The smaller specimen died the next day having eaten 4 *Anomalocera* that were given to it. The other lived till October 6th when it measured 33 mm., but it never ate very much. It was the only one of the small fish except the Lump Sucker that could take *Leander* larvæ, but it was slow to do this and never eager for food. It would only catch the live food if it were on or near the bottom and never rose to chase anything. *Anomalocera*, which was occasionally given it in numbers, it always ate, but would often leave *Calanus* alone for days; possibly because it was more difficult to catch. Brill of the same size were to be caught close inshore, which had all eaten young fish such as *Rhamphistoma belone* and *Onos mustela*, so that probably this specimen was pining for lack of fish food.

GADUS MERLANGUS. Whiting.

Several young Whiting were obtained from the tow-nets. The first three on May 27th measured 16 to 19 mm. *Calanus* was very common in the tow-nets just then, and nearly all the Whiting caught had been feeding on them. Many had them still in their mouths and must have been feeding in the jars after capture. The live specimens were therefore fed on *Calanus,* which they ate greedily and caught cleverly by stalking them and making a dart for them. They always perceived food directly it was put into the aquarium and went for it at once. However, if *Pseudocalanus* and *Temora* were put in with *Calanus* the fish would go for *Pseudocalanus* first, which bears out the fact recorded last year and corroborated this year that, although the young Whiting will eat other things, it seems to prefer *Pseudocalanus* if available. It would never eat a dead Copepod and always refused dead food of any kind or chopped worm. It is also very fond of *Acartia* and prefers it to *Calanus.*

On June 17th the two remaining Whiting (one having died) measured 22 mm.; on that day two live Whiting from the tow-nets measuring 10 mm. were put into the aquarium with the others and these instantly swallowed the smaller specimens and were none the worse after it. The Whiting is naturally a cannibal when it reaches a certain size, and in the food records this year (page 34 of this Journal) a Whiting of 55 mm. is shown to have eaten another Whiting.

The next day plankton was given to the fish containing the following Crustacea in order of abundance :—

Acartia clausi.
Calanus finmarchicus.
Temora longicornis.
Podon intermedius.
Larval *Gebia.*
Larval *Porcellana.*

The Whiting persistently took *Acartia* first, and it was not until all these were eaten (and the fish hunted for them a long time) that anything else was taken ; then one larval *Gebia* was eaten, then the *Podon, Calanus* and *Temora* in order. The *Porcellana* larva was not eaten at all and was still there the next morning. Evidently the long spines were too much for the Whiting.

When Copepods were scarce crab zoëæ were given to the Whiting, but they only ate these when very hungry, and occasionally choked over them. The megalopa stage was also unwillingly eaten and was the cause of death by choking of one of the fish. The other died on

July 22nd measuring 35 mm., having grown from 19 to 35 mm. in less than two months. In its intestine were two full-grown specimens of the trematode *Derogenes varicus* with eggs ; possibly the cause of death.

Other young Whiting were kept alive and behaved in a similar way as regards food. Small *Hyperia* were eaten when Copepods were not available, also other young Amphipods and Isopods. Oyster spat and *Limacina* were refused.

GADUS POLLACHIUS. Pollack.

Two young Pollack were obtained alive from the tow-nets measuring 20 and 22 mm. on May 28th and 31st. The first died the next day, its intestine being full of Harpacticids. The other had a *Calanus* in its mouth and was fed on *Calanus* for some weeks, which it ate eagerly, stalking them in the same way as the Whiting.

The Pollack is, however, not quite so quick as the Whiting at perceiving and catching food, but will try new things more willingly. Thus it took a mouthful of chopped worm, but never took any more, and it was one of the few fish that attempted to eat oyster spat. This Pollack died on July 22nd measuring 35 mm., with no recognizable food inside it. Another specimen, 26 mm. long, kept alive for five days only, had inside it many Copepods, chiefly *Temora*, a crab megalopa and some oyster spat.

ONOS MUSTELA. Rockling.

Rockling rarely came in alive. One of 35 mm. on August 12th lived till November 13th. It ate almost anything alive that was given to it except oyster spat and *Limacina*. When food was put into the aquarium it was at first shy, but would after some time dart at the food and swallow it quickly, eating chiefly Copepods and Decapod larvæ. It was able to catch and eat *Leander* larvæ and also ate crab zoëæ and megalopæ. Young *Hyperia* and other Amphipods and young Isopods were also eaten, and it would sometimes take chopped worm, but unwillingly. It always kept at the bottom of the aquarium except when catching its food. Young Rockling brought in from near the shore were eagerly eaten by young Brill.

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The Food of Post-Larval Fish.

No. II (1918).

By

Marie V. Lebour, D.Sc.
Naturalist at the Plymouth Laboratory.

CONTENTS.

INTRODUCTION.

INVESTIGATION of the food of larval and post-larval fish from the tow-nets has been continued throughout the year (1918) in the same way as previously,* by examining the contents of stomach and intestine in the fresh state. From May 24th a new big net made of stramin, with a wooden frame 36 inches by 25 inches, was used in addition to the ordinary tow-nets. Any live specimens, and these were chiefly caught in the big net, were kept in small aërated aquaria standing in running water and fed with plankton in order to see, when possible, what food they ate. In this way a few post-larval fish went through the metamorphosis into the adult form. Details of these will be found in another paper in the same number of the Journal (page 9).

The tow-nettings were regularly examined by Miss Webb in order to see whether the fish were feeding on what was commonest at the moment, and this was found to be usually the case, so far as the Copepods were concerned, although most of the young fish seemed to select their food to a certain extent. In any month the Copepods which are at that time commonest in the plankton are those most eaten by the young fish, but most of them have preferences and select in various degrees.

Thus in June *Calanus finmarchicus* and *Acartia clausi* were the commonest Copepods, *Temora longicornis* coming next, *Pseudocalanus elongatus* and *Oithona similis* not occurring so frequently. The commonest young fish in the tow-nets in the same month were the Whiting, Pollack, Rockling and Ballan Wrasse (*Labrus bergylta*). It has been shown last year that the Whiting chiefly eats *Pseudocalanus*, and this is borne out in this year's records. In June *Pseudocalanus* is still its chief food, although *Calanus* and *Acartia* are commoner, and these it also eats occasionally. In July, however, when *Pseudocalanus* was usually absent and *Calanus* abundant the Whiting's food was chiefly *Calanus*. The Pollack, on the other hand, in June took *Calanus* more often than *Pseudocalanus* and *Acartia* although it ate all three. *Labrus bergylta* was the only fish of the three to eat *Temora* in June and this is its usual food. The Rockling, *Onos mustela*, alone ate large numbers of *Oithona similis* and very little else.

* Journ. Mar. Biol. Assocn. XI, p. 433, 1918.

It is almost entirely the Copepods which are eaten by the young fish, except those still in the larval state or very small post-larval forms, which eat unicellular organisms and larval mollusks. Cirripede larvæ and the Cladocera, i.e. *Podon* and *Evadne*, when present are, however, eagerly devoured. Larval mollusks form the chief food of the young Gar-fish, *Rhamphistoma belone*, which in its turn is the chief food, with the Rockling, of young Brill of about 1 to 1½ inches in length which are common inshore in summer.

As usual the first fish to appear in the tow-nets are Herring and Sprat. These two and an occasional Pouting are the only species in January. None contained food, and there was little in the plankton except diatoms, although Copepods were on the increase towards the end of the month.

In February, besides Herring, Sprat and Pouting, the Lesser Sand-Eel, *Ammodytes tobianus* and *Cottus bubalis*, were common, and *Agonus cataphractus* and the Lump-Sucker, *Cyclopterus lumpus*, occurred. No food was seen in the Herring except green food remains, a larval bivalve occurred in the Sprat and green food remains in *Ammodytes*, whilst *Cottus* and *Agonus* had eaten *Balanus* nauplii. The plankton was rich in species towards the middle of the month, *Balanus* nauplii occurring first on February 15th.

A large increase of fish occurred in March—Herring, Sprat, *Ammodytes tobianus*, *Cottus bubalis*, Rockling, Whiting and *Solea lutea*. All the Herring that contained any food had eaten *Pseudocalanus*, 17 out of 77 specimens, the rest being empty. The Sprats contained no food. *Ammodytes* and the Rockling contained green food remains, *Cottus* contained *Pseudocalanus* and *Temora* and the Whiting *Pseudocalanus*.

There was a great abundance of life in the plankton in March, *Pseudocalanus* and *Temora* being some of the commonest Copepods throughout the month.

In April the Herring have disappeared and there are only a few Sprat, but there is a large increase of young fish of other kinds—*Cyclogaster Montagui*, *Cottus bubalis*, Rockling, Pouting, Whiting, Pollack, *Callionymus lyra*, Sole, Flounder, Merry Sole, Thickback, *Ammodytes tobianus* and *Gobius* sp. all occurred. The Sprat still contained green food remains or no food at all, *Cyclogaster* contained *Acartia* and *Temora*, *Cottus* contained chiefly *Temora*, but also *Pseudocalanus*, Copepod nauplii and a larval bivalve, the Rockling contained *Temora* and *Pseudocalanus*, chiefly the latter; *Euterpina acutifrons*, Copepod nauplii and a crab zoëa were also eaten. The Pouting contained *Pseudocalanus* and green food remains, the Whiting, which was very abundant during April nearly always contained *Pseudocalanus*, but occasionally *Temora* and Copepod nauplii. Once it had eaten *Balanus* nauplii and once an *Acartia*. The

Pollack contained *Pseudocalanus*. *Callionymus* was often empty, but had often eaten *Pseudocalanus* and once a *Temora* nauplius. The flat fish contained no food.

It is striking that *Pseudocalanus* is the almost universal food of the fish in April, *Temora* coming next, *Acartia* rarely, and these are all that occur more than once in any of the fish. The April plankton is rich in life of various kinds with plenty of Copepods, but of the Copepods *Pseudocalanus*, *Temora* and *Acartia* are certainly the commonest forms.

Fish were fairly numerous in May, the Whiting still continuing to be commonest. Besides the Whiting there occurred Sprat, *Gobius* sp., Flounder, Rockling, Pollack, *Ammodytes tobianus*, *Callionymus lyra* and *Trigla* sp. Up to May 24th the Whiting was feeding almost entirely on *Pseudocalanus,* although again occasionally on *Temora* and *Acartia*, and, very rarely, on *Calanus*. On May 17th one had a specimen of *Calanus* in its mouth and another had two *Calanus* and one *Centropages typicus* also in its mouth. These must have been feeding in the jars after capture. After this *Acartia* was rather more often taken although still *Pseudocalanus* predominated, but on May 27th 37 specimens had all been feeding on *Calanus*, many of which were still in the mouth, some inside, and also some *Temora*, but on that date only one *Pseudocalanus*. After this *Pseudocalanus*, *Acartia* and *Calanus* are all taken, but *Pseudocalanus* is still the favourite. Those specimens that are below 9 mm. in length apparently do not take *Calanus*, but those of quite a large size will take, and often seem to prefer, the smaller forms such as *Pseudocalanus*. The Sprat again contained green food remains or were empty, the Rockling contained Copepod nauplii, *Calanus*, *Pseudocalanus* and *Oithona similis*, *Ammodytes* contained green food remains and Copepod remains including *Pseudocalanus*. The Pollack up to nearly the end of May contained chiefly *Pseudocalanus*, with occasional *Temora*, *Calanus*, *Acartia* and *Oithona*; from May 27th to the end of the month it was chiefly *Calanus*. Sometimes, however, the Pollack contained several different Harpacticids. *Callionymus* contained *Pseudocalanus*, *Temora*, *Acartia* and Copepod nauplii. Thus again this month *Pseudocalanus*, *Temora* and *Acartia* with *Calanus* in addition are the chief food of the young fish, *Pseudocalanus* being commonest until nearly the end of the month and afterwards *Calanus*.

The plankton is full of Copepods all through the month, but there is a distinct falling off in frequency of *Pseudocalanus*, and towards the end of the month *Calanus* is specially abundant and is apparently eaten by those fish that usually feed on *Pseudocalanus*.

A number of fish occurred in June. The Whiting is still the commonest. *Labrus bergylta*, Rockling, *Ammodytes tobianus*, Pollack, *Cyclogaster Montagui*, Sprat, *Gobius Ruthensparri*, Pouting, *Cyclopterus lumpus*, *Callionymus lyra* and *Trigla* sp. also occurred. The Whiting again fed chiefly on *Pseudocalanus*, although *Calanus* was frequently taken especially after capture, when the fish must have fed in the jar. Again *Acartia* and *Temora* were occasionally taken. *Gobius* contained *Acartia* and *Pseudocalanus*. *Labrus* contained *Temora*, the Rockling contained *Oithona* almost exclusively, the Pollack contained chiefly *Calanus*, but also *Pseudocalanus*, *Acartia* and Harpacticids. The other fish contained no food.

In the tow-nets there was much life, *Calanus* and *Acartia* being the chief Copepods, *Pseudocalanus* and *Oithona* not so common.

The plankton other than the young fish was not specially recorded for July, except on the 1st and 2nd of the month. Young fish were on the decrease, *Labrus bergylta* being the commonest, Whiting has nearly disappeared, *Gobius Ruthensparri*, Rockling, *Cyclopterus lumpus*, *Ctenolabrus rupestris*, *Blennius ocellaris*, *Blennius galerita*, *Lepadogaster Candolli*, *Ammodytes* sp., *Trachinus vipera*, *Solea lascaris*, Turbot, Brill, *Rhamphistoma belone* and *Callionymus lyra* all are present. *Labrus* had fed chiefly on *Temora*, although *Podon intermedius* had been eaten frequently, the only other food being occasional Harpacticids. The Whiting had fed on *Calanus* and *Pseudocalanus*, but also on *Podon*, *Acartia* and *Hyperia* sp. No Whiting was caught in the tow-nets after this month. *Gobius* contained *Temora* and *Podon;* the Rockling contained *Pseudocalanus*, *Oithona* and remains of Amphipods ; *Ctenolabrus* contained *Temora; Blennius galerita* contained *Podon* and *Acartia; Lepadogaster Candolli* contained *Podon* chiefly, but also *Temora*, larval gastropods and Harpacticids ; *Ammodytes* contained *Podon*, *Oithona* and *Calanus* nauplius ; *Trachinus* contained *Temora*, *Pseudocalanus* and larval gastropods ; the Turbot contained the amphipod *Apherusa clevii ; Rhamphistoma* contained chiefly larval gastropods, but the older specimens also contained Harpacticids and *Podon*. The rest contained no food.

Podon intermedius occurred commonly in the plankton throughout July and was eaten by seven different sorts of young fish, so that it is evidently a favourite food.

Not many fish were caught in August, *Labrus bergylta* and *Gobius* spp. being the commonest. *Trachinus vipera*, *Lepadogaster Candolli* and *bimaculatus*, *Blennius gattorugine* and *ocellaris*, *Arnoglossus* sp., *Ammodytes* sp., *Rhamphistoma belone*, Rockling, *Ctenolabrus rupestris* and *Callionymus lyra* were also present. *Labrus* had eaten *Temora* only, as also had *Ctenolabrus rupestris ; Trachinus* which is a rather varied feeder had also eaten chiefly *Temora*, but also larval *Gebia*, *Podon*, larval gastropods, larval bivalve, *Corycæus anglicus*, *Oithona similis* and *Pseudocalanus ; Blennius gattorugine* had eaten *Podon ; Lepadogaster*

Candolli contained *Podon* and *Temora ; Arnoglossus* contained the diatom *Tabellaria ; Rhamphistoma* as usual contained larval gastropods. *Gobius* contained *Temora, Pseudocalanus* and Harpacticids; *Callionymus* contained *Pseudocalanus, Temora* and Harpacticids.

The plankton for August is abundant, *Calanus* and *Acartia* being the commonest Copepods; Decapod larvæ are abundant, particularly *Gebia,* which was eaten by *Trachinus.*

Much fewer fish were caught in September : a Sprat of 32 mm., *Gobius* spp., *Ctenolabrus rupestris, Caranx trachurus, Ammodytes* sp., *Blennius ocellaris* and *galerita*, Pilchard, Pollack, *Arnoglossus* sp., *Lepadogaster gouani* and *bimaculatus.* The Sprat contained *Balanus* cypris larvæ and larval gastropods; the Pollack contained *Acartia* and *Temora ; Ammodytes* contained Copepod nauplii including *Calanus ; Caranx trachurus* contained *Temora ; Blennius ocellaris* which measured 30 and 31 mm. contained Decapod larvæ; the Pilchards were empty except for one indistinguishable Copepod; *Lepadogaster bimaculatus* contained larval gastropods, *Balanus* nauplius and Harpacticids, besides a fish's egg; *Gobius* contained *Temora, Pseudocalanus* and Harpacticids; the remainder contained no food.

The plankton early in the month was characterized by large numbers of the Ctenophore, *Bolina infundibulum,* accompanying which were many *Hyperia.* The latter, however, were not eaten by any of the fish examined, although when given to the fish in the small aquaria the smaller specimens were eaten by *Cyclopterus lumpus* and *Solea vulgaris.* The number of Copepods in the plankton decreases, but *Acartia* and *Calanus* are still abundant at times. *Pseudocalanus* and *Temora* although eaten by the fish are not so common in the tow-nets.

Still fewer fish were caught in October, November and December, the tow-nettings not being regularly taken in November. The fish included Pilchard, *Gobius microps, Blennius ocellaris, Cyclopterus lumpus, Lepadogaster bimaculatus* and *Arnoglossus* sp. The last contained *Pseudocalanus ; Blennius* and *Gobius* had eaten *Corycæus anglicus*, the remainder contained no food.

From October to December there is less and less in the plankton, and especially in December very few Copepods are present. *Corycæus anglicus* is at times common in all three months.

From the above observations it is seen that Copepods are certainly the chief food of the young fish caught in the tow-nets, and by far the most important as food are the four species *Pseudocalanus elongatus, Temora longicornis, Calanus finmarchicus* and *Acartia clausi.* Nearly all the commonest larval and post-larval fish feed upon one or more of these, evidently selecting them from the rest of the food. The large numbers of Crustacea larvæ other than Copepods, with the exception of Cirripede larvæ, are very little eaten by these small fish. Cladocera which only occur in summer are, however, often eaten when present. It is only very seldom that Decapod larvæ are found inside the young fish from the tow-nets, an occasional larval *Gebia* or *Hippolyte*, crab larvæ or small Amphipods sometimes occurring, but the young fish will take these when in captivity for want of anything better. If Copepods are available, however, they always choose these rather than the Decapod larvæ, but when hungry they will take the larvæ if not too spiny nor too large.

LABRUS BERGYLTA Asc. Ballan Wrasse.

Fifty-four specimens of the Ballan Wrasse, 4 to 10 mm. long, were examined from the tow-nettings June to August from inside and outside the Breakwater and as far out as the Panther buoy (see plan of Sound, 1917).* 16 contained no food, 21 contained *Temora*, 7 contained *Podon*, 5 contained Harpacticids and the rest contained Copepod remains which were almost certainly *Temora*. Thus *Temora* is the favourite food, and although not very common through June and July yet it was nearly always present in the tow-nettings. This agrees with last year's records when Copepod nauplii, especially *Temora*, were found to be the predominant food of the Ballan Wrasse, other small organisms also being eaten. The smallest specimen, of 4 mm., had eaten nearly full-grown *Temora*. Two live specimens were kept in aquaria and fed on small plankton chiefly consisting of Copepod nauplii and young Copepods at first. Afterwards they ate *Temora*, *Acartia* and *Podon*, but not *Calanus*, which was always left, even by a fish 13 mm. long. *Balanus* nauplii were also eaten and oyster spat, but the pteropod *Limacina retroversa* was refused.

CTENOLABRUS RUPESTRIS L.

Four specimens, 8 to 9 mm. long, occurred in the tow-nettings from the Breakwater, Panther and Knap in July and August. All contained Copepods, one with indistinguishable remains, the others with *Temora longicornis*, so that it is likely that this fish feeds like *Labrus* and prefers *Temora*.

CARANX TRACHURUS L. Horse Mackerel.

Two specimens in September, 15 and 27 mm. long. The larger contained no food, the smaller contained *Temora* and other Copepod remains.

* Journ. Mar. Biol. Assocn. XI, p. 459, 1918.

TRACHINUS VIPERA Cuv. Lesser Weaver.

Nineteen specimens from July to August, 3 to 12 mm. in length, from both inside and outside the Breakwater. 7 contained *Temora*, adult and nauplii, 2 contained *Pseudocalanus*, 1 contained a larval *Gebia*, one an *Oithona similis* and one a *Corycæus anglicus*, 3 contained several larval gastropods. The few records from last year showed varied food, so that evidently the young *Trachinus* takes a variety although it is chiefly Copepods.

COTTUS BUBALIS Euph. Father Lasher.

Thirty-eight specimens from February to April, chiefly from inside although occasionally from outside the Breakwater, from 3 to 8 mm. in length. 25 contained no food, 7 contained *Temora*, 3 contained *Pseudocalanus*, 2 contained *Balanus* nauplii and 3 contained larval mollusks. As before we see that *Cottus* has a varied diet, but this year no diatoms were observed inside it.

TRIGLA SP.

Six specimens of *Trigla*, probably *gurnardus*, but perhaps 2 species, were examined. Four contained no food, one contained Copepod remains and another Copepod eggs.

AGONUS CATAPHRACTUS L. Armed Bullhead.

One specimen on February 26th from the region of the Panther buoy, 8 mm. long, contained 2 *Balanus* nauplii.

BLENNIUS OCELLARIS L. Butterfly Blenny.

Two live specimens in July and August only lived a few days and when dead contained no food.

BLENNIUS GALERITA L. Montagui's Blenny.

Two specimens in July and September. One contained no food, the other of 10 mm. contained *Podon* and *Acartia*.

BLENNIUS GATTORUGINE Bloch.

Three specimens in August, one alive but only lived a few days, one contained no food and the third contained *Podon*.

GOBIUS MINUTUS L.

One specimen in August from inside the Breakwater measuring 12 mm. contained *Pseudocalanus*. 20 smaller specimens which were probably this species occurred from March to August. Those of 2·4 mm. were without food, larger specimens up to 7 mm. contained *Pseudocalanus* and *Temora*.

GOBIUS MICROPS Kroyer.

Seventeen specimens from inside the Breakwater from 8 to 12 mm. Most of these contained no food, one contained a *Pseudocalanus* and one a larval gastropod. A specimen 10 mm. long on July 24th has been kept in a small aquarium and is still alive, having been fed on miscellaneous small plankton, chiefly Copepods. It now (December 18th) measures 16 mm. and has all the adult features.

GOBIUS RUTHENSPARRI Euph.

This is the commonest goby from the tow-nettings in the Sound. 54 specimens were examined from 4 to 14 mm. Copepod nauplii being the chief food, the peridinian *Prorocentrum micans* was in one, *Acartia*, *Temora*, *Podon* and Harpacticids also being present. A specimen of 30 mm. from the Cattewater in July contained the following: 1 *Acartia clausi*, 4 larval gastropods, 6 larval bivalves, 1 *Idya furcata*, 5 Harpacticids indet. One specimen captured alive on June 7th measured 14 mm. It was kept alive until December 5th when it measured 25 mm. It was fed on plankton containing numerous small adult and larval Copepods and sometimes *Balanus* nauplii, all of which were eaten. Oyster spat and *Limacina retroversa* were refused. Evidently small Crustacea form its natural food. This is probably the *Gobius* sp. (a) recorded last year.

GOBIUS PAGANELLUS (L.).

Although this is the commonest goby of the shore rocks its young stages do not occur often in the tow-nets. 8 specimens were examined, 4·5 to 11 mm. long, 2 contained *Pseudocalanus*, one contained *Temora* and 3 contained Harpacticids. A specimen of 20 mm. from the Cattewater contained the following: 33 Harpacticids, one mite, 6 skins of insect larvæ, Copepod eggs. This is the *Gobius* sp. (b) recorded last year.

CALLIONYMUS LYRA L. Dragonet.

Thirty-eight specimens from April to August from both inside and outside the Breakwater. 20 of these contained no food; of the remainder

7 contained *Pseudocalanus*, 5 contained *Temora*, one contained *Acartia*, one an Harpacticid and the remainder contained Copepod remains. Last year's records show it to be a miscellaneous feeder. At 3 mm. it had eaten *Pseudocalanus*, so that it can feed on fairly large Copepods when almost newly hatched.

CYCLOGASTER MONTAGUI Donov.

Three specimens in April and June. Only one contained food—*Acartia* and *Temora*.

CYCLOPTERUS LUMPUS L. Lump Sucker.

Out of 7 from the tow-nets from February to December, 6 were kept alive, measuring 10 to 25 mm. The other contained *Idotea* sp., and Amphipod and Harpacticids. These young *Cyclopterus* live among the *Zostera* eating such things as frequent the weed. The live specimens ate small Crustacea of all kinds and would take *Leander* larvæ almost as long as themselves; young Isopods were also eagerly eaten, almost any Copepods and *Balanus* nauplii.

LEPADOGASTER CANDOLLI Risso.

Eighteen specimens in July and August, 4 contained no food, 5 contained *Temora*, 6 contained *Podon*, one a *Pseudocalanus* and 2 contained Harpacticids. Evidently small Crustacea form its usual food. One was kept alive and fed on fine plankton containing small Copepods, *Podon* and *Balanus* larvæ.

LEPADOGASTER GOUANI Lacep.

This is the common shore form. Only 2 specimens occurred in the tow-nets from near the Breakwater. One contained larval gastropods, the other was kept alive and fed on the same food as *L. Candolli*.

LEPADOGASTER BIMACULATUS Donov.

Two specimens obtained from near the Breakwater and Panther buoy. One was kept alive and fed on the same food as the other two, the second, measuring 6 mm., contained larval gastropods, larval bivalve, *Balanus* nauplius, Harpacticids and a fish egg.

RHAMPHISTOMA BELONE (L.). Gar-fish.

Four specimens from the region of Panther and Knap in July and August from 8 to 36 mm. were all feeding on larval gastropods, as many as 85 in the largest in addition to 18 Harpacticids and 3 *Podon*. One of 11 mm. contained 33 larval gastropods. Several post-larval Gar-fish brought in from the Cattewater also had fed chiefly on larval gastropods and very little else, the stomachs and intestines being full of them. Many young Brill were feeding on these Gar-fish, some as long as themselves being swallowed.

One Gar-fish, which had just completed its metamorphosis and developed the long beak, was put alive into a small aquarium with some very fine plankton consisting chiefly of small Copepods and Copepod nauplii, which had congregated at the surface on one side of the glass. The fish instantly rushed into the middle of these and lashing about with its beak snapped up the food at an amazing rate. Unfortunately it died the same day.

PLEURONECTES FLESUS L. FLOUNDER.

Four specimens from March to May, 7 to 9 mm. long. None contained food.

PLEURONECTES MICROCEPHALUS DONOV. MERRY SOLE.

One specimen of 6 mm. from between Cawsand and Penlee contained no food.

SOLEA VULGARIS QUENS. SOLE.

One specimen from the Panther on April 12th, 11 mm. long, kept alive. For two months it was fed on *Temora*, afterwards on other Crustacea. Still alive on December 18th measuring 40 mm.

SOLEA LASCARIS BONAP. LEMON SOLE.

One live specimen from the Knap on July 15th, 9 mm. long, fed on small Crustacea, chiefly Copepods, died November 18th, measuring 23 mm. At first it ate chiefly *Acartia* and *Pseudocalanus*, afterwards adult *Temora* and *Calanus*, also the smaller Decapod larvæ and small Isopods, but it refused oyster spat.

SOLEA LUTEA RISSO.

One specimen from off White Patch on March 11th, 14 mm. long, contained no food.

SOLEA VARIEGATA DONOV. THICKBACK.

Two specimens in June from the Panther and West Channel, 6 and 10 mm. long. The larger specimen contained no food, the smaller was kept alive for two days only, being fed on small plankton.

ARNOGLOSSUS SP.

Four specimens, probably *Arnoglossus laterna*, in July and August, 7 to 31 mm., 2 contained no food, one contained a *Pseudocalanus* and the largest contained the diatom *Tabellaria*.

RHOMBUS MAXIMUS L. TURBOT.

One specimen from the Knap, July 23rd, measuring 13 mm. contained the Amphipod *Apherusa clevii*.

RHOMBUS LÆVIS RONDEL. BRILL.

Two live specimens in July, one of 15 mm. died the next day having eaten 4 *Anomalocera Pattersoni*, the other of 27 mm. lived till October 6th, having eaten various Crustacea. On July 17th several specimens from 9 to 30 mm. were brought in from the Cattewater; the smallest contained larval bivalves and larval gastropods, the older specimens contained young *Rhamphistoma* and Rockling.

GADUS MERLANGUS L. WHITING.

Two hundred and eighty-eight specimens were obtained altogether from the tow-nets, the first on March 12th, the last on July 24th, from the Sound near the White Patch and Breakwater and beyond the Breakwater by the Knap and Panther buoys and off Cawsand and Penlee. They measured from 3·5 to 35 mm. The smallest, which must have been hatched quite recently, in some cases contained Copepod nauplii showing that it can eat such solid food almost directly. 73, measuring 4 to 21 mm., contained no food, 5 were kept alive in a small aërated aquarium and 3 of these lived for several weeks, being fed on small Crustacea of various kinds, chiefly Copepods from the plankton. 134 from 4·5 to 33 mm. contained *Pseudocalanus*, the largest containing 33 specimens besides other Crustacea. *Pseudocalanus*, common in the tow-nets during April, was the principal food until nearly the end of May, although it was rare or absent in the tow-nets during May and not abundant afterwards. *Acartia* and *Calanus* are eaten when *Pseudocalanus* is not so common, and *Temora* is all the time occasionally eaten, being present in 19 and the nauplius in 5. *Acartia* occurred in 22 (except in one case, after May 23rd), *Calanus* in 41, all after May 11th; most of these *Calanus* were in the mouth and alive and must have been taken from the tow-nettings after capture. However, it is certain that the Whiting does eat *Calanus*, for when *Calanus* was given to the live specimens from the tow-nets it was taken eagerly. *Balanus* nauplii occurred once only in a Whiting in April, Copepod nauplii indistinguishable in 5, *Podon* in 3 in July.

Thus the favourite food of the Whiting is shown to be, as it was last year, *Pseudocalanus*. This year, having larger numbers to work with, it was determined that although *Pseudocalanus* is evidently the favourite food and is taken principally even when *Temora*, *Acartia* and *Calanus* are present in large numbers, yet these three are only taken occasionally except when *Pseudocalanus* is rare and then *Calanus* may be taken abundantly by those of about 9 mm. upwards. Crab megalopæ occurred in two specimens of 22 and 35 mm. and the latter also contained remains of Decapod larvæ. A specimen of 55 mm. contained remains of a Whiting so that a cannibal diet begins at an early age. The two live Whiting of 22 mm., each swallowed a live Whiting of 10 mm. put into the aquarium to live with them. They were snapped up the moment they were put in. A young *Hyperia* was contained in a Whiting of 24 mm. It thus appears that after about 20 mm. other animals are taken as well as Copepods. The live specimens measured 16 to 19 mm., and one grew to 35 mm. All the time they would always eat Copepods, although they took young Isopods and Decapod larvæ if Copepods were not present. They would, however, prefer the Copepods and take these first if a mixture of Copepods and Decapod larvæ were given. *Pseudocalanus* was preferred, *Acartia*, *Calanus* and *Temora* coming next in order of preference. Larvæ with long spines such as *Porcellana* were refused even by the largest Whiting. Oyster spat and *Limacina* were also refused.

GADUS LUSCUS L. POUTING.

The Pouting is one of the earliest of the young fish, occurring from January to June but not commonly. The specimens measured 3 to 8 mm. In the smallest there is green food remains and Copepod nauplii. The specimen of 8 mm. had eaten *Pseudocalanus*. On December 16th two Pouting measuring 18 and 23 mm. were brought from Jennycliff Bay, having been caught in the shrimp trawl. Both had fed on young Amphipods, the larger specimen also contained *Pseudocalanus*, *Candacia armata* and *Calanus*.

GADUS POLLACHIUS L. POLLACK.

Thirty-three specimens from 7 to 25 mm., from both inside and outside the Breakwater, from April to September. Of these 3 were alive, one living nearly two months. Only two of the remainder contained no food, of the others 19 contained *Pseudocalanus*, 12 contained *Calanus*, 5 contained *Temora*, 6 contained *Acartia*, 2 contained *Oithona*. Sometimes several of these species were eaten together, the largest number in any one fish under 10 mm. being 7 *Pseudocalanus* and one *Acartia*, those of larger size containing many more. A few had eaten Harpacticids in numbers. The commonest food is certainly *Pseudocalanus* and *Calanus*. The live specimens were given the same food as the Whiting and seemed to eat all the Copepods, but *Calanus* first. They also took various Decapod larvæ and attempted to eat oyster spat, but refused *Limacina*. One kept alive for 5 days only had eaten many Copepods, chiefly *Temora*, a crab megalopa and oyster spat.

ONOS MUSTELA L. Rockling.

Seventy-three specimens from March to August, 2·5 to 35 mm. The smallest contained green food remains, a few up to 7 mm. contained no food ; all the rest were usually full of Copepods, ova and crab larvæ being occasionally present. In April the food taken was almost entirely *Pseudocalanus* and young *Temora*, usually both together. *Euterpina acutifrons* and a crab zoëa occurred once each, the latter in a specimen only 7 mm. long. In May and June *Oithona similis* was chiefly eaten, *Pseudocalanus* and *Calanus* occasionally, and once a larval mollusk. In July one of 34 mm. contained Amphipod remains in addition to *Pseudocalanus*. Last year in the few specimens examined *Temora* nauplii formed the chief food. It seems that even in the larger specimens the ordinary food consists of the smaller Copepods, although larval crustacea such as crab zoëæ can be taken by quite small specimens and Amphipods by those of a larger size. In captivity the Rockling ate almost any food given to it from the plankton, including young Isopods and *Leander* larvæ. It, however, refused both oyster spat and *Limacina*, although its ordinary food is sometimes larval gastropods. On July 17th and 23rd several young Rockling, 12 to 27 mm., were brought in from the Cattewater. These contained larval gastropods, crab megalopæ, larval *Gnathia* and Harpacticid remains, which shows well the varied character of their diet. These Rockling from near the coast were serving as food for the young Brill which were also eating the young Gar-fish.

AMMODYTES TOBIANUS L. Lesser Sand Eel.

From February to June the Lesser Sand Eel was common in the tow-nets, 109 being examined, 3 to 21 mm. Nearly all contained green food remains as before, or were empty. There was seldom anything definite in the green stuff, but twice the diatom *Coscinodiscus* was present. In one of 4 mm. there were remains of Copepod nauplii, but this is unusual. In specimens of 19 to 21 mm. Copepod remains were present including *Pseudocalanus*.

From July to September a species of *Ammodytes* difficult to distinguish from *tobianus*, but probably *lanceolatus* occurred. Out of 26 specimens 21 were empty, one contained ova, probably of a Copepod, one contained *Oithona similis*, *Podon* and a fish egg, the remainder contained *Calanus* nauplii.

SYGNATHUS ROSTELLATUS Nills.

Seven specimens from January to September, 17·5 to 105 mm.; 4 of these were alive, but only lived a few days and when examined contained no food; one contained 18 *Calanus*, another contained remains of *Calanus* and *Acartia* and the smallest contained no food.

CLUPEA HARENGUS L. Herring.

Not so many herring were caught in the tow-nets this year. Only 87 in all, from January to March. The few caught in January and February contained no food. In March the only food present was *Pseudocalanus* in 17 out of 59, the rest being empty except for parasitic worms which frequently occurred. The Trematodes, *Pharyngora bacillaris* and *Derogenes varicus*, were common, also larval cestodes. *Pseudocalanus* was an important part of the herring food last year, although several other small Crustacea and larval mollusks were eaten.

CLUPEA PILCHARDUS L. Pilchard.

Thirteen Pilchard occurred in the tow-nets in September, 9 to 36 mm. Only one contained any food and that was an unidentifiable Copepod.

CLUPEA SPRATTUS L. Sprat.

Fifty-three Sprat were obtained from January to September. The smaller specimens as before contained green food remains or were empty, the only exceptions being one of 6 mm. containing a larval bivalve and one of 4 mm. containing the diatom *Coscinodiscus excentricus*. All the others were empty except one of 32 mm. in September which contained 4 *Balanus* cypris larvæ and 3 larval gastropods. This specimen was interesting, as its tail was very much frayed and found to contain a number of encysted larval trematodes arranged along the rays of the tail fin. These appeared to be a species of *Gasterostomum* and apparently accounted for the dilapidated state of the tail.

ANGUILLA VULGARIS Turton. Eel.

One specimen of 40 mm. from Jennycliff Bay on March 22nd was perfectly transparent, but had completed its metamorphosis. It contained Crustacea remains.

AMPHIOXUS LANCEOLATUS. The Lancelet.

One specimen of a larval Amphioxus occurred in the tow-nets on August 6th. It measured 6 mm. in length and although swimming about vigorously in the jar, when it was removed to a glass aquarium with a sandy bottom it remained in the sand and burrowed. Unfortunately it only lived two days. In its intestine were several sand grains and 3 *Coscinodiscus* sp.

LITERATURE.

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RECORD OF LARVAL AND POST-LARVAL FISH FROM THE TOW-NETTINGS.

