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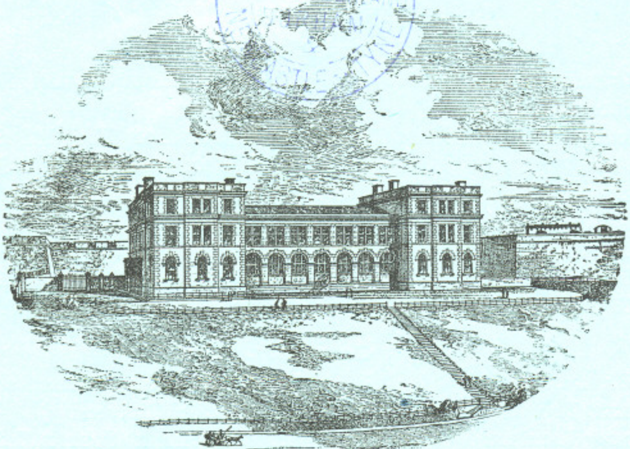

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Assistant to the Director.—H. N. DICKSON, Esq., F.R.S.E.

Journal of the Marine Biological Association.

Director's Report.

In accordance with a resolution of Council, I entered on my duties as Director on the 29th of November last.

On December 16th, Mr. Garstang, who had acted as assistant since the opening of the Laboratory, intimated that he had been successful in obtaining the Berkeley Fellowship at Owens College, and would require to take up his residence in Manchester at the commencement of the Winter term. Mr. Garstang left on the 30th of December, and on the 24th of January, his successor, Mr. H. N. Dickson, F.R.S.E., F.R.M.S., arrived.

Mr. Dickson is a physicist rather than a biologist, and has been identified for some years with the Scottish Meteorological Society, Ben Nevis Observatory, and the Challenger Office. In securing his services I desired to broaden the Association's range of observation by combining this branch of science with the biological work already in progress. In all questions concerning movements, migrations, and spawning of fishes, as well as the movements of their food, I am convinced that both the temperature and currents of the sea must be considered, and that a thorough knowledge cannot be obtained except by the combination of biological and physical observations.

The Council having signified its approval, physical work having in fact been a part of the original design of the Association, a scheme of work has been organised with the hope of eventually obtaining some valuable results in practical fishery questions. Observations will be taken systematically in the Channel, and in the harbours and estuaries in the neighbourhood, with the view of following changes in temperature and density at different seasons of the year and in different years. These observations will be discussed in relation to what fishery statistics are available. Efforts are also being made to interest fishermen in the subject, and to set them to make observations of surface temperature on the fishing grounds.

Besides practical work, Mr. Dickson hopes to deal with material already in existence. Through the courtesy of the Meteorological Council, access has been obtained to the extensive records of sea temperatures in the Meteorological Office. The Council were kind enough to instruct their Secretary, Mr. R. H. Scott, F.R.S., to render all possible assistance in the work, and a large number of documents have already reached Plymouth for criticism and discussion. It is hoped that the changes of temperature from month to month round the whole of the British coasts will be accurately determined; and former investigations of the kind lead to the hope that considerable light may be thrown on the movements of various species of fish.

Another important step taken within the last quarter was the appointment of Mr. Hughes, a chemist from Professor Meldola's laboratory, to carry on experiments as to the production of artificial baits. Mr. Hughes arrived on the 24th of February, and has since been busily engaged in making extracts of all the animals most commonly used as bait. The methods of making and applying these extracts, together with the results of trials, will of course form the subject of subsequent papers. For the present it is enough to state merely the general lines upon which the work is proceeding.

Dr. Grenfell, superintendent of the Mission to Deep Sea Fishermen, who has previously furnished collections of pelagic animals taken by means of the surface net, has kindly consented to add the taking of temperatures to his other observations. With this object in view, the thermometers already in his possession have been carefully examined, and he has been furnished with an additional instrument. Specially prepared books have also been provided so that he may the more easily tabulate his results.

The tank room of the Laboratory, from being open to the public only one day in the week, is now open every day (Sunday excepted), a small charge being made for admission. The system is in every way proving a success; the attendance, especially on holidays, remaining all but up to the former standard. Members are of course still admitted at any time free of charge.

The storm of the 9th of March, so disastrous to shipping and property generally, caused considerable damage to the boats of the Association. One, the hook and line boat, was fortunately beached for repair and escaped injury. The steam-launch was sunk at her moorings and had her funnel, two water tanks, and all inside fittings carried away. The pulling or sailing boat and dingey were both washed ashore, the former having her mast and inside wood-work considerably injured, but the latter, though found half full of mud and snow, has proved to be little the worse. The launch is now under repair and is to be handed over in a finished condition on the 9th of May.

The catalogue of books in the Library has been considerably augmented through the kindness of several members and others.

A valuable hydrometer has also been presented to the Association by D. Y. Buchanan, Esq., F.R.S.

With regard to the working of the Laboratory itself, little need be said, since all the important work of the staff is from time to time published in the Journal. In addition to the ordinary tanks, a hatching box on Captain Dunnevig's principle has been constructed and is now being used by Mr. Cunningham. The severity of the past season seems to have affected the animals in the tanks; the mortality, I am informed, has been decidedly above the average. Larval forms, also, seem scarce in the open sea, the tow-net showing enormous numbers of copepods, &c., but as yet (April 14th) not many larval stages of any importance.

Several experiments have been made with a view to determine the composition of the sea-water in this locality. The water outside Plymouth Sound, in the open Channel, has been compared with that just below the Laboratory, at the mouth of the pipe which supplies the tanks. The two samples agree in every way. The water in the tanks of the Laboratory has since been tested, with this somewhat singular result, that although perfectly normal as regards density it is distinctly deficient in carbonates.

This may possibly result from the system of keeping the same water in circulation over and over again without a fresh supply being brought in from the open sea; it should therefore easily be got over by more frequent pumping, the water at the mouth of the pipe being all that can be desired.

During the winter months only two gentlemen, other than the Permanent Staff, have taken advantage of the Laboratory :—E. A. Minchin, Esq., Anatomical Department, Oxford (Sponges), and T. H. Riches, Esq., late of Caius College, Cambridge (Paguridæ).

W. L. CALDERWOOD.

A few notes as to the methods of catching mackerel in this locality may be of interest.

In addition to the ordinary sunk or floating net—too well known to require description—what is locally known as "brimming" is much practised, especially by the Cornishmen.

Brimming is carried on during quiet nights. As the boat sails slowly along, a man in the bows, at short intervals, stamps loudly with his feet, lets the stock of the anchor fall suddenly on the rail, or makes some other noise, keeping at the same time a sharp look-out. The shoals of mackerel, startled by the sound, make one or two darts through the water, and cause quick flashes of phosphorescence. The suddenness of the flash distinguishes herring or mackerel from other less active fish. This is called the brim, and

The Plymouth Mackerel Fishery of 1889–90. From Data collected by Mr. Wm. Roach, Associate Member M. B. A.

By

W. L. Calderwood.

The returns kindly sent in by Mr. Roach have been tabulated in the following pages.

The period during which Mr. Roach made his observations extends from October 23rd, 1889, to September 29th, 1890.

Concerning the particular localities in which the fish have been caught, it may be useful, for those who are not familiar with the coast, to explain that the fish make their appearance on the coast at a considerable distance to the east of Plymouth (18—20 miles). The shoals then appear to travel in a westerly direction, some going off into deeper water, all moving about in a more or less uncertain manner. The head-quarters of the fishery eventually become fixed south of Plymouth and Eddystone Light. Gradually the fish seem to approach the shore, swimming now in large shoals. Many enter Plymouth Sound and are taken in comparatively shallow water, while others travel west, also in shallow water. The "remarks" for August are instructive. We find that, besides the ordinary and large fish, there are also "small fish about the size of pilchards" in the Sound, that "numerous large shoals" are noticed, and that at a later date the fish "seem to be leaving Plymouth Sound." On September 1st we find the note that "the mackerel are going off into open water and the shoals breaking up." On the breaking up of the shoals the mackerel fishing is considered to be at an end.

