Clione limacina in Plymouth Waters.

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With Plates I and II.

THE pteropod *Clione limacina* (Phipps), now regarded as one of the tectibranchs, occurs at times in the neighbourhood of Plymouth. In 1930, however, it was extraordinarily abundant, especially in the summer, and was breeding freely. Although not specially recorded it has been seen singly or in small numbers in almost any month of the year, and for some years the eggs and larvæ (not recognised at the time as belonging to Clione) have been seen in summer. So far it is known from the British coasts in the North Sea and the west and extreme south-west of England. Its distribution, as known up to 1908, is given fully for the area of International Fisheries Investigations by Paulsen (1910). There it is shown that it is an Arctic-boreal species, spreading southwards nearly to the Bay of Biscay, which is about its southerly limit. It is known to occur in the northern and mid North Sea, but not in the southern North Sea, and at that time was only recorded from the Channel in the extreme west. It is also common in the Atlantic. Paulsen was led to infer that *Clione limacina* did not enter the North Sea from the Channel, but its prevalence sometimes at Plymouth shows that it can come a long way up the Channel and, as few samples are taken to the east and in the southern North Sea, this view should be carefully reconsidered. It was also thought that the presence of *Clione limacina* indicated Atlantic water, but as it may be found in almost any month and breeds at Plymouth in summer, and as its large numbers do not specially coincide with any influx of Atlantic water, it seems more reasonable to suppose that it is a permanent member of the Channel plankton.

Paulsen (*op. cit.*) thinks that the nets used are too small for Clione, but at Plymouth the larvæ may be found in the finest tow-nettings (180 strands to the inch). It is perhaps more probable that the small larvæ, if present, are not generally recognised. At Plymouth the larvæ have been found in the tow-nettings of any mesh, and the adults in medium and course tow-nettings and in the ring-trawl.

Clione limacina usually occurs with *Limacina retroversa*, on which it probably feeds, as the usual food in Arctic waters is *Limacina arctica*, a closely related species. It also feeds on other plankton organisms, being extremely voracious and armed with powerful hooks, strong radula, tentacles, and head-cones. It is itself economically important, for not only does it form an important food for whales in Arctic waters, but is also largely eaten by mackerel and herring. Hardy (1924) states that in the North Sea *Clione limacina*, although of much less importance than Limacina, was taken in fair numbers in the summer of both 1922 and 1923 and formed about 0·21 per cent of the total year's food of the herring.

M'Intosh (1898) has described the late larvæ in various stages from St. Andrews Bay, all of which agree well with the Plymouth specimens. He shows that the southern examples are much smaller than the Arctic forms. Paulsen (*op. cit.*) is of the opinion that the Arctic form and the more southerly form are two distinct races. The Plymouth specimens are mature at 4 or 5 mm., the largest reaching to 12 mm. ; even at 3 mm. they may contain quite large eggs. M'Intosh's largest specimen measured 12 mm. The Arctic form reaches 40–41 mm. In support of Paulsen's view it is found that there are many more teeth in the radula of the adult Arctic form. The usual formula is 14–1–14 or 13–1–13, the side teeth being less in the younger individuals and gradually increasing with age (Pelseneer, 1886). In the Plymouth form the formula is 4–1–4 or 3–1–3 for all adults examined, ranging from 4 to 10 mm. in length. In no case have more than 4 side teeth been found. Thus the adults of the southern form have a radula formula similar to the young of the Arctic form. Another difference is the colour, which is much less intense than in the Arctic form, the hermaphrodite organ being a pale pinkish yellow instead of the brilliant orange-red of the Arctic form. It appears thus that we have truly a southerly form of *Clione limacina* differing from the northern form in size, radula formula, and colour.

In the Arctic regions *Clione limacina* spawns in shallow water ; in the Atlantic it spawns in the open sea. So far the breeding habits of the southern form have never been described.

Clione limacina may occur at Plymouth in any month of the year. The largest specimens have been seen in February and March and in August. The greatest number were seen in the summer of 1930 when all through June until the middle of August they were abundant, adults, young, and eggs were to be found in the plankton both from the outside waters and inside the Sound. Mr. O. D. Hunt notes that it also occurred abundantly in the neighbourhood of the River Yealm, going up the river, and that they reached 10 mm. in length. They were not seen to breed except in the summer months and at this time nearly every individual from 3 mm. in length carried eggs. If one of these laid eggs in a bowl, more eggs were seen

inside, indicating more than one brood. Moreover, development takes place very quickly, and probably only a few months are needed for quite a large size to be attained. It is very likely that those eggs laid in the summer yield mature animals the following summer.