Date. Jan.	Locality.	Fish.	No.	Size in mm.	Food present.
7	Panther	Syngnathus rostellatus	1	17·5	No food.
8	Off White Patch	Clupea harengus	1	11	,,
		Clupea sprattus	4	4–5	,,
		Gadus luscus	1	5	,,
	Breakwater	Clupea sprattus	3	3–6·5	,,
11	Off Picklecombe Fort, W.	Clupea harengus	2	14–15	,,
	West Channel	,,	1	12	,,
14	Breakwater	Gadus luscus	1	3	,,
29	Knap	Clupea harengus	2	9–9·5	,,
	West Channel	,,	2	9–11	,,
Feb.					
2	Breakwater	,,	1	9	,,
	Middle Sound	,,	1	9	,,
5	Off White Patch	Cottus bubalis	1	5·5	,,
12	Panther	Cyclopterus lumpus	1	40	*Idotea* sp., Amphipod and Harpacticid indet.
	Breakwater	Clupea harengus	1	29	No food.
15	Panther	Gadus luscus	1	3	,,
		Ammodytes tobianus	11	4–5	Green food remains.
	Knap	Clupea sprattus	1	6	Green food remains, larval bivalve.
		Ammodytes tobianus	1	4	No food.
	Breakwater	,,	3	5–10	Green food remains.
		Clupea sprattus	9	5–7	,, ,, ,,
		Gadus luscus	1	3	,, ,, ,,
18	Knap	Ammodytes tobianus	7	4–6	,, ,, ,,

Date. Feb.	Locality.	Fish.	No.	Size in mm.	Food present.
18		Clupea sprattus	1	4	No food.
		Gadus luscus	1	3	Copepod nauplii.
	Breakwater	Ammodytes tobianus	2	5	Green food remains.
		Cottus bubalis	2	4·5–5	No food.
		Clupea sprattus	2	4–5	,,
	West end of Breakwater	Ammodytes tobianus	1	5	Green food remains.
		Clupea sprattus	3	4–7	No food.
19	Knap	Ammodytes tobianus	3	5–6	Green food remains.
	Off White Patch	,,	3	4·5–5	,, ,, ,,
		Clupea sprattus	1	6	,, ,, ,,
		Cottus bubalis	1	3	No food.
22	Middle Sound	,,	1	3·5	,,
		Ammodytes tobianus	1	4·5	Green food remains.
25	New Grounds	Cottus bubalis	3	4	*Balanus* nauplii.
		Clupea sprattus	5	4–7	*Coscinodiscus excentricus.*
	Middle Sound	,,	3	4–7	No food.
26	Panther	Agonus cataphractus	1	8	*Balanus* nauplii.
		Clupea sprattus	2	8	No food.
		Ammodytes tobianus	1	3	,,
	Breakwater	Clupea sprattus	1	5	,,
		Cottus bubalis	1	4	Larval gastropod, *Balanus* nauplii.
March.					
1	Off White Patch	Clupea sprattus	1	8	No food.
4	Breakwater	Cottus bubalis	3	4·5–5	,,
		Ammodytes tobianus	1	4·5	,,
	Knap	Cottus bubalis	1	5·5	,,
5	Off White Patch	,,	1	5	,,
		Gobius sp. (cf. minutus)	1	2·4	,,
8	Off White Patch	,, ,,	1	2·5	,,
		Onos mustela	1	2·5	Green food remains.
11	Off White Patch	Solea lutea	1	14	No food.
		Ammodytes tobianus	1	5·5	,,
	Breakwater	,,	1	6·5	Green food remains.
	Panther	,,	4	6–7	No food.
12	Panther	,,	5	5–6	,,
		Clupea harengus	36	17–22	*Pseudocalanus elongatus.*
		Cottus bubalis	1	4	No food.
	Back of Breakwater	Pleuronectes flesus	18		,,
		Clupea harengus	33	17–24	*Pseudocalanus elongatus.*
		Ammodytes tobianus	24	4–6·5	Green food remains.
		Gadus merlangus	1	8	*Pseudocalanus elongatus.*
		Cottus bubalis	1	4·5	No food.
	Knap	,,	5	5	*Pseudocalanus elongatus*, *Temora longicornis*, larval gastropod.
		Clupea harengus	8	17–22	*Pseudocalanus elongatus.*
		Ammodytes tobianus	4	5·5	No food.
18	West Channel	,,	15	4–7	*Coscinodiscus excentricus*, green food remains.
		Cottus bubalis	1	4	No food.
	Middle Sound	Ammodytes tobianus	1	4·5	Green food remains.
	Breakwater	Cottus bubalis	1	5	No food.
19	Off White Patch	,,	1	8	*Temora longicornis.*
		Clupea harengus	2	19–24	No food.
		Clupea sprattus	1	18	,,

Date. March.	Locality.	Fish.	No.	Size in mm.	Food present.
19	Breakwater	Gobius sp. (probably minutus)	1	2	No food.
		Ammodytes tobianus	7	4–9	Green food remains, ovum.
		Cottus bubalis	2	3·5–4	*Temora longicornis.*
	Panther	Ammodytes tobianus	1	8·5	Green food remains.
22	Jennycliff.	Anguilla vulgaris	1	40	Crustacea remains.
April.					
2	Breakwater	Cyclogaster Montagui	1	5	*Acartia clausi, Temora longicornis.*
		Cottus bubalis	1	4	No food.
5	Panther	Onos mustela	1	2·5	,,
		Gadus luscus	1	3	,,
		Clupea sprattus	1	4	,,
8	Panther	Gadus merlangus	5	7–11	*Pseudocalanus elongatus, Temora longicornis, Balanus* nauplii.
		Callionymus lyra	4	2·5–4	*Pseudocalanus elongatus.*
		Cottus bubalis	5	4	No food.
	Breakwater	,,	5	4	Copepod nauplius, larval bivalve.
		Clupea sprattus	2	4	No food.
		Gadus merlangus	2	5–7	,,
	Knap	,,	6	4–11	*Pseudocalanus elongatus,* Copepod nauplius.
		Callionymus lyra	3	2–5	No food.
	Off White Patch	,,	1	5	,,
10	2 miles south of Breakwater	Gadus merlangus	4	7–9	*Pseudocalanus elongatus, Temora longicornis.*
	Breakwater	,,	2	6–8	*Pseudocalanus elongatus.*
12	Panther	Solea vulgaris	1	11	Kept alive.
		Gadus merlangus	15	6–8	*Pseudocalanus elongatus, Temora longicornis.*
		Pleuronectes flesus	1	7	No food.
		Ammodytes tobianus	1	21	*Pseudocalanus elongatus.*
		Cottus bubalis	3	4	Young *Temora, Temora* nauplius.
	Breakwater	Gadus merlangus	8	5–10	*Pseudocalanus elongatus,* Copepod remains.
		Clupea sprattus	1	6	Green food remains.
	Off White Patch	Gadus merlangus	1	7	*Pseudocalanus elongatus.*
	Knap	Pleuronectes flesus	1	7	No food.
		Clupea sprattus	2	12–17	,,
		Gadus merlangus	7	5–8	*Pseudocalanus elongatus.*
		Cottus bubalis	2	4–5	,, ,,
15	Between Cawsand and Penlee	Gadus merlangus	7	4–8	*Temora longicornis, Pseudocalanus elongatus,* Copepod remains, green food remains.
		Onos mustela	1	2·5	No food.
		Pleuronectes micro cephalus	1	6	,,
	West end of Breakwater	Gadus merlangus	5	5–10	*Pseudocalanus elongatus* and eggs, *Temora longicornis,* Copepod remains.
	West Channel	,,	1	6	*Pseudocalanus elongatus.*
		Gadus luscus	1	8	,, ,,
16	Knap	Gobius sp.	1	7	No food.
		Callionymus lyra	2	2·5–3	,,
		Gadus merlangus	1	5	*Temora* nauplius.
	Panther	,,	6	5–7	*Pseudocalanus elongatus.*
		Callionymus lyra	2	2·5–3	No food.

Date. April.	Locality.	Fish.	No.	Size in mm.	Food present.
16	Panther	Cottus bubalis	1	6	*Temora longicornis.*
		Gobius sp. (cf. minutus)	1	5	*Temora* nauplius.
19	Cawsand to Penlee	Gadus merlangus	2	3·5	Green food remains, Copepod nauplii.
	Cawsand to Breakwater	,,	1	3·5	Copepod nauplii.
	West Channel	Gobius sp. (cf. minutus)	3	6·5–8	No food.
		Solea variegata	1	10	,,
22	Breakwater	Gadus merlangus	6	4–10	*Pseudocalanus elongatus*, Copepod remains.
		Callionymus lyra	4	3	Copepod remains.
	Knap	Gadus merlangus	1	7	,,
23	White Patch	,,	1	7	*Pseudocalanus elongatus.*
	Breakwater	,,	6	4–11	*Pseudocalanus elongatus*, Copepod remains.
	Panther	Callionymus lyra	1	3	No food.
26	Knap	Gadus merlangus	2	7	Copepod remains.
	Off White Patch	Gobius sp. (cf. minutus)	1	5	No food.
	Panther	Callionymus lyra	1	3·5	,,
	Breakwater	Gadus merlangus	4	7–10	Copepod remains.
	Breakwater	Gadus pollachius	5	10–13	*Pseudocalanus elongatus.*
		Onos mustela	16	6–7	*Pseudocalanus elongatus. Temora longicornis, Temora* nauplii *Euterpina acutifrons*, crab zoëa.
		Gadus merlangus	8	5–11·5	*Pseudocalanus elongatus, Temora longicornis, Temora nauplius*, Copepod nauplii.
	Panther	,,	3	5–7	*Pseudocalanus elongatus, Acartia clausi.*
		Clupea sprattus	1	9	No food.
		Onos mustela	1	3·5	,,
	Knap	Gadus merlangus	1	6	*Temora* nauplius.
		Gobius sp. (cf. minutus)	1	7	,,
		Cottus bubalis	1	5	,,
May.					
1	Breakwater	Gadus merlangus	1	7	*Pseudocalanus elongatus.*
3	Jennycliff Bay	,,	1	9	*Temora longicornis, Temora* nauplius.
6	Knap	,,	3	6–14	*Pseudocalanus elongatus*, Copepod nauplius.
7	Knap	,,	5	6–22	*Pseudocalanus elongatus, Temora longicornis.*
		Gobius sp. (cf. minutus)	2	4–6	No food.
	Panther	Gadus merlangus	16	5–11	*Pseudocalanus elongatus*, young *Temora.*
		Clupea sprattus	1	10	No food.
		Pleuronectes flesus	1	9	,,
		Gobius sp. (cf. minutus)	1	6	,,
	Breakwater	Gadus merlangus	8	5–10	*Pseudocalanus elongatus*, young *Temora.*
		Clupea sprattus	1	8	No food.
10	Knap	Gadus merlangus	6	6–8	*Pseudocalanus elongatus, Temora longicornis*, Copepod remains.
	Breakwater	,,	2	4·5–6	*Pseudocalanus elongatus.*
		Onos mustela	1	6	No food.
	Panther to back of Breakwater	,,	1	5	,,
		Gadus merlangus	21	5–13	*Pseudocalanus elongatus*, young *Temora* and nauplii.

Date. May.	Locality.	Fish.	No.	Size in mm.	Food present.
10	Off White Patch	Gadus merlangus	1	6	No food.
13	Breakwater	,,	16	7–19	*Pseudocalanus elongatus*, *Temora longicornis*.
	Panther	,,	4	8–11	*Pseudocalanus elongatus*.
		Gadus pollachius	9	7–21	*Pseudocalanus elongatus*, *Calanus finmarchicus*, *Temora longicornis*, *Oithona similis*.
		Ammodytes tobianus	1	19	Copepod remains.
	Off White Patch	Gadus merlangus	3	5–8	,,
14	Panther	Callionymus lyra	1	4	*Pseudocalanus elongatus*.
		Onos mustela	1	3·5	Copepod nauplii.
	Breakwater	Gadus merlangus	3	8–10	*Pseudocalanus elongatus*.
		Callionymus lyra	2	3–4	No food.
	Off White Patch	,,	1	2·5	Copepod nauplii.
17	1½ miles south of Breakwater	Gadus merlangus	7	7–11	*Pseudocalanus elongatus*, *Calanus finmarchicus*.
	2 miles south of Breakwater	,,	11	6–10	*Pseudocalanus elongatus*, Crustacea remains.
		Callionymus lyra	1	5	No food.
	3 miles south of Breakwater	Gadus merlangus	3	7–12	Copepod remains.
	Breakwater	Gadus pollachius	2	16–18	*Calanus finmarchicus*, *Pseudocalanus elongatus*.
	Panther	Gadus merlangus	5	6–12	*Pseudocalanus elongatus*, Crustacea remains, *Calanus finmarchicus*, *Centropages typicus*.
		Onos mustela	1	7	Copepod remains and eggs.
22	Breakwater	Gadus pollachius	1	18	*Pseudocalanus elongatus*, Copepod remains.
24	Breakwater	Gadus merlangus	29	5–10	*Pseudocalanus elongatus*, *Acartia clausi*, Copepod remains.
		Clupea sprattus	3	7–17	No food.
		Ammodytes tobianus	13	6–10	Green food remains, *Coscinodiscus* sp.
		Onos mustela	1	4	No food.
		Gobius sp. (cf. minutus)	2	3–7	,,
		Gobius paganellus	1	4·5	,,
		Trigla sp.	1	7	Copepod eggs.
	Off White Patch	Callionymus lyra	1	6	*Acartia clausi*.
		Gadus merlangus	6	7–9	,,
		Ammodytes tobianus	2	7	No food.
	Knap	Callionymus lyra	4	3–8	Young *Temora* and *Temora* nauplii.
		Gadus merlangus	4	7–12	*Pseudocalanus elongatus*. Copepod remains.
		Ammodytes tobianus	2	4–5	No food.
		Onos mustela	1	4	*Pseudocalanus elongatus*.
	Panther	Callionymus lyra	3	5–6	Young *Temora*.
		Gadus merlangus	11	8–14	*Pseudocalanus elongatus*. *Acartia clausi*, Copepod remains.
		Gadus pollachius	1	19	*Pseudocalanus elongatus*, *Acartia clausi*.
		Ammodytes tobianus	6	6	Green food remains.
		Gobius sp. (cf. minutus)	1	6	No food.
27	Panther	Sygnathus rostellatus	2	95–105	*Calanus finmarchicus*, *Acartia clausi*.

Date. May.	Locality.	Fish.	No.	Size in mm.	Food present.
27	Panther	Gadus merlangus	40	6–55	*Calanus finmarchicus, Temora longicornis, Pseudocalanus elongatus, Acartia clausi,* Harpacticids, remains of *Gadus merlangus.*
		Gadus pollachius	2	18–23	*Calanus finmarchicus Acartia clausi.*
		Onos mustela	6	5–7	Copepod nauplii.
		Trigla sp.	1	9	No food.
	Knap	Gadus merlangus	2	8–10	*Calanus finmarchicus.* Copepod remains.
		Onos mustela	2	6–32	*Calanus finmarchicus,* Copepod remains.
	Breakwater	Gadus merlangus	7	6–12	*Pseudocalanus elongatus, Acartia clausi,* Copepod remains.
28	Knap	Gadus pollachius	3	17–25	*Calanus finmarchicus, Temora longicornis, Acartia clausi,* Harpacticids.
		Gadus merlangus	5	7–14	Copepod remains.
		Onos mustela	1	4	No food.
		Gobius sp. (cf. minutus)	2	3–3·5	,,
	Breakwater	Gadus pollachius	2	20	*Calanus finmarchicus, Temora longicornis, Tigriopus fulvus.*
		Onos mustela	5	4–11	*Oithona similis, Pseudocalanus elongatus,* Copepod nauplii.
		Gadus merlangus	3	8–10	Copepod remains.
		Clupea sprattus	1	5	Green food remains.
		Pleuronectes flesus	1	9	Copepod remains.
	Panther	Gadus merlangus	2	10·5–12	No food.
		Onos mustela	31	8	*Oithona similis,* young Copepods.
31	Panther to Breakwater	,,	2	5	Green food remains.
	Panther	,,	1	12	*Oithona similis,* Copepod eggs.
		Gadus merlangus	5	9–15	*Calanus finmarchicus, Pseudocalanus elongatus.*
	Off White Patch	Onos mustela	1	25	Copepod remains.
		Gadus pollachius	1	22	*Idya furcata, Microsetella norvegica, Harpacticus chelifer, Harpacticus uniremis.*
June.					
3	Breakwater	Ammodytes tobianus	1	5	No food.
	Knap	Onos mustela	1	9·5	Larval gastropod.
	Panther	,,	1	8	Copepod remains.
		Gadus merlangus	1	8	*Calanus finmarchicus.*
		Labrus bergylta	2	3–4	No food.
4	Breakwater	Gadus pollachius	1	22	Alive.
	Panther to west end of Breakwater	,,	2	18	*Calanus finmarchicus, Pseudocalanus elongatus, Acartia clausi.*
		Gadus merlangus	1	8	Copepod remains.
	Panther	,,	1	9	*Calanus finmarchicus.*
		Onos mustela	3	8–10	*Oithona similis.*
		Cyclogaster Montagui	2	7	No food.

Date. June.	Locality.	Fish.	No.	Size in mm.	Food present.
4	Off White Patch	Gadus merlangus	1	8	No food.
	Knap	Clupea sprattus	1	22	,,
		Gadus merlangus	1	9	Copepod remains.
		Gadus pollachius	2	14–16	*Calanus finmarchicus, Pseudocalanus elongatus, Acartia clausi, Oithona similis.*
		Onos mustela	3	8–22	*Oithona similis, Pseudocalanus elongatus.*
7	Breakwater	Gadus merlangus	1	13	Copepod remains.
		Gadus pollachius	1	20	*Calanus finmarchicus, Pseudocalanus elongatus, Dactylopusia vulgaris, Dactylopusia tisboides.*
	Panther to Breakwater.	Onos mustela	1	12	*Oithona similis*, Copepod remains.
		Gobius Ruthensparri	18	9–14	*Temora* nauplius and Copepod nauplii.
		Gobius paganellus	1	11	*Temora longicornis.*
	Panther	,,	15	7–12	*Pseudocalanus elongatus, Acartia clausi.*
		Ammodytes tobianus	1	14	No food.
	Off White Patch	Gadus merlangus	2	7–8	Copepod remains.
		Gobius Ruthensparri	2	9–10	Copepod nauplii.
11	Breakwater to Panther	,,	5	4–13	,,
	Knap	,,	3	5	No food.
		Onos mustela	1	5	,,
	Breakwater	Onos mustela	1	5	,,
12	Panther to Breakwater	Gobius Ruthensparri	1	13	*Acartia clausi.*
		Labrus bergylta	1	6	Not examined.
	Panther	Cyclopterus lumpus	1	10	,,
		Gadus merlangus	1	10	Copepod remains.
	Knap	,,	1	13	*Calanus finmarchicus, Pseudocalanus elongatus.*
14	Breakwater	,,	1	5	*Acartia clausi.*
	Off White Patch	,,	5	7–13	*Pseudocalanus elongatus, Calanus finmarchicus, Oithona similis, Acartia clausi, Podon intermedius.*
19	Middle Sound	,,	23		*Pseudocalanus elongatus, Oithona similis.*
		Gobius sp. (cf. minutus)	1	3	Alive.
	Cawsand	Gasterosteus spinachia	1	20	,,
21	Knap	Onos mustela	2	4·5–5	No food.
	Panther	,,	1	7	,,
		Gadus pollachius	1	12	*Calanus finmarchicus, Acartia clausi.*
	Breakwater	Onos mustela	1	4	No food.
		Cyclopterus lumpus	1	15	Alive.
		Gadus merlangus	3	5–15	*Temora*, young, and nauplius, *Pseudocalanus elongatus, Acartia clausi.*
24	Knap	,,	2	9–14	*Calanus finmarchicus.*
		Labrus bergylta	1	8	Young *Temora.*
		Cyclopterus lumpus	1	15	Not examined.
	Panther	Labrus bergylta	1	7	No food.
		Gadus merlangus	2	7	Copepod remains.

Date. June.	Locality.	Fish.	No.	Size in mm.	Food present.
24	Panther to Breakwater	Gadus merlangus	2	9–10	Copepod remains.
		Roccus labrax (?)	1	9	Not examined.
		Trigla sp.	3	9–11	Copepod remains.
		Labrus bergylta	1	5·5	No food.
		Callionymus lyra	2	5	,,
	Breakwater	Gadus merlangus	2	9–10	*Acartia clausi*, Copepod remains.
25	Panther	,,	1	19	*Calanus finmarchicus.*
	Breakwater	,,	1	13	Copepod remains.
	Panther to Breakwater	Onos mustela	1	10	Copepod eggs.
		Labrus bergylta	3	6–12	Young *Temora*, Copepod remains.
		Trigla sp.	1	8	No food.
	Knap	Gobius Ruthensparri	2	6	Not examined.
		Labrus bergylta	1	6	No food.
28	Off White Patch	Gadus merlangus	3	7–10	Copepod remains.
	Breakwater	Onos mustela	4	5	No food.
	Panther to Breakwater	,,	5	5–6	,,
	Panther	Solea lascaris	1	6	,,
	Knap	Gadus merlangus	1	5	Crustacea remains.
		Labrus bergylta	1	7	,,
July.					
1	Panther	Gadus merlangus	5	14–29	*Calanus finmarchicus*, crab megalopa.
		Onos mustela	1	8	Ova.
		Ammodytes sp.	1	15	,,
		Clupea sprattus	1	19	No food.
		Labrus bergylta	2	7	,,
	Off White Patch	Gadus merlangus	1	25	*Calanus finmarchicus.*
	Knap	Rhombus maximus	1	27	Not examined.
	Breakwater	Gadus merlangus	2	26–28	,,
		Onos mustela	1	20	,,
2	Knap	Gadus merlangus	2	22–35	Crab megalopa, decapod larvæ, *Calanus finmarchicus.*
	Middle Sound	Trigla sp.	1	9	No food.
	Breakwater	Labrus bergylta	1	7	Young *Temora, Temora* nauplii.
	Panther	Labrus bergylta	1	6	Young *Temora.*
		Callionymus lyra	2	6–7	No food.
5	Knap	Gobius Ruthensparri	1	5	Not examined.
	Panther	,,	2	5–14	Copepod nauplii, *Prorocentrum micans.*
		Onos mustela	1	5	No food.
	Breakwater	Labrus bergylta	1	9	Young *Temora.*
8	Panther	Blennius ocellaris	1	18	Alive.
		Cyclopterus lumpus	1	16	,,
		Ctenolabrus rupestris	1	9	Copepod remains.
		Gadus merlangus	1	13	*Pseudocalanus elongatus.*
		Labrus bergylta	5	6–7	Ova, Copepod remains.
		Gobius Ruthensparri	1	9	Not examined.
	Off White Patch	Onos mustela	1	7	No food.
	Breakwater	Labrus bergylta	2	5–6	Crustacea remains.
9	Panther	Labrus bergylta	3	7–8	Copepod remains.
	Knap	Lepadogaster Condolli	1	5	Harpacticids.
		Labrus bergylta	2	6–7	Young *Calanus*, *Temora longicornis*, Harpacticids.
		Ammodytes sp.	1	14	*Calanus* nauplii.

Date. July.	Locality.	Fish.	No.	Size in mm.	Food present.
9	Breakwater	Gadus merlangus	2	11–15	*Calanus finmarchicus*, *Pseudocalanus elongatus*.
		Ammodytes sp.	3	9–45	No food.
		Trachinus vipera	1	6	Not examined.
		Labrus bergylta	5	5–6	Young *Temora*, Copepod remains.
		Lepadogaster Candolli	1	4·5	No food.
		Gobius Ruthensparri	1	6	,,
15	Knap	Solea lascaris	1	9	Not examined.
		Ctenolabrus rupestris	1	8	*Temora longicornis*.
		Gobius Ruthensparri	2	5–8	No food.
		Labrus bergylta	2	6–7	*Podon intermedius*, *Temora longicornis*.
16	Breakwater	,,	1	7	*Temora longicornis*, *Podon intermedius*, Harpacticids.
	Panther to Breakwater	,,	2	7	*Temora longicornis*, *Podon intermedius*.
		Blennius galerita	1	10	*Podon intermedius*, *Acartia clausi*, Copepod eggs.
		Lepadogaster Candolli	1	5	No food.
	Off White Patch	Cyclopterus lumpus	1	25	Alive.
19	Breakwater	Gadus merlangus	3	21–24	*Podon intermedius*, *Hyperia* sp.
23	Knap	Rhombus maximus	1	13	*Apherusa clevii*.
		Labrus bergylta	2	5–7	*Temora longicornis*, Harpacticids, larval gastropods.
		Lepadogaster Candolli	1	6	*Podon intermedius*, Harpacticids.
	Panther	Rhamphistoma belone	1	30	Larval gastropods, Harpacticids.
		Ctenolabrus rupestris	1	9	*Temora longicornis*.
		Trachinus vipera	1	6	,,
		Gobius Ruthensparri	1	7	*Podon intermedius*.
	Breakwater	Blennius ocellaris	1	14	Alive.
		Trachinus vipera	1	12	,,
		Ammodytes sp.	1	11	*Oithona similis*, *Podon intermedius*, fish eggs.
		Clupea sprattus	2	31–33	No food.
24	Panther	Rhombus lævis	1	15	Alive.
		Gadus merlangus	1	33	*Pseudocalanus elongatus*, *Acartia clausi*, *Podon intermedius*.
		Onos mustela	2	17–34	Amphipod remains, *Pseudocalanus elongatus*, *Oithona similis*.
		Rhamphistoma belone	2	11–36	Larval gastropods, Harpacticids, *Podon intermedius*.
		Gobius microps	2	10	No food.
		Trachinus vipera	1	9	*Pseudocalanus elongatus*.
		Ammodytes sp.	1	15	No food.
	New Grounds	Gobius microps	1	8	,,
	Breakwater	,,	1	10	Alive.
29	Panther to Breakwater	Lepadogaster Candolli	8	5–7	*Temora longicornis*, *Podon intermedius*, larval gastropods, Copepod nauplii, Harpacticids.
		Lepadogaster gouani	1	5	Larval gastropods.
		Callionymus lyra	1	8	No food.

Date. July.	Locality.	Fish.	No.	Size in mm.	Food present.
29	Knap.	Labrus bergylta	1	6	*Temora longicornis, Podon intermedius.*
	Breakwater	Trachinus vipera	1	6	Larval gastropods.
	Knap	Labrus bergylta	4	5–6	*Podon intermedius, Temora* juv., larval gastropods.
		Trachinus vipera	4	5–8	*Temora longicornis*, Copepod remains.
		Ammodytes sp.	1	7	No food.
Aug.					
2	Breakwater	Gobius microps	1	12	Larval gastropod.
		Gobius minutus	1	12	*Pseudocalanus elongatus.*
	Panther	Trachinus vipera	1	12	Alive.
		Ammodytes sp.	1	8	No food.
		Lepadogaster Candolli	1	5	*Podon intermedius.*
		Labrus bergylta	1	6	*Temora* nauplii.
6	West Channel	Gobius microps	1	9	*Pseudocalanus elongatus.*
		Blennius gattorugine	1	30	No food.
		Amphioxus lanceolatus	1	6	Coscinodiscus sp.
7	Breakwater	Gobius microps	2	9	Copepod remains.
		Labrus bergylta	1	7	Alive.
	Knap	,,	2	7	*Temora longicornis, Temora* nauplii.
	Panther	Arnoglossus sp.	1	13	*Tabellaria*, sp.
9	Breakwater	Trachinus vipera	1	8	Larval *Gebia, Podon intermedius, Temora longicornis.*
		Labrus bergylta	1	7	*Temora longicornis.*
		Gobius paganellus	2	9	*Pseudocalanus elongatus*, Harpacticids.
	Panther	Blennius ocellaris	1	30	Not examined.
		Labrus bergylta	1	4	Copepod remains.
		Trachinus vipera	1	7	*Temora longicornis.*
		Ammodytes sp.	1	12	No food.
		Blennius gattorugine	1	30	*Podon intermedius.*
	Knap	Rhamphistoma belone	1	8	Larval gastropods, Crustacea remains.
12	New Grounds to Melampus	Trachinus vipera	1	30	Larval *Gebia, Temora longicornis.*
	Panther	Labrus bergylta	1	4	*Temora longicornis.*
	Breakwater	Trachinus vipera	1	10	*Podon intermedius, Temora longicornis.*
		Gobius microps	1	8	No food.
		Labrus bergylta	1	5	*Temora* nauplii.
		Ammodytes sp.	1	13	*Calanus* nauplius.
		Blennius gattorugine	1	30	Not examined.
		Onos mustela	1	35	,,
13	Breakwater	Ammodytes sp.	4	4–10	No food.
	Off White Patch	Trachinus vipera	1	7	Alive.
		Gobius sp.	1	9	Not examined.
16	Panther	Gobius paganellus	2	9–13	Harpacticids.
	Breakwater	Lepadogaster Candolli	1	7	No food.
19	Breakwater	Ammodytes sp.	1	12	,,
		Lepadogaster Candolli	1	6	Not examined.
		Trachinus vipera	2	4	Young *Temora, Temora* nauplii.
20	Off White Patch	Gobius Ruthensparri	1	12	Not examined.
	Panther to Breakwater	,,	1	13	,,
		Lepadogaster Candolli	1	5	*Temora longicornis.*
26	Breakwater	,,	1	5·5	,,
		Ctenolabrus ruspetris	1	8	,,

Date. Aug.	Locality.	Fish.	No.	Size in mm.	Food present.
26	Breakwater.	Trachinus vipera	1	3	Larval gastropods, larval bivalve.
	Penlee to Knap	Lepadogaster Candolli	1	6	*Pseudocalanus elogatus.*
		Callionymus lyra	1	6	*Temora longicornis,* Harpacticids.
27	Knap	,,	2	6–7	*Pseudocalanus elongatus.*
		Trachinus vipera	1	7	*Pseudocalanus elongatus, Temora longicornis, Corycæus anglicus, Oithona similis.*
30	Knap to Breakwater	Arnoglossus sp.	1	7	No food.
Sept.					
2	Knap	Gobius Ruthensparri	1	8	*Temora longicornis,* Harpacticids.
5	Off White Patch	Blennius galerita	1	32	No food.
	Panther	Gadus pollachius	1	8	*Acartia clausi, Temora*
9	Breakwater	Lepagodaster gouani	1	8	Not examined.
		Ammodytes sp.	1	6	Copepod nauplii.
13	Panther	Lepadogaster bimaculata	1	6	Larval gastropods, larval bivalve, *Balanus* nauplius, fish egg, Harpacticids.
16	Middle Sound	Caranx trachurus	2	15–27	*Temora longicornis,* Copepod remains.
		Sygnathus rostellatus	4	50	Not examined.
		Gobius microps	9	9–10	Harpacticids, *Corycæus anglicus.*
		Gobius paganellus	2	9	Not examined.
		Ctenolabrus rupestris	1	8	No food.
		Ammodytes sp.	8	9–28	,,
		Blennius ocellaris	2	30–31	Copepod and decapod remains.
18	Knap	Ammodytes sp.	1	15	No food.
23	Middle Sound	Clupea pilchardus	1	25	,,
		Sygnathus rostellatus	1	40	*Pseudocalanus elongatus, Acartia clausi.*
24	Penlee to Knap	Clupea pilchardus	2	35–36	No food.
	Jennycliff Bay	,,	6	17–27	,,
27	Breakwater	,,	3	24–26	Remains of Copepod.
Oct.					
1	Panther	Arnoglossus sp.	2	10	*Pseudocalanus elongatus.*
	Breakwater	Clupea pilchardus	1	9	No food.
4	Breakwater	Blennius ocellaris	1	17	*Corycæus anglicus.*
	Panther to Breakwater	Clupea pilchardus	1	10	No food.
	Jennycliff Bay	Gobius microps	1	7	*Corycæus anglicus.*
Nov.					
29	Breakwater	Lepadogaster bimaculatus	1	15	Alive.
Dec.					
6	Breakwater	Cyclopterus lumpus	1	20	,,

The Young of the Gobiidæ from the Neighbourhood of Plymouth.

By

Marie V. Lebour, D.Sc.
Naturalist at the Plymouth Laboratory.

With 4 plates and 3 figures in the text.

CONTENTS

For reference to C. G. J. Petersen's recent work on gobies (1919) see page 146.

INTRODUCTION.

Several *Gobius* species and also *Aphya* and *Crystallogobius* are common near Plymouth, from up the estuaries in the neighbourhood of Saltash to the west and Chelson Meadow to the east, as far as the open sea, well beyond Rame Head and the Eddystone Lighthouse. It has, however, always been difficult to determine the young of the various species as they usually differ very little from one another and it is hoped that the following notes may be a help in the elucidation of the subject.

It has been found that although the differences in the young are not great yet they are usually constant and, in cases where the adults have been regarded as different forms only of one species, the young differ in certain characters from one another and can be separated fairly easily. This is the case with *Gobius minutus* and *microps* and the deep water form of *minutus* which is probably the form *norvegicus* of Collett (1902), and in this paper is regarded as *Gobius elongatus*. These three were regarded by Holt and Byrne (1901) as distinct forms of *Gobius minutus* having different habitats ; *microps* being the estuarine form, *minutus* proper living near the shore but not penetrating far up the estuaries, and the deep water form always living further out. Petersen (1917) is doubtful about *minutus* and *microps* being separate species and describes the young together as *Gobius minutus*, although Boulenger (1911) definitely separates them. Fage (1914, 1915 and 1918) shows that *G. minutus* and *microps* can be distinguished easily by the very different arrangement of the sensory papillæ, and that *Gobius elongatus* of Canestrini differs from *minutus* also by the arrangement of the papillæ, although it is very much nearer the arrangement in *minutus* than in *microps*. For this reason and because of other small differences he separates *G. elongatus* from *minutus* and regards it as a species representing *minutus* in the Mediterranean. On examination of the deep water form of *minutus* round about Plymouth, it is seen to agree with Canestrini's description of *elongatus* and to differ from the inshore form of *minutus* in number of vertebræ and fin rays, and also in the arrangement of the sensory papillæ which agree with that of *elongatus* as described by Fage.

The young stages of these three forms are quite distinct and differ from one another in number of vertebræ, number of fin rays and in pigmentation, so that they are usually easily recognisable. Variation in the number of vertebræ and fin rays occurs only rarely, the typical number being very nearly constant. It seems therefore that one is as much justified in regarding these three as separate species as one is in regarding *Gobius pictus* as distinct, this species having closer relationship with *microps* than *microps* has with *minutus*. The natural grouping seems to be to regard *Gobius minutus* and *elongatus* as two closely related species, and *G. microps* and *pictus* as two closely related species. Each group separated distinctly in the adults by the type of arrangement of the sensory papillæ (Fage op. cit.).

The most estuarine species is *Gobius microps*. The young are caught in the Sound in the tow-nets within and more rarely outside the Breakwater, and the adults occur in the estuaries, notably in Chelson Meadow where the water is brackish or frequently nearly fresh. *Gobius niger* also occurs in the estuaries (Holt and Byrne, 1901), but the young besides occurring in the Sound are also found beyond Rame Head and the Eddystone. *Aphya pellucida* is recorded from the Lynher River and the Tamar (Holt, 1897), but is more frequently found further from the shore.

Near the shore *Gobius minutus* and *Gobius pictus* occur and frequently *Gobius Ruthensparri* is caught with these, but the latter fish lives near the surface and not at the bottom. The young of all these are found in the Sound, but whereas *Gobius minutus* appears never to be far from the shore, *Gobius pictus* may be found in the open water beyond Rame Head at about 25 to 30 mm., and the adults are also found in the more open water as well as inshore. In the Sound the young of *Gobius Ruthensparri* are frequently taken by the tow-nets, but not far out to sea.

Gobius paganellus is very common under stones at the level of the lowest spring tides. The young are caught in the tow-nets in the Sound both inside and outside the Breakwater and occasionally occur further out.

The species of young *Gobius* found commonly in the deeper water are *Gobius elongatus* and *Gobius Jeffreysii*, *Gobius elongatus* taking the place of *G. minutus*, which does not occur so far out. The young *Gobius Jeffreysii* are often obtained with those of *G. elongatus* in the deeper water beyond Rame Head and the Eddystone. These are the most striking of all the young gobies, as they are much pigmented and develop into the bottom stage very early.

Gobius scorpioides has only been obtained very rarely and its young stages have not as yet been noticed in this district.

Crystallogobius Nilssoni occurs frequently in the more open water, but the very young are not often obtained.

We thus have 9 species of *Gobius* occurring in the neighbourhood of Plymouth, and also *Aphya pellucida* and *Crystallogobius Nilssoni*. Of these all the young have been obtained with the exception of *Gobius scorpioides*.

In identifying the young gobies the vertebræ and fin formulæ are the most valuable points of difference as the scales and sensory papillæ are not developed until the later stages. In fresh specimens the vertebræ and fin rays can be readily counted. General form and pigment are also of importance, especially in preserved specimens, where in order to count the vertebræ one has to employ special methods. The size of the eye is also a useful guide, especially in two species where the number of vertebræ is the same (e.g. *G. elongatus* and *G. Ruthensparri*). The position of the air bladder very near the anus is distinctive of *Aphya* and *Crystallogobius*.