Concerning the forming of the shoals Mr. Roach also makes some remarks. I quote from his paper, "May 3rd: Mackerel are now gradually drawing to land. Some years ago they used to shoal in May, but of late years they have not shoaled so early. . . . I think it is owing to our April month being often so stormy. . . . Last year they did not shoal until July (1889)."

On June 21st he says, that, on an average, the shoal mackerel are much smaller than those taken with hook and line.

Such remarks as these serve to throw some light on the systematic movements of the mackerel shoals. Like the herring, they appear at certain parts of the coast at certain seasons, are driven by instinct to approach the land, and penetrate into the arms of the sea. At the same time shoals of younger fish are present, behaving in exactly the same way. The experience of fishermen goes to prove that the shoals of different sized fish do not intermingle; after a time the fish recede from the land and the shoals break up. But we also notice that there are certain causes which may retard or accelerate this series of movements. Meteorological conditions may affect the fish directly or they may affect their food, but since we have no regular record of the state of the weather, temperature of the sea in which the shoals swim, state of their food or reproductive organs, we are unable to discuss this point.

In relation to the state of the wind and the actual takes, however, this passing note may be made, that stormy weather seems to be favourable for "whiffing" (trolling a spinning bait), as the mackerel then seem to come to the surface, but whether the smaller classes of fish may not be taken at the same time by sunken nets is uncertain. As a rule only the largest fish are caught by "whiffing."

It is difficult to give, with any degree of accuracy, the total number of mackerel landed, since the record of the number of boats fishing is often incomplete. Such a record is, of course, not easily obtained except through some one regularly in attendance at the fish quays.

In studying the price column it is necessary to understand that in Plymouth, as in almost every other fishing centre, weights and measures are considerably distorted. In selling mackerel or herring by auction, as landed from the boats, 100 always means six score.

A few notes as to the methods of catching mackerel in this locality may be of interest.

In addition to the ordinary sunk or floating net—too well known to require description—what is locally known as "brimming" is much practised, especially by the Cornishmen.

Brimming is carried on during quiet nights. As the boat sails slowly along, a man in the bows, at short intervals, stamps loudly with his feet, lets the stock of the anchor fall suddenly on the rail, or makes some other noise, keeping at the same time a sharp look-out. The shoals of mackerel, startled by the sound, make one or two darts through the water, and cause quick flashes of phosphorescence. The suddenness of the flash distinguishes herring or mackerel from other less active fish. This is called the brim, and

Date.	Locality.	No. of boats.	Catch per boat.	Wind. Force.	Wind. Direction.	Weather.	Price per 100.	Remarks.
1889. Oct.								
23	Between Bolt Head and Start Point	—	24,000 and under	—	—	—	14/0–17/0	—
24	16 miles off Bolt Head	—	10,000 ,,	—	E.	Fine	14/0	—
25	20 miles S.W. of Start Point	—	10,000 ,,	Fresh	E.	—	14/0–16/0	Good quality. Considerable damage done by dog-fish (*Acanthias*). In 10,000 mackerel, 2000 to 3000 will have pieces bitten out of them by dogs.
26	12 miles S. of Salcombe	—	6000 ,,	—	—	—	17/6	—
30	S.S.W. of Salcombe	—	3000 ,,	—	—	—	25/0 large fish; 9/0 small fish	Storm.
31	S. of Salcombe	—	3000 ,,	—	W.	Fine	20/0–24/0	Dog-fish again very numerous.
Nov.								
1	12 miles W.S.W. of Start Point	—	900 ,,	Gale	W.	—	17/0–21/0	
2	—	—	—	—	—	—	—	Too stormy.
4	10 miles S. of Salcombe	—	400 ,,	—	—	—	21/0–25/0	—
5	6–10 miles S.W. of Start Point	—	2000 ,,	—	—	—	20/0–26/6	
6	10 miles S.W. of Bolt Head	—	A few hundred	—	—	—	24/0	Fish scarce. Bright moon given as reason.
7	15 miles S.W. of Start Point	2 or 3	200	—	—	—	25/0	—
8	20 miles S. of Salcombe	3	200	—	—	—	25/0	—
9	—	—	—	—	—	—	—	Mackerel become so scarce boats starting pilchard fishing.
15	4 miles S.E. of Eddystone	3	200–300	—	—	—	37/0	The nets worked by these boats are half mackerel and half pilchard.
16	6 miles S. of Eddystone	4	200–1000	—	—	—	30/0	P. Z. boats.
17	15 miles S.S.W. of Start Point	4	400–500	—	—	—	30/0	P. Z. boats. Dog-fish are reappearing.
18	15 miles S.S.W. of Eddystone	—	200 and under	—	—	—	30/0	—
19	15 miles S.S.W. of Start Point	—	3000 ,,	—	—	—	34/0	P. Z. boats using sunken nets. Thousands of small mackerel are along the coast.
20	Ditto	6	1500 ,,	—	—	—	27/0	—
21	20–30 miles S.S.W. of Start Point	8	2500	Strong	E.	—	25/0–27/0	—
22	15 miles S.W. of Start Point	—	800 and under	—	—	—	27/0	—
23	20 miles S.S.W. of Start Point	3	400 ,,	—	—	—	26/0	Stormy.
27	15 miles S.S.W. of Start Point	5	300 ,,	—	—	—	37/0	Stormy.
28	15–20 miles S.W. of Start Point	6	1500 ,,	—	—	—	36/0	About 60 boats out.
29	20 miles S.W. of Start Point	—	400 ,,	—	—	—	26/6	A great many boats given up for want of luck.
		2	300					

Dec.								
10	—	5	None	—	—	—	—	Got their nets full of dog-fish, greatly injuring the nets.
13	15 miles S.W. of Bolt Head	1 1	3700 700	—	—	—	37/0	—
17	15 miles S. of Plymouth	1	900 and under	—	—	—	37/0–40/0	Very large.
1890. Jan.								
14	40 miles S. of Plymouth	1	1150	—	—	—	87/0	The first take of mackerel for nearly a month.
16	30 miles S. of Mewstone	1 1 or 2	700 100	—	—	—	84/0	
Feb.								
12	35–45 miles S. of Plymouth	1 20	2000–3000 3000 & under	—	—	Stormy	35/0–40/0	The presence of dog-fish complained of, injuring the mackerel.
15	28 miles S.S.W. of Start Point	—	450 and under	—	E.S.E.	,,	47/0	A gale followed, blowing from N.N.W.
17	—		200 ,,	—	S.S.E.	,,	100/0	—
18		10	30 ,,	—	E. by S.	,,	1/0 each	—
20	20 miles S. of Bolt Head	1	450	—	—	—	50/0	A calm followed.
22	—	2 75	700–1000 A few fish	—	—	—	41/0	Caught by "brimming," encircling fish seen at night by the phosphorescence they cause when frightened.
24	30 miles S.S.W. of Start Point	1 1 70	1900 1500 50 and under	Strong	E.		44/0	Sunken nets.
26	30 miles S.S.W. of Berry Head	Several 1 1 1	A few hundred 4400 3000 1000	—	—	—	39/0–44/0	—
Mar.								
3	—	—	—	—	—	—	—	20 Lowestoft boats arrived without any fish after trying for 3 or 4 days.
5	30 miles S.S.W. of Start Point	Many 1	Very few 250	—	—	—	50/0	—
7	40 miles S. of Plymouth	1 8	300 20–30	Strong	S.W.	—	60/0	—
10	35 miles S.S.W. of Mewstone	6	350 and under	—	W.	Fine	75/0	Floating nets.
12		1 2 8 1	1500 700 200–1000 400	—	W.	—	40/0–48/0	Largest catches taken in sunken nets.
13	25–30 miles S.S.E. of Mewstone	30	1500 and under	—	S.S.W.	Very fine	37/0–41/0	Equally distributed between floating and sunken nets.