If placed in a bowl on the Laboratory bench the mature individuals will nearly always lay eggs overnight. From these eggs some of the larvæ were reared until the stage in which the shell was lost and the three circlets of cilia were formed.

The later larvæ of *Clione limacina* have often been described, but the younger larvæ which are provided with a shell are not so well known, although very young larvæ of other species of the Clionidæ have been briefly described (Krohn, 1860). From the work of Fol (1875) we know the general form of the spawn of various pteropods, which appears to be of the same character in all species, both thecate and naked. The eggs are minute and laid in a perfectly transparent gelatinous ribbon, which is sometimes free and sometimes entangled in any light hairy object which may be floating in the plankton. There seems to be no reason to think, as Paulsen (*op. cit.*) has suggested, that they are laid on the bottom, for the eggs of both Clione and Limacina frequently appear in the plankton at Plymouth. The eggs are placed in the gelatinous ribbon at regular intervals, arranged differently in the different species, and are themselves perfectly transparent and begin to develop when only a few hours old, emerging as larvæ, with or without a shell according to the species.

Clione limacina has been described many times, the chief works being those of Eschricht (1838), Souleyet (1852), Boas (1886), Wagner (1885), Pelseneer (1886) and Meisenheimer (1906). All these treat mainly of the purely Arctic form. M'Intosh's (*op. cit.*) description of the southern form from St. Andrews Bay shows the differences between the two.

The eggs of *Clione limacina* are laid in a clear oblong or square gelatinous mass, sometimes more elongated, the matrix being very elastic and catching in any light obstacle which may be floating about. A typical mass may measure about 1 mm. to 1·2 mm. across, the perfectly colourless eggs being scattered about irregularly, of an oval shape, and measuring about 0·09 mm. by 0·08 mm. (Plate I, Figs. 1 and 2). In two or three days the larvæ emerge. The newly-hatched larva has a thimble-shaped shell, usually slightly irregular, measure about 0·15 to 0·16 mm. in length and 0·11 mm. in breadth. The shell is very thin and perfectly transparent, slightly pointed at the end, with the mouth widening a little. The larva is fixed to the shell by longitudinal muscles reaching from near the tip to the mouth of the shell (Plate I, Figs. 3, 4, 5). There is a well-developed bi-lobed velum edged with large cilia and a ridge below edged with small cilia, the two forming a groove to the mouth. The whole animal, including

the velum, is capable of complete retraction into the shell. The beginning of the foot sticks out between the velar lobes and is ciliated all over, stomach, intestine, and liver are seen and there are two conspicuous otoliths. The larva grows rapidly ; two or three days after hatching the shell has increased in length to about 0·18 mm. and the margin of the shell is finely striated longitudinally (Plate I, Fig. 6). The velum projects far out of the shell when the animal is swimming. In the next few days the shell rapidly increases, very soon almost doubling its original length. It has now reached the maximum size (Plate I, Figs. 7–8). Spicules can be seen lining the stomach and in it remains of food. The larvæ in the bowls were given a pure culture of Nitzschia and the spermatozoids of Fucus, but the food inside the stomach was not usually recognisable. The dinoflagellate *Prorocentrum micans* was once seen in the œsophagus of a larva which had lost its shell. There is strong ciliation down the intestine, œsophagus, and round the mouth region. The shell now disappears. It was not possible to be certain whether it was cast off or absorbed, but it is probable that it was cast off, as empty shells were found in the bowl. There are now three circlets of cilia round the larva, one at the neck, just below the velum, one near the centre of the body, and one at the hind end (Plate I, Fig. 10 ; Plate II, Figs. 1–6). The whole body is covered with very fine cilia. Beginnings of the radula can now be seen and the tentacles and head-cones begin to form ; the foot shows a small hind lobe and the velum very soon disappears. The larvæ were reared in the finger-bowls until the disappearance of the velum when they were 17 and 18 days old and measured about 0·32 mm. in length. After this they died. They were still quite colourless and transparent. Larvæ were then collected from the plankton, the earlier stages corresponding exactly with those reared in the bowls. From this stage onwards the internal organs gradually move forward so that, as has been noted by many workers, in the adult they occupy only the fore part of the body, leaving the hind part for the developing ova. Larvæ from the plankton slightly older than those reared in the bowls and measuring 0·48 mm. in length had head-cones, tentacles and hooks well developed, the radula present, the wings beginning to form behind the foot ventrally (Plate I, Fig. 11). The liver and intestinal mass has begun to move forward. At about 0·9 mm. to 2 mm. the wings are still more developed and at 2 mm. they may project well beyond the sides of the body. Whilst they are developing the ring of cilia at the neck becomes irregular as it is interrupted ventrally by the foot and wings. At 2 mm. the intestinal mass lies almost entirely in front of the middle ring of cilia (Plate II, Figs. 1–6). At 2·8 mm. all the cilia may have disappeared and the wings are well developed, the penis showing at the right side. The last row of cilia may however persist even when the animal is breeding. In a specimen 3 mm. long all the organs are formed,