The number of vertebræ and fin rays are usually very constant characters, in only very few cases overlapping. The use of the arrangement of papillæ on the head and body as employed by Sanzo (1911) and Fage (1914, 1915, 1918) is valuable for the young which have attained a certain size, but of no use for the very young, for, as Fage himself shows, these do not attain their full development in the young and frequently, even if developed, differ in many respects from the adults. For half-grown fish or even less the papillæ form a valuable guide to the species. For showing up the papillæ the method of Sanzo (1911) was used, the specimens being first soaked in alcohol, then in a 2% solution of chromic acid for about 24 hours.

For the preserved material the vertebræ and fin rays were examined by staining with alizarin : a very dilute solution acting for a fairly long period giving the best results. In counting the vertebræ the first with a spine is counted as one, the curved portion at the tail end being counted as the last (Fig. 1).

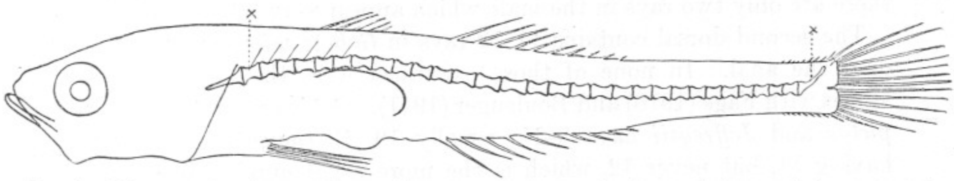


FIG. 1.—Diagram showing vertebræ ; the crosses indicate the first and last vertebræ counted.

Gobius minutus possesses the largest number of vertebræ, nearly always 33, rarely 34, very rarely 32.

Gobius elongatus has 32 vertebræ, very rarely 33, 31 or even 30 (those with 31 and 30 not being quite certainly identified).

Gobius Ruthensparri has also 32 vertebræ.

Gobius microps has 31 vertebræ, rarely 30.

Gobius pictus has 30 vertebræ, rarely 29.

Gobius Jeffreysii has 30 vertebræ, constant in all those examined.

Gobius paganellus has 28 vertebræ, rarely 29.

Gobius niger also has 28 vertebræ, rarely 29.

Crystallogobius Nilssoni has usually 30 vertebræ, rarely 29.

Aphya pellucida has 27 vertebræ, a smaller number than any of the gobies here described.

The fins are perhaps even more valuable as differentiating characters as they can often be counted without any special preparation. The first dorsal, which is not developed in the very young, usually contains 6 rays and, as shown by Petersen (1917) for *Gobius minutus*, in those with 6 rays the 6th ray is further away from the 5th than those in front are from one another (Fig. 2A). 6 rays occur thus in *Gobius minutus, microps, pictus, elongatus, Jeffreysii, paganellus* and *niger*. In *G. Ruthensparri*, which has 7 rays, the first 6 are close together, the 7th further back (Fig. 2B). When, as is exceptionally the case in *G. minutus* or *elongatus*, any of the others have 7 rays, the 6th may be as usual far

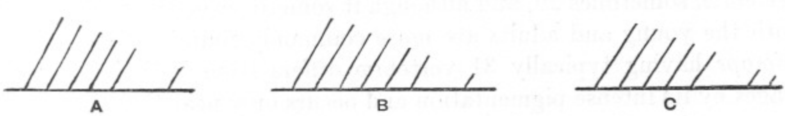


FIG. 2.—Diagram of first dorsal fin.

A. *Gobius minutus* and others with 6 rays (typical).
B. *Gobius Ruthensparri.*
C. *Gobius elongatus,* variety with 7 rays.

away from the 5th, the 7th being closer to the 6th (Fig. 2C), or the arrangement may be as it is in *G. Ruthensparri*.

Aphya pellucida has 5 rays, the same distance apart, but these do not appear for a long time and may still be absent at about 18 mm. In *Crystallogobius Nilssoni* the first dorsal is absent in the female and there are only two rays in the male which appear very late.

The second dorsal contains 11–12 rays in *Gobius minutus* and so also does the anal. In none of those examined were there less, and this agrees with Fage (1918) and Boulenger (1911). *Gobius elongatus*, *microps*, *pictus* and *Jeffreysii* have 9–10, usually 10, *G. elongatus* occasionally having 11, but never 12, which is the more usual number in *minutus*. *Gobius Ruthensparri* has 10–11, nearly always 11. *Gobius paganellus* 13–15, anal 11–13 ; *Gobius niger* 13–14, usually 13, anal 11–13, usually 12. *Aphya pellucida* has 12–13, anal 14 ; *Crystallogobius Nilssoni* has 19–20, anal 21. It is thus seen that whereas *Aphya* and *Crystallogobius* have usually a larger number of rays in the anal than in the dorsal fin [Fage (1918) gives an equal number for *Aphya*], in *Gobius* these are usually either equal or there are more rays in the dorsal. Variations in *G. minutus* sometimes occur having one more ray in the anal than in the dorsal fin.

Gobius minutus can be distinguished from those which resemble it closely by its vertebræ and fins, the species nearest it being *G. elongatus*, but whose habitat is always in deeper water than *G. minutus*. *Gobius Ruthensparri* can be distinguished from *elongatus* by its almost uninterrupted ventral chromatophores from anus to tail and later on by its first dorsal fin which appears after about 10 mm. *Gobius microps*, *pictus* and *elongatus* are most easily differentiated by the number of vertebræ when very young, *G. pictus* and *Jeffreysii* both typically having 30 vertebræ. The young of *G. Jeffreysii*, however, is easily distinguished from *pictus* by its heavier build, much more intense pigmentation and earlier development of fins with longer fin rays. Of the others *G. elongatus* and *pictus* are the most easily mixed as they have very little pigmentation up to a late stage and forms which are apparently varieties of *elongatus* sometimes occur having some of the characters of *pictus*. As a rule, however, *G. elongatus* has 32 vertebræ, is found in deeper water than *pictus* and never comes so near inshore ; *G. pictus* has 30 vertebræ, sometimes 29, and although it sometimes occurs in deep water both the young and adults are more commonly found inshore. *Gobius microps* having typically 31 vertebræ differs from both in its young stages by its intense pigmentation and occurs only near the coast and up the estuaries. Never in deep water like *G. elongatus*.

Gobius niger and *paganellus* have the same number of vertebræ, usually 28, but besides a difference in fin rays, *G. niger* has much more pigment than *paganellus* and develops into the bottom form at a much smaller size. It occurs in deeper water than *paganellus* although it also occurs in the Sound and up the estuaries.

Aphya and *Crystallogobius* can be distinguished from the *Gobius* species in their young stages by their very slender form, slight pigmentation and extremely slow development of the paired fins, besides the position of the air bladder very near the anus. The *Gobius* most easily confused with *Aphya* in the young stages is *G. paganellus* with its slender form and slight pigmentation, but it is always less slender and more pigmented than *Aphya* and can be distinguished from it by the development of the fins and the position of the air bladder besides the additional vertebra. *Crystallogobius* having so many more fin rays in the dorsal and anal fins cannot be confused with any of the other species.

The paired fins are developed in varying degrees in the different species, being much the most backward in *Aphya* and *Crystallogobius*. The pectorals are in most cases omitted in the figures as they usually show little in side view except when very well developed as in *Gobius Jeffreysii* or in the later stages. The pelvics, however, vary much in their length and state of development in the different species and are useful in differentiating them. Thus in *G. Ruthensparri* they are only very slightly developed at 12 mm., whilst in *G. elongatus* of the same size they reach to nearly the end of the air bladder.

It is only in the older stages that any use can be made of the arrangement of the sensory papillæ as a distinguishing character, but specimens of *G. elongatus* of 18 mm. show certain distinctive characters, and in *G. Jeffreysii* at 16 mm. although they are not quite of the adult form yet they show that they belong to that type. Specimens of *G. pictus* of 23 mm. show the adult characters in the sensory papillæ so that they can be distinguished from *microps*, to which species they bear a close resemblance.

Of the work on young gobies beyond the newly hatched forms the most detailed is that by Petersen (1917) who distinguishes between all stages of *Gobius Ruthensparri*, *Gobius niger* and *Gobius minutus* and *microps* together. The two latter are described as one species although two forms are recognised which agree with *Gobius minutus* proper and *Gobius microps* as distinguished by Boulenger (1911). The two forms are, however, not differentiated in the descriptions of the young, and most of the figures are almost certainly of *microps*. Fage (1918) describes from off Brest young gobies which he refers to *minutus*, but these possess 30–31 vertebræ, and the figure given shows pigment which differs from our specimens in being more profuse on the head, with a chromatophore behind the head dorsally and one behind the first dorsal fin, also two large ramifying dorsal chromatophores on the tail corresponding to two similar chromatophores ventrally. The pigmentation and proportions are more like our post-larval *G. Jeffreysii* than *minutus*. Ehrenbaum and Strodtmann (1904) describe and figure young *Gobius niger* from the Baltic which are very similar to those from open water near Plymouth, and these are probably the form as differentiated by Fage (1915) which are larger than *Gobius niger* proper and undergo metamorphosis at a larger size. Collett (1877) refers to the young of *Aphya* and *Crystallogobius* and Ehrenbaum (1905) gives original drawings of the later post-larval stages of these, besides describing several of the young *Gobius*. Other descriptions chiefly refer to the eggs and newly hatched young, those of special importance being by Guitel (1892) and Petersen (1910). Hefford (1910) describes the egg and newly hatched young of *Gobius paganellus*, but beyond this stage the young of this species have apparently remained undescribed. The young *Gobius Jeffreysii*, *pictus* and *elongatus* are also described here for the first time and the young *Gobius minutus* and *microps* distinguished and separated.

The material worked on was from the hauls with the Young Fish Trawl made by Clark in 1913 and 1914 from the neighbourhood of Plymouth [Clark (1913), Allen (1917)], and also from tow-nettings made throughout the year 1918 in Plymouth Sound, together with some odd bottled specimens from the same localities. For the various parts of the Sound and outside, reference should be made to the chart by Clark (1913) and the plan of the Sound by Lebour (1918). A few specimens from the tow-nets were kept alive in small aërated aquaria (see page 9 of this Journal), and by this means *Gobius Ruthensparri* and *Gobius microps* were reared to a stage at which it was impossible to mistake the species.

The eggs of *Gobius paganellus* were reared and hatched out, several adult specimens being isolated until the eggs were laid on the under surface of stones and these eggs were then kept in aquaria and examined every day. In this way a series of drawings was made from the day the egg was laid up to a few days after hatching. *Gobius Ruthensparri* were also isolated and eggs were laid in an empty oyster shell. These were also reared and drawings made up to the time of hatching. It is hoped later to do the same with the other species.

The young gobies from the Young Fish Trawl occurred from May to October and were most common in the tow-nets from July to September, the commonest size being from about 10 to 15 mm. Young *Aphya* occurred in the Young Fish Trawl in 1913 in July to September measuring from about 10 to 20 mm., but only older specimens occurred in the tow-nets, and these only very rarely. Most of the *Crystallogobius* captured in the Young Fish Trawl were of fairly large size.

Of the young of the *Gobius* species from deeper water, *G. elongatus* is undoubtedly the commonest, *G. Jeffreysii* coming next. At times in deeper water, but more commonly nearer the shore the young of *G. pictus* is fairly abundant. The commonest young gobies caught in the tow-nets are *Gobius Ruthensparri*, *paganellus* and *microps*, although *G. minutus* is quite as common in the adult stage and abounds in the Sound from the Cattewater to the Breakwater and along the coast outside the Breakwater, notably in Cawsand Bay.

GOBIUS MINUTUS Pallas.

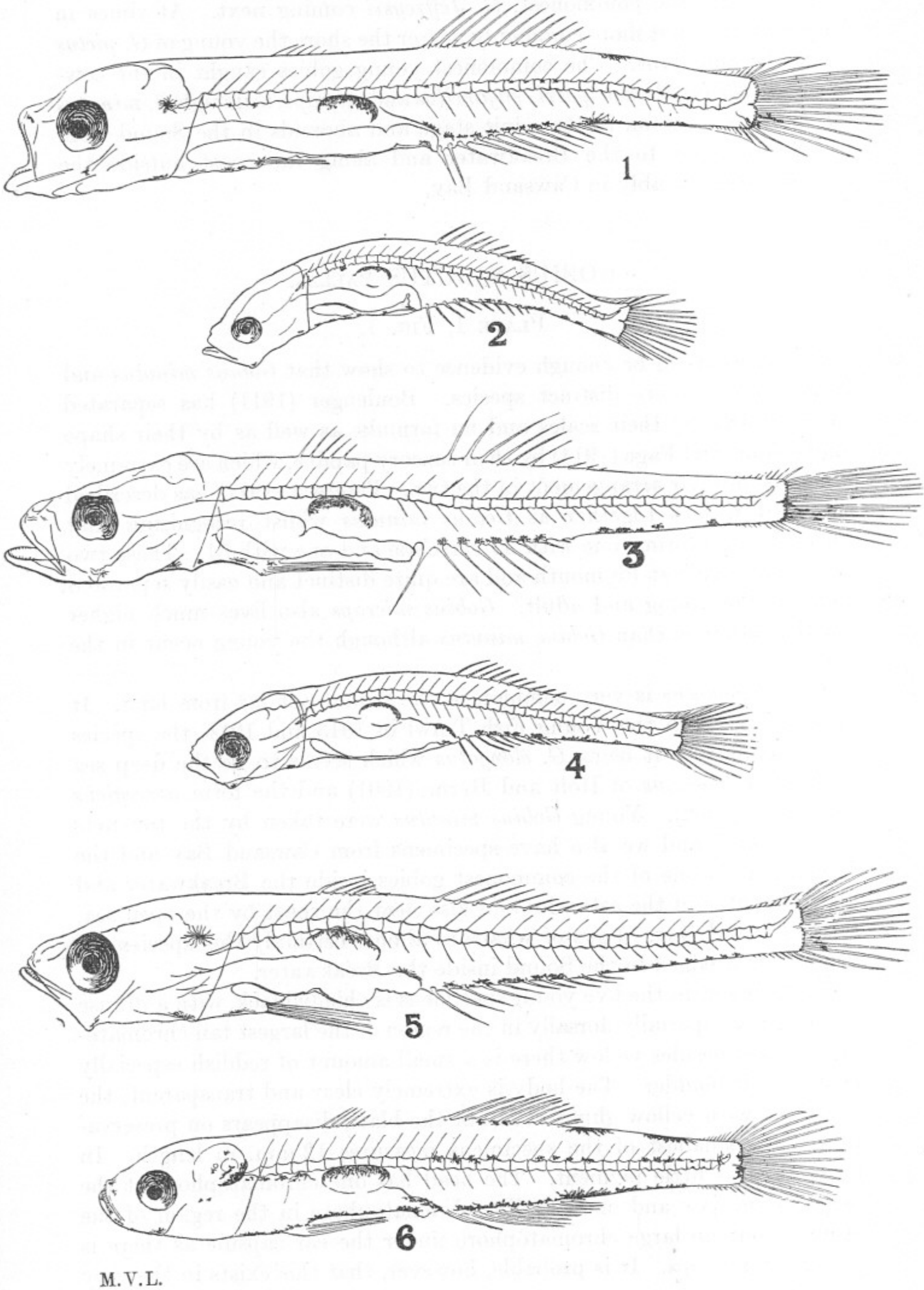
Plate I, Fig. 1.

There seems to be enough evidence to show that *Gobius minutus* and *Gobius microps* are distinct species. Boulenger (1911) has separated them clearly by their scales and fin formulæ as well as by their shape and colour, and Fage (1914) by their sensory papillæ, which are extremely different in their arrangement in the two. Petersen (1917) has described the two species together as *Gobius minutus* whilst recognising that there are two forms, one with 33 vertebræ and one with 31. These two are recognisable at Plymouth and are quite distinct and easily separated both in the young and adult. *Gobius microps* also lives much higher up the estuaries than *Gobius minutus* although the young occur in the Sound.

Gobius minutus is very common in the Sound not far from land. It was not taken in the Young Fish Trawl in 1913 and 1914, the species corresponding to it being *G. elongatus* which seems to be the deep sea form of *G. minutus* of Holt and Byrne (1901) and the form *norvegicus* of Collett (1902). Young *Gobius minutus* were taken by the tow-nets in the Sound and we also have specimens from Cawsand Bay and the Tamar. It is one of the commonest gobies inside the Breakwater and at the mouths of the estuaries and also near the coast by the open sea, e.g. Whitsand Bay. Eggs of what are almost certainly this species are frequently dredged in the Sound inside the Breakwater.

The pigment in the live young specimens is chiefly black, with a diffuse yellow tinge especially dorsally in the region of the largest tail chromatophores, and besides yellow there is a small amount of reddish especially near the air bladder. The body is extremely clear and transparent, the eyes blue with yellow glints. All but the black disappears on preservation. The smallest of the specimens measures 12 mm. in length. In these there is little pigment. The head has one chromatophore at the angle of the jaw and one star-like chromatophore in the region of the otoliths, but no large chromatophore under the ear capsule as there is present in *microps*. It is probable, however, that this exists in the very

PLATE I.



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young stages and disappears as it does in *G. Ruthensparri*, for young hatched out of eggs which were almost certainly *Gobius minutus* possessed this chromatophore. There may be a small chromatophore in the nose region. Usually there is no dorsal pigment at this stage although there may be one chromatophore behind the second dorsal fin. Later on this is always present. There are usually chromatophores from the throat to the base of the pelvic fin, but hardly any pigment below the intestine until just in front of the anus, where there is one chromatophore. There is the usual pigment on the dorsal surface of the air bladder. From above the anus along the base of the anal fin as far as about the level of the second vertebra from the tail end is a series of chromatophores, interrupted at about the level of the 11th vertebra from the tail end for a space equal to about two or three vertebræ. Just behind this is a specially ramified chromatophore, which lies immediately opposite the single dorsal chromatophore when that is present. Two or three streaks of pigment occur on the ventral half of the caudal fin. Indication of three groups of pigment spots along the region of the vertebræ may occur at this stage, and soon afterwards these are always present. At 15 mm. there may be, and usually is, a chromatophore in the front of the lower jaw, and the dorsal pigment may have increased to several chromatophores behind and in the region of the second dorsal fin, but usually, not near the first dorsal even at 16 mm. At 18 mm., in the largest specimen, taken at Cawsand Bay, the pigment has increased so that there are several small chromatophores on the upper and lower jaw and in the ear region, and dorsally on the top of the head and in front of the first dorsal fin. A chromatophore is now present at the base of the 5th ray of the first dorsal and at the base of several of the rays in the second dorsal. The three patches of pigment are more distinct, and there is now one in front of the air bladder and one at the base of the tail fin. The pigmentation at this stage approaches that of *microps* at 10 mm., although there are distinct differences, notably the absence in *minutus* of the large chromatophore under the ear capsule, besides the much more intense pigment of *microps*.

The vertebræ number 33 in 15 out of 16 counted, the 16th having 34. In an adult from Whitsand Bay there were also 33, one specimen from

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EXPLANATION OF PLATE I. (Pectoral fins omitted.)

FIG. 1.—*Gobius minutus*, length 12 mm. From tow-nets, Plymouth Sound, August 13, '18.
FIG. 2.—*Gobius elongatus*, length ca. 7 mm. From 2 miles beyond Prawle Point, Young Fish Trawl, July 2, '14.
FIG. 3.—*Gobius elongatus*, length 12·2 mm. Same locality, July 2, '14.
FIG. 4.—*Gobius pictus*, length 7·5 mm. From off Looe, Young Fish Trawl, August 13, '13.
FIG. 5.—*Gobius pictus*, length 12 mm. Same locality, August 13, '13.
FIG. 6.—*Gobius microps* from fresh specimen, length 10 mm. From tow-nets inside the Breakwater, September 6, '18.

Ireland had 32. 33 may be regarded as the typical number which agrees with Petersen's more open water form of *minutus* (1917). The fins are D II 11–12, A 11–12, usually 12 in both dorsal and anal, sometimes 11 in one and 12 in the other. The eye is larger than in *microps* of the same size. Thus at 12 mm. it measures 0·7 mm. across which is about the same as in *microps* of 14 mm. At 15 mm. it measures 0·8 mm. across.

At 12 mm. the permanent rays of the pectoral fin are not completely developed, the pelvics reaching not quite to the level of the centre of the air bladder. At 13 mm. they may reach to the end of the air bladder and at 14 mm. to just beyond it. At 15 mm. the pectoral rays are developed and the pelvics reach nearly to the anus, which is the adult position.

Gobius minutus may thus be distinguished from *microps* in its young stages by its less intense pigmentation, notably the absence of a large chromatophore under the ear capsule (with the probable exception of the newly hatched stage), by the larger number of vertebræ and fin rays, less rapid development of the pelvic fins and by the larger eye. In the adults and in the young stages of about 20 mm. or less, the sensory papillæ show a totally different arrangement in the two species.

GOBIUS ELONGATUS Canestrini

Plate I, Figs 2 and 3.

The first mention of this species is by Canestrini (1862) from the Gulf of Genoa. Fage (1917) describes it as differing from the typical *Gobius minutus* by its slenderer build, absence of scales on the neck and throat and the persistence of certain larval characters, the chief being the arrangement of the sensory papillæ, which is nearer to the young *Gobius minutus* than it is to the adult. It apparently takes the place of *G. minutus* in the Mediterranean. This species seems to take the place of *G. minutus* also in the deeper waters round about Plymouth, and it is apparently the more open water form of *Gobius minutus* of Holt and Byrne (1901) and the *Gobius minutus* form *norvegicus* of Collett (1902). Through the kindness of Mr. Holt I have been able to examine some of his specimens from Ireland, which agree with the characters given for *G. elongatus*, especially with regard to the sensory papillæ and pigmentation of the adult, which in the male particularly, is inclined to be in bars along the body. The fin formula agrees with Canestrini, D VI 9–10, A 9–10. A few of the Irish specimens have 11 rays in both dorsal and anal. Only a few adult specimens are available from the Plymouth waters, but these agree with the characters given above, having less fin rays than *Gobius minutus* proper, streaky pigmentation and sensory papillæ as described by Fage. The papillæ are in all the specimens much less strongly developed than in *minutus* and much more difficult to see, especially in half-grown specimens which are only very slightly pigmented.

Young specimens are very common in the Young Fish Trawl both in 1913 and 1914, always from deeper water and often with the young of *Gobius Jeffreysii*. They range from quite small specimens of about 5 mm. long to older forms up to about 18 mm. The latter show to a certain extent the sensory papillæ characteristic of *G. elongatus* and differ somewhat from those in the young *minutus*, but they are still in the post-larval stage and very little pigmented.

The typical number of vertebræ is 32. Fins D VI 9–10, A 9–10 (rarely 11 in both). Rarely there are 7 rays in the first dorsal fin.

This is by far the commonest young *Gobius* from the Young Fish Trawl from 23 to 36 fathoms, from beyond the Eddystone, Rame Head, off Prawle Point and Start Point and beyond Looe Island. It is often accompanied by the young of *Gobius Jeffreysii*, occasionally by the young of *Gobius niger*, but is never found with *Gobius minutus*, *microps* nor *Ruthensparri*. *Aphya* and *Crystallogobius* occasionally occur with it and *Gobius pictus* of a fairly large size, although not actually caught with it occurred sometimes in the same localities.

The youngest stage found in the Young Fish Trawl measures 5 mm. and the oldest 18 mm. The young specimens (preserved only, as no live material was examined which contained this species) up to about 10 mm. and more have very little pigment, none at all in or on the head except a touch of black at the angle of the jaw, a few chromatophores on the throat and sometimes below the alimentary canal, the usual pigment on the air bladder and a row of ventral chromatophores usually beginning well behind the anus and reaching to nearly the end of the tail. These ventral chromatophores are interrupted at about the level of the 10th or 11th vertebra for a space equal to about three or four vertebræ. The first chromatophore behind the space is usually but not always ramified. Later on, sometimes at 10 mm., sometimes not till after 14 mm., there is a chromatophore in the auditory region in the same position as it is in *Gobius minutus*. A chromatophore behind and above the anus is absent in nearly all the specimens, occasionally being indicated by a minute black spot, rarely being fully developed. In older specimens, after about 16 mm., chromatophores appear at intervals along the vertebral column, and at about 18 mm. speckles appear externally with regular dark spots.

The eye is small, conspicuously smaller than in *minutus* and *pictus*, measuring at 7 mm. 0·32 mm. across, and at 12 mm. 0·64 mm. across, although an occasional abnormal specimen may have a larger eye.

The body is long and thin. At a length of 7 mm. the unpaired fins, except the first dorsal, are developed and have the complete number of fin rays, usually 10 in both dorsal and anal, sometimes 9, rarely 11 (11 have never been seen in the Plymouth specimens). At 12 mm. the first dorsal is formed and has longer rays than in *G. minutus* of the same length. The pelvics at this stage reach to the end of the air bladder or past it. All the fins in the young have a somewhat straggling appearance and the fin membranes are easily torn.

The number of vertebræ may reach 33 and probably may go down to as low as 30, but 32 is the typical number. A specimen having 33 vertebræ can be distinguished from *minutus* by the smaller number of fin rays in the second dorsal and anal fins and the smaller eye. If, as rarely happens, a specimen has 31 vertebræ, which is the typical number for *microps*, it can be distinguished by the very different pigmentation, but it is hardly likely to be confused with that species as it always inhabits much deeper water than *microps* and is never found inshore. It is with *Gobius pictus* that it is most likely to be confounded in the young stages, for if they occurred together it seems almost impossible to distinguish the two if not quite typical, for although typically *G. elongatus* has 32 vertebræ, a very small eye and no chromatophore behind and above the anus, specimens sometimes occur with one or two of the following characters—31 or 30 vertebræ, larger eye, or a chromatophore above and behind the anus as in *G. pictus*, and *G. pictus* although apparently never having more than 30 vertebræ and always possessing the typical chromatophore above and behind the anus may rarely have a much smaller eye.

It is probable, however, that whilst *Gobius elongatus* occurs always in fairly deep water *Gobius pictus* in the young stages lives nearer the shore, although when older, at 23 to 30 mm., and when adult the latter also occurs in deeper water. The variable specimens which occur among the young *G. elongatus* are thus more likely to be variations in that species than isolated specimens of *Gobius pictus*.

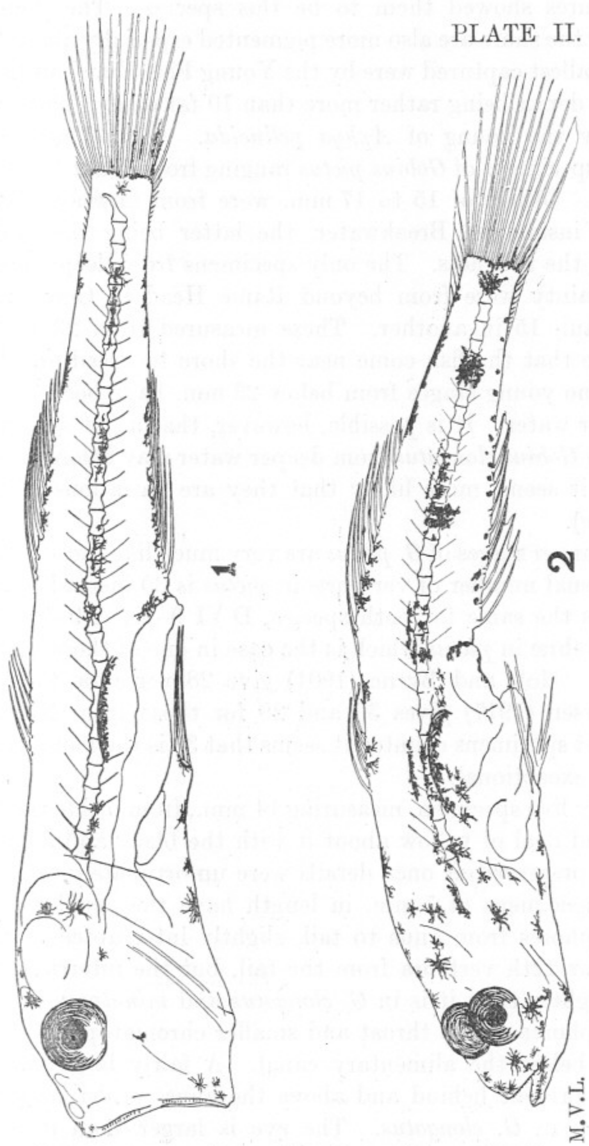
Gobius elongatus although so little pigmented is easily distinguished from *Aphya* by the number of vertebræ and fin rays, and especially by the development of the paired fins, also by the chromatophore at the angle of the lower jaw, which is absent in *Aphya*.

GOBIUS PICTUS Malm.

Plate I, Figs. 4 and 5. Plate II, Fig. 1.

Gobius pictus has a wide range of distribution, as it occurs in the Sound chiefly near the shore, more rarely right out as far as Rame Head. It is often taken with *Gobius minutus* and *Ruthensparri*, and the young occurred in the Young Fish Trawl in 1913 in August to October. Those from off Rame Head in October were much older than the others and

PLATE II.



EXPLANATION OF PLATE II. (Pectoral fins omitted.)

FIG. 1.—*Gobius pictus*, length 14 mm. From tow-nets inside the Breakwater, August, '18.

FIG. 2.—*Gobius microps*, length ca. 14 mm. From Young Fish Trawl off Penlee, September 4, '18.

measured 23 to 30 mm. They were much less pigmented than those of the same size from the Cattewater although the sensory papillæ and ther features showed them to be this species. The younger stages from near the shore are also more pigmented especially about the head.

The smallest captured were by the Young Fish Trawl off Looe, August, 1913, the depth being rather more than 10 fathoms. They were accompanied by the young of *Aphya pellucida.* In the haul were over a hundred specimens of *Gobius pictus* ranging from about 5 mm. to 15 mm. in length. Others of 15 to 17 mm. were from Cawsand Bay, Bigbury Bay and inside the Breakwater, the latter being the only specimen caught in the tow-nets. The only specimens from deep water identified with certainty were from beyond Rame Head in October, 1913, 147 in one haul, 15 in another. These measured from 23 to 33 mm. It is possible that the fish come near the shore to breed and then go out again, as no young stages from below 23 mm. have been identified from the deeper water. It is possible, however, that a few specimens among the young *Gobius elongatus* from deeper water may belong to this species, although it seems more likely that they are variations of *G. elongatus* (see above).

The younger stages of *G. pictus* are very much like those of *G. elongatus*, but the usual number of vertebræ in *pictus* is 30 instead of 32. The fin formula is the same for both species, D VI 9–10, A 9–10. There may be 29 vertebræ in *pictus* which is the case in one of those figured (Fig. 1, Plate II). Holt and Byrne (1901) give 28 vertebræ for this species, and Petersen (1917) gives 30 and 29 for those from Norway. From the present specimens counted it seems that 30 is the more usual number, 29 rather exceptional.

The only live specimen, measuring 14 mm., from inside the Breakwater had a good deal of yellow about it with the black and a little red, but as it was preserved at once details were unfortunately not noted. The smallest specimens of 5 mm. in length have the usual row of ventral chromatophores from anus to tail, slightly interrupted at the level of the 11th or 12th vertebra from the tail, but the interruption is nearly always slighter than it is in *G. elongatus* and *minutus* : there are large chromatophores at the throat and smaller chromatophores more or less apparent below the alimentary canal. A fairly large chromatophore is always present behind and above the anus, whilst its occurrence is exceptional in *G. elongatus*. The eye is larger than it is usually in *G. elongatus*. The fin rays are beginning to form in those of 5 mm., and they are fully formed at 7 mm. At 12 mm. and sometimes earlier a large ramifying chromatophore is present in the auditory region, and at 14 mm. there may be a few more near it, and also chromatophores at the base of some of the rays in the second dorsal fin and behind it, and dark patches in the region of the vertebral column. At 12 and 14 mm. the eye is distinctly larger than it is in *G. elongatus* of the same length, measuring about 0·72 mm. across at 12 mm., and 0·86 mm. across at 14 mm., whilst that of *G. elongatus* at 12 mm. measures only about 0·56 mm. across. The difference in the size of the eye is particularly noticeable at this stage. The specimen from inside the Breakwater is more pigmented than those from off Looe, approximating more in pigmentation to *G. microps*, but is easily distinguished from that species by the absence of the large streak-like chromatophore beneath the auditory capsule, the fewer vertebræ and the larger eye, besides being still much less intensely pigmented than *microps*. The pelvic fins are absent at 7 mm., at 12 mm. they reach to slightly beyond the level of the hind end of the air bladder, at 14 mm. they reach nearly to the anus.

The older specimens from beyond Rame Head are much more developed and are practically like the adult. In those of 23 mm. the eyes are on the dorsal surface, the scales are present, the adult fins developed and the characteristic arrangement of the sensory papillæ can be recognised. However, in comparing specimens from the mouth of the Cattewater they are seen to be much paler than these, so that they cannot be recognised by pigment alone as one can recognise the adults. The pale colour may be due to preservation, but this is not very likely to be the case as adults keep their colour well in the same preservative.

The few very young specimens with 30 vertebræ from deeper water, that occurred with *G. elongatus*, probably belong to that species although it is exceedingly difficult to distinguish them from *pictus* with any certainty. Some agree with *pictus* in number of vertebræ and chromatophore above the anus, but the eye is more like *elongatus*, others are without the chromatophore, but have 30 vertebræ. The two species at this stage (7–10 mm.) can only be separated with difficulty, and the fact that one or two abnormal specimens occur with a number of *G. elongatus* in the usual habitat of the latter renders it more probable that we are dealing with a variety of *elongatus* than with *G. pictus*.

That the above-described specimens are really the young of *Gobius pictus* there can be little doubt, for the only other species with the same number of vertebræ and fin rays is *Gobius Jeffreysii*, which inhabits deep water and apparently never comes inshore, although *G. pictus* may occur in deeper water as well as near the shore. The young of what must be regarded as *G. Jeffreysii* were taken frequently in the deeper water, but never near shore, and finally the older specimens of *G. pictus* at 23 mm., which from their sensory papillæ, vertebræ and fins show them to be undoubtedly this species, agree very well with the younger forms.

GOBIUS MICROPS Kröyer.

Plate I, Fig. 6. Plate II, Fig. 2.

Gobius microps is definitely recognised as a species by Boulenger (1911), and Fage (1914) shows that it can be distinguished from *pictus* to which it is closely related, by the arrangement of the sensory papillæ. The number of vertebræ is typically 31, fin rays D VI 9–10, A 9–10. This species lives chiefly in estuaries and occurs as high up as Chelson Meadow by the Laira. In the Sound the young are caught in the tow-nets, and with the Young Fish Trawl specimens were taken by Clark in 1913 from Jennycliff Bay, and in 1914 from Cawsand Bay and one off Penlee Point.

Specimens from 5·5 mm. to 12 mm. in length occurred from various parts of the Sound as far out as the Knap Buoy, but usually within the Breakwater. They were commonest in July, and a live specimen of 10 mm. was taken in the tow-nets on July 24th, 1918, and kept alive till December when it measured 16 mm. and was very clearly a *Gobius microps*. The pigment when alive was very bright. The intensely black chromatophores were mixed with a bright yellow with a little red, the yellow spreading on to the sides and dorsally on the tail. Those of 16 to 18 mm. showed many black speckles both internally and externally.

The young are long and narrow with a small eye from 0·30 mm. across at 14 mm. The pigment is very conspicuous and agrees with Petersen's figures of *Gobius minutus* (including *microps*) at 7 to 14 mm., all three of which are apparently drawings of *microps* (1917). From the smallest to the largest there is an almost continuous row of black chromatophores ventrally from anus to tail, which specially ramify just behind the anal fin, and are placed opposite one or two dorsal chromatophores which also ramify and occur immediately behind the second dorsal fin. When the ventral chromatophores are contracted there is a slight interruption at about the level of the 12th vertebra from the tail. Beneath the auditory capsule is a large chromatophore, and in the region of the larger otolith (there is one very large and one very small) is a smaller star-shaped chromatophore. At the angle of the jaw is a conspicuous chromatophore and a series from the throat to the anus, sometimes leaving a gap in the region below the air bladder. This pigmentation occurs in all from 5·5 mm. to 14 mm. Usually also in those from 7 mm. onwards there are pigment spots on the lower jaw and above the eye, often also in front of the eye. At 9 mm. two more spots may appear in the region of the auditory capsule, but these may not come until later. At 11 mm. there are a good many more pigment spots on the head and at 14 mm. still more. With the increase of pigment on the head comes pigment at the base of the rays of the second dorsal fin, pigment above and below the vertebræ forming three elongated dark patches, and more pigment at the base of the caudal fin. Later on come patches of pigment on the outside corresponding to pigment along the vertebræ. In the specimen of 14 mm. the pigment is connected with the rays of the first dorsal fin. In all there is much pigment on the dorsal surface of the air bladder.