Date.	Locality.	No. of boats.	Catch per boat.	Wind. Force.	Wind. Direction.	Weather.	Price per 100.	Remarks.
Mar. 14	30 miles S. of Mewstone	40	1300 and under	—	S.	Very fine	34/0–40/0	Sunken nets.
15	Ditto	20	100–300	—	—	—	38/0–41/0	A storm from S. followed.
		40	None					
19	Ditto	30	20–40					
	Ditto	5	500–600	—	—	—	53/0	Floating nets.
	40 miles S. of Mewstone	3	1000–1500					
20	40 miles S. of Plymouth	5	200–500	Fresh	N.W.	—	39/0–44/0	Floating nets. Several boats put back.
		4	1000–2000					
22	35 miles S.S.W. of Plymouth	20	1700 and under	—	—	—	31/0–33/0	Sunken nets.
24	Ditto	50	500 ,,	—	—	—	32/0–36/0	Storm from S.S.E. followed.
26	32–37 miles S. of Stoke Point	20	800 ,,	—	S.W.	Fine	44/0–50/0	Most of the boats not out. No boat with more than 800.
27	30–35 miles S. of Mewstone	30	20–1000	—	S.	Foggy	40/0	Floating nets by Lowestoft boats. Very few boats with fish, and few boats with more than a score of fish.
29	—	Several	Very few	—	—	—	—	—
31	30–35 miles S. by W. of Plymouth Harbour	1	2900	1	E.	Fine	48/0–50/0	The fish are being caught further and further west. The large takes were got by floating nets, the small by sunk nets.
		1	1000					
		15	100–400					
April 1	30–40 miles S.W. of Eddystone	30	900 and under	—	—	—	40/0–50/0	In floating nets.
2	30 miles S.W. by W. of Eddystone	20	800 ,,	3	E.	—	35/0–40/0	Floating nets. Taken in the early morning after the moon went down. Fish still travelling west. Each boat getting 10 or 12 garpike with the mackerel. Large quantities of small Crustacea noted on surface of water.
5	—	—	—	—	N.E. a.m. S.E. noon	—	—	Poor takes. Attributed to the very bright moon.
7	—	4	400–500	—	—	—	—	Only 3 or 4 boats with fish.
10	20–30 miles S.S.W. of Start Point	50						
	30–40 miles S. of Plymouth Harbour 20–30 miles S.S.W. of Eddystone 30 miles S. of Deadman Point	} 6 } 44	800 and under 25–100	3	N.	—	25/0–35/0	Many boats with no fish. Fish of poor quality.
11	40 miles S. of Plymouth	4	400 and under	—	—	—	27/0	Floating nets. Fish of poor quality.

12	20–30 miles S.W. of Eddystone	2 7	700–800 300–400	—	E. a.m. S. noon, backing.	—	27/0–30/0	Boats taking to the floating nets.
14	40–50 miles S.S.W. of Eddystone	4	1000 and under	4	E.	—	27/0–30/0	—
15	—	4	200	4	E., abating	—	—	Too stormy for much fishing.
16	50 miles S.S.W. of Eddystone	4	2000–3000	Strong	E.	—	27/0–34/0	—
17	—	—	—	,,	E. by N.	—	—	A few boats with few fish.
18	—	—	—	—	—	—	—	Too stormy for fishing.
19	45–50 miles S. by W. of Eddystone	3 Others	2900 & under 1200	Light	E. by N.	Fine	19/0–21/0	—
21	Ditto	4	2000 ,,	Fresh	S.	Foggy	19/0–20/0	—
23	Ditto	2 3	5000 2000 & under	,,	S.W.	—	30/0–34/0	—
24	35 miles S. by W. of Eddystone	8	500 ,,	—	N.W.	—	30/0–32/0	Large quantity of small Crustacea noticed on surface.
28	—	—	—	—	W. by S.	Fine	28/0–30/0	Only a few hundred fish taken.
29	25 miles S.W. of Eddystone	8	500 and under	Fresh	S.E.	—	27/0	—
30	20 miles S.E. of Plymouth	20	100–300	—	E. by S.	—	31/0	—
May								
1	20–30 miles S.W. of Eddystone	8	1000–2000	—	E.	Fine	30/0	—
2	10–15 miles S.S.W. of Eddystone	10	100–300	Calm	E.	—	27/0–29/0	Too calm to enable boats to go far to sea.
3	10–15 miles S. of Eddystone	15	800 and under	—	—	—	17/0–18/0	Quality rather poor. The fish are now being taken nearer the land. Mackerel said to be shoaling later.
5	5–8 miles S. of Eddystone	15	700 ,,	—	S.E.	—	30/0	—
6	Outside Eddystone	—	1000–1500	—	S.E.	Showery	17/0–18/0	—
8	10–20 miles S. of Eddystone	Several	100–300	—	E. by S.	—	17/0–20/0	Quality rather poor. Several Lowestoft boats visited Plymouth, but also doing very badly, although having tried off Falmouth and St. Ives.
10	—	,,	Poor takes	—	S.E.	Fine	—	—
12	—	,,	100–300	—	S.W.	,,	—	—
13	30 miles W.S.W. of Eddystone	1 1	3000 1000	—	N.	,,	16/0–20/0	—
14, 15	—	—	A very few fish taken	Fresh	S.W.	,,	—	—
17	50 miles W.S.W. of Eddystone	1	5000	—	S.W.	—	16/0	Many boats out, but only about 1 in 20 with a few fish.
19	—	—	Poor takes	—	S.W.	Fine	—	No boat with more than 100 fish.
20	3–4 miles S. of Eddystone	—	,,	—	—	—	$2\frac{1}{2}d.$ each (for bait)	—