and it may now lay eggs. One specimen, 2·8 mm. long, had eggs nearly ripe occupying the hind end of the body (Plate II, Fig. 7) and one of 3 mm. laid eggs in the Laboratory. Fol (*op. cit.*) notes that a young *Clione aurantiaca* Fol. from Messina which still retained the last ring of cilia was full of eggs. Pelseneer (*op. cit.*) suggests that this is *Clione flavescens*. The animals have gradually been acquiring red and orange pigment in parts, and although the adult is fairly transparent it is much less so than in the young stages. The head end is bright orange-red, especially the head-cones and tentacles and round the mouth, also orange-red at the extreme hind end, the penis being pinkish yellow. The liver which surrounds the intestinal mass is dark brown and very conspicuous, the gonad sometimes pinkish yellow or sometimes colourless and the wings a pale pink.

In 1930 Clione was unusually abundant in the neighbourhood of Plymouth, but it had also been noticed in fair numbers, though not specially recorded, in the previous years. In 1931, however, it was not seen after January until late in August, when it was plentiful in the outside grounds. It is evidently irregular in its appearances. The following records from 1930 to September, 1931 (when it was last seen), are given, showing that it has been observed every month during one year :—

1930. *January, February, March, April, May*—in ring-trawl, from outside, fairly large specimens, especially in February. In tow-nettings occasionally both inside and outside Sound.

June. Abundant all through the month. Many adults and young, especially from outside. Eggs just seen in fine tow-net from W. of Eddystone on June 30th.

July. Eggs, young of all ages, and adults very plentiful, inside and outside. On July 17/18 one specimen of 4 mm. laid eggs during the night in a finger-bowl. Many more did the same all through July.

August. Many in early part outside and inside, eggs, young and adult, gradually dwindling, very few in latter part.

September. Very few. A few still breeding.

October 28*th*. One 1·9 mm. long, with hind circlet of cilia, from beyond Eddystone.

November 6*th*. One with 3 circlets of cilia, from outside. *November* 17*th*. Two with 3 circlets of cilia, 4 miles south of Penlee. *November* 21*st*. One larva with 3 circlets of cilia. Between New Grounds and Breakwater.

December 3*rd*. Three larvæ with 3 circlets of cilia, off Eddystone. *December* 4*th*. One with 3 circlets of cilia, off Rame. *December* 18*th*.

Three with 3 circlets of cilia, from Sound. *December* 19*th*. Two with 3 circlets of cilia, off Mewstone.

1931. *January* 19*th*. Two with 3 circlets of cilia, off Mewstone.

August 25*th*. A few mature specimens and one larva with 3 circlets of cilia, outside Sound. Some laid eggs in the Laboratory which hatched.

26*th*. About 150 mature specimens and many larvæ from Station E 2 between Eddystone and Ushant.

28*th*. A few adults, one larva with 3 circlets of cilia, near Eddystone. Two larvæ from inside the Sound.

September 3*rd*. Many adults and larvæ with 3 circlets, near Eddystone.

9*th*. A few adults and larvæ, near Eddystone.

16*th*. Two adults and a few late larvæ, near Eddystone.

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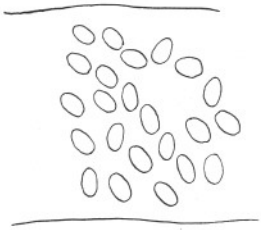
KEY TO FIGURES.

(Scale B is 6 times the scale of A.)