In 29 specimens, all except one had 31 vertebræ, one having 30 only. In all of these the number of fin rays in both second dorsal and anal fins is 10. The pectoral fin rays are not developed until about 10 mm. and then only feebly. The pelvics at 8·5 mm. reach to beyond the level of the centre of the air bladder, at 11 mm. they reach nearly to the anus, but apparently even in the larger specimens never quite reach it. A specimen of 18 mm. from Chelson Meadow has a speckly appearance, very much pigmented dorsally, but the large spots and patches not definitely marked. Eye 1 mm. across. A specimen of 25 mm. from the same locality has all the appearance of the adult, but the sensory papillæ under the eye have not reached the full number. From *Gobius pictus*, which is the species nearest to it, the young of *microps* may be distinguished by the pigment, smaller eye and larger number of vertebræ. The head in *pictus* is longer than that of *microps*, which can be easily seen in the older specimens of about 23 mm. and over. *Gobius pictus* also is sometimes found much further out to sea than *microps*, and although it is captured at the mouths of estuaries with *minutus* it apparently never penetrates up them as *microps* does. The distinguishing character of *minutus* and *microps* will be found under the description of *Gobius minutus* (p. 55).

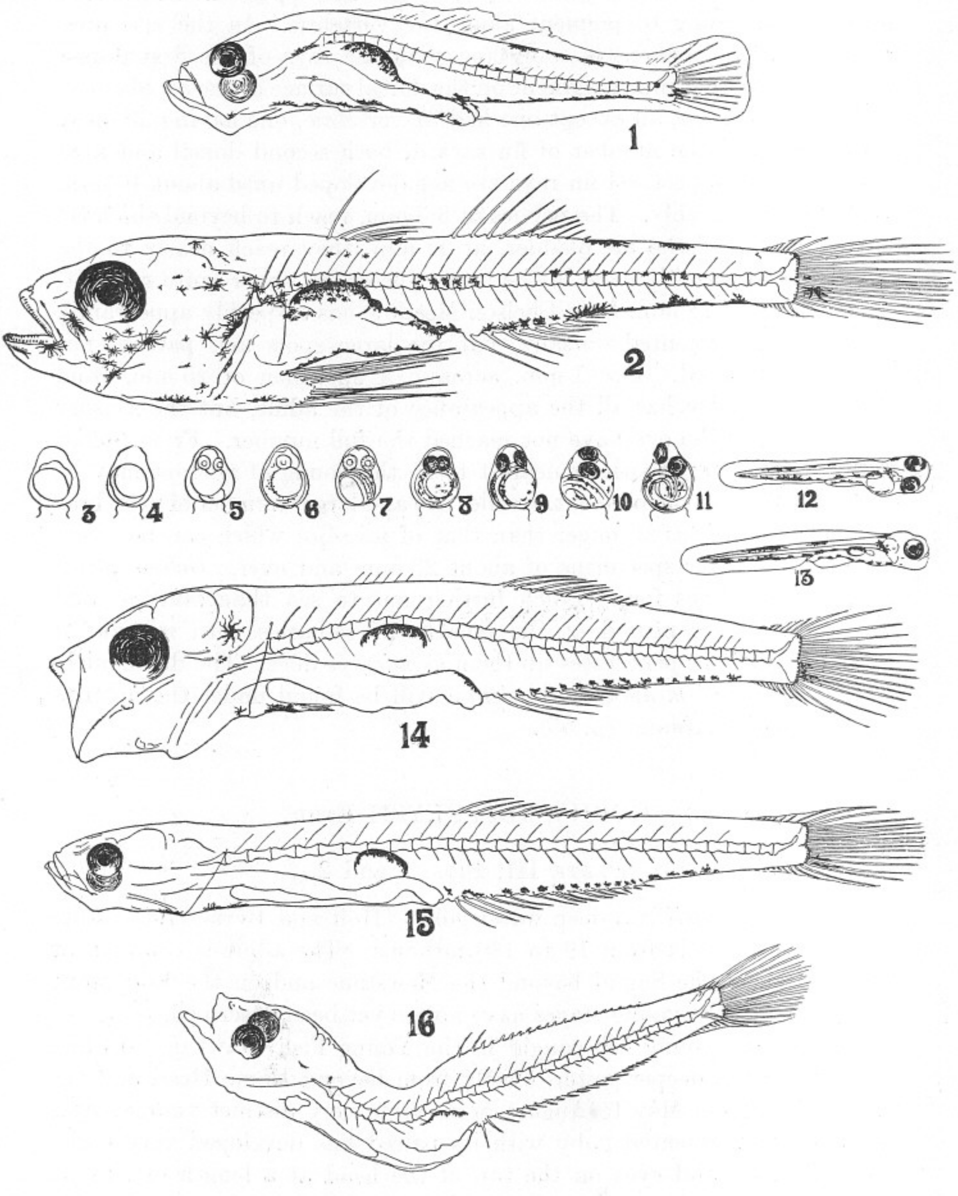
GOBIUS JEFFREYSII Ethr.

Plate III, Figs. 1 and 2.

Gobius Jeffreysii is a deep water goby. Holt and Byrne (1901) state that its habitat is from 19 to 180 fathoms. The adult is common at the mouth of the Sound beyond the Mewstone and on the Eddystone grounds, but the young stages have not as yet been described.

Among the young fish caught in the Young Fish Trawl in 1913 and 1914 from the deeper water, chiefly from beyond Rame Head and the Eddystone from May to August, were some very distinct young stages of a much pigmented goby with its paired fins developed very early, long fin rays and eyes on the top of the head at a length of 12 mm. or less. In all those counted (25) there were 30 vertebræ, fin formula D VI 9–10, A 9–10. A few adult *G. Jeffreysii* from the same localities showed 30 vertebræ and the same fin formula as above. The only other

PLATE III.



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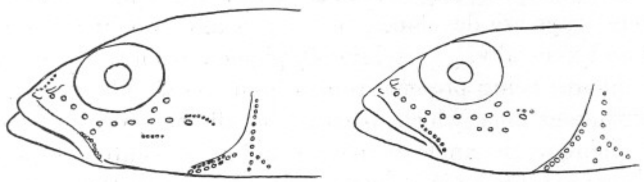
species of *Gobius* that has typically 30 vertebræ and the same fin formula is *Gobius pictus*, the young of which although found sometimes as far out as *G. Jeffreysii* occurs more commonly much nearer the shore, and can easily be distinguished from it by its different pigmentation, shorter fin rays and by its remaining in the post-larval condition until it reaches a much greater length.

The arrangement of the sensory papillæ in the adult *Gobius Jeffreysii* was examined, although as the specimens were not in good condition the examination was necessarily incomplete. Enough was seen, however, to show that it approximates in arrangement to *Gobius affinis* (Sanzo, 1910. T. 9, Fig. 9), Fig. 3.



A B

Fig. 3.—Diagram showing arrangement of the sensory papillæ on the head of *Gobius Jeffreysii*. A. adult, B. young form.

In the young above mentioned, the larger specimens measuring 15 to 17 mm. had an arrangement of the sensory papillæ which showed the same type as that of *Jeffreysii* although not quite the same as the adult. A specimen of 17 mm. had large scales beginning to be formed from the region behind the pectoral fin along the body. It seems therefore that one is safe in attributing this post-larval form to *Gobius Jeffreysii*. It always occurs fairly far out, and in the present material has not been taken at a less depth than 20 fathoms. It is generally accompanied by the young of *Gobius elongatus*, which with occasional specimens of *Gobius niger* is the only other *Gobius* commonly found in such deep water.

Explanation of Plate III. (Pectoral fins omitted.)

Fig. 1.—*Gobius Jeffreysii*, length ca. 7 mm. From Young Fish Trawl, north of Eddystone, June 25, '14.

Fig. 2.—*Gobius Jeffreysii*, length 12 mm. From Young Fish Trawl, N.E. Prawle Point, July 2, '14.

Figs. 3–12.—Eggs and newly hatched young of *Gobius Ruthensparri* laid and hatched in the Laboratory, drawn every day from July 30th (probably the second day) to August 7th, the day of hatching. Fig. 3, egg 0·70 mm. long. Others the same scale. Fig. 12, 2·6 mm. long.

Fig. 13.—*Gobius Ruthensparri*, 3·1 mm. long, hatched in a tank in the Laboratory, probably 4 or 5 days old.

Fig. 14.—*Gobius Ruthensparri*, length 11 mm. From near Panther Buoy, Plymouth Sound, July 5, '18.

Fig. 15.—*Aphya pellucida*, length 11 mm. Young Fish Trawl off Bell Buoy, Looe, August 13, '13.

Fig. 16.—*Crystallogobius Nilssoni*, length ca. 8 mm. Young Fish Trawl, 4 miles beyond Rame Head, August 12, '14.

These young forms are common in the collections from the Young Fish Trawl and are the most striking of all the post-larval gobies, pigment at a very early stage being well developed and the fin rays very conspicuous. The most usual size is from 12 to 14 mm., and in these the eyes already almost meet on the top of the head. They are easily recognised from the other post-larval gobies by the position of the eyes (*Gobius niger* being the only species having them on the top so early) and three pigment spots, one behind the 6th ray of the first dorsal fin and spreading on to it, and two behind the second dorsal. The thick build, large eye and long fin rays are also characteristic.

The smallest specimens measure 7 mm. and are from beyond the Eddystone, the depth being over 30 fathoms. These still retain the larval fin although rays are developed in the tail and are beginning to form dorsally and ventrally. Vertebræ 30, pigmentation very characteristic, chromatophores being present from behind the air bladder to the anus in a continuous line which persists in all the stages. There is a chromatophore at the angle of the jaw and a large chromatophore under the auditory capsule as it is in *microps*. From the throat to the anus is an uninterrupted series of chromatophores which also run from the anus to near the end of the tail. Dorsally there are three or four chromatophores opposite the ventral tail row and behind the developing second dorsal fin. In the region of the vertebræ are groups of small chromatophores. The eyes at this stage are not very large, about 0·48 mm. across. The pectoral and pelvic fins are very feebly developed, the pelvics reaching to about the middle of the air bladder which is heavily pigmented. At 10 mm. the fins are well developed and the characteristic post-larval pigmentation is present. At 12 mm. the form is peculiarly thick and heavy, eye large, 1 mm. across, fin rays long, the rays of the first dorsal reaching nearly to the beginning of the second dorsal, pectorals and pelvics well developed, the pelvics extending behind the anus, head heavily pigmented in front of and below the eye and in the auditory region, air bladder very far forward beginning near the second vertebra, three chromatophores dorsally, the first below and upon the 6th ray of the first dorsal fin, the other two large and ramified behind the second dorsal corresponding to the two largest ventral chromatophores, vertebral pigment in four patches along the body.

At 15 to 17 mm. there are four dark patches externally corresponding to the vertebral pigment and showing up conspicuously as intense brownish black spots. The rest of the pigment is much the same, but scales are beginning to form in the largest specimen (17 mm.), which are large and the sensory papillæ approximate in arrangement to the adult *Gobius Jeffreysii*.

GOBIUS RUTHENSPARRI Euphras.

Plate III, Figs. 3–14.

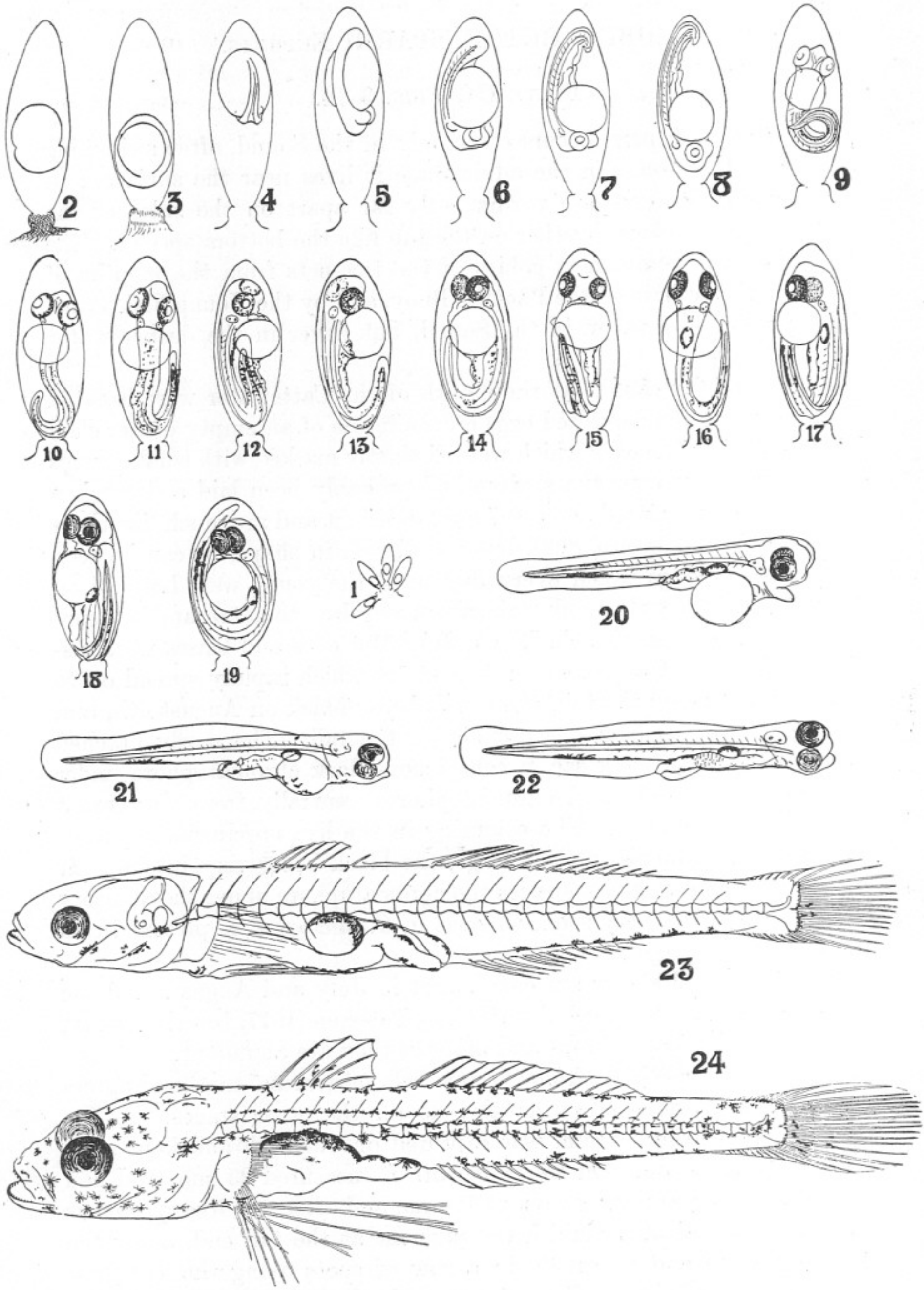
Gobius Ruthensparri occurs commonly in the Sound, often swimming among the Zostera. In the adult stage it lives near the surface, and consequently its eyes are permanently far apart on the sides of the head instead of close together on the top like the bottom species. The young are the commonest gobies in the tow-nets from the mouths of the estuaries to beyond the Panther Buoy, and by the Young Fish Trawl it was sometimes taken in the Sound, but never in the deeper water outside.

Several adults caught at the mouth of the Cattewater were isolated in a tank and one deposited eggs on the inside of an empty oyster shell on July 30th. The eggs which were distinctly marked with small groups of fine striations over the surface had probably been laid a day when found. They measured about 0·7 mm. in height and are much like those described by Petersen (1892), but vary much in shape, as can be seen from the drawings taken every day until the young were hatched on August 7th. They thus only take about ten days to hatch and measure 2·6 mm. when newly hatched. On July 31st eyes and lenses were distinct and pigment appeared on August 1st which rapidly spread on to the eyes and along the tail, the pupils being black on August 4th, and the pigment concentrated especially on the tail. The newly hatched young has a large yolk sac, a conspicuous dark chromatophore under the auditory capsule and chromatophores ventrally from the throat to the end of the tail. The colouring in the live specimens is yellow and black with no red at this stage, the black being very intense. It is to be noted that in this species the chromatophore under the auditory capsule disappears very soon, whereas in *G. microps* it is present in all the post-larval stages.

The post-larval stages are commonest in July and August. All the young stages have been well described by Petersen (1917) from Denmark, where with *G. niger*, *microps* and *minutus* they are abundant.

The smallest specimen from the tow-nets measures 5 mm. and agrees with Petersen's description, as also do all the other stages. A live specimen measuring 10 mm. was captured on July 7th and kept alive in a small aquarium. On December 5th it measured 25 mm. and had all the adult characters. At about 10 mm. and after, the live specimens have a good deal of a pinkish red pigment at the tail end, along the ventral surface and internally in a row of spots along the vertebral column. There is also yellow pigment mixed with the black. Up to about 10 mm. there is little pigment, the continuous row of black

PLATE IV.



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chromatophores from anus to tail being characteristic, and these are very seldom ramified. At about 8 or 9 mm. a large chromatophore appears in the auditory region, and there is pigment at the angle of the jaw and on the throat, but not along the ventral surface of the alimentary canal. Behind and above the anus there is the usual large chromatophore which is absent only in *Gobius elongatus* amongst all the young gobies here described. The pelvic fin has not appeared at 9 mm., and at 11 mm. it does not reach as far as the front of the air bladder. At 11 mm. all the rays of the first dorsal fin are present having the arrangement shown in Fig. 2B. The fin formula is D VII 11, A 11, the number of vertebræ is 32 in all those counted (over 30). The eye is large, 0·76 mm. across in a specimen 11 mm. long. It is thus larger than *G. elongatus* and nearly the same size as *G. pictus*. After 10 mm. the black pigment (the red only showing in live specimens) is present in a continuous series of spots in the region of the vertebral column, and after 12 mm. there is much more pigment altogether, the body having a speckled appearance and the paired fins rapidly developing.

The only species which also has 32 vertebræ is *Gobius elongatus*, but the habitat being quite different they are not likely to be confused. Distinguishing characters are the continuous ventral series of chromatophores ventrally (discontinuous in *elongatus*), and the 7 rays in the first dorsal fin (very rarely 7 in *G. elongatus*), also the larger eye and chromatophore above and behind the anus in *G. Ruthensparri*.

GOBIUS PAGANELLUS L.

Plate IV, Figs. 1–23.

Gobius paganellus is the common goby of the shore round Plymouth, and is to be found under stones at low water at spring tides all round the coast from near the dockyard opposite the Hamoaze and in Batten Bay to the more open bays of Bigbury and Cawsand ; also on Drake's Island in the Sound. From early spring to late summer the males may

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Explanation of Plate IV. (Pectoral fins omitted except in Fig. 24.)
Gobius paganellus and *Gobius niger*.

Fig. 1.—*Gobius paganellus*, part of a layer of eggs laid on the under surface of a stone in a tank in the Laboratory. Eggs 2·6 mm. long.

Figs. 2–19.—*Gobius paganellus*, eggs from same specimen as above drawn every day (all on the same scale) from the day of laying, March 28th, until the day of hatching, April 14th. 1st egg 2·6 mm. long.

Fig. 20.—*Gobius paganellus*, newly hatched, April 14th, length 4 mm.

Fig. 21.—*Gobius paganellus*, hatched in small aquarium, 4·5 mm. long.

Fig. 22.—*Gobius paganellus*, hatched in small aquarium, length 4·8 mm.

Fig. 23.—*Gobius paganellus*, length 11·5 mm. From the Sound inside the Breakwater, August 13, '17.

Fig. 24.—*Gobius niger*, length 12 mm. Young Fish Trawl off Looe, August 13, '13.

be seen guarding their eggs, which are attached to the under surface of stones in large masses, and the fish lay their eggs every year in a Laboratory tank. Some of these fish from Batten Bay were isolated in a tank in April, 1918, and several lots of eggs were obtained. The eggs on the stones were then put into small aërated aquaria standing in running water, and hatched out. In this way a drawing was made every day from the time of laying to the time of hatching.

The post-larval forms are caught occasionally in the tow-nets both inside and outside the Breakwater, and also further out in the Young Fish Trawl in 1913 and 1914. The eggs and newly hatched young are conspicuously larger than those of *Gobius niger*, which they closely resemble, and the bottom stage is not reached until a much greater length. The pigmentation in *G. paganellus* is not nearly so abundant as it is in *G. niger*.

Hefford (1910) describes the ova and newly hatched young and figures the latter; the specimen figured by him having the chromatophores much retracted. This measures 4·8 mm. Those hatched in my small aquaria were 4 mm. long and differ from Hefford's description and figure by having the ventral chromatophores behind the anus concentrated into one large mass which ramifies so that it nearly meets the dorsal chromatophore just above it, also in having a large yolk sac present. It is possible that these specimens were prematurely hatched as several died in the egg capsules, and the whole appearance was somewhat unhealthy. Older specimens measuring 4·8 mm. almost exactly resemble Hefford's drawing, having the chromatophores separate and the yolk sac absorbed. These were 30 days old from the time of laying, and had been swimming about for some days.

The eggs are long and narrow with the apex ending in a rounded point, thus differing from the egg of *G. niger*, which is bluntly rounded at the apex. The usual size of the egg is about 2·5 mm. long, but it varies a good deal in length and breadth. The same day that the egg is laid the blastoderm is nearly as large as the yolk and has become a mass of small cells. The next day it has spread round still more, the third day shows the embryo folded off and the neural groove conspicuous; on the fourth day the eyes appear, and on the fifth day eyes, ears, notochord and myotomes are all present. Up to the seventh day the head is nearly always below, but after this the embryo turns round and the head is uppermost. Heart and alimentary canal have now formed, and a little black pigment on the tail and at the eye margin. After this the young fish is very active in the egg capsule, pigment increases and on the 15th day has spread round the eye, but leaving the pupil still uncoloured; the air bladder is now pigmented and yellow pigment as well as black is present. On the 17th day the pupil is black, the tail pigment concentrated into two large ventral and dorsal patches, and the corpuscles of the blood are red. At this stage the young fish hatched on the 19th day, measuring 4 mm. It still possessed a large yolk sac, but its mouth was open. The yolk sac completely disappeared on the 30th day when the fish measured 4·8 mm. At 4 mm. when just hatched it closely resembles the newly hatched *Gobius niger* as described and illustrated by Petersen (1917), but is much larger, *G. niger* measuring only 2·5 mm. It has a dorsal chromatophore on the tail when newly hatched, which in *G. niger* does not develop until the yolk sac has disappeared, and it measures 4·5 mm. *Gobius paganellus* at 4·5 mm. still has a large yolk sac, and in this way can be distinguished from *G. niger* of the same size. Throughout its post-larval life we find *G. niger* always more advanced than *paganellus* of the same size, and in the later stages possessing more pigment especially on the head.

Petersen describes *G. niger* as having only black pigment and a pale yellow tinge diffused over the whole of the body even at a length of 9 mm., whereas there is a good deal of yellow pigment mixed with the black in *G. paganellus* even before hatching. The yellow is pale and there is no trace of an orange tinge.

The young of *Gobius paganellus* reared from the egg died before any metamorphosis took place. Young stages from 7 to 12 mm. occurred in the tow-nets and occasionally in the Young Fish Trawl, the most usual size being about 10 to 12 mm. These were caught in the Sound both from inside and outside the Breakwater, and in the Young Fish Trawl from Cawsand Bay and Whitsand Bay in 1914, and from Whitsand Bay, Bigbury Bay, New Grounds, Jennycliff Bay and Cawsand Bay in 1913.

In live specimens of 11 mm. the body is very transparent with little pigment. The head is spread over with diffuse yellow, and there is a yellow spot dorsally where in the very young it is black. At the base of the anal and caudal fins the black chromatophores are accompanied by reddish and yellow pigment. In specimens of 7 mm. the black dorsal chromatophore on the tail has disappeared or there is only the merest trace of it, and there is still no black pigment on the head. There are 28 vertebræ, rarely 29, 28 being typical also for *G. niger*. Fin rays, D VI 15 (rarely 14), A 12–13 (rarely 11).

At 7 mm. the ventral chromatophores between the anus and tail are in a row, leaving a short space at about the level of the 10th vertebra from the end, the space not always being apparent owing to ramifications of the chromatophores which, however, are always slight. The fin rays of the second dorsal and anal are fully formed, but there is no trace of the first dorsal nor of the pelvics. The pectorals are mere flaps. The eye at this stage measures 0·32 mm. across. There is a row of chromatophores from the throat to the anus, a large chromatophore above and behind the anus and dark pigment on the air bladder, which in live specimens is mixed with yellow. Very soon after this a dark star-like chromatophore appears in the auditory region, but it sometimes is not present until 11 mm. In front of and below this there is sometimes another chromatophore, and there may be a small one above, but except for these there is no more head pigment, at least up to 12 mm., and at that size the pelvic fins do not reach to the end of the air bladder and the whole fish is still completely in the post-larval condition, and unlike the typical *G. niger*, which at the same length is almost like the adult. At 11 mm. the pelvic fins reach to about the middle of the air bladder, and the pectorals reach not quite to the beginning of it. The air bladder itself is situated well in front of the middle line between the front of the head and the beginning of the tail fin. The eye measures 0·54 mm. across. The first dorsal fin is well developed with all its rays present.

The more open water form of *Gobius niger*, the young of which occurs sometimes in the Young Fish Trawl, is more like *G. paganellus* than the typical form, as it is larger and does not undergo metamorphosis at so small a size. It can, however, be distinguished from *paganellus* by the black pigment on the dorsal surface of the tail and by the possession of more head pigment, although not so much as in the typical *niger*. *Gobius paganellus* can be distinguished from *Aphya* of the same size by the general shape, pigment, number of vertebræ and more developed condition of the fins, also by the position of the air bladder much further in front of the anus. It is, however, the species that comes nearest to *Aphya* of all the gobies.

GOBIUS NIGER L.

PLATE IV, FIG. 24.

Gobius niger is found in the neighbourhood of Plymouth in the estuaries and along the coast, sometimes with *Gobius paganellus*, but usually on more muddy ground with fewer stones. The post-larval forms of about 10 mm. are occasionally caught with the tow-nets in the Sound and also in the Young Fish Trawl from more open water. Petersen (1917) describes this species from the newly hatched young to the bottom stage, and finds that the small bottom stages are found in the more open parts of the fiords, although the eggs are laid near the shore in the same places as those of *G. minutus* and *G. Ruthensparri*. Ehrenbaum and Strodtmann (1904) found young gobies, which they attribute to *G. niger*, in the Western Baltic and, less abundantly, east of Bornholm. It is evident that *G. niger* occurs in the more open water as well as in the estuaries. In the Young Fish Trawl material in 1913 were a few specimens, all from open water with a depth of from 29 to 32 fathoms, which are very like *G. niger*, but remain longer in the post-larval stage than the inshore forms and are less pigmented. These agree exactly with the figure of *Gobius niger* from the Baltic given by Ehrenbaum and Strodtmann. The specimens from nearer inshore, on the other hand, are just like Petersen's, having very nearly attained the adult form at about 12 mm., and the younger stages having more head pigment. Fage (1915) has shown that there is an inshore form and a more open water form of *Gobius niger*, the latter being the *Gobius jozo* L. of the Mediterranean. It seems probable that in this region we also have the two forms, one from more open water, which is the same as *G. jozo*, and is the species called *niger* by Ehrenbaum and Strodtmann, and one from nearer inshore, the *Gobius niger* proper, which is the same as Petersen's Scandinavian species. The young *Gobius niger* are well described and figured by Petersen, our own specimens from shallower water agreeing with his description. There are 28 vertebræ, fin rays, D VI 12–13, A 11–12. Before the bottom stage is reached the young under 10 mm. has a black pigment spot on the dorsal surface of the tail, sometimes two, and the head has several dark chromatophores both dorsally and in the region of the otoliths. At 12 mm. shape, fins and colouring are much more like the adult.

The specimens from deeper water from beyond Rame Head and the Eddystone have the same number of vertebræ and fin rays, but at 15 mm. they still have the post-larval pelagic form, and there are not so many chromatophores on the head as in *niger* proper. These agree very well with Ehrenbaum's figure (1904, p. 108) from the Baltic, and it seems likely that they are both the *Gobius jozo* which Fage regards as a form of *G. niger*.

Gobius niger in the young stages can be distinguished from *G. paganellus* by the fewer fin rays, and by the black pigment on the dorsal surface of the tail; also by the greater number of chromatophores in the head region, especially in the inshore form, and this form also differs in always being more advanced in specimens of the same length, consequently reaching the bottom stage at a much smaller size.

APHYA PELLUCIDA (NARDO).

PLATE III, FIG. 15.

Aphya is abundant round about Plymouth, but not many post-larval stages have been obtained. These were in Clark's material from the Young Fish Trawl in 1913, from the end of July to the beginning of

September, most of the specimens occurring in August. They were most abundant in the surface hauls between 10 and 20 fathoms, but some were from beyond Rame Head and the Eddystone, where the depth was 25 to 30 fathoms. The largest haul (21 specimens) came from a surface haul off the Bell Buoy, Looe, at midnight, the depth over 10 fathoms. These measured from 12 to 16 mm. in length.

The post-larval stages of *Aphya* can be distinguished from those of *Gobius* by their extremely narrow bodies, which give the fish an appearance of great length, and the very undeveloped state of the paired fins, which are not fully formed even at 20 mm. The air bladder is very near the anus, which makes it appear further back than it really is, but it is actually situated further back than it is in most of the *Gobius* species. The anal fin has more rays (1 or 2) than the second dorsal, whereas in *Gobius* they are usually either equal or there are more in the dorsal. There are 27 vertebræ, which is less than in any British *Gobius* except *Gobius scorpioides*, which is now usually regarded as belonging to another genus *Lebetus*. Even in the adult the body is so transparent that the vertebræ can be seen through its walls and there is very little pigment. Several of the post-larval *Gobius* species, however, possess very little pigment, *G. elongatus* and *G. minutus* at 10 mm. and up to about 14 mm. having no head pigment, except a chromatophore in the region of the ear (which may be absent in *elongatus*), and a minute black mark at the angle of the lower jaw. These are both lacking in *Aphya* which has no head pigment in front of the throat. It is, however, to *Gobius paganellus* that it bears more close resemblance, for this goby has also very little pigment and only 28 or 29 vertebræ, but there are a few chromatophores on its head, which distinguish it in pigmentation from *Aphya*, and the broader body and well-developed fins would leave no doubt about the species.

The smallest specimen of *Aphya* seen measures 7 mm., from Looe near the Bell Buoy. The greatest breadth, in the region of the air bladder, is 1·2 mm., diameter of eye 0·36 mm. The end of the air bladder is almost exactly half-way between the front of the head and the end of the body before the caudal fin. No pelvic fins developed, pectorals only minute flaps. Specimens of 8 mm. are much the same, some of them having chromatophores ventrally in front of the anus and one above it. The chromatophore above the anus is present in nearly all from this size upwards, but the ventral chromatophores in front of the anus are only present in a few specimens except at the throat. A very fine membraneous larval fin is present in those up to about 20 mm. from the throat to the anus. The alimentary canal is nearly straight and the air bladder is near the anus, nearer than in any of the *Gobius* species. The ventral row of unramified chromatophores behind the anus runs nearly to the end of the tail and has a slight tendency to interruption at the level of about the 9th vertebra from the end. In some this is hardly perceptible. On the lower half of the tail fin are a few black streaks. There are 27 vertebræ in all examined, fin rays, 13 in the second dorsal, rarely 12, 14 in the anal. Fage (1918) gives an equal number of rays in second dorsal and anal fins. The first dorsal, which in the adult consists of 5 rays, is only developed after it reaches a length of 16 mm., and is therefore not shown in the figure which represents a specimen 11 mm. long. Even up to 20 mm. the first dorsal is not completely formed. The pectorals at this stage are short flaps without rays. The pelvics have not yet appeared.

The older specimens are much the same with the exception of the development of the paired fins and first dorsal. As the length increases the air bladder, which is still very near the anus, is rather nearer the front than it is in the very young stages, so that it is slightly in advance of the point half-way between the head and tail (exclusive of the tail fin), the tail growing faster than the fore part of the body. At 20 mm. the rays of the pectoral fins and first dorsal fin have appeared and the pelvic fins are beginning, although still very short. The 5 rays of the first dorsal are set at the same distance apart, the last not being further away than the others, as is the case in *Gobius*.

It is thus seen that there is very little difference between post-larval and adult *Aphya*, the pigmentation being practically the same. The only important difference is in the growth of the fins. Post-larval stages of several species of *Gobius* resemble it, for these post-larvæ are pelagic and live part of their life near the surface of the sea, as *Aphya* does for the whole of its life. Thus we have a clear transparent body, usually with little pigment and eyes far apart on the sides of the head. *Aphya* remains so, but most of the *Gobius* species change their mode of life at a certain time and descend to live at the bottom. Their eyes are then on the dorsal surface instead of at the sides, and the varied pigmentation approximates to the colour of the sandy or muddy bottom. *Aphya* is a goby that has remained in the post-larval stage until maturity, and as far as we know it is an annual vertebrate and dies after reproduction.

Collett (1878) describes the young of *Aphya* in a general way, the description in every particular agreeing with our material. Ehrenbaum (1905) in describing the young from Scandinavia states that they occur in August, thus agreeing with the present records.

CRYSTALLOGOBIUS NILSSONI v. DUB AND KOR.

PLATE III, FIG. 16.

The young of *Crystallogobius* are common in the Young Fish Trawl in both 1913 and 1914, but chiefly the older stages of over 20 mm. in length. Only one very young specimen was obtained, measuring about 9 mm., which unfortunately was very badly preserved. This came from Rame, E. by N., 4 miles, the depth being 26 fathoms, in August, 1914. All the rest came from fairly deep water, chiefly from beyond Rame and the Eddystone. Clark (1913) found the eggs in June on the Eddystone grounds. The young occurred from May to August.

The young specimen of 9 mm. shows at once the distinctive characters of *Crystallogobius*, the long second dorsal and anal fins being clearly defined. From these fins alone we can distinguish it from *Aphya* and from the various species of *Gobius*. The number of rays in the second dorsal is 19 or 20, in the anal 21. Thus, as in *Aphya pellucida*, we have more rays in the anal than in the second dorsal. The pelvic fins have not appeared and the pectorals are mere flaps without rays. The first dorsal, which is only present in the male and then has only two rays, is not developed for a long time. In the present specimen there is no pigment at all except in the eye and air bladder, but we cannot be sure that this is typical as this is the only small specimen found. In rather older examples pigment similar to the adult is present. At 20 mm. the pelvics in the male have just begun to develop, and the pectorals are smaller than they are in *Aphya* of the same size, but no pelvics show in the females even at 25 mm., when ovaries are well advanced. Only after 30 mm. are the pelvics developed in the female and are then hardly distinguishable. There are 30 vertebræ in *Crystallogobius*, but it is so clearly distinguished from *Gobius* by other features that there is no fear of confusion with *G. pictus* and *G. Jeffreysii*, which also possess 30 vertebræ.

Collett (1878) describes briefly the young of *Crystallogobius*, and Fage (1918) found post-larval forms from the coasts of Brittany of 14 mm. In these the pigment was present along the base of the anal fin, and the characteristic ventral line of pigment from the throat to the anus was present, a large chromatophore at the posterior end of the air bladder and a touch of pigment on the caudal fin. In these he describes the ovary as easily recognisable.

A key to the species of young *Gobius*, *Aphya* and *Crystallogobius* as above described is here given, based principally on the typical number of vertebræ and fin rays. When these vary a footnote is given showing the variations.

A KEY TO THE SPECIES OF YOUNG *GOBIUS*, *APHYA* AND *CRYSTALLOGOBIUS* BASED ON THE NUMBER OF VERTEBRÆ AND FIN RAYS AS TYPICALLY PRESENT.

I. 33 Vertebræ, fin rays D VI 11–12, A 11–12. *Gobius minutus.**

II. 32 Vertebræ.
- A. Fin rays D VI 9–10, A 9–10. *Gobius elongatus.*†
- B. Fin rays D VII 11, A 11. *Gobius Ruthensparri.*

III. 31 Vertebræ, fin rays D VI 9–10, A 9–10. *Gobius microps.*‡

IV. 30 Vertebræ.
- A. Fin rays D VI 9–10, A 9–10.
  - a. Spot at base of last ray of 1st dorsal fin. *Gobius Jeffreysii.*
  - b. No spot at base of last ray of 1st dorsal fin (up to 14 mm.) *Gobius pictus.*§
- B. Fin rays D II (in male only) 20, A 21. *Crystallogobius Nilssoni.*

V. 28 Vertebræ.
- A. No dorsal pigment on tail, fin rays D VI 14–15, A 12–13. *Gobius paganellus.*§
- B. Dorsal pigment on tail, fin rays D VI 12–13, A 11–12. *Gobius niger.*§

VI. 27 Vertebræ, fin rays D V 12–13, A 14. *Aphya pellucida.*

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* Rarely 34 vertebræ, very rarely 32.
† Rarely 30 to 33, 1st dorsal rarely VII, second dorsal and anal rarely 11.
‡ Rarely 30 vertebræ. § Rarely 29 vertebræ.

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The Development of the Species of Upogebia from Plymouth Sound.

By

Gladys E. Webb.

Temporary Assistant Naturalist at the Marine Biological Laboratory, Plymouth.

With Plates I–XII.

Upogebia deltura Leach and *Upogebia stellata* (Mont.) are both of common occurrence on the coasts of Devonshire and Cornwall, but in the adult stage they are not easily obtained, owing to their burrowing habits.

The larvæ, however, are very common in the tow-nets, occurring throughout the year with the exception of the midwinter months, and are particularly plentiful from June to August.

The two species are closely allied, and for some time it was believed that the differences between them might be merely sexual, and not specific (Bell 1853). They are now clearly recognised as separate and distinct species, and De Morgan (1910) has obtained males and females of both forms.

Upogebia deltura Leach may be distinguished by its greater size, sometimes five or six inches in length when full-grown, as well as by its broad abdomen with soft abdominal pleura. The two joints of the chela on the first thoracic leg are almost equal in length.