Date.	Locality.	No. of boats.	Catch per boat.	Wind.		Weather.	Price per 100.	Remarks.
				Force.	Direction.			
May 22	S. of Eddystone	—	A few hundred	—	S.E.	Fine	Sold for bait	—
23	8–10 miles S. of Eddystone	8	1800 and under	—	E.	,,	11/0–13/0	Also 200–300 herrings per boat. Mackerel very small. These were L. T. boats, using a smaller mesh at this season.
26	Between Penlee Point and Rame Head	—	5000	—	E.	,,	12/0–14/0	Also some boats got from 4–6 doz. by hook.
27	Ditto	—	4–6 doz.	—	E.	—	—	By hook.
28	Off Penlee Point	2	3000	—	E.	Fine	12/0	Seine net.
29	Ditto	—	A few hundred	Fresh	W.	—	12/0	Drift nets.
	Close off Penlee Point	1	3000	—	—	—	—	Seine net.
June 2	—	—	2000–3000	—	N.W.a.m.	—	—	Port Rinkle boats.
	—	—	3000	—	W. p.m.	—	—	Cawsand boats.
	40 miles S. of Penzance	2	2000–3000	—	—	—	13/0–14/0	Lowestoft boats. Large fish.
3	—	—	2000–3000	Fresh	S. by W.	—	14/6	Plymouth boats.
			2000–3000	—	—	—	14/6	Cawsand boats.
4	½ mile off Penlee Point	—	3000	—	S.W.	—	12/6	Cawsand boats.
5	—	—	2000	—	S.W.	—	12/6	Cawsand boats. Each boat had also a few dozen trolled mackerel.
			6000	—	—	—	—	Port Rinkle boats. Caught by trolling.
6	—	2	1000–2000	Strong	S.W.	—	14/0	Each boat had also a few dozen trolled mackerel.
	30–40 miles off Scilly	5 or 6	2000–3000	—	—	—	16/0	Very large fish.
7	Off Scilly	—	A few thousand	—	S.W.	Fine	12/0	P. H. boats having very poor success.
9	Off mouth of Plymouth Sound	—	10–15 doz.	—	W.	—	1/4–1/6 per doz.	All taken by trolling, locally termed "whiffing."
	Off Cawsand	2	2000	—	—	—	14/6	Seine nets.
10	½ mile S. of Penlee	—	20–30 doz.	—	—	—	—	By the hook and line boats (whiffing?). Great complaint about the gun practice here.
11	Ditto	—	10–20 doz.	—	W.S.W.	—	1/2–1/4 per doz.	By hooks (whiffing?).
12	Ditto	—	10–40 doz.	—	N.W.	—	1/3–1/6 per doz.	By hooks (whiffing?). A few also caught in the drift nets.
13	1–2 miles S. of Mewstone	—	10–15 doz.	—	E.	—	1/0–1/5 per doz.	Gun practice requiring the boats to go farther to sea than they would otherwise have done.
14	Off St. Ives	10	500–1000	—	W.	Fine	12/0	Taken in drift nets. Sold at Plymouth. Boats bound home to Lowestoft. They have made £100 to £380 in 6 to 8 weeks.

16	Ditto	8	500–600	—	S.W.	,,	13/0	These boats also bound home to Lowestoft. Two of them are said to have made £380; the rest about £200 each.
17	Between Rame Head and the Eddystone	—	200–900	—	S.W.	,,	15/0–16/0	
18	S. of Eddystone	—	600–700	—	W.S.W.	,,	15/0	Taken by hook.
19	6–10 miles S. of Eddystone	—	400–700	—	W.	,,	13/0–15/0	By drift nets.
20	5–10 miles S. of Eddystone	—	100–200	—	—	—	13/0–15/0	Drift nets.
		—	200–300	—	—	—	—	Whiffing.
21	—	—	200–600	—	S.W.	Fine	14/0	Whiffing.
			200–300	—	—	—	—	Drift nets. Gun practice said to break up the shoals.
23	20–30 miles S. of Plymouth	—	400–500	—	W.	Fine	14/0	Whiffing 2–3 fathoms below surface.
		20–30	1000–1800	—	—	—	15/0	Whiffing. These boats went out on 22nd.
25	—	—	400–500	—	S.W.	Fine	16/0	Whiffing.
26	—	40	400–500	—	W.N.W.	,,	16/0	A number of boats after whiffing to sunset shot drift nets, but only took about 50 fish per boat.
27	—	—	200–500	—	—	—	17/0	Whiffing.
28	25–30 miles S. of Mewstone	—	300–400	—	—	—	16/0	The whiffing boats have made from £10 to £18 in the past week.
	Between Penlee Point and Rame Head	—	2000	—	—	—	12/0	Seine net. Almost all boats have given up trying to catch mackerel by drift nets.
30	—	2	4000	—	N.W.	—	14/0	Seine net.
July 1	Port Rinkle	4	1000–2000	—	S.W.	—	15/0–16/0	—
3	Ditto	6	1000–2000	—	—	—	16/0	Seine net.
	20 miles S. of Eddystone	—	400–1000	—	N.W.	Fine	16/0	Whiffing.
4		—	400–500	—	—	—	14/0	Whiffing.
5		—	500–1000	—	—	—	13/6	Whiffing.
7	—	2	1000–2000	Strong	S.W.	Rain	14/0	Seine nets.
			100–300			—	—	Drift nets.
8	—	20	100–600	—	—	—	16/0–18/0	Whiffing. Wind increased to a gale, which seemed to favour the whiffing, the mackerel coming to the surface in great numbers.
10	—	—	—	—	S.W.	Fine	—	No mackerel to be found by any boat. Messages sent over from Guernsey asking boats to come over, fishing being good there.
16	Between Penlee Point and Eddystone	—	2 or 3 doz.	—	—	—	—	Still no mackerel on usual ground.
17	Ditto	—	10–15 doz.	—	Variable	Showery	2/0 per doz.	Fresh shoals of mackerel arrived. Whiffing.
		1	2000	—	—	—	21/0	Seine net.
		1	1000	—	—	—	—	Seine net.

Date.	Locality.	No. of boats.	Catch per boat.	Wind. Force.	Wind. Direction.	Weather.	Price per 100.	Remarks.
July 21	1 mile S. of Mewstone, Penlee Point, and Rame Head	—	100–300	—	N.W.	Dull a.m. Fine p.m.	17/0–18/0	Whiffing.
22	—	—	100–200	Fresh	N.W.	—	16/0	Whiffing.
		1	1000					
		1	1500					
23	—	—	100–200	—	N.W.	Fine	—	Whiffing.
		1	1500					
24	—	2	800	Fresh	W.	—	12/0	Seine nets. The whiffing has rather fallen off.
25	—	2	500–600	Light	S.	—	11/6	Seine nets.
	Mouth of Plymouth Sound	30	100–300	—		—	12/6	Whiffing.
26	Cawsand	1	1000	—	S.W.	—		Seine net.
29	—	—	100–300	—	S.W.	Fine	12/0	Whiffing.
30	—	—	100–150	—	—	—		Whiffing.
		1	1000	—		—	11/6	—
31	Between Knap Buoy and Penlee Point	—	100–200	Fresh	S.W.	—	11/0	Whiffing.
Aug. 1	—	—	5–10 doz.	—	S.W.	Foggy	11/6	
2	—	—	A few hundred	—	N.	,,	—	6 large shoals of mackerel seen off the Sound, but not taken in any quantity (a few hundred by whiffing).
4	Cawsand Bay and Whitsand Bay	6	1000–1500	—	N.W.	Fine	10/0–11/0	Seine nets.
5	—	—	3000	0	—	,,	11/0	—
6	—	5	1000–2000	—	—	—	14/0–14/6	Seine net.
7	—	3	3000	—	—	—	13/0–14/0	Seine net.
9	Between Mewstone and Rame Head	—	100–300	—	—	—	15/0	Whiffing.
			4000	—	E.	Fine	14/6	Seine net.
11	—	—	100–200	Fresh	W.	—	15/0	Whiffing. Many small mackerel on the coast at present. When caught sold at 4/0 per 100.
12	—	—	100–150	—	—	—	14/6	—
19	Plymouth Sound, inside	—	3–4 doz.	—	Variable	—	2/0–2/6 per doz.	—
22	—	—	100–200	—	—	—	12/0–14/0	Large fish.
			100–200	—	W.	Fine	2/0–4/0	Small fish; about the size of pilchards.
23	Between Penlee Point and Rame Head	—	100–200	—	—	—	—	Numerous large shoals noticed, but poor fishing. Seem to be leaving Plymouth Sound.