PLATE I. (Fig. 1 Scale A., 2–11 Scale B.) *Clione limacina.*

FIG. 1.—Ribbon of eggs, laid in finger-bowl, 30.6.30.
FIG. 2.—Egg a few hours old, 0·11 mm. long.
FIG. 3.—Empty shell of newly hatched larva, 0·14 mm. long.
FIG. 4.—Shell of newly hatched larva with animal retracted, 0·16 mm. long.
FIG. 5.—The same, side view, swimming.
FIG. 6.—Young larva, five days old, reared in Laboratory, 0·32 mm. long.
FIG. 7.—Empty shell of larva 12 days old, reared in Laboratory, 0·28 mm. long.
FIG. 8.—Larva 14 days old, reared in Laboratory, 0·38 mm. long.
FIG. 9.—Larva 16 days old, reared in Laboratory, having lost its shell, 0·35 mm. long.
FIG. 10.—Larva 18 days old, reared in Laboratory, having lost its velum, 0·32 mm. long.
FIG. 11.—Larva from plankton, 0·48 mm. long, side view.



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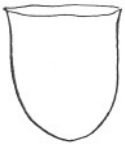

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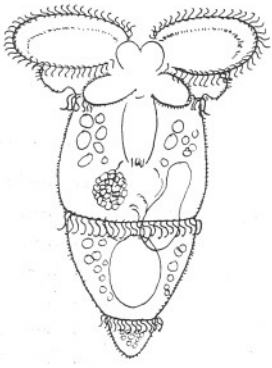

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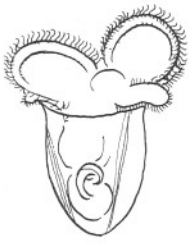

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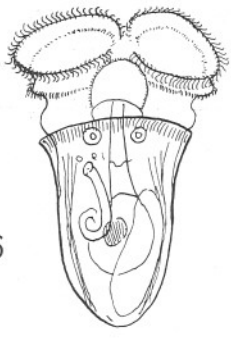

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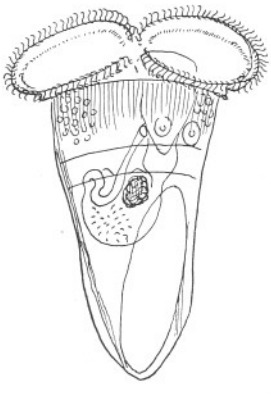

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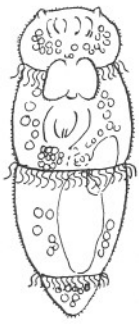

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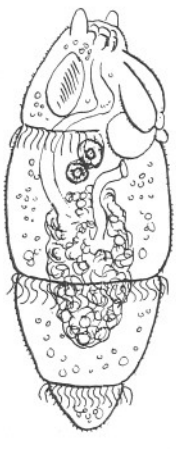

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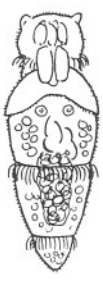
PLATE II. (Scale A.) *Clione limacina* from plankton.

FIG. 1.—Larva 0·96 mm. long, side view.
FIG. 2.—Larva 1 mm. long.
FIG. 3.—Larva 1·44 mm. long, ventral view.
FIG. 4.—Larva 1·6 mm. long, side view.
FIG. 5.—Larva 2 mm. long, dorsal view.
FIG. 6.—Larva 2 mm. long, ventral view, older than Fig. 6.
FIG. 7.—Larva 2·8 mm. long, with developing eggs.
FIG. 8.—Head of adult showing radula protruded.



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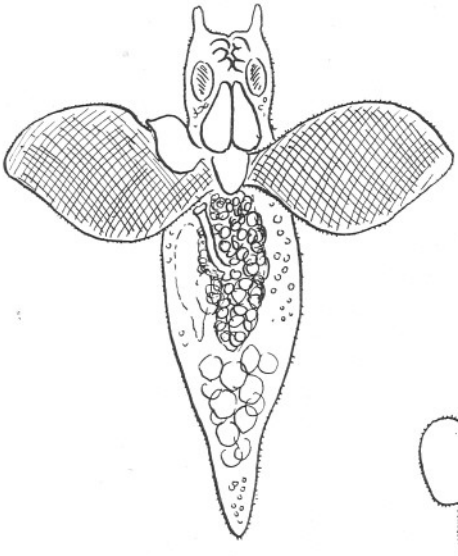

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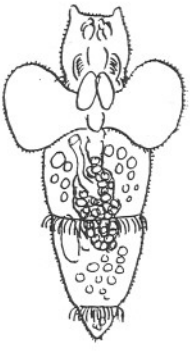

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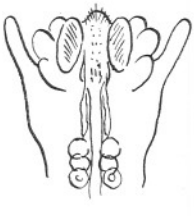

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