Upogebia stellata (Mont.) is an altogether smaller and more slender animal, seldom exceeding two and a half inches in length. The abdomen is narrower, and the fixed finger of the chela very much shorter than the dactylus. There is also a small point on the side of the carapace, just over the base of the second antenna, which has been established as a specific character by De Morgan (1910).

In the living state the body of the animal is covered with orange-red spots (hence its name *stellata*), while *Upogebia deltura* Leach is of a uniform dirty cream colour.

They live in long burrows beneath the mud, *U. stellata* being the more common in this district, and a day's digging in the mud flats uncovered by low tides at Salcombe may yield about a dozen specimens of both species.

The four larval stages and two or three early post-larval stages of both species are here described and figured. A careful table of comparison has been drawn up between the two British species and the Norwegian form whose development has been recorded by Sars (1884).

Several features of special interest in the development have been noted as possibly indicating that sex differentiation commences at a very early period—perhaps right from the beginning of the larval development—and that the two sexes differ in the number of moults they undergo during the larval life.

I am indebted to Dr. M. V. Lebour for looking after the experiments during my absence in July, and to Mr. De Morgan for the loan of some preserved specimens of the first larval stage of *Upogebia stellata* which he hatched last year from a berried female, in the Laboratory.

My thanks are also due to Dr. Calman for his kindness and courtesy in allowing me to examine numerous specimens from the British Museum collections.

METHODS.

The larvæ were taken from the tow-nets and the various stages placed in separate jars filled with sea-water from beyond the Breakwater. To prevent confusion, the different jars were labelled by means of small pieces of porcelain numbered and sunk in each jar ; they were stood in one of the tanks in the Laboratory and kept aerated by means of porous air-nozzles.

The larvæ were taken out every day and examined in a watch-glass under the microscope ; moults, if any, were removed, and the water partly renewed.

A careful record of the various stages and their moultings was kept. In this way the consecutive stages were plainly determined.

When they reached the first post-larval stage, they were removed from the jars and placed in shallow glass dishes filled with sea-water, with a little sand and vegetable débris from one of the tanks at the bottom.

Specimens were generally preserved in 5% formalin and then transferred to 70% alcohol. Moults were placed directly in 70% alcohol.

Dissections from which drawings were made were mounted either in water or, if a permanent preparation was desired, in glycerine jelly. Those parts not surrounded by a chitinous skeleton (e.g. the developing endopodites of the thoracic limbs) were always mounted in water, as they were found to shrink in a glycerine mount.

Drawings were made to scale on squared paper by the use of a squared eye-piece fitted into the microscope.

NOMENCLATURE.

Although several members of the genus Upogebia have been known for over a century, yet considerable confusion appears still to exist as to the correct application of the specific names *stellata*, *deltura*, and *littoralis*.

The species *Upogebia stellata* was first described by Montagu from the south coast of Devonshire in 1805, under the name of *Cancer Astacus stellatus*.

In 1813 Leach removed it from this position in the Crustacea, and re-named it *Upogebia stellata*, its correct name being now *Upogebia stellata* (Mont.).

In a paper read before the Linnean Society in 1814, and published in the following year (1815) Leach altered his own generic name from Upogebia to Gebia. The former name, however, has the precedence, and must therefore be considered correct.

The second species was first described by Leach in the same paper under the name of *Gebia deltaura*, presumably in reference to the deltoid shape of the inner uropod.

In the Malacostraca Podophthalmata Britanniæ (1815–17), however, he refers to it under the title of *Gebia deltura*. Thus the specific name of *deltaura* actually has the precedence over *deltura*, but as it was corrected by Leach himself, and as the animal is commonly known and referred to as *deltura*, it is here called *Upogebia deltura* Leach, in deference to an established name.

The name *Gebiopsis* was first used by A. Milne Edwards in 1868, and in 1903 Borradaile suggested the subdivision of the genus Upogebia into two sub-genera—Gebiopsis and Upogebia ; thus the nomenclature of the British species would be

Upogebia (*Gebiopsis*) *deltura* Leach
and *Upogebia* (*Upogebia*) *stellata* (Mont.).

This subdivision has not been followed in this paper, as the characters on which it is based are inconspicuous, and considered of insufficient importance to warrant the establishment of a separate sub-genus.

The third specific name, *littoralis*, was first applied by Risso in 1816 to a specimen from the neighbourhood of Nice, which he called *Thalassina littoralis*.

In 1825 it was brought into the genus Gebia by Desmarest, and it has been fairly fully described by Heller in 1863, in his " Crustaceen des südlichen Europa."

Its larval stages have been described by Cano, from the Mediterranean, in 1891.

The descriptions of this Mediterranean species all seem to denote an animal very similar to *Upogebia stellata* (Mont.) with the exception of the following points—the colour of the Mediterranean species is a uniform greenish grey, while the English species is well known to be thickly covered with bright orange-red spots.

The base of the first antenna in *Gebia littoralis* (according to Heller) is longer than the two flagella, while in both *Upogebia stellata* and *deltura* it is considerably shorter.

The British Museum collection contains about ten specimens of this genus from the Mediterranean, all of which come from the Market, Malta. These have been examined, and found to be all specimens of *Upogebia deltura* Leach, displaying the long fixed finger of the chela, and the absence of the supra-antennal point which are the characteristics of this species. (See De Morgan 1910.)

G. O. Sars has written an account of the larval development of a species of Gebia, which he calls *Gebia littoralis* Risso (1884). Meinert, in his " Hauch's Togter " (1893), states that he obtained two young specimens, which he identified as the species described by Sars, and calls *Gebia stellata* Mont, believing the two species to be synonymous. In a later paper by Stephensen on the marine decapods of Denmark (1909), this species *Gebia littoralis* of Sars is again given as a synonym of *Gebia stellata* Mont. Stephensen, however, who has evidently examined the two specimens from the Hauch's cruise, notes certain differences in one specimen from the Norwegian species, which indicate that the animal in question was a first post-larval stage of *Upogebia deltura* Leach, Form B, and not *Gebia littoralis* of Sars.

Although both Meinert and Stephensen give *Gebia littoralis* of Sars as a synonym of *Upogebia stellata* (Mont.), yet a comparison of Sars' figure of the first thoracic leg of the animal in the first post-larval stage (Tab. 5, Fig. 13) with that here shown of the same limb in *Upogebia stellata* (Pl. XI, Fig. 3) exhibits a striking difference in general build, and especially in the relative lengths of the dactylus and the fixed finger of the claw.

Other differences occur in the larval stages, noticeably the plumose seta on the second joint of the endopodite of the first maxilliped in stages one and two of *Upogebia stellata*, and the different number of plumose setæ on the exognath of the second maxilla.

Thus it seems certain that *Gebia littoralis* of Sars cannot be identified with *Upogebia stellata* (Mont.) ; yet neither does Sars' account exactly agree with the description here given of the development of *Upogebia deltura* Leach—the greater number of plumose setæ on the exognath of the second maxilla, and of denticles on the fixed finger of the chela in the first post-larval stage of Sars' species being two points of difference.

These facts seem to denote that Sars' description refers to neither of the British species [*Upogebia stellata* (Mont.) and *Upogebia deltura* Leach], but to a different and possibly purely Norwegian form.

Risso's original description of *Thalassina littoralis* (1816) gives insufficient details to enable one to identify it with certainty, but it seems very unlikely that the same species should occur both in Norway and the Mediterranean, and not on the British coasts.

Risso's Var. A., which he notes as "une très belle thalassine d'un rouge carmin plus ou moins foncé avec l'abdomen d'un blanc nacré," may possibly be *Upogebia stellata* (Mont.).

There appear therefore to be four distinct European forms, two of them at least constituting well-defined species.

Form 1. From British Coasts.
Upogebia stellata (Mont.).
Synonyms.
Cancer Astacus stellatus Montagu.
Gebia stellata Leach.

Form 2. From British Coasts and Mediterranean.
Upogebia deltura Leach.
Synonyms.
Gebia deltura Leach.
Gebiopsis deltura Stephensen.

Form 3. From Mediterranean.
Gebia littoralis (Risso).
Synonyms.
Thalassina littoralis Risso.
Gebia littoralis Desmarest.
Gebia litoralis Heller.

Form 4. From Norway.
Gebia littoralis of Sars.

A careful comparison of Norwegian and Mediterranean specimens is necessary before the true value or position of the two latter forms is ascertained.

UPOGEBIA DELTURA Leach.

First Larval Stage (Pl. I, Fig. 1).

The first larval stage which occurs in the tow-nets measures about $2\frac{1}{2}$ mm. in length from the tip of the rostrum to the end of the swimming plate. In general appearance it resembles certain species of Hippolyte, and Dr. M. V. Lebour's reference (1917) to "Macruran larvæ indet. chiefly allied to Hippolyte, common in July and August," probably refers to the early larval stages of this and the allied species *Upogebia stellata* (Mont.)

In colour the larva is almost perfectly transparent, with a few bright red chromatophores on the antennæ and thorax, and one at the base of the swimming plate.

The *carapace* is smooth, rounded behind and at the sides, and produced in front into a moderately acute rostrum, which reaches well beyond the eyes.

The *eyes* are large, of the usual decapod crustacean type, and fixed on short immovable stalks which are united with each other at the base.

The *First Antenna* (Pl. II, Fig. 1) is a simple unjointed process about 0·4 mm. in length, projecting forwards on either side of the median line in front. At its anterior end it bears a few spines and a long ribbon-like æsthotasc, while at a short distance behind the tip, on the inner side, is attached a single plumose seta.

The *Second Antenna* (Pl. II, Fig. 2) consists of an unjointed base, which is continued on the inner side into a process (the flagellum) bearing three plumose setæ at the end, and on the outer side into a flat oval plate (the antennal plate) reaching somewhat beyond the flagellum, and terminating in a small spine. The outer margin of the antennal plate is smooth and somewhat arched, but round the tip and along the inner edge is attached a row of nine long plumose setæ. On the ventral surface of the base, just behind the junction of the antennal plate, is a tooth-like spine.

The *Mandibles* (Pl. II, Fig. 3) are of moderate size, with a strongly chitinised and toothed inner border, and united by the lower lip.

The *First Maxilla* (Pl. II, Fig. 4) is composed of a basal portion, produced on its inner margin into two lobes of sub-equal size, both of which are thickly set with coarsely barbed spines,* and a three-jointed process, or palp, at the tip, also bearing spines though of a rather more slender kind than those on the basal lobes.

The *Second Maxilla* (Pl. II, Fig. 5) is more membranous in character, and bears on the inner surface a maxillary palp in front and four masticatory lobes behind, of which the hindmost is the largest, and all of which (including the palp) are thickly set with coarsely barbed spines. On the anterior part of the outer edge is attached a flattened oval lobe, the exognath, around the margin of which are fixed nine plumose setæ.

The *First Maxilliped* (Pl. II, Fig. 6) consists of a two-jointed base or protopodite, from which spring a five-jointed endopodite and a two-

* The term "*plumose*" is used here to denote those feather-like setæ which are armed with fine regular hairs, while "*barbed*" is used to describe the coarser and more irregular arrangement of hairs on certain spines (e.g. in Pl. II, Fig. 14, the spines along the inner surface of the endopodite are barbed, while the long setæ at the end of the exopodite are plumose).

jointed exopodite, terminating in four long plumose setæ and serving as a swimming paddle. Arranged in pairs along the inner margin of the endopodite and the base, are numerous coarsely barbed spines; one pair on the first basal joint (coxopodite) four pairs on the second joint (basipodite) while all the joints of the endopodite except the third and the last, bear one pair each. The last joint bears two pairs in a cluster at the tip, and the third has only a single short one. On the outer surface of the last joint of the endopodite is attached a short plumose seta.

The *Second Maxilliped* (Pl. II, Fig. 7) closely resembles the first, with a few differences of detail. The endopodite is only four-jointed, and the barbed spines are more sparsely distributed, especially on the basal portion, while the coxopodite is entirely bare of spines.

Behind the second maxilliped, decreasing in size from before backward, appear the rudiments of the remaining thoracic limbs (Pl. XII, Fig. 1) of which the first four pairs are already bifid, and the two last pairs simple and very small.

The *Abdomen* is long, composed of six segments and slightly tapering towards the posterior end. The last abdominal segment is produced into a flattened swimming plate (Pl. II, Fig. 8) of a roughly triangular shape, on the ventral surface of which, covering the opening of the anus, is a single median tooth-like spine.

The hind margin of the swimming plate is indented in the middle line, and on either side of this median " notch " are five long plumose spines arranged at regular intervals, while at the outer corner is a short tooth-like spine.

There is as yet no trace of abdominal limbs.

Second Larval Stage (Pl. I, Fig. 2).

This larva, obtained directly from the moulting of that of the first stage, shows an increase in size, but nevertheless bears a strong resemblance to the previous stage. The most noticeable difference is the increased number of exopodites furnished with terminal swimming setæ.

On examining a considerable number of larvæ of this stage, it was found that instead of being all exactly similar, they fall into two classes, differing in the number of setose exopodites and in the development of the true walking legs (endopodites).

An individual of the first class (Class A) has four pairs of exopodites, furnished with swimming setæ (the three pairs of maxillipeds and the first pair of legs) while that of the second (Class B) has, in addition to these, two terminal setæ on the second pair of legs, making five pairs in all.

Moreover, individuals of Class A occasionally bear an additional seta on the first pair of legs (six setæ instead of five) while this extra seta is almost always present in members of Class B.

Thus the total number of limbs furnished with swimming setæ in the two classes is as follows :—

Class A.

First Maxilliped	has	5	setæ
Second ,,	,,	7	,,
Third ,,	,,	6	,,
First Pair of Legs	,,	5 or 6	,,

Class B.

First Maxilliped	has	5	setæ
Second ,,	,,	7	,,
Third ,,	,,	6	,,
First Pair of Legs	,,	6	,,
Second ,, ,,	,,	2	,,

In correlation with this increased development of the thoracic exopodites, the endopodites in the second class are considerably more advanced both in size and structure, and the abdominal limbs, which in Class A do not project through the cuticle, stand out freely from the four middle abdominal segments in members of this class. (Pl. III, Fig. 11—only three segments shown.)

There is very little difference in size between the two kinds of larvæ, Class B being generally slightly the larger, and apart from the differences here cited they appear to be entirely similar, so that one description serves for both.

The larva at this stage measures just over 3 mm. in length from the tip of the rostrum to the end of the swimming plate. The general shape of the body is little altered from that of the previous stage, save for a slight increase in the relative length of the abdomen, which gives the animal as a whole a more slender appearance.

The *rostrum* reaches well beyond the eyes, almost half-way up the shaft of the first antenna.

The *eyes* are large, and united only by a narrow connection at the base.

The *First Antenna* (Pl. II, Fig. 9) shows a great advance in complexity on that of the previous stage. It now consists of a main stem or shaft, from which two conical processes or palps are cut off at the anterior end ; of these the outer is distinctly the larger, and furnished with a few scattered spines and three long ribbon-like æsthotascs, while the inner one is terminated by a single plumose seta. On the inner border of the shaft are attached two long plumose setæ, and opposite the more anterior of these is a spot from which spring a few weak spines.

The *Second Antenna* (Pl. II, Fig. 10) is not much changed ; but the flagellum is now cut off from the base, and the inner margin of the antennal plate bears eleven plumose setæ. In addition to the spine on the ventral surface of the base, there is another similar spine on the outer border of the base, just below the junction of the antennal plate.

The *Mandible* (Pl. II, Fig. 11) is rather longer than before, and has developed a beak-like prominence on the inner border.

The *First Maxilla* (Pl. II, Fig. 12) is very similar to that of the first stage, though somewhat larger.

The *Second Maxilla* (Pl. II, Fig. 13) has much the same appearance as in the last stage, but the spines are more thickly set, and the exognath bears eleven or twelve setæ, in place of the nine previously present.

The *First Maxilliped* (Pl. II, Fig, 14) has one more plumose seta at the end of the exopodite, making five in all ; otherwise it is unchanged.

The *Second Maxilliped* (Pl. II, Fig. 15) has an increased number of swimming setæ, of which there are now seven on the exopodite.

The remaining limbs differ in their degree of development in the two classes.

The *Third Maxilliped* (Pl. III, Figs. 1, 2) has a two-jointed base, from which spring two processes, the two-jointed exopodite, similar to those of the other two pairs of maxillipeds, and bearing six plumose setæ at the end, and the developing endopodite, which in Class A (Fig. 2) does not quite reach to the end of the basal joint from which it springs, but in Class B (Fig. 1) exceeds it in length. It bears a single plumose seta near the end.

The *First Leg* (Pl. III, Figs. 3, 4) is constructed on a similar plan, but in Class A (Fig. 4) the endopodite reaches to the end of the first joint of the exopodite, while in Class B (Fig. 3) it distinctly exceeds the exopodite in length, and shows near the tip on the inner surface the first signs of the formation of the fixed finger of the chela.

The *Second Leg* (Pl. III, Figs. 5, 6) displays an even more striking difference between the two classes, for in Class A (Fig. 6) it is merely a deeply bifurcated process, unsegmented save for the single division at the base, and bearing no setæ of any kind ; while in Class B (Fig. 5), on the other hand, it is almost as well developed as the third maxilliped, and the endopodite is longer than the exopodite, which bears two plumose setæ of moderate length.

The following three pairs of thoracic limbs, of which the first pair is bifid (Pl. III, Figs. 7, 8) show once more a greater development in Class B (Fig. 7) than in Class A (Fig. 8).

The abdomen is long and tapering towards the posterior end, and, in Class B, each of the four middle segments bears a pair of blunt, forwardly directed outgrowths which are the rudiments of the future pleopods (Pl. III, Fig. 11). In Class A they have not yet pierced the cuticle.

The swimming plate (Pl. III, Figs. 9, 10) in both classes is almost the same shape as in stage one, but on the centre of the hind border, where the median "notch" (in Class A practically effaced, Fig. 9) is situated, there are three very small spines, one median, and one on either side. This brings the total number of spines up to fifteen. Within the cuticle can be seen quite distinctly the developing uropods of the following stage.

Third Larval Stage (Pl. I, Fig. 3).

The two classes of larvæ noted in stage two are still present in stage three, but they are not so readily distinguished from each other, because their chief mark of distinction lies in the degree of development reached by the endopodites of the thoracic limbs; and as these, being only covered by a soft skin and not by a rigid cuticle, grow considerably in size during the progress of the larva from one moult to the next, it is difficult to distinguish with certainty a young third stage larva of Class B from an older one of Class A.

Both classes of larvæ have been obtained directly from the moulting of second stage larvæ during the course of the experiments, but actual proof that a Class A third stage larva always results from the moulting of a Class A second stage larva, and similarly with Class B, has not yet been established owing to the difficulty above mentioned of distinguishing the two classes of third stage larvæ until they are approaching the next moult, when the new appendages may be perceived through the cuticle of the old. This serves as a means of distinction, because at this moult the two kinds of larvæ pursue different courses of development, those belonging to Class A moulting into a fourth larval stage which closely resembles the third, while those of Class B moult directly from the third larval stage into the first post-larval stage, thus missing entirely the fourth larval stage.

That this is actually the case has been proved many times during the rearing of the larvæ in the Laboratory, and numerous moults from both A and B forms have been obtained. Third stage larvæ were isolated in jars of sea-water, and removed daily for examination under the microscope, and when they moulted the skins were taken out and preserved in 70% alcohol.

Between August 9th and October 17th, 1918, the records kept give a total of nine moults from the third to the fourth larval stage, ten from the fourth larval to the first post-larval stage (Class A) and fourteen moults direct from the third larval stage to the first post-larval stage (Class B).

Moreover, in several cases, when the animal was unable to complete the moult, a post-larval stage not yet entirely freed from the third stage larval skin was obtained, a fact which must be considered as proof positive that such a moult actually does take place.

The post-larval forms thus obtained from Class B were in no way deformed or abnormal, nor were they less active and vigorous than those which had passed through four larval stages, although they were slightly smaller, and differed from the others in a few structural details (see descriptions).

The following description applies to both A and B Classes.

The animal in the third larval stage measures about $3\frac{1}{2}$ mm. in length, but a much greater amount of variation is apparent in this than in either of the preceding stages. It shows certain definite signs of progress on the previous stage, notably the presence of six pairs of setose exopodites on the thoracic limbs, and of two pairs of uropods, which stand out on either side of the telson.

The *rostrum* is acute, reaching to about one-third of the length of the first antenna ; the *eyes* are large and completely separated from one another at the base.

The *First Antenna* (Pl. IV, Fig. 1) is much the same shape as in the previous stage, but considerably longer and stouter. There are five plumose setæ (or occasionally four) on the inner border, and three more on the anterior end of the shaft, just over the junction of the palps with the stem, making eight setæ in all. The outer edge has two or sometimes three offsets marked by a cluster of weak spines, and the base exhibits a slight swelling, within which is forming the auditory organ of the adult.

The *Second Antenna* (Pl. IV, Fig. 2) is very similar to that of the preceding stage, but the number of plumose setæ on the antennal plate has increased to thirteen or fourteen, while the flagellum now forms a tapering process almost as long as the plate, and tipped with a single spine.

The *Mandible* and *First Maxilla* (Pl. IV, Figs. 3, 4) have not altered materially in appearance.

The *Second Maxilla* (Pl. IV, Fig. 5) is still the same general shape, but the exognath has developed a posterior lobe, and bears twelve to fifteen plumose setæ.

The three pairs of *Maxillipeds* (Pl. IV, Figs. 6–9) have altered very little, the only differences being the presence of an additional seta on the exopodites of the first and third pair, making the total number on the three pairs respectively six, seven, and seven ; also the appearance of a plumose seta on the outer surface of the second joint of the endopodite in the first Maxilliped.

This seta is of some importance, because it is also present in the first and second larval stages of *Upogebia stellata ;* and thus serves as an easy mark of distinction between the first two larval stages of the two species. The plumose seta tipping the endopodite of the third maxilliped is not always present in this stage (Figs. 8, 9).

The first three pairs of *thoracic legs* (Pl. V, Figs. 1–6) are now provided with setose exopodites, of which the first and third have seven and five setæ respectively, while the second may have either five or six. The development of the endopodites varies according to the class and the age of the larva, but Class A (Figs. 2, 4, 6) never attains such a high degree of development as that reached by members of Class B before moulting (Figs. 1, 3, 5).

All the endopodites except that of the third maxilliped are wholly without spines ; the two last pairs of thoracic legs are uniramous and carried pointing forwards beneath the others (Pl. XII, Fig. 3).

The *Pleopods* vary in length ; in advanced stages of Class B they may extend over two segments. In such cases they exhibit a swelling on the inner side near the base, representing the inner lappet of the pleopod in the future post-larval stage.

The pleopods are carried pointing forwards and are still quite immovable.

The *Uropods* (Pl. IV, Fig. 10) are attached to the last abdominal segment, and are not yet entirely separated from each other, the inner one forming a mere spineless outgrowth of the outer and larger uropod, which is bare of spines on the outer margin, but furnished at the tip and along the inner edge with a row of twelve to fourteen plumose setæ.

The *Telson* (Pl. IV, Fig. 10) is roughly oblong in shape, rather wider towards the distal end, which is weakly concave, and produced at each corner into a strong toothed spine. In the median line is a small tooth-shaped spine, and on either side of this are four medium plumose spines of a similar kind. Outside the corner spines, on the lateral border of the telson, are two, or occasionally three, small spines on either side.

Class A only.

Fourth Larval Stage (Pl. I, Fig. 4).

The fourth and last larval stage may be readily distinguished from the preceding one by the full development of the inner pair of uropods, as also by the increased size of the endopodites of the thoracic limbs (Pl. XII, Fig. 4) and of the abdominal appendages.

The larva is now just over 4 mm. in length and the general body form is unaltered save for a broadening of the fore part of the abdomen.

The *rostrum* and *eyes* are unchanged.

The *First Antenna* (Pl. VI, Fig. 1) has developed another plumose seta on the inner border of the shaft, making nine in all.

The *Second Antenna* (Pl V, Fig. 7) still has fourteen (occasionally fifteen) plumose setæ on the antennal plate, which is now distinctly overtopped by the flagellum.

The *Mandible* (Pl. VI, Fig. 2) is larger, but otherwise unaltered.

The *First and Second Maxillæ* (Pl. V, Figs. 8, 9) present an unchanged appearance, save for the increased development of the exognath on the second maxilla, which now bears about eighteen plumose setæ.

The number of setæ on the six pairs of swimming exopodites has increased to seven on all but the first pair of maxillipeds, which have only six.

The *First and Second Maxillipeds* (Pl. VI, Figs. 3, 4) are otherwise unchanged.

The *Third Maxilliped* (Pl. VI, Fig. 5) generally lacks the plumose seta at the end of the endopodite. The remaining thoracic limbs, of which the first three pairs are furnished with swimming exopodites (Pl. VI, Figs. 6–8) are larger than in the previous stage, but still quite spineless.

The *Pleopods* are still immovable, but have increased slightly in length.

The *Uropods* (Pl. V, Fig. 10) are now mounted on a distinct basal joint ; the inner pair is separated from the outer and attached to the base independently ; it is nearly as long as the outer, and bears at the tip and along the inner margin a row of about thirteen plumose setæ.

The *Telson* (Pl. V, Fig. 10) is considerably longer and narrower than in the preceding stage, but the arrangement of the spines, which are no longer plumose, is similar.

First Post-larval Stage (Pl. X, Fig. 1).

At this stage of its life history the animal undergoes a sudden and very striking change both in appearance and habits. Hitherto it has been a free-swimming pelagic larva, living at or near the surface of the sea, swimming actively by means of its six pairs of well-developed exopodites, and feeding probably on diatoms and other unicellular planktonic organisms.

In its next stage it becomes a typical Decapod crustacean, pale pink in colour and very hairy, with a well-developed flattened abdomen bearing four pairs of swimming pleopods, and with a powerfully chelate first pair of legs and four more posterior pairs, all of which show some adaptation to fossorial habits. The animal instead of swimming near the surface, sinks to the bottom and burrows in the sand or mud.

Class B.

From the tip of the rostrum to the end of the telson it measures about $3\frac{1}{2}$ mm. The carapace is strongly compressed laterally, so that its height considerably exceeds its breadth; and it is produced in front into a short rostrum which terminates behind the level of the end of the eyes in an upwardly directed point (Pl. VII, Fig. 1).

The abdomen is long and flattened dorso-ventrally; it comprises six segments, of which the middle four each bear a pair of very hairy swimming pleopods, and the last bears the two pairs of uropods. The telson is short and broad, and is generally carried flexed beneath the abdomen, by means of a quick straightening and reflexing of which the animal can dart backwards with great rapidity if alarmed.

The *First Antenna* (Pl. VII, Fig. 2) projects in front on either side of the rostrum; it bears a general resemblance to the antennæ of the Brachyura, being very short and more or less bent into a knee-shape. The first joint is swollen at the base, and contains an auditory organ; on the anterior outer corner of this joint is a strong tooth-like spine. The second joint is smaller, and produced at its anterior inner corner into a short process bearing a tuft of spines. The third joint is almost as long as the first, and is bent on the second to form with that joint a rather wide angle. At the tip it bears a short palp tipped with spines, and a three-jointed process, on which are three long ribbon-like æsthotascs and a few scattered spines.

The *Second Antenna* (Pl. VIII, Fig. 3) is long and slender, and projects forwards and outwards beneath the eyes. Each is composed of a stout four-jointed base or shaft, and a long whip-like flagellum, of about sixteen joints. The fourth joint of the shaft bears a crown of spines, and on about every other joint of the shaft is a similar ring of spines. On the outer surface of the second joint of the shaft is a small process which represents the remains of the antennal plate.

The *Eyes* (Pl. VII, Fig. 4), though relatively much smaller than those of the larva, still reach beyond the end of the rostrum, and in most cases they cover the first antenna up to the terminal palps, and the second antenna to beyond the first joint of the flagellum.

The *Mandible* (Pl. VI, Fig. 9) is much the same shape as that of the larva, but it has a mandibular palp on the anterior surface, tipped with a few short spines.

The *First Maxilla* (Pl. VII, Fig. 5) has two masticatory lobes, of which the basal one is much the larger and triangular in shape. It bears a few short spines on its inner edge. The other is somewhat enlarged at the tip, which is beset with a number of similar short spines. The maxillary palp is reduced to a spineless process on the outer side of the smaller masticatory lobe.

The *Second Maxilla* (Pl. VII, Fig. 6) has altered very little in form from that of the larval stages. It still has four masticatory lobes on the inner border, of which the two innermost are very narrow.

The masticatory lobes are, however, much more sparsely set with spines than in the previous stages, the first three lobes bearing only a few short spines, while the last and largest lobe is entirely naked. In front of the masticatory lobes projects inwards a rather slender maxillary palp, with a single plumose seta near the end. The exognath is well developed and bears along its margin about twenty-nine plumose setæ.

The *First Maxilliped* (Pl. VII, Fig. 7) is much reduced in size. The two basal joints are produced inwards to form two masticatory lobes, fairly thickly beset with spines. The palp is reduced to a short spineless process which seems to show some slight signs of division into three parts, and the exognath, which is a little longer than the palp, bears on its outer surface four curved and finely barbed setæ.

The *Second Maxilliped* (Pl. VII, Fig. 8) is slightly larger than the first. It consists of a single basal joint, which bears a five-jointed palp and a simple exognath. The palp, of which the second joint is distinctly the longest, is curved inwards on itself. A few rather short spines are situated on the inner border of the first and second joints, while two very long, curved, and finely barbed setæ are borne on the outer surface of the penultimate joint. The exognath is a slender spineless process, springing from the outer surface of the first joint of the palp, and pointing forwards.

The *Third Maxilliped* (Pl. VII, Fig. 9) is distinctly the longest of the three, and is constructed on a plan similar to the preceding, but may be distinguished from it by the much stronger development of the inner branch or palp. This is composed of five joints, of which the second is the longest, and the two last joints are both fairly thickly set with rather strong ciliated setæ. The exognath is simple and unjointed as in the second maxilliped, and on the outer surface of the basal joint is a pair of gills.

The *First Leg* (Pl. VII, Fig. 10) is the most prominent appendage of the animal at this stage. It is held pointing forwards, and when extended reaches almost half-way up the second antenna. The first three joints, of which the basal bears a pair of gills on its outer surface, are short and almost spineless. The fourth is very long and set with several short stout spines along the inner border, while near the end on the outer surface is a strong thorn-like spine.

The fifth joint is very short, and terminates on both its inner and outer side in a similar thorn. The sixth joint is somewhat flattened in the horizontal plane, and enlarged towards its distal part, where it ends on the outer border in a tooth-like spine ; on the inner edge it is produced forwards into the fixed finger of the chela, and forms a process almost as long as the seventh joint, broad at the base and tapering towards the point, bearing near the base on the inside three strong tooth-like projections or denticles. The whole joint is somewhat sparsely set with rather long spines, except the fixed finger which is bare, and on the inner surface near the base where there are three long barbed setæ.

The last and seventh joint forms the movable finger of the chela (the dactylus) ; it can be bent inwards towards the fixed finger, thus forming a strong and formidable pair of pincers, and is thickly set with rather strong spines.

The *Second Leg* (Pl. VII, Fig. 11) is about equal in length to the first but more slender. The basal joint, which bears a pair of gills, is rather short, as are also the two following joints ; while the fourth is long, and bears near the end of the outer border a short stout spine. On its inner edge near the base, are two exceptionally long, forwardly curved and coarsely barbed setæ. The fifth joint is rather short, and has a thorn on its anterior inner edge, just behind which is inserted a seta similar to those on the preceding joint. The sixth joint is rather longer, and thickly set with strong spines on both borders, while at the base on the inner edge are four long curved setæ like those already described. The last joint is short and tapers to a point, where it terminates in a strong toothed spine. There are several scattered spines on its inner border, while along the outer edge is a dense row of spines, increasing in length from before backwards.

The following three pairs of legs (Pl. VII, Figs. 12–14) are all constructed on a plan similar to that of the limb just described ; they decrease in size from the third to the fifth, and the spines are more sparsely set, but on none of them are there any of the specially long curved setæ such as are present on the second pair. On the outer surface of each leg except the last is a pair of gills.

The *abdomen* is broad and flattened dorso-ventrally ; at the sides the membranous pleura of one segment slightly overlap those of the segment behind. The first three segments are sub-equal in length, the next two somewhat shorter, and the last is the longest of all.

The *Pleopods* (Pl. VIII. Fig. 1) are attached to the under surface of the four middle joints near their posterior border, and in a position of rest they point forwards beneath the abdomen. Each pleopod consists of a basal joint bearing two lobes, a long oval outer lobe, which is slightly bent inwards on the shaft, and a much smaller inner lobe or lappet, which points inwards towards its fellow of the opposite side. The longer lobe is surrounded by about thirty-one strong plumose setæ, and the tip and posterior edge of the inner lappet bears seven similar setæ, as well as one small seta on its anterior border near the base.

The setæ on the inner lappets of the pleopods probably interlock with those of the opposite side, so as to make a more effective swimming paddle, and prevent independent movement.

The *Uropods* and *Telson* (Pl. VIII, Fig. 2) together form the "tail-fan" of the animal. The telson is roughly rectangular in shape, rather longer than it is broad, and set along its posterior edge with plumose setæ.

The *Outer Uropod* is of an ellipsoid form, and is surrounded by a row of plumose setæ, and short scattered spines.

The *Inner Uropod* is a little shorter, and its weakly concave outer margin is bare, while the tip and the curved inner border are set with plumose setæ.

Class B.

Second Post-larval Stage.

After the first post-larval stage, the animal's development seems to pursue one of two alternative courses.

When a period of ten or twelve days has elapsed, it may either moult into a second post-larval form, of which the most distinctive characteristic is the presence of dense combs or fringes of setæ on the mouth parts and the inner borders of the first and second pairs of legs (Pl. IX, Figs. 1, 2); or it may moult into a second post-larval stage which resembles the first post-larval except for an increase in size, and in the number of setæ on certain appendages (e.g. the pleopods and the second maxilla). This unfringed second post-larval then moults into the fringed form, which may thus occur at either the second or third post-larval stage.

First post-larval stages of Class B were isolated in shallow glass dishes containing sea-water and a little fine sand or mud sprinkled on the bottom, and both fringed and unfringed second stages obtained, with the skins from which they moulted. In the case of the unfringed second post-larval forms, attempts to keep them alive until the third stage were not successful, but an examination of their appendages shows the formation beneath the cuticle of the dense rows of setæ characteristic of the animal in its fringed condition (Pl. VIII, Fig. 5).

A possible explanation of these facts is that through weakness due to artificial conditions or lack of proper food, the formation of the long fringes, necessitating the expenditure of a large amount of reserve material, may be postponed until after the second moult.

This supposition receives some support from the fact that all the unfringed second post-larval forms died before moulting into the third or fringed stage.

Class B.

Second Post-larval Stage. Fringed Form.

This stage closely resembles the corresponding stage in Class A, and in the case of certain appendages, that form only has been figured.

It is about 4 mm. in length, showing a definite increase in size on that of the last stage, and is altogether more robust and very much more setose than that form.

The *First Antenna* has much the same structure as before, but has increased in size.

The *Second Antenna* (Pl. VIII, Fig. 3) is slightly longer, the flagellum comprising eighteen joints, in place of the sixteen of the previous stage.

The *Eyes* are relatively smaller and closer together.

The *Mouth parts* are on the whole similar to those of the fringed stage of Class A (see description).

The *First Leg* (Pl. IX, Fig. 1) has two fringes on the inner border of the fourth joint, composed of plumose setæ of different lengths, those of the upper fringe being considerably shorter, and lying rather obliquely across the lower fringe, to form a kind of sieve. There is also a single comb of long plumose setæ on the inner surface of the sixth joint. Both this and the following joint are thickly set with rather strong spines, and the fixed finger bears five denticles on the inside of the chela.

The *Second Leg* (Pl. IX, Fig. 2) also has two fringes on the inner border of the fourth joint, similar to those on the first leg, but the lower and longer fringe is continued in a curve over the fifth joint to its outer border. Along the inner margin of the sixth joint is a dense comb of long plumose setæ, and the outer edge of the last joint is set with a thick row of strong though rather short spines.

The remaining legs are similar to those of the preceding stage, but correspondingly longer.

The *Pleopods* show a distinct advance on the first stage in that the inner lappet is completely surrounded by a ring of about sixteen setæ.

The *Telson* is rather longer, and the uropods, especially the inner pair, considerably wider than before.

Class B.

Second Post-larval Stage. Unfringed Form.

This stage very closely resembles the first post-larval, but the following differences may be noted.

A definite increase in size has taken place, the animal now measuring just over 4 mm. in length.

The *Rostrum* reaches just to the level of the end of the eyes (Pl. VIII, Fig. 4) which are relatively smaller, and cover the second antenna only as far as the third joint of the shaft.

The *Second Antenna* appears to have twenty-six joints, although some of these are not very clearly defined.

The *First Maxilla* (Pl. VIII, Fig. 5) is figured as showing beneath the cuticle of the basal masticatory lobe, the developing spines of the fringed form.

The *Second Maxilla* (Pl. VIII, Fig. 6) has thirty-four spines on the exognath in place of the twenty-nine present in the last stage, and, moreover, this appendage shows a considerable increase in size.