25	—	—	100–300	—	—	—	14/0 and 3/0	Large and small. Whiffing.
26	—	—	100–300	—	—	—	14/0 and 3/0	—
30	—	—	50–100	—	—	—	25/0	Large.
			100–200	—	—	—	7/0	Small.
Sept. 1	5–10 miles S. of Eddystone	2	200–400	—	—	—	35/0	Drift nets. These boats are now fitting out, the mackerel going off into open water. Shoals breaking up.
2	Ditto	4	500–1000	—	—	—	—	Drift nets.
3	—	—	300–1500	—	N.W., backing	—	—	—
4	—	—	500–800	—	N.W. and	—	25/0–35/0	—
	Centre of Sound	—	1–2 doz.	—	S.W.		—	Whiffing. Large fish.
5	—	—	500–3000	—	—	—	10/0–15/0	Drift nets. Also large quantities of small mackerel by hook and net.
6	—	—	100–2000	—	Very variable	—	6/0–7/0	Market too full of all kinds of fish for prices to be good. Pilchards as low as 1/6 per 1000.
8	5–10 miles S. of Eddystone	—	500–5000	—	E.	Fine	—	Still enormous quantities of pilchards and thousands of common shad.
11	—	60	500–1500	—	—	—	10/0–12/6	—
13	—	—	500–600	—	—	—	10/0–12/6	—
15	—	—	100–500	—	—	—	14/0–16/0	—
18	—	—	Poor takes	—	S.E.	—	0/9–2/6 per doz.	—
23	—	10	400	—	S.W.	—	15/0–17/0	—
24	—	2	2500					
	—	5	600					
	—	40–50	25–2000	—	—	—	17/0	—
25	—	—	100–600	—	—	—	17/6	—
26	10–15 miles S. of Eddystone	40	2000 and under	—	—	—	15/0–17/0	Majority of catches 300–600.
	8–10 miles off Foyee and Lowe	40	2000–4000	—	—	—	17/0	—
27	—	3	2000	—	S.W.	Fine	11/0–13/0	—
	—	6	800–900					
	—	20	100–200					
29	—	4	300 and under	—	—	—	—	—

by it the size of the shoal is estimated, as well as the depth at which the fish are swimming. The net is regulated accordingly, and the shoal encircled.

The famous Lochfyne herring are also for the most part caught by this process.

Whiffing or trolling for mackerel with a spinning bait has also been practised for many years. Each boat works six lines. Each line is attached to a sinker, from which depend first a fathom of snood, then a fathom or a fathom and a half of gimp, a swivel, a foot or so of gut, and the swivel bait or spinner. When fish are plentiful, the bare spinner will take fish well. At other times it is necessary to have a fish bait.

The bait most preferred is called "britt" or "mackerel bait" (young sprat, whitebait). When this cannot be procured a substitute is manufactured by cutting about an inch out of the under or white surface of a mackerel's tail.

One remarkable circumstance of last season's "whiffing" was that boats engaged in this method of fishing south of the Eddystone had to be sailed in a southerly direction. In June boats sailing for ten to fifteen miles south of the Eddystone would pick up from 200—400 in one course. They then got "outside" of the fish, and had to return to their starting-point to repeat the process. While sailing back, although the lines were kept out all the while, only a very few fish could be taken.

This method of fishing can only be employed during daylight.

The Lobster Fishing of one Boat in Plymouth District, from May 1st to September 29th, 1890.

The data for this paper were again supplied by Mr. Roach, and have all been reduced to tabular form. I shall here state only the general results.

The total number of lobsters taken was 1753. Of these 1226 were males and 527 females, *i. e.* 699 more males than females.

Concerning the number of "berried hens" in each month, we find—

In May, 21 out of 105 females.

In June, 21 out of 133 females.

In July, till 11th day of the month, 14 out of 47 females.

On July 11th notes as to presence of females with ova end abruptly, nor is any note made of the number in August. On September 8th there is note of one female, on the 15th two, on the 22nd one, on the 26th three, 27th two, and 29th two.

The notices of soft-shelled lobsters are also confined to the first part of the paper. In May about three out of every four males are soft, most of them measuring eight to ten inches. There are eighteen females mentioned as having soft shells.

It is to be regretted that the last two items have not been attended to more carefully.—W. L. C.

On the Reproduction and Development of the Conger.

By

J. T. Cunningham, M.A.,
Naturalist to the Association.

I. *Review of previous Observations on Sexually Mature Conger.*

Before the Laboratory of the Association was built, it had often been observed in other aquaria that female conger after living for some time in captivity, feeding regularly and voraciously, and growing with considerable rapidity, passed into a swollen and apparently gravid condition and then died. Such conger when dissected after death were invariably found to contain enormously developed ovaries or roes, which entirely filled up and distended the abdominal cavity, and pressed the intestine and other abdominal organs into as small a space as possible. The following are the principal records of cases in which this has been observed.

R. Schmidtlein* gives an account of the occurrence in the aquarium of the Zoological Station of Naples in a paper published in 1879. He writes, " All that we can say concerning the reproduction of the conger, is that sometimes the body of large specimens became considerably swollen as though distended with gas, and these specimens hung for some days at the surface of the water on their sides, without eating and without the power of swimming, and then died. When opened, the abdominal cavity was found filled, almost to bursting, with colossal masses of eggs, and all the organs were compressed and reduced to a minimum. In some of these specimens some small masses of eggs were extruded even during life, but the deposition of large numbers of eggs never occurred. All died from the presence of the excessive numbers of eggs which from causes difficult to understand could not be expelled from the body." In a table† published the same year, the same author states that

* *Beobachtungen über die Lebensweise einiger Seethiere innerhalb der Aquarien der Zoologischen Station*, Mittheil. aus der Zoolog. Station zu Neapel., Band i, 1879, p. 492.

† *Beobachtungen über Trächtigkeits- und Eiablage-perioden verschiedener Seethiere*, Mitt. Zoolog. Stat. Neapel., Band i, 1879, p. 135.

two specimens in this condition died in the middle of August, and he adds that large numbers of young conger scarcely 3 cm. (1¼ inches) long are captured in the middle of April. Schmidtlein does not give the measurements of the gravid conger which he mentions, but he calls them large, and in another place says that the fish grows to a length of over 2 metres (6 feet), so that it is probable the gravid conger were 5 or 6 feet in length.

Similar observations upon female conger are recorded by Dr. Otto Hermes, the Director of the Berlin Aquarium, in the *Zoologischer Anzeiger*, vol. iv, 1881. Dr. Hermes states that he is convinced that the development of the ovaries of the conger in captivity is often a cause of death. When some females which had died in the Berlin Aquarium were opened, the ovaries were found to be much enlarged, and one which died in the Frankfort Aquarium was actually burst by the extraordinary development of the ovaries. This specimen weighed 22½ lbs., the ovaries weighed 8 lbs., and the number of eggs in them was calculated to be 3,300,000.

According to Francis Day (*Fishes of Great Britain and Ireland*) a female conger which died in the Southport Aquarium in June, 1876, weighed 15¼ lbs., and the ovaries 7 lbs., the number of eggs in which was calculated at 6,336,512. It is evident that these calculations are probably not very accurate, for according to the latter there would be nearly a million of eggs to 1 lb. of ovary, while according to that of Hermes, there would be only about one million to 6 lbs. of ovary.

These are the only published observations concerning the ripe ovary of the conger that I have been able to find. With regard to the structure of the ovaries the most complete account is that given by Brock* in 1881, and founded on observations made at Naples. I have in a previous number of this Journal briefly described the external structure and relations of the ovaries. There is one ovary on each side of the mesentery suspending the intestine. Each consists of a long ribbon-like membrane, attached dorsally, with a free edge ventrally. The median side of the ribbon is smooth and flat, the lateral side bears a series of very numerous thin plates or lamellæ, attached to the ribbon-like membrane edgewise and transversely, and in contact with one another by their faces like the leaves of a book. These lamellæ contain the numerous small ova. Thus the ovary is not a closed tube as in most fishes, and consequently the eggs when they leave the ovary lie free in the body-cavity, whence they escape by an aperture behind the anus.