The *First Maxilliped* (Pl. VIII, Fig. 7) has five long curved setæ on the outer surface of the exognath, which is now definitely two-jointed.

The *Legs* (Pl. VIII, Fig. 8) are similar to those of the preceding stage, but larger, and they show no trace of the fringes which are so characteristic a feature of these appendages in the other second post-larval form.

Class A.

First Post-larval Stage.

This stage immediately succeeds the fourth larval stage, and bears a close resemblance to the corresponding first post-larval stage of Class B ; but it displays several minor points of difference which denote that it is at a slightly more advanced degree of development than Class B, a fact which might reasonably be expected from its having an extra larval stage.

The following are the chief differences between this stage and the same of Class B.

The animal measures 3·9 mm., and the rostrum reaches to the level of the end of the eyes.

The *Second Antenna* has twenty-three joints in all, instead of only twenty.

The *Second Maxilla* (Pl. VIII, Fig. 9) has thirty-seven setæ on the exognath, in place of twenty-nine.

The *First Maxilliped* has five curved setæ on the outer surface of the exognath, being one more than in Class B.

The *Second Maxilliped* may have three long curved setæ on the outer surface of the penultimate joint, though this is not quite constant, as only two are sometimes present, as in Class B.

The *First Leg* (Pl. XII, Fig. 7) has a distinctly longer and more slender chela than Class B, and the fixed finger does not reach quite to the end of the dactylus, but springs from the sixth joint a short distance behind the tip.

The *Second Leg* has five long curved setæ on the inner surface of the sixth joint, instead of only four.

The *Pleopods* generally have thirty-two setæ on the outer lobe.

Class A.

Second Post-larval Stage.

This stage is again closely comparable to the similar stage of Class B, i.e. the fringed second post-larval form. The animal measures just over 4 mm. from the tip of the rostrum to the end of the telson, and the rostrum reaches slightly beyond the eyes, which conceal the first three joints of the second antenna.

The *First Antenna* has scarcely altered from that of the previous stage.

The *Second Antenna* comprises twenty-three joints in all, so that no increase in number has taken place.

The *First Maxilla* is similar in shape to that of the preceding stage, but the two masticatory lobes are much more thickly set with spines, particularly the basal lobe, which has a dense row of rather long spines all along its inner border (cf. Pl. IX, Fig. 5). At the base of the outer margin of the second masticatory lobe are attached two long curved setæ. The maxillary palp is still small, but bears a few scattered spines.

The *Second Maxilla* (Pl. IX, Fig. 3), although very like that of the preceding stage in shape, shows a great increase in its armature. The four masticatory lobes on the inner border are all thickly set with spines, and the basal lobe bears a second row, slightly within the edge. In addition, a new lobe or lappet has been developed, slightly in front of the hindmost lobe, and around its margin are seven plumose setæ. The exognath is well-developed, particularly at its lower end, where it terminates in a slight swelling, and the margin is set with about forty-two spines. The maxillary palp shows no difference from the preceding stage.

The *First Maxilliped* (Pl. IX, Fig. 4) has also increased its armature. The basal masticatory lobe bears a number of curved spines, and the second lobe is thickly bordered along its inner margin with similar spines. The palp has a row of about eight finely barbed setæ on its inner edge, and the tip and outer margin of the exognath, now distinctly three-jointed, are set with a number of similar setæ.

The *Second Maxilliped* (Pl. VIII, Fig. 10) resembles that of the preceding stage in shape, but a thick row of spines borders the inner edge of the first two joints of the palp, and the last two joints are also densely set with more scattered spines. The unjointed exognath bears a double row of rather short ciliated setæ.

The *Third Maxilliped* (cf. Pl. IX, Fig. 8) is thickly fringed with finely barbed setæ along the inner border of the palp, with the exception of the short third joint, so that the whole limb looks rather like a brush. All the joints bear scattered spines, and on the exognath are about six long setæ.

The *Walking Legs* are similar to those of the same stage in Class B, the two first pairs bearing the characteristic fringes of setæ, the remainder decreasing in size from before backwards.

The *Pleopods* bear thirty-one to thirty-three setæ on the outer lobe, and sixteen to twenty on the inner.

The *Telson* and *Uropods* have increased in width, particularly the inner pair of uropods.

Class A.

Third Post-larval Stage.

Among the preserved post-larval specimens of Class A, two stages of the fringed form were found to be present, and, although absolute certainty is not possible as the moults were not obtained, it is extremely probable that the more advanced stage is the third post-larval of this class.

The length is nearly $4\frac{1}{2}$ mm., and the rostrum projects slightly beyond the eyes.

The *First Antenna* shows a definite advance, in that the third joint of the shaft is now divided into two, thus forming a four-jointed stem. The smaller of the two terminal processes or palps, also shows signs of division into two joints.

The *Second Antenna* (Pl. XI, Fig. 1) is composed of twenty-eight joints ; the rudiment of the antennal plate on the second joint is scarcely perceptible, while on the opposite side of the same joint is a row of seven long ciliated setæ.

The *Mandible* has increased its armature of spines on the palp, but is otherwise unchanged.

The *First Maxilla* (Pl. IX, Fig. 5) is like that of the previous stage, but even more setose.

The *Second Maxilla* (Pl. IX, Fig. 6) again shows a definite advance on the last stage, both in size and complexity of structure. The masticatory lobes are still thickly bordered with spines, and the new lappet has increased in size and bears about ten setæ, while yet another lobe has arisen on the basal masticatory lobe, surrounded by about eight plumose setæ. The exognath is larger, and much swollen at the lower end, while the marginal setæ, numbering about forty-seven, now spread round the lower end and up the inner edge of the exognath. The maxillary palp bears three setæ, in place of the one hitherto present.

The *First Maxilliped* (Pl. IX, Fig. 7) is also definitely a stage in advance of the previous one. The spines on the larger of the two masticatory lobes are now divided into two longitudinal rows, slightly separated from each other ; the palp is three-jointed, and the number of setæ, both on palp and exognath, has noticeably increased.

The *Second Maxilliped* is similar to that of the last stage (Pl. VIII, Fig. 10), but slightly larger and more setose.

The *Third Maxilliped* (Pl. IX, Fig. 8) is also very similar to that of the second post-larval stage, but the exognath is two-jointed and bears numerous setæ, while a definite row of about five long ciliated setæ occurs on the outer border of the second joint of the palp.

The *Legs* resemble those of the last stage, but the fringes on the first two pairs are slightly longer.

The *Pleopods* bear nineteen to twenty-one setæ on the inner lappet.

The *Uropods* (Pl. IX, Fig. 9), particularly the inner pair, have again increased in breadth.

UPOGEBIA STELLATA (Mont.).

The larvæ of this species are also of common occurrence in the townets, but they are most abundant in the early summer (May and June) ; they fall off considerably in numbers during July, and are rarely found after the middle of August.

This indicates a rather earlier breeding season for the adults than is the case with *Upogebia deltura*, and this supposition gains some slight support from the fact that on an expedition to Salcombe on August 23rd, 1918, over a dozen specimens of the two species were taken, of which only two were *Upogebia deltura*, yet one of these two was a female in berry, and was the only berried female in the whole catch.

The first two post-larval specimens obtained during the experiments appeared from a moult on July 8th, and were both *Upogebia stellata*. Throughout the month of July numerous post-larval *U. stellata* were obtained from moultings. The first post-larval *Upogebia deltura* was obtained on Aug. 6th, and after that only one more post-larval specimen was *U. stellata* (Aug. 15th), the remainder were all *U. deltura*.

Thus the early collections of larvæ, made in May and June, were nearly all *U. stellata*, and similarly the later ones were almost entirely *U. deltura*. This served as a guide in the discrimination of the two species, and confirmation of the result was obtained by comparison with the first stage larvæ of *Upogebia stellata* hatched last year from a berried female in the Laboratory by Mr. De Morgan.

UPOGEBIA STELLATA (Mont.).

First Larval Stage.

The larva in this stage is rather larger and more robust than the corresponding stage of *Upogebia deltura*. The appendages are very similar save for a slight but definite increase in size throughout, but the following constant differences may be noted.

The exognath of the *Second Maxilla* (Pl. X, Fig. 2) bears ten plumose setæ, instead of nine as in *Upogebia deltura*.

The *First Maxilliped* (Pl. X, Fig. 3) has a plumose seta on the outer surface of the second joint of the endopodite, in addition to that on the last joint, which is common to both species.

The coxopodite of the same limb may or may not bear the two coarsely barbed spines which are always present on this joint in *Upogebia deltura* Leach.

Second Larval Stage.

Two classes of larvæ, comparable to those found in the corresponding stage of *Upogebia deltura* may be distinguished amongst the larvæ of this stage in *U. stellata*.

Class A has four pairs of setose exopodites, from the first maxilliped to the first walking leg, while in Class B there are, in addition to these, four setæ on the exopodite of the second leg, making five pairs in all.

The general structure of the appendages is similar to that of the allied species *U. deltura* with the following constant differences.

The exognath of the *Second Maxilla* (Pl. X, Fig. 4) bears twelve plumose setæ instead of eleven, as is the general rule in *U. deltura*.

The plumose seta on the second joint of the endopodite in the *First Maxilliped*, which was a distinctive character of this species in the first stage, is still present; but in *U. deltura* this does not appear till the third larval stage.

The median " notch " on the hind margin of the telson is not flattened out, but remains distinct (Pl. X, Fig. 5).

Third Larval Stage.

The larva at this stage is very similar to that of *Upogebia deltura*, but may readily be distinguished from it by the following characteristics.

The general proportions of the body are rather different; the antennæ in front, and the last abdominal segment behind, being much larger in comparison with the rest of the animal.

The total length may reach as much as $4\frac{1}{2}$ mm. The *First Antenna* has seven plumose setæ on the shaft.

The *Second Maxilliped* (Pl. X, Fig. 6) has developed a plumose seta on the second joint of the endopodite, corresponding in position to that on the first maxilliped, while the similar but smaller seta on the last joint seems to have disappeared.

The *Telson* (Pl. X, Fig. 7) is somewhat longer than that of the other species, and the hind margin is distinctly more concave.

The *Uropods* are longer, and the inner pair already jointed at the base, and in several specimens, tipped with a single plumose seta.

The larvæ comprised specimens displaying very various degrees of development of the pleopods and the endopodites of the thoracic limbs, as is also the case in the corresponding stage of *U. deltura*, a fact which suggests that the two classes of larvæ found in this stage of that species may also be traced in *U. stellata*.

Corroborative evidence of this is afforded by the fact that one of the first two post-larval specimens of *Upogebia stellata*, moulted (July 8th) from a larva with partly developed inner uropods—as in stage three—but at that time it was merely noted as an abnormality.

The light cast by the later experiments on the development of the allied species, *Upogebia deltura*, makes it seem most probable that the moult referred to above was that of a Class B third stage larva to the first post-larval stage.

Fourth Larval Stage.

This stage of *Upogebia stellata* is distinctly more slender in build than the corresponding stage of *U. deltura*, and in addition it presents the following differences in structural detail.

The *First Antenna* (Pl. X, Fig. 8) bears seven or eight plumose setæ instead of nine, and their arrangement differs slightly from that in *U. deltura*.

The *Second Antenna* (Pl. X, Fig. 9) bears thirteen setæ on the antennal plate.

The masticatory lobes of the *First Maxilla* are not so thickly set with spines.

The *Second Maxilla* bears about fourteen setæ on the exognath, instead of eighteen in *U. deltura*.

The *Second Maxilliped* displays the same distinctive seta as in the previous stage.

The *Telson* and *Uropods* (Pl. X, Fig. 11) are longer, and the hind margin of the telson somewhat more concave than in *U. deltura*.

The endopodites of the thoracic limbs are longer and more slender than those of *U. deltura* at this stage.

First Post-larval Stage.

In the early summer of 1918, when the larvæ of *Upogebia stellata* were plentiful in the tow-nets, the occurrence of the moult from the third larval stage to the first post-larval in the other species was not known, and consequently no attempt was made to detect it in this species by isolating the larvæ and preserving the moults.

All the unfringed post-larval specimens were preserved together, but on examination they were found to fall naturally into two classes, according to the shape of the chela on the first leg.

Pl. XII, Fig. 5 is an example of Class A, Pl. XII, Fig. 6 of Class B; a comparison of the two shows that the latter is characterised by a longer penultimate joint and dactylus, a larger fixed finger which points forwards and inwards towards the movable one, and bears one or more denticles on the inner surface, and in general by a more robust build.

In Class A there is a tendency for the fixed finger to spring from the sixth joint just below the level of the dactylus, which gives the last joint a somewhat pedunculated appearance; while the fixed finger projects outwards in a manner that suggests a rather ineffective grasping power.

Now these same characterictics may be seen in the chelæ of the two classes of larvæ in *Upogebia deltura*.

Pl. XII, Fig. 7 shows the chela in Class A, while members of Class B have a claw such as is figured in Pl. XII, Fig. 8. It will readily be seen that although the former figure is evidently drawn from a rather larger individual, yet it presents the general proportions characteristic of Class A, i.e. a slender penultimate joint, a dactylus which is narrow at the base and slightly pedunculate, and a less effective grip formed by the two fingers of the claw, due partly to the smaller size of the fixed finger, and partly to the smooth inner surface of the dactylus, which in Class B is roughened into points.

It is not only in the young stages, however, that these two kinds of claw may be distinguished; they are even more noticeable and distinct in the adults, where they form one of the secondary sexual characters.

It is not stated in the standard descriptions of these species that the chela of the first leg differs in the two sexes. Pl. XII, Figs. 9 and 10 are drawn to scale from a male and female *Upogebia stellata* of approximately the same length, and they show the striking difference which exists between the chelæ of the two sexes. (Spines and setæ not figured.)

The limb in the male is stout and broad; the fixed finger, which bears a denticle on the inside, is more than half as long as the movable one, and is evidently capable of acting as an efficient grasping organ. The movable finger or dactylus is strongly curved, broad at the base and tapering towards the point.

In the female, on the other hand, the limb is altogether of a more slender character ; the fixed finger is much shorter and does not bend inwards towards the dactylus, which itself is much weaker in appearance and not nearly so broad at the base as that of the male.

On comparing Fig. 6 with Fig. 9, Fig. 5 with Fig. 10, it will be seen that the characters of the two sexes in the adult are foreshadowed almost exactly in the two types of chela displayed by the young post-larval stages, Class A resembling the female and Class B the male.

A comparison with the development of *Upogebia deltura* renders it probable that these two types in both species arise from the two classes of larvæ, which come from the third and fourth larval stages respectively ; in which case the female has one more larval stage than the male, which moults directly from the third larval stage to the first post-larval.

As yet, however, all attempts to determine the sex of the young specimens have been unsuccessful, and their peculiar mode of life renders them particularly difficult to rear to maturity in the Laboratory, so that conclusions reached on this point are necessarily based on analogy, the present material not admitting of absolute proof.

The following is a description of the first post-larval stage of *Upogebia stellata*, taken from an individual of Class B.

The specimen measures 4½ mm. in length from rostrum to telson ; the rostrum reaches just beyond the eyes, which are relatively smaller than in *Upogebia deltura* at this stage.

The *First Antenna* is similar to that of the other species (see Pl. VII, Fig. 2).

The *Second Antenna* is composed of twenty-seven joints, the first four forming the shaft and the remainder the flagellum.

The *Mandibles* and *First Maxilla* are like those of *Upogebia deltura*, but the *Second Maxilla* (Pl. XI, Fig. 2) is considerably larger, and bears twenty-eight plumose setæ on the exognath.

The three pairs of *Maxillipeds* do not display any important differences from those of *U. deltura*.

The *First Leg* (Pl. XI, Fig. 3) is longer and more slender than the other species, and presents a striking contrast in the chela, of which the dactylus is long and tapering, while the fixed finger is very short, barely one-fifth the length of the dactylus and slightly toothed on the inner border.

The *Second Leg* (Pl. XI, Fig. 4) is like that of *U. deltura*, but bears five long barbed setæ on the fourth joint and five on the penultimate.

The remaining thoracic limbs are similar to those of *U. deltura*, but more slender.

The *Pleopods* are composed of two lobes as in the other species, but of these the outer bears about twenty-eight setæ, and the inner five or six.

The *Uropods* and *Telson* (Pl. XI, Fig. 5) which together form the swimming tail-fan of the animal, are similar in general appearance to those of *U. deltura*, but the uropods are relatively longer, and the margins of both uropods and telson are set with long scattered spines, in addition to the regular row of plumose setæ.

SECOND POST-LARVAL STAGE.

The second post-larval stage of *Upogebia stellata* exhibits the same combs of setæ on the mouth parts and the two first pairs of thoracic legs as in the fringed stage of *U. deltura*, which it indeed closely resembles in structure ; the following points of difference, however, may be noted.

The total length from rostrum to telson is about $4\frac{1}{2}$ mm.

The *Second Antenna* generally consists of thirty-three joints.

The exognath of the *Second Maxilla* is bordered with about thirty-nine plumose setæ.

The first and second *Legs* are similar to those of the previous stage, and the fringes of setæ are not quite so dense as in *U. deltura*.

The *Pleopods* have fourteen and thirty-five setæ on the inner and outer lobes respectively.

The *Uropods* (Pl. XI, Fig. 6) are longer and more slender than those of *Upogebia deltura*.

The following table has been drawn up to show the differences between the three forms, *Gebia littoralis* of Sars (1884), *Upogebia deltura* Leach, and *Upogebia stellata* (Mont.).

TABLE OF COMPARISON

Stage.	Name of Part.	*Gebia littoralis* of Sars.	*Upogebia deltura* Leach.	*Upogebia stellata* (Mont.)
Larval I	*Second Maxilla.* Setæ on exognath	" About fourteen "	Nine	Ten
	First Maxilliped. Seta on second joint of endopodite	Absent	Absent	Present
	Rudiments of Limbs behind second maxilliped	Five pairs	Six pairs	Six pairs
Larval II	*Setose exopodites*	Four pairs	*Class A.* Four pairs *Class B.* Five pairs	*Class A.* Four pairs *Class B.* Five pairs
	Second Antenna. Flagellum	Not cut off from base	Cut off	Not cut off
	Second Maxilla. Setæ on exognath	Not stated	Eleven	Twelve
	First Maxilliped. Seta on second joint of endopodite	Absent	Absent	Present
	Third Maxilliped. Terminal seta on endopodite	Absent	Present	Present
	Abdominal Limbs	Absent	*Class A.* Absent *Class B.* Present	Absent
	Telson. Median notch	Almost gone	Almost gone	Still present
Larval III	*First Antenna.* Setæ on shaft	Not stated	Eight	Seven
	Second Maxilliped. Seta on second joint of endopodite	Not stated	Absent	Present
	Third Maxilliped. Terminal seta on endopodite	Absent	Generally present	Generally present
	Outer Uropod. Marginal setæ	Twelve	Generally fourteen	Generally thirteen
	Inner Uropod. Terminal seta	Present	Absent	Sometimes present
	Telson. Hind margin	Weakly concave	Weakly concave	Strongly concave

Stage	Name of Part	*Gebia littoralis* of Sars	*Upogebia deltura* Leach	*Upogebia stellata* Mont.
Larval IV	*Length*	5 mm.	About 4 mm.	About 4 mm.
	First Antenna. Setæ on shaft	Six	Nine	Seven or eight
	Second Maxilla. Setæ on exognath	Twenty-two	Eighteen	Fourteen
	Second Maxilliped. Seta on second joint of endopodite	Not stated	Absent	Present
Post-larval I	*Length*	5 mm.	*Class A.* About 4 mm. *Class B.* About $3\frac{1}{2}$ mm.	About $4\frac{1}{2}$ mm.
	Colour	Whitish	Pale pink	Pale pink
	Rostrum. Length	Beyond eye-level	*Class A.* Just to eye-level *Class B.* Not quite to eye-level	Beyond eye-level
	Eyes	Cover $2\frac{1}{2}$ joints of second antenna	Cover $5\frac{1}{2}$ joints of second antenna	Cover $2\frac{1}{2}$ joints of second antenna
	Second Antenna. Number of joints	Twenty-three	*Class A.* Twenty-three *Class B.* Twenty to twenty-two	Twenty-seven
	Second Maxilla. Number of setæ on exognath	Thirty-five	*Class A.* Thirty-seven *Class B.* Twenty-nine	Twenty-eight
	Arrangement of setæ	Massed at either end	Evenly arranged	Evenly arranged
	Chela. Lengths of fixed finger and dactylus	Sub-equal	Sub-equal	Dactylus much longer than fixed finger
	Denticles on fixed finger	Five	Three	One
	Inner Uropod. Outer border	Convex, with row of setæ	Weakly concave, bare of setæ	Straight, bare of setæ

LITERATURE.

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PLATE I. (All Figs. × 24.)

FIG. 1.	*Upogebia deltura.*	First Larval Stage.	Dorsal View.		
,, 2.	,, ,,	Second ,, ,,	(Class A.)	Dorsal View.	
,, 3.	,, ,,	Third ,, ,,	,,	,,	,,
,, 4.	,, ,,	Fourth ,, ,,	,,	,,	,,

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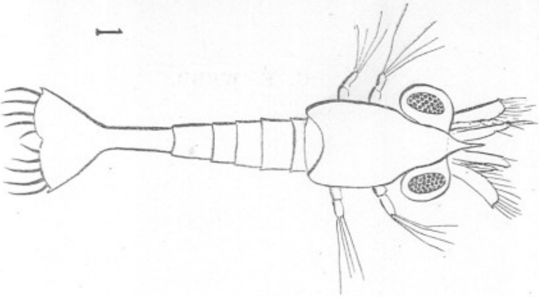

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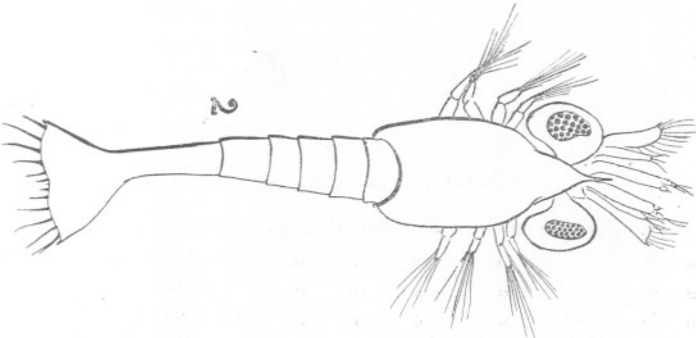

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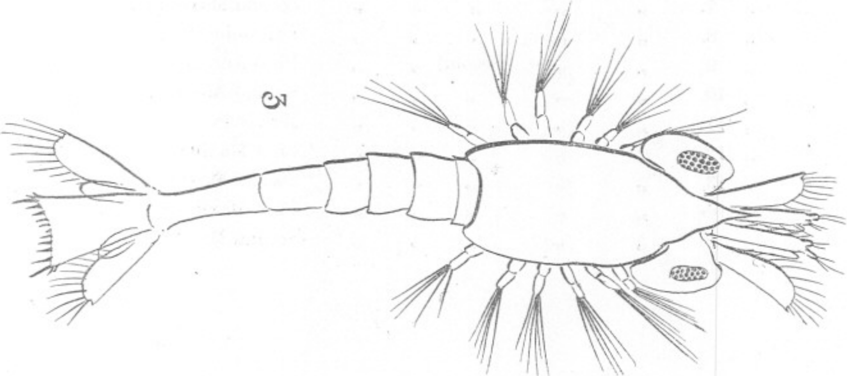

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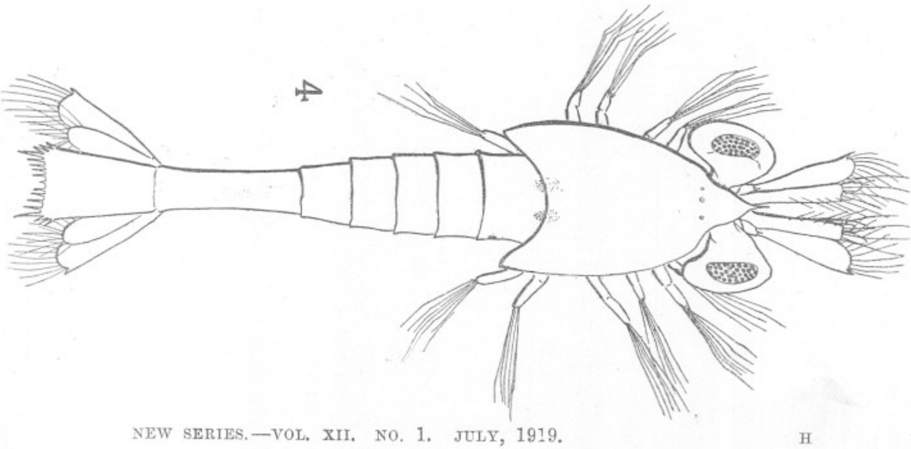

PLATE II. (All Figs. × 70.)

FIG.	1.	*Upogebia deltura.*	First Larval Stage.	First Antenna.
,,	2.	,, ,,	,, ,, ,,	Second Antenna.
,,	3.	,, ,,	,, ,, ,,	Mandible.
,,	4.	,, ,,	,, ,, ,,	First Maxilla.
,,	5.	,, ,,	,, ,, ,,	Second Maxilla.
,,	6.	,, ,,	,, ,, ,,	First Maxilliped.
,,	7.	,, ,,	,, ,, ,,	Second Maxilliped.
,,	8.	,, ,,	,, ,, ,,	Swimming Plate.
,,	9.	,, ,,	Second ,, ,,	First Antenna.
,,	10.	,, ,,	,, ,, ,,	Second Antenna.
,,	11.	,, ,,	,, ,, ,,	Mandible.
,,	12.	,, ,,	,, ,, ,,	First Maxilla.
,,	13.	,, ,,	,, ,, ,,	Second Maxilla.
,,	14.	,, ,,	,, ,, ,,	First Maxilliped.
,,	15.	,, ,,	,, ,, ,,	Second Maxilliped.

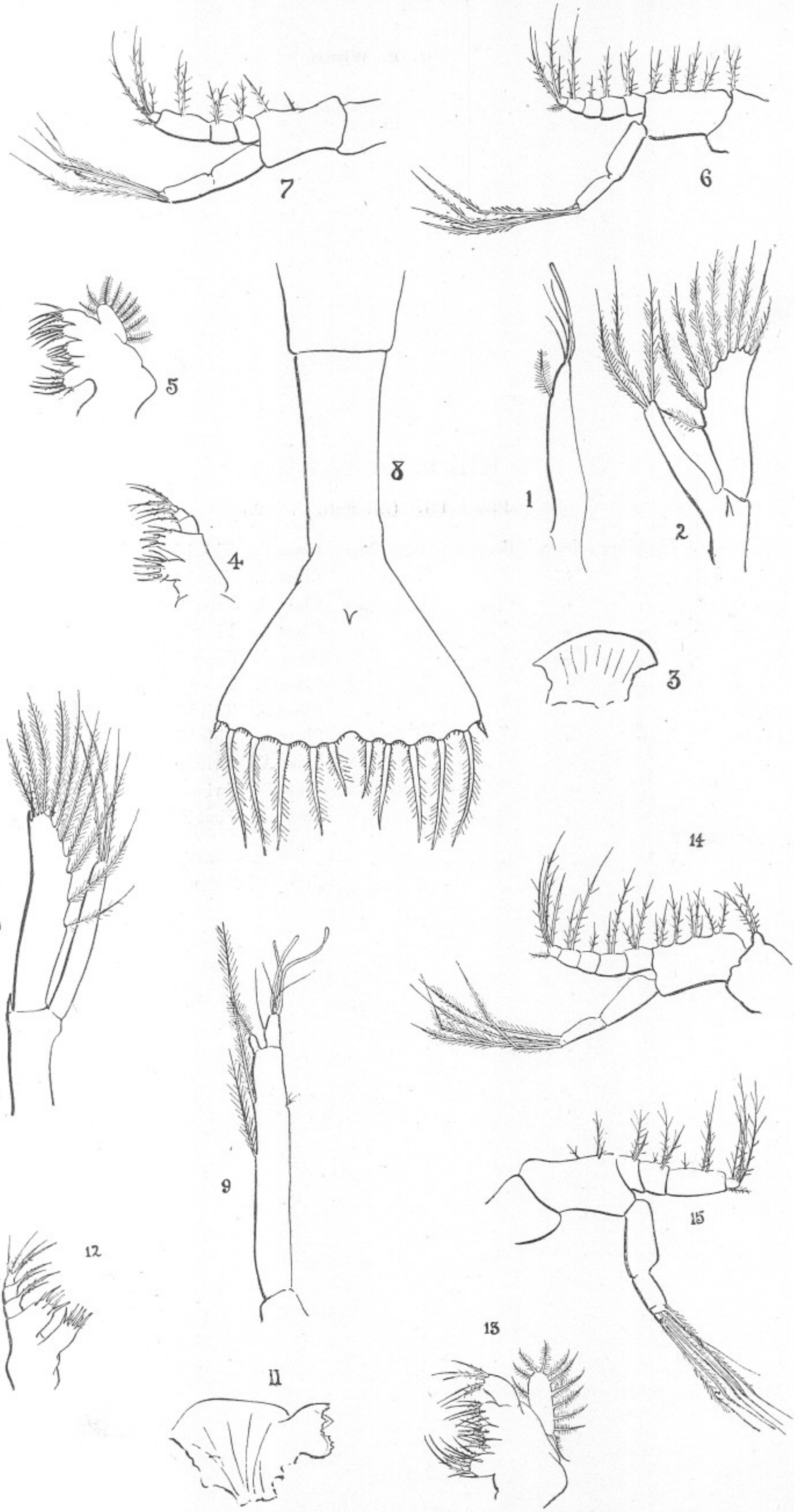

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PLATE III. (All Figs. × 70.)

FIG. 1.	*Upogebia deltura.*	Second Larval Stage.	Class B.	Third Maxilliped.
,, 2.	,, ,,	,, ,, ,,	Class A.	Third Maxilliped.
,, 3.	,, ,,	,, ,, ,,	Class B.	First Leg.
,, 4.	,, ,,	,, ,, ,,	Class A.	First Leg.
,, 5.	,, ,,	,, ,, ,,	Class B.	Second Leg.
,, 6.	,, ,,	,, ,, ,,	Class A.	Second Leg.
,, 7.	,, ,,	,, ,, ,,	Class B.	Third Leg.
,, 8.	,, ,,	,, ,, ,,	Class A.	Third Leg.
,, 9.	,, ,,	,, ,, ,,	Class A.	Swimming Plate.
,, 10.	,, ,,	,, ,, ,,	Class B.	Swimming Plate.
,, 11.	,, ,,	,, ,, ,,	Class B.	First Three Abdominal Seg- [ments with Pleopods

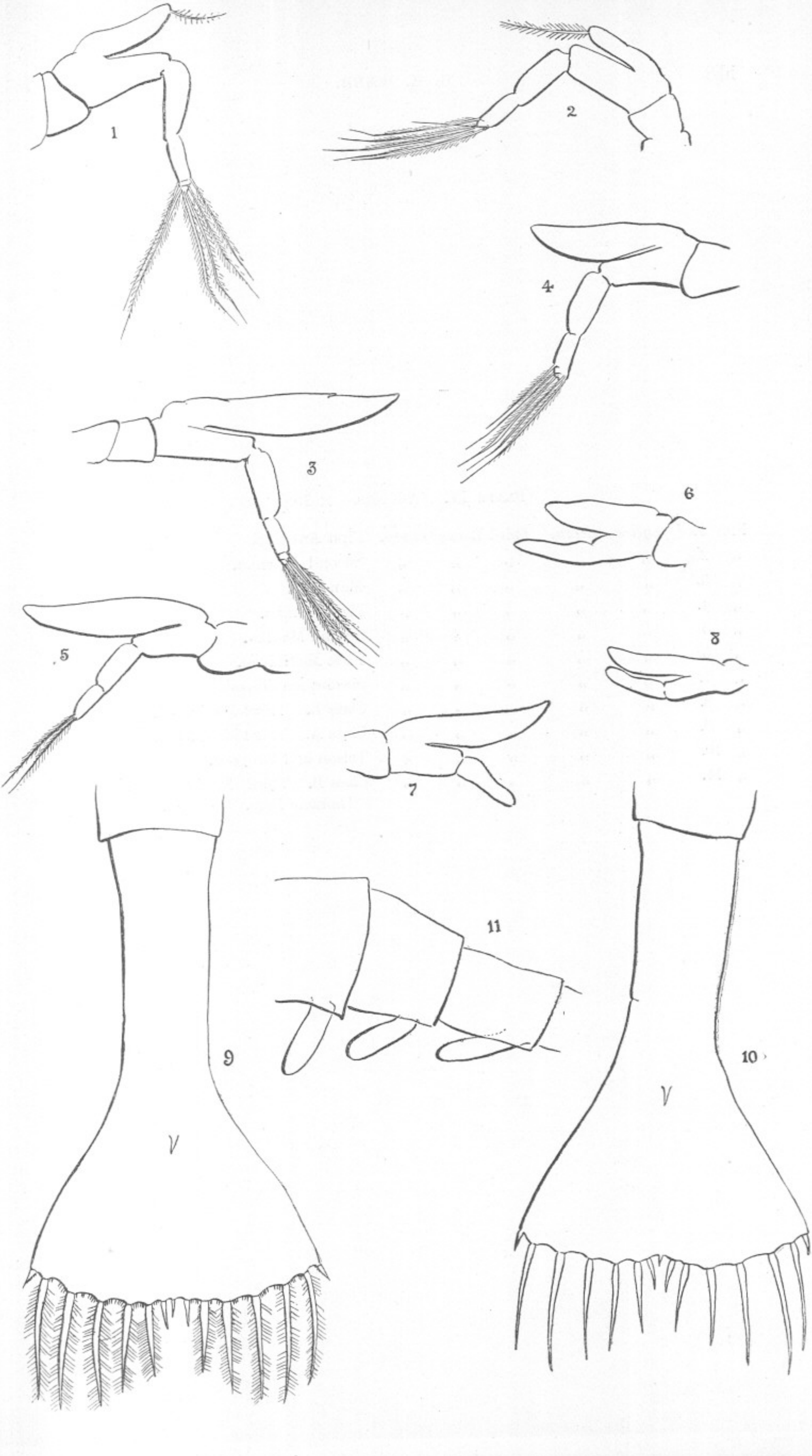
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PLATE IV. (All Figs. × 70.)

FIG. 1.	*Upogebia deltura.*	Third Larval Stage.	First Antenna.
„ 2.	„ „	„ „ „	Second Antenna.
„ 3.	„ „	„ „ „	Mandible.
„ 4.	„ „	„ „ „	First Maxilla.
„ 5.	„ „	„ „ „	Second Maxilla.
„ 6.	„ „	„ „ „	First Maxilliped.
„ 7.	„ „	„ „ „	Second Maxilliped.
„ 8.	„ „	„ „ „	Class B. Third Maxilliped.
„ 9.	„ „	„ „ „	Class A. Third Maxilliped.
„ 10.	„ „	„ „ „	Telson and Uropods.
„ 11.	„ „	„ „ „	Class B. Third Maxilliped and Five [Thoracic Legs. (Exopodites dotted.)


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PLATE V. (All Figs. × 70.)

FIG. 1.	*Upogebia deltura.*	Third Larval Stage.	Class B.	First Leg.
,, 2.	,, ,,	,, ,, ,,	Class A.	First Leg.
,, 3.	,, ,,	,, ,, ,,	Class B.	Second Leg.
,, 4.	,, ,,	,, ,, ,,	Class A.	Second Leg.
,, 5.	,, ,,	,, ,, ,,	Class B.	Third Leg.
,, 6.	,, ,,	,, ,, ,,	Class A.	Third Leg.
,, 7.	,, ,,	Fourth ,, ,,	Second Antenna.	
,, 8.	,, ,,	,, ,, ,,	First Maxilla.	
,, 9.	,, ,,	,, ,, ,,	Second Maxilla.	
,, 10.	,, ,,	,, ,, ,,	Uropods and Telson.	