We have next to ascertain what was known up to the commence-

* *Untersuchungen über die Geschlechtsorgane einiger Muraenoiden,* Mitt. Zool. Stat. Neapel., Band ii, p. 415.

ment of my own observations concerning the male conger. The most convenient publication to start from in this inquiry is Hermes' paper already mentioned. The principal subject of this paper was the discovery of ripe testes full of ripe actively motile spermatozoa in a specimen of the conger. The specimen was one of a number caught near Havre, and sent to the Berlin Aquarium in the autumn of 1879. These specimens when they arrived were 60 to 70 cm. long (2 feet to 2 feet 4 inches). They all throve in the aquarium and grew rapidly with the exception of one, which increased very little in size, and which died on June 20th, 1880. It was then 74 cm. ($29\frac{1}{10}$ inches) in length. When this specimen was opened organs were seen in it which looked like ripe testes, and when a cut was made in one of these milt flowed from the incision; this milt was found on examination under the microscope to be swarming with actively moving spermatozoa.

The form and size of the ripe testes are carefully described by Hermes. Each was an elongated laterally compressed mass fastened at the side of the air-bladder by a suspending membrane. The greatest breadth of the organ was 18 mm. ($\frac{7}{10}$ths inch), its greatest thickness from side to side 9 mm. (·36 inch). Each organ extended through nearly the whole length of the body-cavity, commencing near its anterior end and continuing some distance behind the anus. A number of transverse fissures divided each organ into several lobes, namely five in the right organ, and about the same number in the left. At the base of each organ was a closed duct or vas deferens through which the milt was conveyed to the exterior. Opposite the rectum a downward branch passed from each vas deferens, and these two branches united to open by a single aperture behind the anus to the exterior. Hermes points out that the testes of the conger discovered by him, correspond, when allowance is made for the fact that they were ripe and fully developed, very perfectly with the lobed organs of the common eel described by Syrski in 1874. He concludes, therefore, that Syrski's organ is, as that author believed, the testis of the male eel. The conger further agrees with the common eel in the relation of the size of the male to that of the female, Syrski having found that the male eel was considerably smaller than the female.

Dr. Syrski,* while holding the post of Director of the Museum of Natural Sciences of Triest , was commissioned by the authorities of that town to ascertain the spawning season of the fishes of the neighbourhood. He included the eel in his researches, and con-

* My knowledge of the investigations of Syrski and Jacoby is derived from a translation of Jacoby's work on *The Eel Question*, in the Report of the U.S. Commissioner of Fisheries for 1879. Washington, 1882

sidering that in many animals the male is smaller than the female, he began to look for male eels among the smaller specimens. In the second specimen he examined, which was 40 cm. (16 inches) in length, he discovered the organs which he identified as testes. His conclusion as to their nature has been confirmed by all subsequent inquirers, although no one has yet found these organs in the ripe condition, and thus brought the final evidence of demonstrating the ripe spermatozoa of the eel.

The largest male eel observed by Syrski was 43 cm. (17 inches) in length. But Dr. L. Jacoby, who investigated the eel both at Trieste and Comacchio after Syrski, in 1877, found males as long as 48 cm. ($18\frac{9}{10}$ inches) and as small as 24 cm. ($9\frac{4}{10}$ inches) in length. The female eels reach a length, according to Jacoby, of one metre (39 inches) and the thickness of a man's arm, but the majority of adult females which migrate in autumn to the sea are not longer than 70 cm. ($27\frac{1}{2}$ inches). Therefore if Hermes' specimen of the male conger is of the average size of the male in that species, then there is a much greater difference in size between the sexes in the conger than in the eel. The male conger discovered by Hermes was 2 feet $5\frac{3}{5}$ inches long, while adult females are 5 to 7 or even 8 feet in length. The largest male eel recorded by Jacoby was 1 foot $7\frac{1}{5}$ inches long, while adult females are only 2 feet 4 inches to 3 feet 3 inches long.

Brock, in his account of the researches he made at Naples, does not include any discussion of the relative sizes of the two sexes. Of the conger he merely says that he examined forty-five specimens, of which the males and females were about equal in number. He states that he obtained only one male which was perfectly ripe, and that he got this in the middle of November. The size of this specimen he neglects to mention. Of the female sex Brock describes no ovaries far advanced in development, and here also he neglects to mention the size of the specimens which he examined. Of the common eel Brock only states that out of ninety specimens of 35 cm. (14 inches) in length and under which he examined, seventy-nine or 88 per cent., were males, and among those of 35 to 40 cm. (14 to 16 inches) in length six were males.

II. *History of my own Observations.*

I have now to record the observations and experiments on the conger which I have made at the Plymouth Laboratory from November 7th, 1887, up to the end of the year 1890. I find that my notes on the conger in No. 2 old series of this Journal, although dated February 29th, 1888, only comprise my observations up to November 7th, 1887, at which time I had not met with a male specimen.

On November 17th I bought eighteen small specimens on the fish-quay. The smallest of these was 1 foot 4 inches, the largest 2 feet 8 inches long. One of them, 1 foot 8 inches in length, was a male with well-developed but not ripe testes. The testis was 7 mm. broad and 2 mm. thick (about $\frac{1}{4}$ inch broad, $\frac{1}{12}$ inch thick). In form and relations this testis agreed with the description given by Hermes, except that there was no division into lobes; the organ was continuous from end to end. Two other specimens were very young males, 18 and 19½ inches long respectively; ten were females, and in five of the smallest the reproductive organ was so undeveloped that the sex could not be determined.

On December 4th I examined the ovary of a very large conger over 6 feet in length; the ovary was large, forming a milk-white opaque elongated mass on each side of the body-cavity. The organ was 8 cm. wide, the ova or eggs visible as separate grains to the unaided eye. Measured under the microscope the eggs were found to be ·5 mm. in diameter; they were perfectly opaque and granular, and spherical in shape. The ovary contained, besides very numerous ova, a good deal of fat-tissue.

On March 2nd, 1888, I got the roe of a large conger, 5 or 6 feet long, from the fish-quay. The ova in the roe were visible to the unaided eye, and when measured were found to have a diameter of ·5 to ·7 mm.

In ovaries less developed than these the ova are not separately visible to the unaided eye, and can only be seen when a piece of a lamella is examined with the microscope. The appearance then

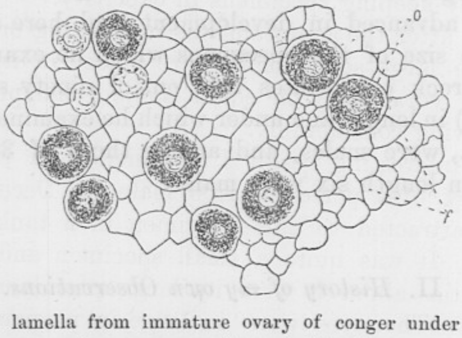


FIG. 1.—Portion of lamella from immature ovary of conger under low power of the microscope. *o.* Ova. *f.* Fat-cells.

presented by the fresh tissue is that shown in the woodcut, fig. 1; the small ova are still transparent enough to show the germinal vesicle in the centre, and they are irregularly distributed throughout the fat-tissue which makes up the greater part of the bulk of the ovary. The conger from which the figure was taken was 5 feet 3 inches long, 24½ lbs. in weight, and captured and killed on October 6th. Fig. 2 shows a portion of a lamella of the ovary of an eel 22 inches long killed December 10th; the ova here were ·14 mm. in diameter. Fig. 2 is from a more highly magnified image than fig. 1, and the ova are also somewhat more developed.

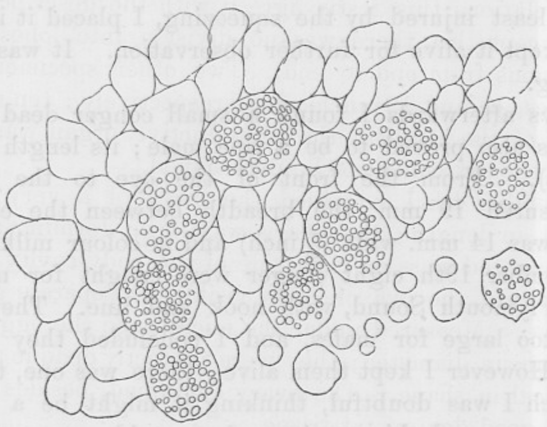


FIG. 2.—Portion of lamella from immature ovary of common eel.

The aquarium of the Plymouth Laboratory was filled with seawater and ready for use by June 30th, 1888. Before this time, as appears from the above observations, I had not succeeded in procuring ripe conger, either males or females, from the fishermen, and I hoped to obtain more light on the subject of the reproduction of the species by keeping specimens in captivity.

Very soon after the aquarium was in working order several living conger, some large some small, were placed in it, and they throve well, feeding voraciously on squid (*Loligo*) and pilchard, and some of them growing considerably.

The first interesting result I obtained from the aquarium was the discovery of a perfectly ripe male on December 13th. My notice was attracted to this specimen in a tank by its peculiar appearance. It was quite a small specimen and somewhat thin; the peculiarities about it were its large prominent eyes and short broad snout. The eyes were so large in proportion to the head that their upper edges projectly slightly above the dorsal surface of the skull, and that surface between the eyes was quite depressed and hollow. Before seeing this specimen I had not noticed any differences by which male congers could be distinguished from females of the same size, although I had found that all the large specimens (3 feet long and upwards) were females. I took out this specimen, intending to kill it and examine its generative organs, but before killing it I held it alive in a cloth and gently squeezed its abdomen towards the generative aperture. Thick fluid white milt immediately exuded from the aperture, and when I examined a little of this milt under the microscope, I found it swarming with innumerable ripe spermatozoa in most active motion. As the specimen was not in the least injured by the squeezing, I placed it in a tank by itself and kept it alive for further observation. It was 45 cm. (18 inches) long.

Two days afterwards I found a small conger dead in another tank. This also proved to be a ripe male; its length was 51 cm. (20 inches). From the front of the eye to the end of the snout measured 19 mm., the breadth between the eyes 17 mm. The testis was 14 mm. wide ($\frac{5}{8}$ inch) and in colour milk-white.

On December 19th eight conger were caught for me near the mouth of Plymouth Sound, with hook and line. They seemed to me to be too large for males, and I concluded they were young females. However I kept them alive; there was one, the smallest, about which I was doubtful, thinking it might be a male. The next day I squeezed this specimen, but could get no milt from it. At this time I was not experienced in detecting the peculiarities of the male in unripe specimens. This specimen when killed and opened proved to be a male with large well-developed almost ripe testes. The specimen was 19½ inches long (48 cm.). A piece of the testis examined under the microscope showed no ripe spermatozoa.

I then opened another of the specimens caught on the 19th. I was confident that this one was female, but it proved to be a male with fully-developed but not ripe testes. A few ripe spermatozoa were found on teasing up a portion of the testis. This was the largest male I had yet seen, it was 2 feet 2 inches in length (66 cm.). The testis on the left side was 3 cm. wide (from attachment to edge). I pressed ripe milt with my finger, after the abdominal cavity was laid open, into the vas deferens at the base of the testis, and thence along the transverse duct behind the rectum to the exterior.

These two males were not darker on the back and sides than a female 2 feet 3 inches long, with which I compared them; in fact both of them were piebald, some parts of the skin being quite light, others dark. But there was a difference in the colour of the ventral surface, which in the female was pure white, entirely without pigment, and in the male was clouded to a considerable degree with black pigment cells. The prominence of the eyes previously described in a ripe male was not visible in these last two, which were almost ripe. But I detected another constant difference which enables one to detect a male with almost absolute certainty, whether they be ripe or unripe. In the female the outline of the head when looked at from above is triangular, the snout being pointed; in the male the same outline is much less pointed, the snout being distinctly blunter. Also in the female the dorsal surface of the snout in front of the eyes is arched, so that a transverse section of the dorsal surface is an arc of a circle; in the male the surfaces of the snout are flat, its sides above the mouth being perpendicular, and the upper surface almost level, so that a transverse section forms three sides of a square.

However, I found I still required some practice before I could distinguish males among a number of live conger with certainty. On December 21st I examined three small specimens, and concluded that two were female, while the third was doubtful. I killed the latter, and it proved to be a male 58 cm. (23 inches) long, with very small and undeveloped testes.

Of course the identification of the males is more difficult the smaller and younger the specimens under examination. On January 1st, 1889, I received four small living conger, which were pale reddish and delicate looking. I decided that two of these were females, and therefore killed them, keeping the other two alive among the males I was collecting. But the two I killed proved to be both males, one of them having the testes very small, while in the other they were moderately developed. One of these specimens was 1 foot 7 inches, the other 1 foot 7½ inches in length.

Thus, in the course of December, 1888, and January and February, 1889, I collected several small living conger, which I believed to be males, and I kept these in a tank by themselves in order that they might sooner or later develop into a condition of sexual maturity. On March 7th I made an examination of this collection of males. There were eight specimens in all, in addition to the one which was found to be perfectly ripe on December 13th, 1888. The specimen when handled on March 7th, yielded extremely fluid milt, which under the microscope seemed quite healthy, and was full of active spermatozoa. But the specimen itself was considerably diseased; although it was lively and active when irritated, it had little strength. It was quite blind, one of its eyes being reduced to a loose red ulcerous mass, while the other was clouded and opaque all over the cornea. The skin was also abraded at one or two places on the body. These abrasions appeared as white patches which showed no signs of inflammation. Under the jaw were other abrasions, which were red and inflamed.

The other eight males were still unripe, none of them yielding milt when squeezed.

The ripe male discovered on December 13th, 1888, died in the aquarium on June 24th, 1889. It had taken no food since it was first found to be ripe on the former date, that is for a period of six months, and before its death had become very thin and feeble, and somewhat crooked as well as blind.

We have now to turn our attention to the history of the large females in the aquarium. Among these there was one which was distinguishable as early as December 17th, 1888, by her large size and by the somewhat distended appearance of the abdominal region. But at this time she was feeding voraciously. In March, 1889, I was told by the attendant that this conger had ceased to feed. Before that I had, with the help of the attendant, caught her in a sac fastened to a large hand-net and squeezed her, but had obtained no trace of eggs. On April 6th I fed the conger myself in order to verify the report that this specimen had ceased to feed, and found it was perfectly true. Never after that date did she take any food.