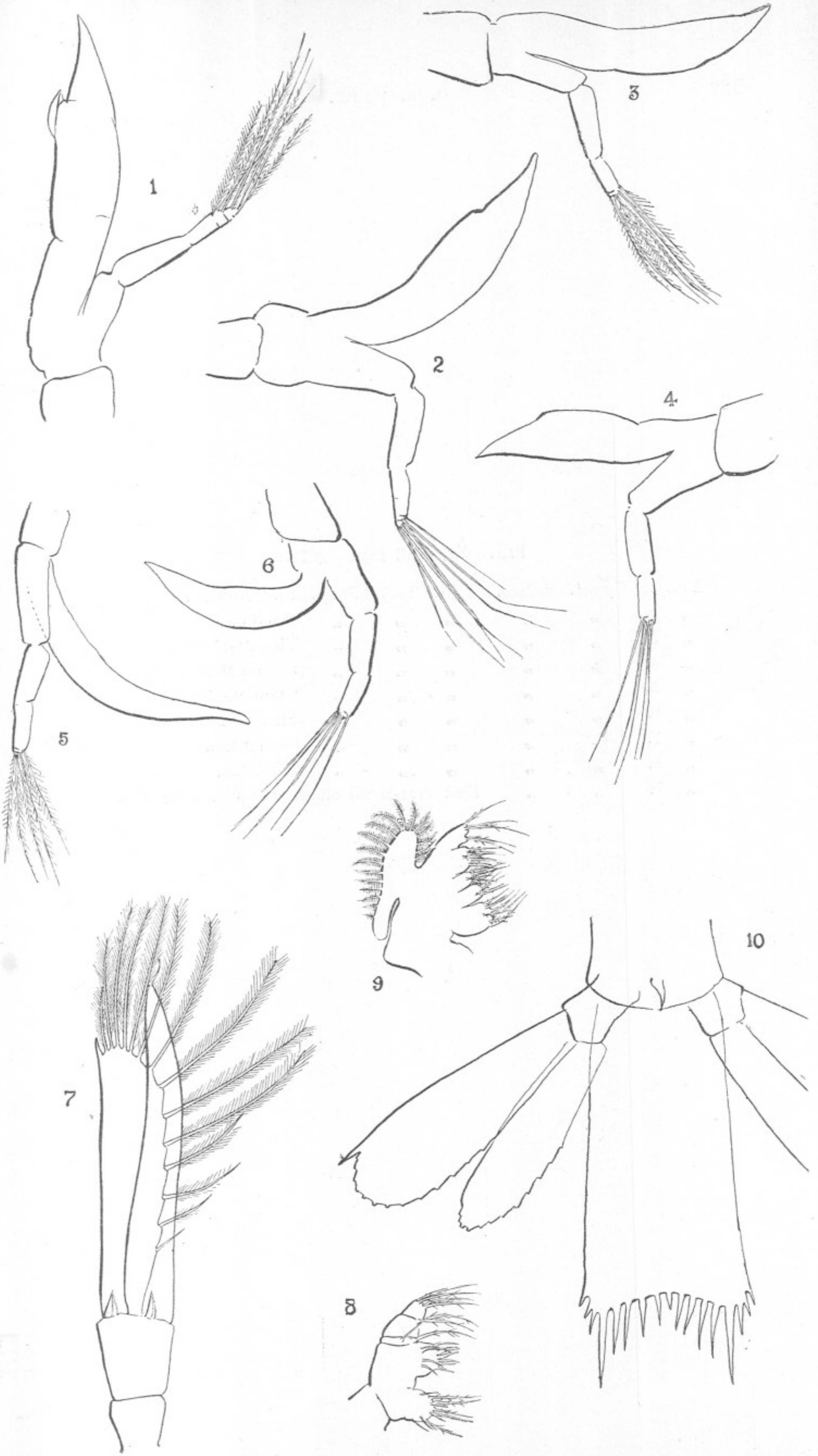
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PLATE VI. (All Figs. × 70.)

FIG. 1.	*Upogebia deltura.*	Fourth Larval Stage.	First Antenna.
„ 2.	„ „	„ „ „	Mandible.
„ 3.	„ „	„ „ „	First Maxilliped.
„ 4.	„ „	„ „ „	Second Maxilliped.
„ 5.	„ „	„ „ „	Third Maxilliped.
„ 6.	„ „	„ „ „	First Leg.
„ 7.	„ „	„ „ „	Second Leg.
„ 8.	„ „	„ „ „	Third Leg.
„ 9.	„ „	First Post-larval Stage.	Class B. Mandible.

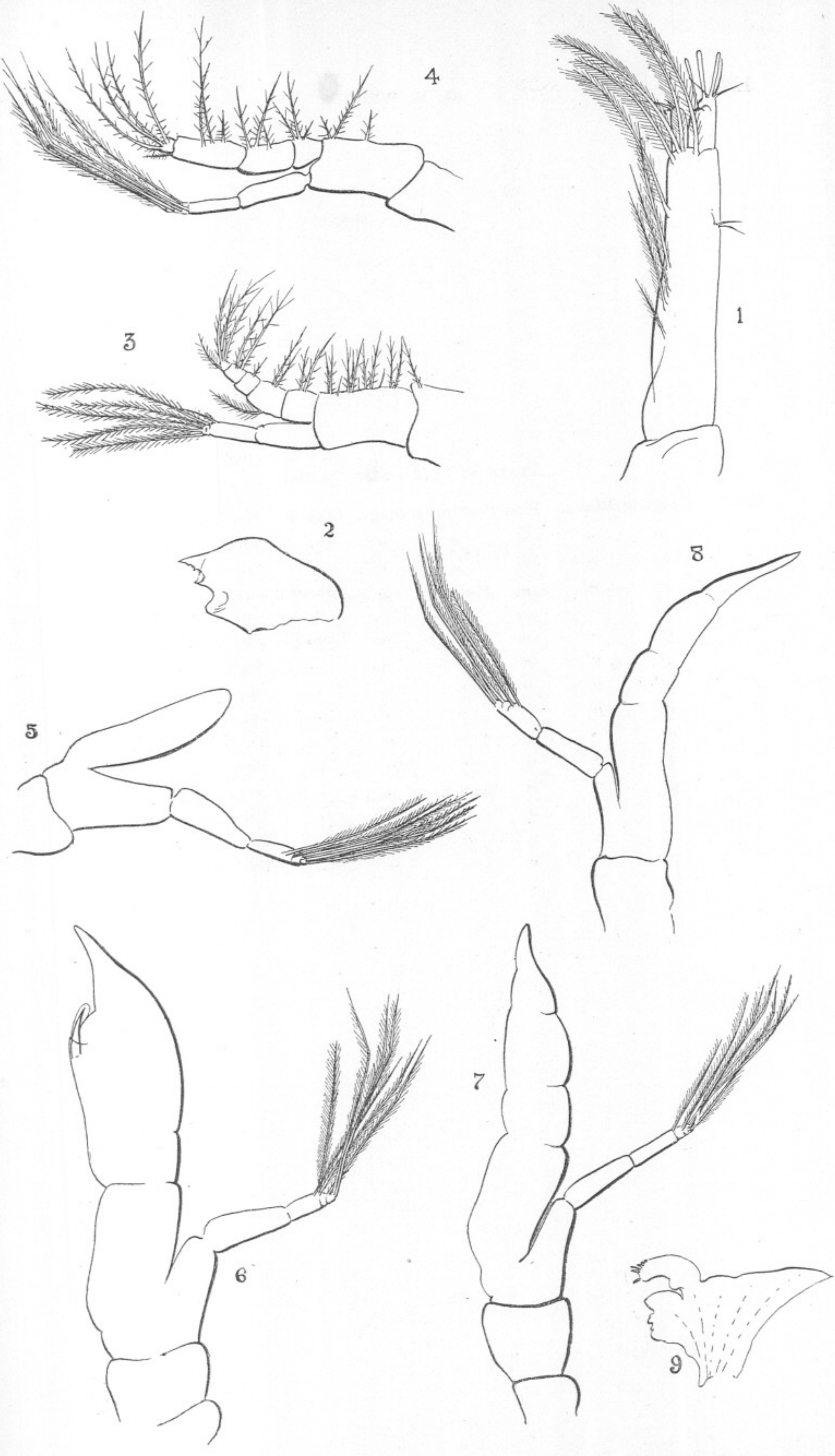
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Plate VII. (All Figs. × 70.)

Fig. 1.	*Upogebia deltura.*	First Post-larval Stage.	Class B.	Rostrum.
,, 2.	,, ,,	,, ,, ,,	,,	First Antenna.
,, 3.	,, ,,	,, ,, ,,	,,	Second Antenna.
,, 4.	,, ,,	,, ,, ,,	Rostrum removed to show relation of eyes and antennæ.	
,, 5.	,, ,,	,, ,, ,,	Class B.	First Maxilla.
,, 6.	,, ,,	,, ,, ,,	,,	Second Maxilla.
,, 7.	,, ,,	,, ,, ,,	,,	First Maxilliped.
,, 8.	,, ,,	,, ,, ,,	,,	Second Maxilliped.
,, 9.	,, ,,	,, ,, ,,	,,	Third Maxilliped.
,, 10.	,, ,,	,, ,, ,,	,,	First Leg.
,, 11.	,, ,,	,, ,, ,,	,,	Second Leg.
,, 12.	,, ,,	,, ,, ,,	,,	Third Leg.
,, 13.	,, ,,	,, ,, ,,	,,	Fourth Leg.
,, 14.	,, ,,	,, ,, ,,	,,	Fifth Leg.

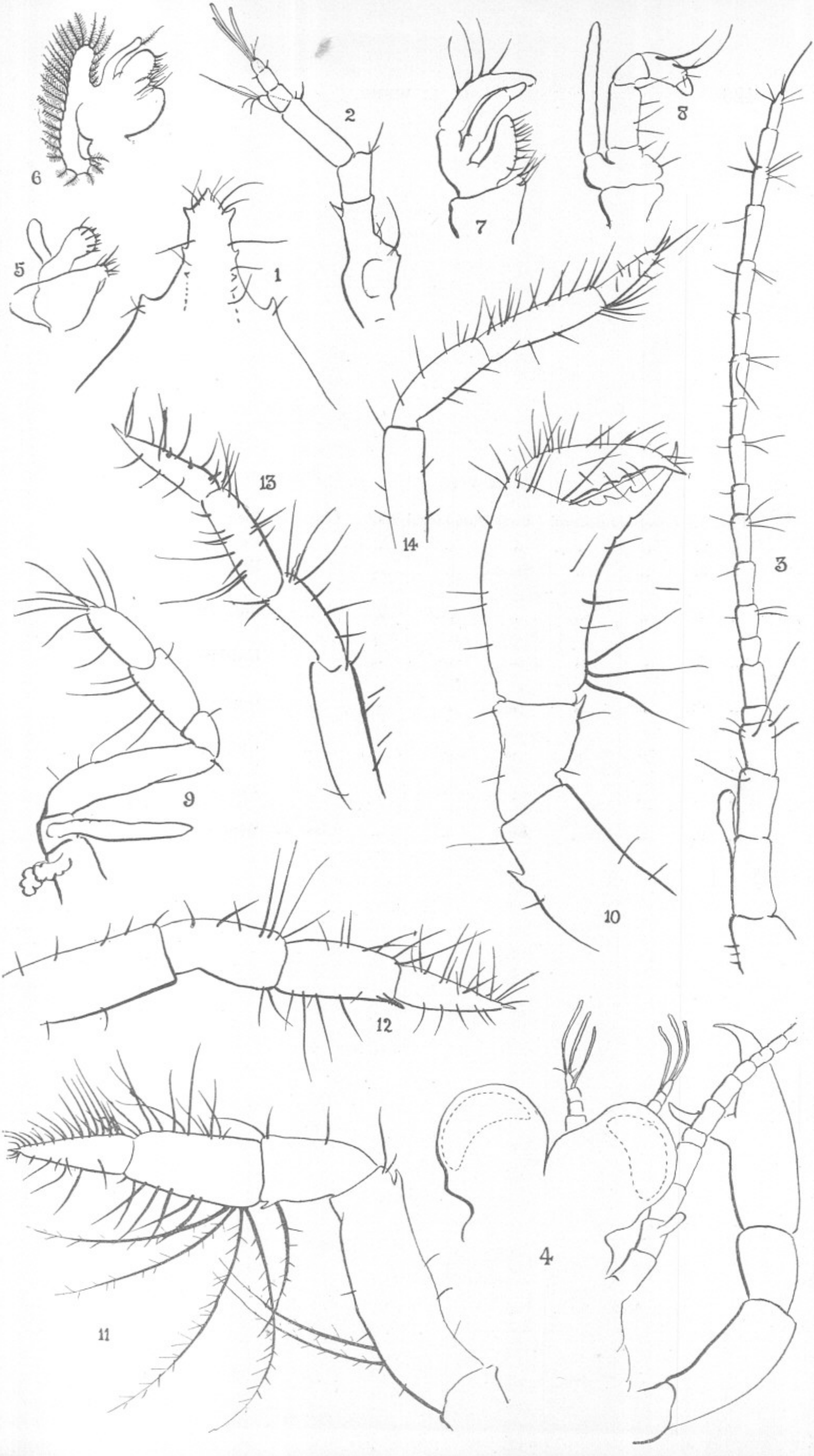
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PLATE VIII. (All Figs. × 70.)

FIG. 1.	*Upogebia*	*deltura.*	First	Post-larval	Stage.	Class B.	Pleopod.
„ 2.	„	„	„	„	„	„	Uropods and Telson.
„ 3.	„	„	Second	„	„	„	Fringed Form. Second [Antenna.
„ 4.	„	„	„	„	„	„	Unfringed Form. Eyes and Antennæ.
„ 5.	„	„	„	„	„	„	Unfringed Form. First [Maxilla.
„ 6.	„	„	„	„	„	„	Unfringed Form. Second [Maxilla.
„ 7.	„	„	„	„	„	„	Unfringed Form. First [Maxilliped.
„ 8.	„		„	„	„	„	Unfringed Form. First [Leg.
„ 9.	„	„	First	„	„	Class A.	Second Maxilla.

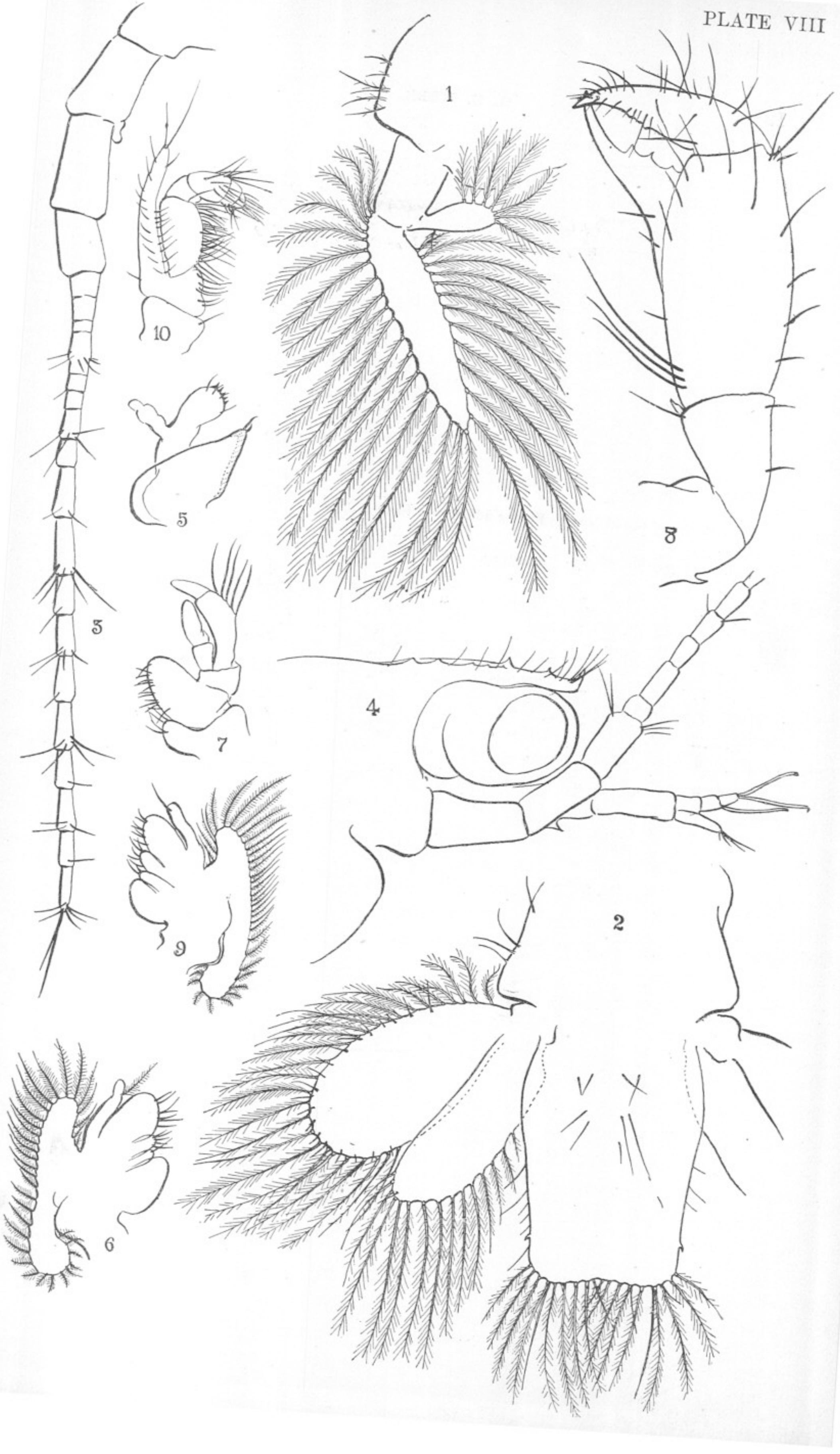
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PLATE IX. (All Figs. × 70.)

FIG.	1.	*Upogebia deltura.*	Second	Post-larval	Stage.	Class B.	Fringed Form. First [Leg.
,,	2.	,, ,,	,,	,,	,,	,,	Fringed Form. Second [Leg.
,,	3.	,, ,,	,,	,,	,,	Class A.	Second Maxilla.
,,	4.	,, ,,	,,	,,	,,	,,	First Maxilliped.
,,	5.	,, ,,	Third	,,	,,	,,	First Maxilla.
,,	6.	,, ,,	,,	,,	,,	,,	Second Maxilla.
,,	7.	,, ,,	,,	,,	,,	,,	First Maxilliped.
,,	8.	,, ,,	,,	,,	,,	,,	Third Maxilliped.
,,	9.	,, ,,	,,	,,	,,	,,	Telson and Uropods. (Spines omitted.)

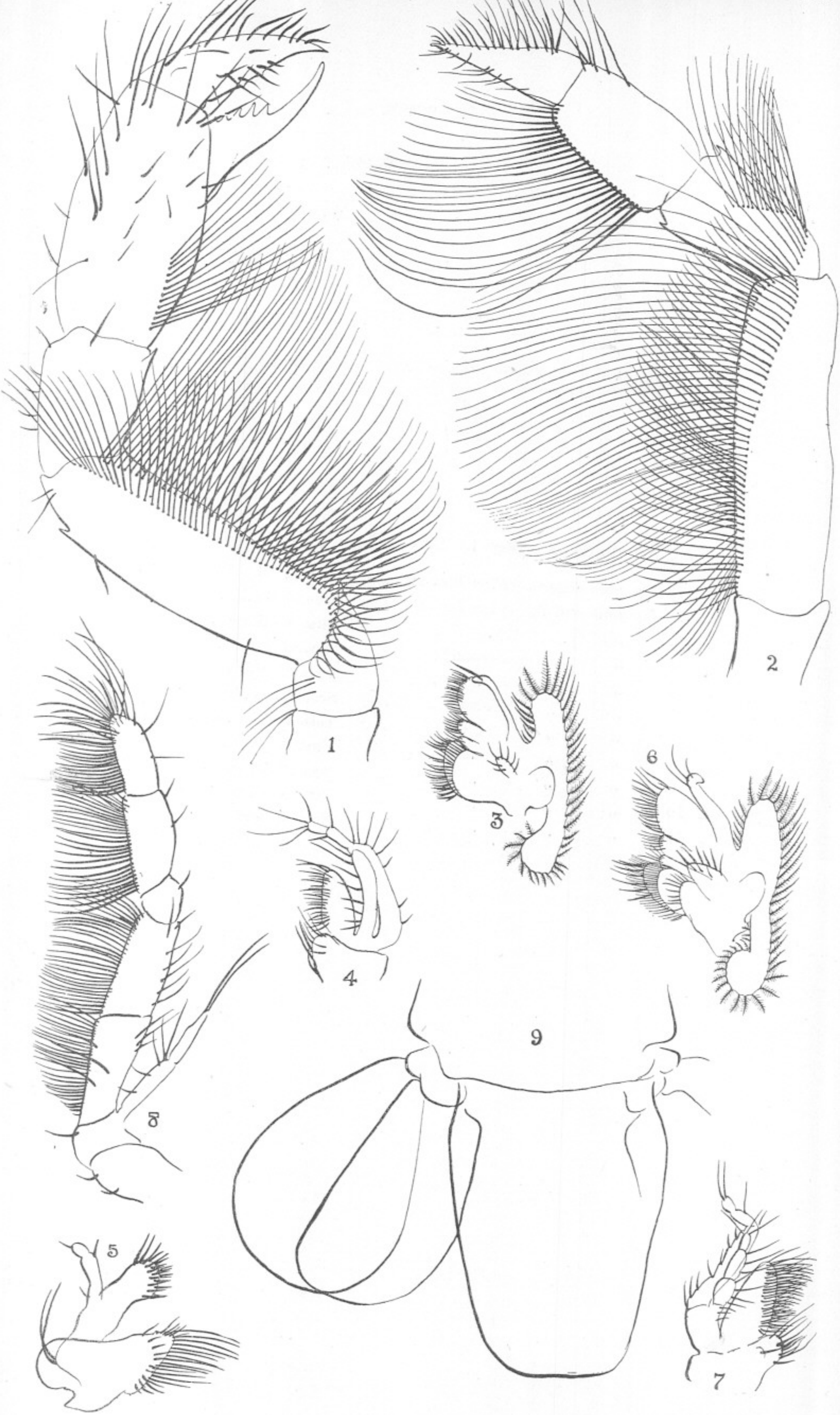
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PLATE X. (Fig. 1. × 24. Figs. 2–11. × 70.)

FIG. 1.	*Upogebia deltura.*		First Post-larval Stage. Class B.			Dorsal View.
,, 2.	*Upogebia stellata.*		First Larval Stage.			Second Maxilla.
,, 3.	,,	,,	,,	,,	,,	First Maxilliped.
,, 4.	,,	,,	Second	,,	,,	Second Maxilla.
,, 5.	,,	,,	,,	,,	,,	Swimming Plate.
,, 6.	,,	,,	Third	,,	,,	Second Maxilliped.
,, 7.	,,	,,	,,	,,	,,	Telson and Uropods.
,, 8.	,,	,,	Fourth	,,	,,	First Antenna.
,, 9.	,,	,,	,,	,,	,,	Second Antenna.
,, 10.	,,	,,	,,	,,	,,	First Maxilla.
,, 11.	,,	,,	,,	,,	,,	Uropods and Telson.

PLATE X.

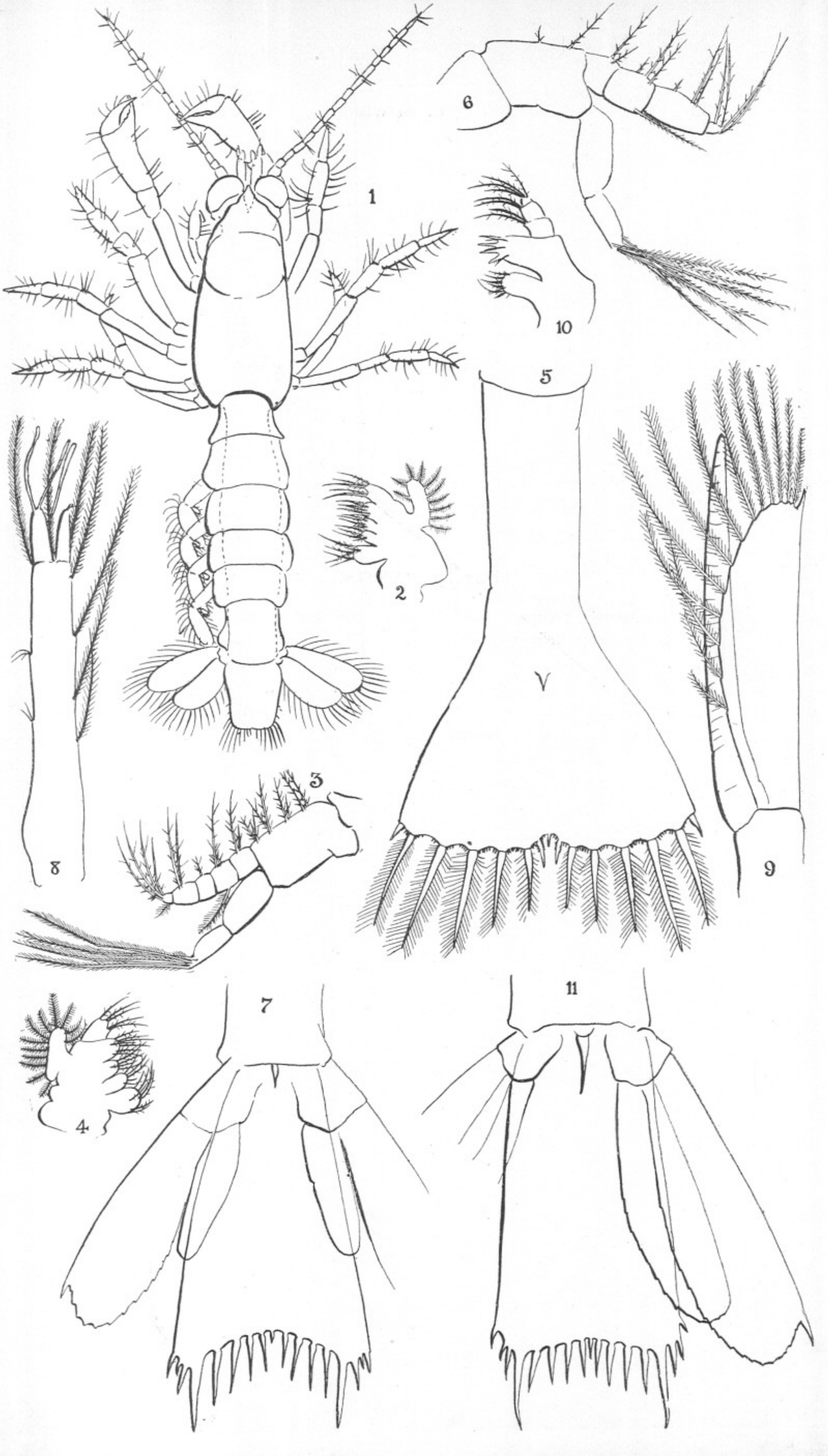

PLATE XI. (All Figs. × 70.)

FIG. 1.	*Upogebia deltura.*	Third Post-larval Stage.	Class A.	Second Antenna.
„ 2.	*Upogebia stellata*	First „ „	Second Maxilla.	
„ 3.	„ „	„ „ „	Class B.	First Leg.
„ 4.	„ „	„ „ „	„	Second Leg.
„ 5.	„ „	„ „ „	Uropods and Telson.	
„ 6.	„ „	Second „ „	„	„ (Spines omitted.)

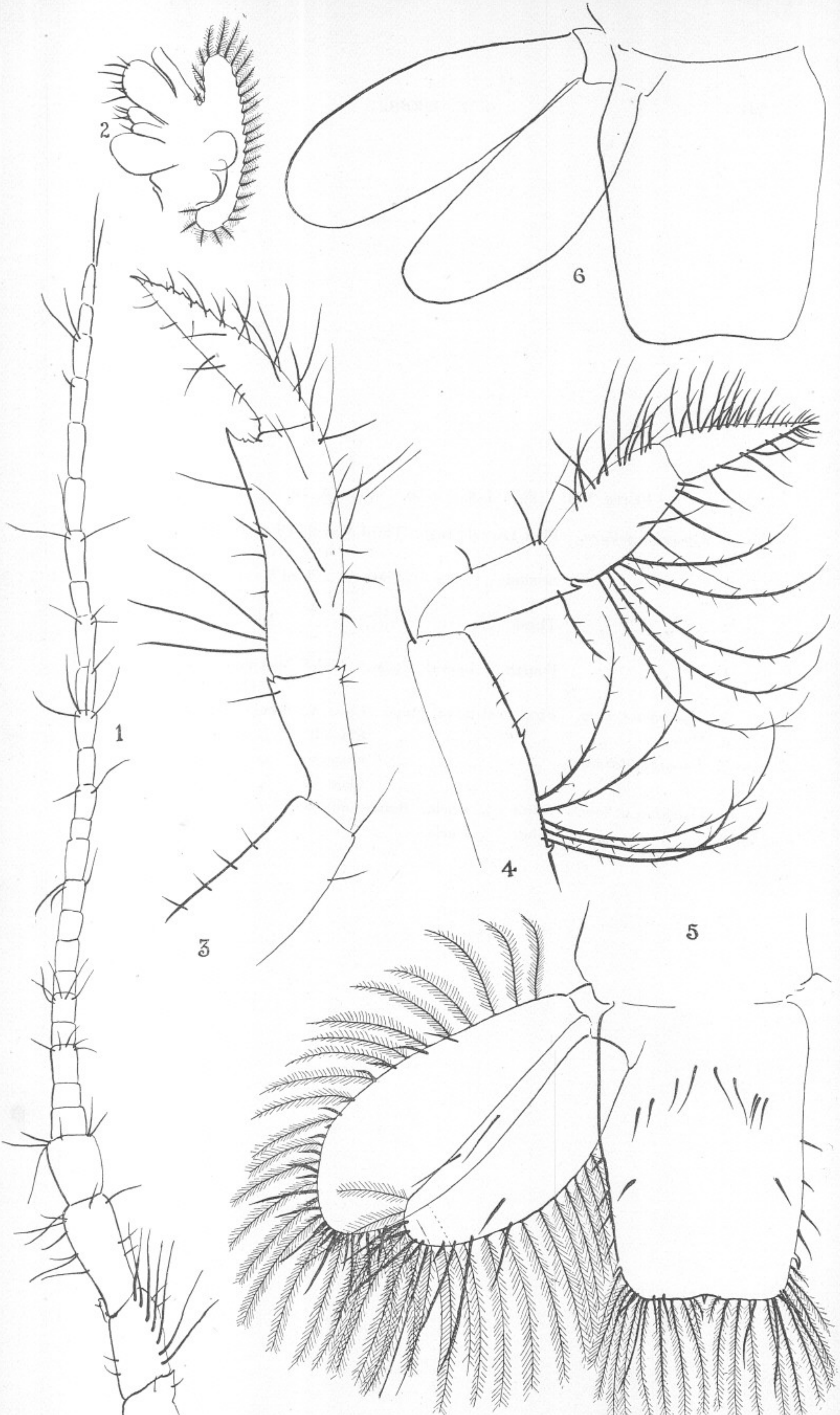

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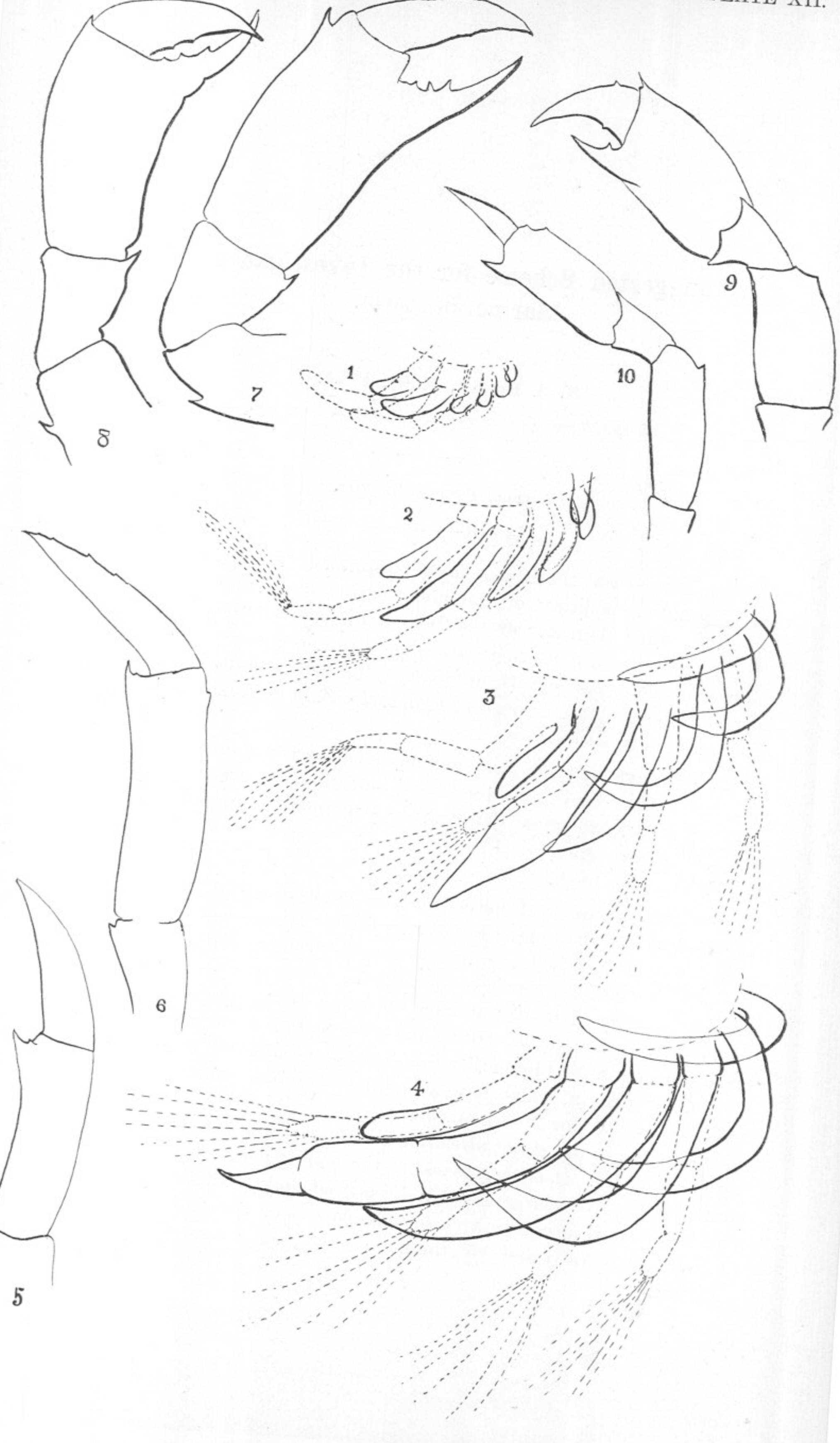
PLATE XII. (Figs. 1–8. × 70. Figs. 9, 10. × $3\frac{1}{4}$.)

FIG. 1.	*Upogebia deltura.*	First Larval Stage. Third Maxilliped to Fifth Leg. (Exopodites dotted.)	
,, 2.	,, ,,	Second ,, ,, Class A. Third Maxilliped to Fifth Leg. (Exopodites dotted.)	
,, 3.	,, ,,	Third ,, ,, ,, ,, Maxilliped to Fifth Leg. (Exopodites dotted.)	
,, 4.	,, ,,	Fourth Larval Stage. Third Maxilliped to Fifth Leg. (Exopodites dotted.)	
,, 5.	*Upogebia stellata.*	First Post-larval Stage. Class A.	Chela. Spines omitted.
,, 6.	,, ,,	,, ,, ,, Class B.	,, ,, ,,
,, 7.	*Upogebia deltura.*	,, ,, ,, Class A.	,, ,, ,,
,, 8.	,, ,,	,, ,, ,, Class B.	,, ,, ,,
,, 9.	*Upogebia stellata.*	Adult ♂. Chela. Spines omitted.	
,, 10.	,, ,,	Adult ♀. Chela. ,, ,,	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A Suggested Scheme for the Investigation of Marine Bacteria.

By

H. S. Holden, M.Sc., F.L.S.

Bacteriologist (Temporary), R.N. Hospital, Plymouth.

With one Figure in the Text.

Whilst employed at the Royal Naval Hospital, Plymouth, I have been kindly granted facilities for the investigation of marine bacteria by Dr. E. J. Allen, Director of the Marine Biological Laboratories, and although the pressure of other duties has made progress extremely slow the experience obtained with different media will perhaps be of use to future workers. After a number of trials the three routine media found to be most satisfactory were :—

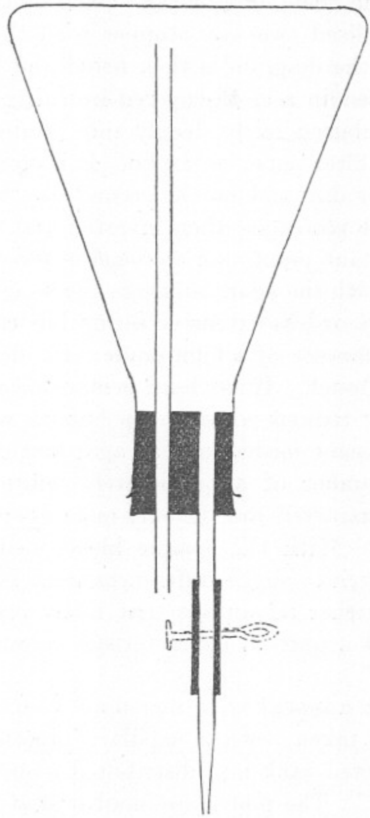
1. Blood glucose agar, a slight modification of an opaque medium devised by Dr. Warren Crowe whilst investigating the epidemic of Cerebro-spinal Fever at the Devonport Military Hospital.
2. Trypsin Agar.
3. Trypsin Broth.

Since the trypsin broth enters into the composition of both 1 and 2 its preparation will be described first. The fat is removed from a fresh bullock's heart and the lean muscle is passed through a mincing machine. The minced muscle is placed in a saucepan with four litres of water and the whole rendered faintly alkaline to litmus with 40% NaOH. It is then slowly heated to 70°–80° C. and allowed to cool to 45° C. Forty cubic centimetres of Liquor Trypsin Co. (Allen and Hanbury) are added to the warm broth, which is placed, after thorough mixing, in the incubator at 37° C. for $2\frac{1}{2}$–3 hours to trypsinise. After removal from the incubator the broth, if not already so, is rendered faintly acid to litmus with acetic acid. It is then raised to the boiling point, filtered through sterile muslin into a large vessel and rendered slightly alkaline to litmus. The filtrate is returned to a clean saucepan, and, after the addition of 10 grammes of NaCl and 0·5 gramme of $CaCl_2$, again raised to the boiling point.

It is finally filtered into sterile flasks, autoclaved on three successive days, and stored in the dark.

Trypsin Agar is a 2% Agar made up with trypsin broth, and clarified and filtered in the usual way.

The Blood Glucose Agar consists of defibrinated bullock's blood* to which trypsin agar and glucose have been added. The blood is collected



Apparatus for the distribution of Blood Glucose Agar into Petri dishes. The position of the pinchcock is dotted.

by an assistant from the abbatoir in a large enamel pail which, just prior to the collection, is thoroughly rinsed with chloroform. It is defibrinated with a large wire whisk, about ten minutes *continuous* whisking being usually sufficient to remove the major portion of the clot. Whilst this part of the preparation is under way 15 grammes of glucose and 25 cubic centimetres of distilled water are placed in a two-litre flask and autoclaved to dissolve the glucose. At the same time 500 cubic centimetres

* Defibrinated sheep's blood would doubtless work equally well.

of trypsin agar and the necessary delivery tubes, stopper, and pinch cock (*vide* diagram), the latter previously put together and wrapped in a cloth, are also autoclaved. On reaching the laboratory a litre of the defibrinated blood is filtered through sterile gauze into the flask containing the glucose solution, which is then warmed in a bowl of water to 56° C. being shaken gently at intervals. The agar at the same time is cooled to 56° C. and then added to the blood and glucose and *mixed thoroughly*. The sterilised two-way stopper with the tubes and pinch cock as indicated in the diagram is then fitted and the flask promptly inverted and supported in a cloth-covered iron ring on a retort stand. The medium is distributed fairly deeply into sterile petri-dishes each with a tightly fitting filter paper in the lid. It is sterilised at 70° C. for 3–4 hours on the first day and on the second day heated slowly (four hours) to 80° C. The plates are then inverted and stored in the dark. The two most important points are *thorough defibrination* and *thorough mixing* of the blood with the agar, failure in the second respect entailing the formation of more or less extensive serum blisters. A good sample should have the appearance of a high-grade milk chocolate and have a slightly soft rubbery touch. If too hard it is unsuitable. This medium is admittedly slightly tedious to make up but its value is undoubted Working with translucent media such as agar and gelatin one is faced by a bewildering number of approximately white colonies and the surface and margin characters are the only macroscopic means of readily differentiating them. With the opaque blood medium, on the other hand, emphasis is given to slight differences both in colour and transparency, with the further advantage that many organisms react with the haemoglobin and acquire a characteristic coloration varying from shell pink to brown.

The routine I have adopted is to inoculate a number of plates with 0·05 cc. of sea-water taken, with a capillary pipette, from just below the surface of a selected tank and distributed over the surface with a small glass 'spreader.' The plates are incubated at 20° C. for 3–5 days and colonies which are common to a number are sub-cultured on to two agar slopes and into trypsin broth, a record being made of the size, configuration, margin, consistency and colour of the primary growth.

From the broth culture the following observations are made after 48 hours' incubation :—

1. A loopful is mounted as a hanging drop to determine form and motility.
2. A loopful is placed in the centre of a clean cover slip, held for a moment in the fumes of 1% osmic acid and then inverted on a clean slide. Measurements are carried out on this material and variations in length, etc. noted.

The culture is then left undisturbed to study the nature of the continued growth, e.g. the development or not of uniform turbidity, sedimentation, the formation of flocculi, development or not of a surface scum.

If the organism is motile a film is made from a 24-hour culture on agar. The method which has given the best results is that of Stephens.* A little of the culture is rubbed up in a small drop of water in a watch glass and from this a *very small* loopful is transferred to a *minute* drop of water on an absolutely clean grease-free slide, mixed and spread at once. If this operation has been properly done the film should dry immediately. It is then mordanted for 1–2 minutes in the following :—

2% Aqueous Solution of	Osmic Acid	1 part.
20% ,, ,,	Tannin	3–4 parts.

after which it is washed thoroughly in running water and drained well.

A few drops of silver nitrate solution (silver nitrate crystals, 1 gramme ; water 100 cc.) are then placed on the film for a few seconds and the excess shaken off. A drop of reducing solution (2% aqueous solution of gallic acid, 1 part ; ammonia *fort.*, 1 part) is placed on the centre of the film which rapidly blackens. As soon as blackening is complete rinse in tap water, pour on a few drops of the silver solution for about 30 seconds, rinse again in tap water, blot and dry over a flame.

From the agar slopes the following sub-cultures are recommended as a routine :—

1. Gelatin stab. Note the nature of the growth and of liquefaction if present.
2. Potato.
3. Carbohydrate media. These consist of peptone water with the addition of the appropriate carbohydrate and an indicator. A Durham's tube is usually inserted to collect some of the gas given off. Besson† gives the following general formula :—

Peptone	1–2 grammes.
Water	100 cc.
Test substance	1 gramme.
Litmus	Quant. suff.

Many carbohydrates are at present either unobtainable or cost prohibitive sums, but glucose, lactose, maltose, saccharose and mannite can be usually procured. Lately I have used acid fuchsin 0·5% solution as an indicator and find it distinctly preferable to litmus as it gives very

* Besson, A., Practical Bacteriology, Microbiology and Serum Therapy, trans. H. J. Hutchens, pp. 153–154, pub. Longmans and Co.

† Loc. cit., pp. 34–35.

sharp readings. The peptone water and added carbohydrate are rendered slightly alkaline with normal NaOH and 1% of the indicator added. Hot titration with N/10 HCl is employed, the acid being added cautiously until a *faint* pink colour appears. The medium is colourless when cold, and becomes bright red after inoculation with an acid producing organism.

4. Gran's medium or Drew's modification of this to study nitrate reduction if present.*

Weak dilutions of emulsified growth in filtered, sterilised sea-water should also be plated out on agar and gelatin plates and the character of the discrete colonies noted.

(A film should be made and stained by Gram's method.)

I should finally suggest a working knowledge of the following organisms as an essential since they have all been encountered during the investigations so far done: *Staphylococcus aureus*, *S. albus*, *Bacillus coli communis*, *B. proteus*, *B. fluorescens liquefaciens*, *B. fluorescens non-liquefaciens*, *B. Prodigiosus*, *and B. subtilis*.

* G. Harold Drew, 'On the Precipitation of Calcium Carbonate in the Sea, etc., J.M.B.A., Vol. IX, No. 4, 1913.

Seashore Diptera.

By

Colonel J. W. Yerbury.

THOUGH it is easy to write down this heading, it is by no means so to define it. The simplest and best definition seems to be "A dipteron which spends a considerable portion of its existence in salt or brackish water," but our present chaotic knowledge of the early life histories of shore diptera does not advance us far towards clearing up the doubtful period, and we are thrown back on the shore frequenting perfect insects, many of which are of wide distribution.

The insects have been grouped by surroundings and not topographically as it seems probable that more use can be got out of the list under this arrangement than in any other.

ROCKY SHORES.

Salt water pools on the rocks.

Clunio marinus Hal. Between Penlee Point and Rame Head. Uncommon.

Wet rocks.

Thalassomyia frauenfeldii Schiner. This fly occurred in fair numbers on the big blocks of chalk at Durleston Bay near Swanage, but several visits to the rocks between Bovisand and Wembury failed to produce any result, possibly the rocks under the Hoe would have given better results.

Wet rocks covered with growing seaweed. Big rocks.

Aphrosylus raptor Hal. Mount Batten Rum Bay, Bovisand, Coast Guard Station, East Prawle—it seems possible that this fly may spend some portion of its perfect state under water, as at the last mentioned locality they were flying at low water about the seaweed covered rocks quite a hundred yards from the shore. Fairly common.

Small rocks.

Aphrosylus ferox Hal. Mount Batten Rum Bay, Torcross. Common.

More or less dry rocks.

Fucellia maritima Hal. Stonehouse in front of the Winter Villa, Torcross; but common everywhere, perhaps has a preference for wet rocks and sandy shores.

Fucellia fucorum Fln. Sand Hills at Bantham, and heaps of dead seaweed on the shore—perhaps not so common as the preceding species.

Under dead seaweed on both rocky and sandy shores.

Scatophaga villipes Tett. On one occasion in fair numbers under seaweed in the little bay near the Picklecombe Lodge of Mount Edgcumbe Park; Torcross, a few with an interesting entirely red-legged variety; rare in Devonshire though more common in Cornwall, while it becomes quite common in the Scilly Isles (St. Marys).

Under dead seaweed both on rocky and sandy shores.

Scatophaga litorea Fln. Common all round the coast.

Ceratinostoma ostiorum Hal. Stonehouse in front of the Marine Villa on human ordure near high-water mark, generally distributed round the coast though hardly to be called common anywhere.

Limosina limosa Fln. A few under seaweed in the little Picklecombe Bay.

Borboridæ. Two or three species with the last, but no records kept of identification.

Malacomyia sciomyzina Hal. A few under seaweed in this bay, it occurs here and there along the coast but is never common.

Cœlopa pilipes Hal. Probably not uncommon but no record kept.

Fucomyia frigida Fln. In great numbers in the Picklecombe Bay, apparently the perfect insects were just emerging from a glutinous seaweed with thick almost circular stalks; many of the flies were deformed, the glutinous secretion of the seaweed having stuck their wings together. Common and generally distributed all round the coast.*

Orygma luctuosum Mg. Common everywhere, but appears to prefer the dry seaweed and other marine rejectamenta lying along the high-water mark of muddy creeks such as Millbrook and St. John's Creek.

Phoridæ. A few under seaweed in Picklecombe Bay, but no record kept of the species.

On thrift blossom.

Eristalis aeneus Scop. Fairly common in the early spring on the rocks between Bovisand and Wembury, probably breeds in the rocky pools and fissures in the rock.

* See a paper by Major E. V. Elwes, "The Life History of a Shore Fly," which appeared in Vol. II, No. 1 of the Journal of the Torquay Natural History Society, 1915

E. sepulchralis Linn. In the early spring in company with the last species, but wanders much further inland far into the Midlands where it breeds in the horse ponds. According to Lundbeck, *Diptera Danica*, Part V, *Syrphidæ*, these two species spend their early lifetime as is recorded below against *Stratiomyia longicornis*.

SANDY SHORES.

Wet sand.

Chersodromia hirta Walk. Under loose sea weed and also running about on the wet sand. Cawsand Bay and Torcross. Common.

Ch. cursitans Zett. Cawsand Bay and Torcross under wet seaweed. Common. It is an interesting question as to what becomes of these Empids at high water—do they make rafts of the seaweed and sail away to sea ? or are they carried with the seaweed up to high-water mark and left there to run away on to the dry sands ? Against this latter idea it may be noted that the Chersodromia found on the dry sand belongs as a rule to a third species.

Actora æstuum Mg. On wet sand and marine rejectamenta as a rule, common but apparently absent from our district—it is particularly abundant on the wet sands between the mouth of Poole Haven and the village of Studland, but is very difficult to catch being probably the most alert fly to be found in the British Isles.

Dry sand, marram grass and sand hills.

Œdoparea buccata Fln. Bantham Sand Hills on the Marram grass. Torcross on herbage on the shore, but rare in Devonshire.

Ochthiphila flavipalpis Hal. Bantham on the Marram grass.

Thereva annulata Fab. Bantham sitting on the ground among the Sand Hills, common on one of my visits to Bantham, but Therevidæ are almost absent from S. Devon.

Spilogaster protuberans Zett. Bantham on the sand between the plants of Marram grass. Rare.

Pebbly beds of small streams running across the sandy bays.

Hecamede albicans Mg. Below the Whitsand Bay Hotel on small pebbles in the bed of a stream running across the beach.

MUD FLATS AND SALT MARSHES.

Mud flats.

Machærium maritimæ Hal. Probably occurs on the wet mud flats of Millbrook, St. John's Creek, Warleigh, etc., but as these flats are unexplored nothing can be said about their inhabitants. This fly was in numbers in Poole Haven on the mud alongside of the Goathorn Peninsula, their surroundings there having much resemblance to those around Warleigh.

The flies were bred by Mr. Joshua Brown from cocoons found on the sands at a bay about two miles beyond Weston-super-Mare ; he also bred them from cocoons found in like situations at Weymouth. These cocoons are pale grey elongate ovals and appear to be composed of fine sand, and are to be seen in the B.M. Collection.

See " Brown, The Entomologist," Vol. VII, p. 207 and p. 215, 1874.

Hydrophorus bisetus Hal. A common seashore fly which occurs in great numbers at Poole Haven on the Parkstone side of the Sand Banks Peninsula.

Stratiomyia longicornis Scop. Possibly occurs in the neighbourhood of Warleigh and round the shores of the Lynher and Notter ; it was bred in 1874 by Mr. B. L. Rye from a larva found on the Lymington Salterns under rotting sea weed. This specimen is now in the B.M. Collection ; it may be noted, however, that Stratiomyidæ are rare insects in Devonshire.

Salt marsh.

Hæmatopota italica Mg. Sheviock Wood near the water's edge of the Lynher Creek, probably occurs elsewhere round the creek at the beds of Sea Lavender and Sea Aster.

Tephritis plantaginis Hal. Probably occurs abundantly at Sea Aster on the banks of the Lynher and Notter, as it has been taken in numbers in like situations at Walton-on-Naze, Parkstone, Port Talbot and other places round the coast.

Atylotus latistriatus Brauer. Possibly occurs about the mouth of the Notter at Sea Lavender, as several specimens were taken at Walton-on-Naze and Poole Haven in a similar locality.

Lispe litorea Flu. Probably occurs on the black mud of the salt marshes and at the edge of the ditch of the sea wall.

Lispe tentaculata. Very common in company with the last species, but it extends in the British Isles far inland on the mud round the edges of the horse ponds.

There are many species of Dolichopodidæ and Ephydridæ which occur on the mud flats and salt marshes along other parts of the coast and which are bound to occur round Plymouth, e.g. :

DOLICHOPODIDÆ.

Thinophilus flavipalpis.
Tachytrechus two or more species and others.

EPHYDRIDÆ.

Parydra more than one species.
Ephydra do.
Cœnia do.
Scatella do.

On the salt water pools, both on the rocks and in the salt marshes, a Dolichopid is often seen skimming along the surface of the water, this fly is generally *Hydrophotus bipunctarus*, but other species may have like habits.

The small streams trickling down the rocks on to the beach below are visited by many flies which may be called "Shore Flies," though many of them wander far inland, examples of these are :

DOLICHOPODIDÆ.

Syntormon pallipes.
Liancalus virens.

ANTHOMYIDÆ.

Many small species of *Cœnosininæ.*

ACALYPTRÆ.

Many families and species.

Another haunt which claims attention is the ditch on the land side of the sea wall. Here may be met with :

Two or more species of *Ceroxys*,
Dolichopodidæ of many species and genera,
Sciomyzidæ and other *Acalyptratæ.*

Lundbeck, in *Diptera danica*, Part IV, *Dolichopodidæ*, records 17 species as sea shore dwellers. Probably all these species occur in the neighbourhood of Plymouth.

Further Notes on the Young Gobiidæ from the Neighbourhood of Plymouth.

By

Marie V. Lebour, D.Sc.
Naturalist at the Plymouth Laboratory.

THE above paper on the Plymouth gobies (p. 48) was finished and in print before the new work of C. G. J. Petersen (" Beretning til Landbrugsministeriet fra den danske biologiske Station," XXVI, 1919) came to hand. Although a second description and differentiation of the common forms is now unnecessary after his accurate and detailed account of them, yet as a corroboration of his identifications and as a record of the occurrence and distribution of the young gobies to be found at Plymouth (three of which are not described by Petersen), it seems advisable to keep the whole of my work intact, although in some measure it contains a repetition of the conclusions arrived at by him. I have therefore altered nothing, except adding the words " up to 14 mm." with regard to *Gobius pictus* in the table, p. 79, and merely confine myself to a few notes in this appendix with regard to any slight differences between his specimens and those from Plymouth. The three species not described by Petersen, namely *Gobius elongatus*, *Gobius Jeffreysii* and *Gobius paganellus* are apparently, with the exception of *Gobius Jeffreysii*, not present at all in the Danish waters. On reading his conclusions as to the specific value of the number of vertebræ and fin rays I feel still more strongly that the form hitherto known as the deep water form of *Gobius minutus*, and which I have here distinguished as *Gobius elongatus*, is a true species, although closely related to *Gobius minutus*.

Petersen shows, and my notes agree with him, that *Gobius minutus*, *microps* and *pictus* are distinct species, separable by the number of vertebræ and fin rays and also to a certain extent by their pigmentation. Since the above paper was written I have hatched the young of all three species (isolating the members of each species and obtaining the eggs from properly identified specimens), which agree well with Petersen's figures with the exception of some of the small spots on the head and the dorsal tail spots which differ slightly from the Danish specimens. In the Plymouth *Gobius microps* just hatched, there are two chromatophores on the dorsal margin, one just above the anus, the other in the usual position opposite the large ventral ramifying chromatophore, the front one usually smaller, but both may be ramified. There is also a dorsal spot above the median head chromatophore (the median head chromatophore of Petersen is described by me as the large chromatophore beneath the auditory capsule, as it is median, Petersen's is the better term) similar to that in *Gobius pictus*, a spot behind the eye and one on the snout. The lower jaw spot and tongue spot are usually absent in the newly hatched Plymouth specimens.

The median head chromatophore is present in all three specimens when newly hatched. In *Gobius minutus* there is usually a small spot above it and again the lower jaw spot is usually absent, and on the dorsal margin there is often present a chromatophore opposite to the anus, as in *Gobius microps*, and there may also be a spot behind the eye which is also present in *Gobius pictus*. In *Gobius Ruthensparri* the dorsal spot above the median chromatophore is also present. It is thus evident that small variations are common in the pigmentation of the newly hatched young.

The pigmentation of all three, *Gobius minutus*, *microps* and *pictus*, beyond about 12 mm. seems to be developed rather earlier in the Danish specimens, especially the dorsal pigment. Further investigation has shown me that specimens of young *Gobius minutus* which have come up the estuaries may be much more pigmented than those from nearer the open sea, and that whilst the latter stay in the condition shown in Plate I, Fig. 1 of my paper on p. 56, and Petersen's Plate I, Fig. 7, up to 15 mm. or more, those from up the river are much more like the Danish figure from 12 to 16 mm. (Plate I, Fig. 8). A black chromatophore may be present dorsally at 12 mm. in the position of the yellow chromatophore, described by Petersen.

Gobius pictus agrees well with Petersen's figure of 1919 up to 15 mm., but his Figure 10, Plate I of 1917 of *Gobius minutus-microps*, which he now attributes to *pictus*, of 14.3 mm., and which I regarded as *microps* is much more pigmented than the Plymouth specimens of 14 mm. As the Danish specimens show dorsal pigment at the base of the first dorsal fin after 14 mm., my table on page 79 should read, after IV A*b* : No spot at the base of the last ray of 1st dorsal fin (up to 14 mm.), the words in brackets being added. The sensory papillæ on the back of the pectoral fin of the adult male mentioned by Petersen are present in the Plymouth specimens. The appearance and disappearance of *Gobius pictus* in Danish waters is interesting ; the adults are very common on sandy bottoms in the shallow waters of Plymouth Sound, half-grown specimens occurring sometimes, as recorded above, in the deeper waters.

Gobius Ruthensparri has, in all specimens counted from Plymouth, 11 fin-rays in its second dorsal and anal fin ; whereas this is rare in the Danish specimens, which usually have 10. Holt's Irish specimens also, with very few exceptions, have 11. Petersen records a few specimens having 31 vertebræ. With regard to his remark as to the last ray of the anal fin in gobies being double, it has here also always been counted as one.

In *Aphya* the Plymouth young so far examined have no pigment spot on the lower jaw which is usually present in the Danish specimens, and the Danish *Crystallogobius* young at 11 mm. have ventral pigment along the tail, and at 9 mm. a few spots ventrally and one dorsally ; my single specimen of 9 mm., with no tail pigment, is therefore probably not typical.

Marine Biological Association of the United Kingdom.

Report of the Council, 1918.

The Council and Officers.

Four meetings of the Council were held during the year at which the average attendance was eight. A Committee of four members visited and inspected the Plymouth Laboratory.

The meetings of the Council were held in the Rooms of the Royal Society, and the thanks of the Association are due to the Council of the Royal Society for allowing the use of their rooms.

The Council has to record with regret the death of the Rev. Dr. A. M. Norman, F.R.S., one of the original members and for thirty years a Vice-President of the Association, and of Mr. Edwin Waterhouse, also a Vice-President, who for many years generously served the Association as Honorary Auditor.

The Plymouth Laboratory.

In order to reduce the amount of gas used in pumping, the circulation of sea-water through the tanks has been stopped each day for six hours out of the twenty-four, three hours in the early morning and three hours in the evening. The fish and other animals in the aquarium have remained healthy and do not seem to have suffered in any way from the restriction. The engines and pumps have worked satisfactorily, though a good deal of our machinery is now getting old and will soon require attention.

The Boats.

The steamer *Oithona* was requisitioned by the Admiralty at the beginning of the year and has been used for war purposes. The rate of hire paid for the vessel has been one pound per day.

Collecting work in and around Plymouth Sound has been carried on during the year by the eighteen-foot sailing boat *Anton Dohrn*.

The Staff.

There were no changes in the staff during 1918, the Director (Dr. E. J. Allen, F.R.S.), Dr. Marie V. Lebour and Miss G. E. Webb being regularly employed.

The Council are glad to record that all the members of the staff who joined H.M. Forces are alive and well, and it is hoped that they will all return to their work at the Laboratory. These names are Messrs. L. R. Crawshay, E. W. Nelson, J. H. Orton, R. S. Clark and E. Ford.

Occupation of Tables.

The following naturalists have occupied tables at the Plymouth Laboratory during the year :—

W. De Morgan, Plymouth (Pomatoceros and Protozoa).
Dr. E. S. Goodrich, F.R.S., Oxford (Blood Corpuscles).
Mrs. Goodrich, Oxford (Parasitic Protista).
Miss H. S. Pearson, London (General Zoology),
Mrs. E. W. Sexton, Plymouth (Gammarus).
Capt. A. K. Totton, M.C., London (Hydrozoa).
Capt. R. E. Trebilcock, A.I.F., M.C., Victoria (Hydroids).
Dr. W. Wallace, London (*Ostrea edulis*).
Dr. A. Willey, F.R.S., Montreal.

General Work at the Plymouth Laboratory.

Continuing his work on the culture of plankton organisms, Dr. Allen has been able to show by actually growing the organisms, that the number of individuals living in samples of sea-water taken outside the Sound is very much larger than can be demonstrated by the use of the centrifuge, the method which had previously given the highest figures. A paper on the subject has been prepared for the next number of the Journal.

Dr. Marie Lebour has again been examining and recording the food of post-larval and young fish collected in Plymouth Sound and its immediate neighbourhood. A second paper, containing her results for 1918, is in the printer's hands. Dr. Lebour has also been able to make some interesting observations on the feeding habits of some of the young fishes, as seen by watching them in small glass aquaria kept in the Laboratory tanks.

In addition to this work on the food of young fishes, Dr. Lebour has devoted her attention to the discrimination of the different species of *Gobius* in their young stages. A descriptive paper on this subject is nearly ready for publication.

Miss G. E. Webb has been assisting Dr. Lebour's work by a regular examination of the plankton during the year. She has also made a special study of the life histories of two species of the burrowing crustacean *Gebia*, the larvæ of which are always a conspicuous feature in the summer and autumn tow-nettings taken off Plymouth.

One number of the Journal has been issued during the year. It contains a paper by Mr. D. Ward Cutler entitled " A Preliminary Account of the Production of Annual Rings in the Scales of Plaice and Flounders," and describes the results of experiments carried out in the Laboratory to ascertain the effect of differences of temperature and differences in the food supply on the growth of the scales of these fishes. Mr. Cutler concludes that high temperatures, such as are found in the summer months, lead to the formation of broad bands (sclerites) on the scales, whilst narrow ones are called forth by low winter temperatures. To the same number of the Journal Dr. Lebour contributes, in addition to the account of the food of past-larval fishes in 1917, a paper on Trematode parasites of the whelk and of some young fishes. Mr. J. H. Keys gives records of the different beetles (Coleoptera), which live on the shores of Devon and Cornwall.

Mrs. E. W. Sexton has continued the study of the inheritance of eye-colour in the amphipod *Gammarus chevreuxi*, and results of considerable theoretical interest have been obtained. She has also acted as district secretary in connection with a scheme for the collection and preparation of Carragheen sea-weeds (*Chondrus crispus* and *Gigartina mamillosa*) for use as gelatine substitutes in Red Cross hospitals. This has involved a good deal of experimental work in order to find out the most satisfactory method of curing the weed.

Dr. W. Wallace, now an official of the Board of Agriculture and Fisheries and formerly a member of the Association's staff, spent some time at the Laboratory studying the food of oysters, and in arranging some experiments on the subject which are still being continued by the Laboratory staff.

The Library.

The thanks of the Association are again due to numerous Government Departments, Universities, and other institutions at home and abroad for copies of books and current numbers of periodicals presented to the Library. The list is similar to that published in the Reports of Council of former years. Thanks are due also to those authors who have sent reprints of their papers for the Library.

Donations and Receipts.

The receipts for the year include a grant from H.M. Treasury of £500 and a grant from the Board of Agriculture and Fisheries, Development Fund (£400). In addition to these grants there have been received Annual Subscriptions (£100), Composition Fees (£30), Rent of Tables in the Laboratory, including £25 from the University of London, and £20 from the Trustees of the Ray Lankester Fund (£45), Sale of Specimens (£425) and Admission to Tank Room (£119).

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1919–20 :—

President.

Sir E. RAY LANKESTER, K.C.B., LL.D., F.R.S.

Vice-Presidents.

The Duke of BEDFORD, K.G.
The Earl of DUCIE, F.R.S.
The Earl of STRADBROKE, C.V.O., C.B.
Lord MONTAGU OF BEAULIEU.
Lord WALSINGHAM, F.R.S.
The Right Hon. A. J. BALFOUR, M.P., F.R.S.
The Right Hon. AUSTEN CHAMBERLAIN, M.P.
W. ASTOR, Esq., M.P.
G. A. BOULENGER, Esq., F.R.S.
Sir ARTHUR STEEL-MAITLAND, Bart., M.P.
Prof. W. C. McINTOSH, F.R.S.

COUNCIL.

Elected Members.

Prof. W. M. BAYLISS, D.SC., F.R.S.
L. A. BORRADAILE, Esq.
W. T. CALMAN, Esq., D.SC.
W. C. DE MORGAN, Esq.
Prof. F. W. GAMBLE, D.SC., F.R.S.
E. S. GOODRICH, Esq., D.SC., F.R.S.
J. GRAY, Esq.
S. F. HARMER, Esq., SC.D., F.R.S.
E. W. L. HOLT, Esq.
Prof. E. W. MACBRIDE, D.SC., F.R.S.
H. G. MAURICE, Esq., C.B.
F. A. POTTS, Esq.
C. TATE REGAN, Esq., F.R.S.
Prof. D'ARCY W. THOMPSON, C.B. F.R.S.

Chairman of Council.

A. E. SHIPLEY, Esq., D.SC., F.R.S.

Hon. Treasurer.

GEORGE EVANS, Esq.

Hon. Secretary.

E. J. ALLEN, Esq., D.SC., F.R.S.,
The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of Council :—

G. P. Bidder, Esq., Sc.D.

Ronald Malcolm, Esq. (Prime Warden of the Fishmongers' Company).

W. T. Brand, Esq. (Fishmongers' Company).

George Evans, Esq. (Fishmongers' Company).

R. L. Towgood, Esq. (Fishmongers' Company).

T. T. Greg, Esq. (Fishmongers' Company).

Major Nigel O. Walker, O.B.E. (Fishmongers' Company).

Prof. G. C. Bourne, D.Sc., F.R.S. (Oxford University).

A. E. Shipley, Esq., D.Sc., F.R.S. (Cambridge University).

Prof. W. A. Herdman, D.Sc., F.R.S. (British Association).

Dr. *Statement of Receipts and Payments for*

		£ s. d.	£ s. d.
To Balances from Last Year :—			
Cash at Bankers		568 15 10	
Cash in hand		7 1 1	575 16 11
,, Current Receipts :—			
H.M. Treasury for the year ending 31st March, 1919		500 0 0	
Board of Agriculture and Fisheries to 31st March, 1918		400 0 0	
Annual Subscriptions		99 14 11	
Rent of Tables (Ray Lankester's Trustees, £20; University of London, £25)		45 0 0	
Interest on Investments		11 18 2	
,, Deposit		12 9 2	1,069 2 3
,, Extraordinary Receipts :—			
Donations, G. H. Fox	£0 10 6		
,, S. A. Walton	1 1 0	1 11 6	
Naval Bank—Dividend		1 19 10	
Composition Fees		30 15 0	34 6 4
,, Laboratory Boats and Sundry Receipts :—			
Sale of Apparat		2 8 6	
,, ,, Specimens		425 7 3	
,, ,, Nets, and Gear, etc.		265 6 10	
Hire of "Oithona"		289 0 0	
Other Items		8 1 6	990 4 1
			£2,669 9 7

The Association's Bankers hold on its behalf:—

£410 14s. 8d. New Zealand 4% Stock, 1943–63.

£373 0s. 0d. War Savings Certificates.

the Year ending 31*st December*, 1918. **Cr.**

	£ s. d.	£ s. d.
By Investment in £373 War Savings Certificates, being the money received for the Hire of the "Oithona"		289 1 6
By Salaries and Wages—		
Director	300 0 0	
Senior Naturalist	51 12 6	
Additional ,, ...	131 15 6	
,, ,, ...	180 0 0	
Assistant ,, ...	13 2 6	
,, ,, (temporary)	130 13 0	
Salaries and Wages	468 12 1	1,275 15 7
,, Travelling Expenses		26 0 3
,, Library........	35 1 5	
Less Sales of Duplicates	1 1 5	34 0 0
,, Journal........	87 5 6	
Less Sales........	14 14 9	72 10 9
,, Buildings and Public Tank Room—		
Gas, Water, and Coal	165 10 1	
Stocking Tanks and Feeding	21 1 6	
Maintenance and Renewals	148 2 4	
Rent, Rates, Taxes, and Insurance........	60 11 3	
	395 5 2	
Less Admission to Tank Room........	119 13 0	275 12 2
,, Laboratory, Boats, and Sundry Expenses—		
Glass, Apparatus, and Chemicals	51 18 0	
Purchase of Specimens	67 7 6	
Maintenance and Renewal of Boats, Nets, etc.	58 9 11	
Boat Hire and Collecting Expenses........	5 2 3	
Stationery, Office Expenses, Carriage, Printing, etc.	87 18 3	270 15 11
,, Balance :—		
Cash at Bankers	422 0 5	
Cash in hand	3 13 0	425 13 5
		£2,669 9 7

Examined and found correct,

(Signed) N. E. Waterhouse.
Thomas T. Greg.
J. O. Borley.
Edward T. Browne.

3 *Frederick's Place,*
Old Jewry, London, E.C. 2
31*st January*, 1919.

List of Annual Subscriptions

Paid during the Year 1918.

	£	s.	d.
A. Adams, Esq., M.B., B.CH.	1	1	0
W. M. Aders, Esq.	1	1	0
E. J. Allen, Esq., D.SC., F.R.S.	1	1	0
G. L. Alward, Esq.	1	1	0
J. H. Ashworth, Esq., D.SC., F.R.S.	1	1	0
John Bawcomb, Esq.	1	1	0
Prof. W. M. Bayliss, D.SC., F.R.S.	1	1	0
Mrs. M. G. Bidder	1	1	0
E. J. Bles, Esq., D.SC.	1	1	0
H. H. Bloomer, Esq.	1	1	0
L. A. Borradaile, Esq.	1	1	0
Colonel H. Bowles	1	1	0
Sir John Rose Bradford, K.C.M.G., F.R.S.	1	1	0
H. H. Brindley, Esq.	1	1	0
E. T. Browne, Esq.	1	1	0
Mrs. E. T. Browne	1	1	0
L. W. Byrne, Esq.	1	1	0
Prof. Charles Chilton	1	1	0
J. Clark, Esq., D.SC.	1	1	0
G. S. R. Kitson Clarke, Esq.	1	1	0
L. R. Crawshay, Esq.	1	1	0
Monsieur J. Delphuy	1	1	11
W. C. DeMorgan, Esq.	1	1	0
Prof. A. Dendy, F.R.S.	1	1	0
F. A. Dixey, Esq.	1	1	0
C. Clifford Dobell, Esq.	1	1	0
F. Martin Duncan, Esq.	1	1	0
Major E. V. Elwes	1	1	0
G. Evans, Esq.	1	1	0
Sir David Ferrier, F.R.S.	1	1	0
R. Foster, Esq.	1	1	0
G. H. Fowler, Esq., PH.D.	1	1	0
H. M. Fox, Esq.	1	1	0
Prof. F. W. Gamble, D.SC., F.R.S.	1	1	0
E. S. Goodrich, Esq., D.SC., F.R.S.	1	1	0
Prof. F. Guitel	1	1	0
Sir Eustace Gurney	1	1	0
Prof. W. D. Halliburton, F.R.S.	1	1	0
Commander M. W. Campbell Hepworth	1	1	0
Prof. W. A. Herdman, F.R.S. (1917 and 1918)	2	2	0
Carried forward	43	1	11

95

	£	s.	d.
Brought forward	43	1	11
Prof. S. J. Hickson, D.Sc., F.R.S.	1	1	0
Prof. J. P. Hill, F.R.S.	1	1	0
T. V. Hodgson, Esq.	1	1	0
W. E. Hoyle, Esq., D.Sc.	1	1	0
P. Hoyte, Esq.	1	1	0
R. Kirkpatrick, Esq.	1	1	0
D. G. Lillie, Esq.	1	1	0
J. J. Lister, Esq., F.R.S.	1	1	0
Prof. E. W. MacBride, D.Sc., F.R.S.	1	1	0
W. N. McClean, Esq.	1	1	0
S. Makovski, Esq.	1	1	0
D. J. Matthews, Esq. (1917 and 1918)	2	2	0
J. H. Midgley, Esq.	1	1	0
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OBJECTS

OF THE

Marine Biological Association

OF THE UNITED KINGDOM.

THE ASSOCIATION was founded at a Meeting called for the purpose in March, 1884, and held in the Rooms of the Royal Society of London.

The late Professor HUXLEY, at that time President of the Royal Society, took the chair, and amongst the speakers in support of the project were the late Duke of ARGYLL, the late Sir LYON PLAYFAIR, the late Lord AVEBURY, the late Sir JOSEPH HOOKER, the late Dr. CARPENTER, the late Dr. GÜNTHER, the late Lord DALHOUSIE, the late Professor MOSELEY, the late Mr. ROMANES, and Sir E. RAY LANKESTER.

The Association owes its existence and its present satisfactory condition to a combination of scientific naturalists, and of gentlemen who, from philanthropic or practical reasons, are specially interested in the great sea fisheries of the United Kingdom. It is universally admitted that our knowledge of the habits and conditions of life of sea fishes is very small, and insufficient to enable either the practical fisherman or the Legislature to take measures calculated to ensure to the country the greatest return from the "harvest of the sea." Naturalists are, on the other hand, anxious to push further our knowledge of marine life and its conditions. Hence the Association has erected at Plymouth a thoroughly efficient Laboratory, where naturalists may study the history of marine animals and plants in general, and where researches on food-fishes and molluscs may be carried out with the best appliances.

The Laboratory and its fittings were completed in June, 1888, at a cost of some £12,000. Since that time investigations, practical and scientific, have been constantly pursued at Plymouth. Practical investigations upon matters connected with sea-fishing are carried on under the direction of the Council; in addition, naturalists from England and from abroad have come to the Laboratory, to carry on their own independent researches, and have made valuable additions to zoological and botanical science, at the expense of a small rent for the use of a working table in the Laboratory and other appliances. The number of naturalists who can be employed by the Association in special investigations on fishery questions, and definitely retained for the purpose of carrying on those researches throughout the year, must depend on the funds subscribed by private individuals and public bodies for the purpose. The first charges on the revenue of the Association are the working of the sea-water circulation in the tanks, stocking the tanks with fish and feeding the latter, the payment of servants and fishermen, the hire and maintenance of fishing-boats, and the salary of the Resident Director and Staff. At the commencement of this number will be found the names of the gentlemen on the Staff.

The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

CONTENTS OF NEW SERIES, Vol. XII., No. 1.

NOTICE.

The Council of the Marine Biological Association wish it to be understood that they do not accept responsibility for statements published in this Journal excepting when those statements are contained in an official report of the Council.

TERMS OF MEMBERSHIP.

		£	s.	d.
Annual Members	per annum	1	1	0
Life Members	Composition Fee	15	15	0
Founders		100	0	0
Governors		500	0	0

Members of the Association have the following rights and privileges: they elect annually the Officers and Council; they receive the Journal of the Association free by post; they are admitted to view the Laboratory at Plymouth, and may introduce friends with them; they have the first claim to rent a place in the Laboratory for research, with use of tanks, boats, &c.; and have access to the books in the Library at Plymouth.

All correspondence should be addressed to the Director, The Laboratory, Plymouth.