I carefully watched this female specimen, and occasionally squeezed her carefully after the same method as that already described. When I tried in June I could obtain no eggs from her; but on July 24th a few eggs were obtained by squeezing. These eggs were very small and were chalk-white in colour. Examined under the microscope, they were perfectly opaque, the vitellus being composed of numerous small spherules; there were no separate oil-globules, and the egg-membrane or envelope was everywhere in close

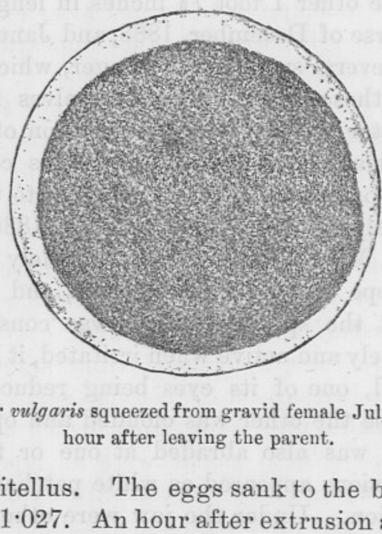


FIG. 3.—Egg of *Conger vulgaris* squeezed from gravid female July 24th, 1889. Drawn one hour after leaving the parent.

contact with the vitellus. The eggs sank to the bottom in a bottle of sea-water, density 1·027. An hour after extrusion a perivitelline space had developed between the enveloping membrane and the vitellus, as shown in Fig. 1, but the latter was as opaque as before, and there was no indication of a germinal disc (blastodisc). The formation of the perivitelline space indicates that these eggs were almost ripe, but it does not follow that they had acquired the characters of the perfectly ripe eggs; it is quite possible, I think, that the eggs might become transparent and buoyant when perfectly ripe. The diameter of one of these eggs after the formation of the perivitelline space was 1·6 mm.

On July 25th I isolated this female specimen in a separate tank, and placed with her three small specimens identified as males, but the latter were not ripe and did not yield milt on squeezing. I observed no signs of sexual excitement in either female or males when they were thus placed together.

On August 13th I again squeezed the female but got no eggs. After she was released on this occasion it was found that her head was bent down at an angle with the body, and she appeared almost paralysed. Some injury had evidently been done to the vertebral column and spinal cord in the process of handling, but she continued to breathe and lived some time afterwards.

On the 14th and 15th I again tried to squeeze eggs from her, and obtained some separate ova and some small pieces of the ovary. No violence was used in the process, but the ovary is, when enlarged, very soft and tender, and pieces of it are therefore easily detached. The eggs obtained were in the same condition as those obtained in July, I could see no advance in their development; one of them measured ·95 mm. in diameter. A perivitelline space, in most eggs somewhat irregular in shape, was formed after extrusion as before, but the eggs were still without the appearance of perfectly ripe eggs.

This female died on September 10th, having then been without food since April 6th, that is five months at least; she had ceased to feed before that, and had therefore probably been fasting for six months. After her death the ovaries were found to weigh 7 lbs. 5 oz.

In the autumn of 1889 I collected some more male conger, in order to continue my experiments with other large females which were approaching maturity in the aquarium.

On January 24th, 1890, I removed from among the rest two large females which had ceased to feed for some time, and placed them with eight males in a tank from which all other animals had been removed. These males were all ripe or very nearly so, some of them having been ascertained to yield ripe milt when squeezed. Among these specimens unmistakable signs of sexual excitement were observed. The males were generally active and restless, but seemed to take a good deal of notice of the females, frequently smelling at their genital apertures. The females rested on the gravel at the bottom of the tank, and constantly swayed from side to side so as to press the abdomen and genital aperture on the gravel. The smaller of the two females rested for days with its head in one of the corners of the tank, and one of the males for some days remained almost constantly by her side, his snout level with hers, his body in the angle between her body and the gravel, on her left side. While he was in this position I frequently noticed a rapid quivering vibration pass along his longitudinal fins, a motion quite different from that of the same fins when used in swimming or in hovering, and only suggestive of sexual excitement. I drove this male away once or twice with a stick, but after one or two digressions he invariably returned slowly to his former position beside the female. Sometimes the female made an excursion up and down the tank, and the male followed her. At other times the male would move away of his own accord, but after a short time would return to his former post beside the female.

While I was absent from the Laboratory in February, through illness, one of the males was taken out dead; it was exceedingly ripe, and was probably the one I saw with the female, for after this I saw no such constant association between a male and female.

On March 23rd I took out this smaller female and very carefully squeezed her abdomen; mucus and blood escaped from the genital aperture together with one free ovum. The ovum was, in all respects, similar to those obtained from the female that died in 1889. The escape of blood showed that the ovary was ruptured, although the squeezing had been performed very gently; probably, I think, the rupture had taken place before the squeezing. Next day this female was seen to be writhing about and lying on her side. Not long afterwards she was found to be dead. I squeezed her after death and obtained a number of free ova and small pieces of the ovary consisting of eggs fastened together by the scanty ovarian tissue. I placed these eggs in sea-water with some ripe milt from a male, and then kept them in a circulation of sea-water for some days. But though a perivitelline space was formed as before, I never saw any signs of the formation of a blastodisc or of segmentation.

The results of a post-mortem examination were as follows:—The ovaries together weighed 3 lbs. 4½ oz. The stomach was quite empty, its walls very thin, and containing numerous coiled-up parasitic nematodes or thread-worms. The intestine was very thin, containing only yellow mucus; the stomach and intestines were compressed into the smallest possible space by the enlarged ovaries. All the viscera, including liver and spleen, without the ovaries, weighed 8 oz.

14 dr. Length of the fish 4 feet 5½ inches; total weight of fish, including everything, 16 lbs. 2 oz. 6 dr. It may be supposed that by taking out this female and squeezing her I caused her death and prevented the normal extrusion of the ova, but my subsequent experience shows that there is little probability in such a supposition.

It is interesting to compare the above weight and dimensions with those taken from a female which died of disease on February 24th, 1891. This specimen was 4 feet 8½ inches in length, and weighed 22 lbs. 1 oz. The teeth and bones of the head were still normal, and the ovaries immature. In the latter under the microscope the largest eggs were found to be ·35 to ·45 mm. in diameter, and to be separated from one another by fat-cells; the eggs were perfectly opaque. The ovaries together weighed 2 lbs. The intestine, liver, and other viscera weighed 1 lb. 7 oz. The stomach and intestines, although containing no food, were evidently in a normal condition, not collapsed or reduced in size.

From this comparison it follows that the ovaries increase very much in size and weight during the fasting period at the expense of the rest of the body, while in the total weight of the fish a great reduction takes place. It is evident, therefore, that the nutrition of the developing ova consumes not only the fat in the ovary itself, but a large quantity of additional material drawn from the rest of the body.

The second of the two females placed with the males on January 24th died on April 22nd. For two days previously it seemed to be in travail, gasping and twisting itself about as if trying to get rid of its eggs. I expected to find the eggs riper than in the other specimen, but when it was opened I found them rather less developed; none were free, all firmly attached in the ovary; they measured ·97 mm. in diameter (1 mm. = $\frac{1}{25}$ inch). The length of the fish was 5 feet 11 inches, weight 28 lbs. 9 oz.; the two ovaries weighed 4 lbs. 5 oz. This specimen was never squeezed or handled in any way after its removal from one tank to another on January 24th, so that its death was not due to any mechanical injury.

On March 15th two other female congers which had ceased to feed were removed from the largest tank in the aquarium and placed in the tank where the males were. As it now seemed hopeless to expect any female to produce ripe eggs in the aquarium, I put these two with six ripe males in a box, and sank the box in ten fathoms of water in Plymouth Sound. I occasionally hauled up the box and examined the fish. On August 18th I found one of the females dead, but the other was alive and vigorous. The dead one measured 5 feet 4 inches in length. Its total weight was 33 lbs. 8 oz., of which the ovaries together weighed 7 lbs. 6½ oz. By counting the eggs in a grain of the ovary, I calculated the total number in the two ovaries to be 7,925,280. Thus the result of my calculation agrees closely with that made at the Southport Aquarium, and therefore the number obtained by Dr. Otto Hermes at Berlin was probably very much too small. The last female I have referred to had taken no food since March 15th, five months.

On August 30th I put the box containing the remaining female down in another part of the Sound, attaching the rope connected with it to the moorings of a buoy. Probably the motion of the buoy broke the rope, for the latter was recovered, but the box could never again be found. The eggs in the female which died in the box were in the same condition as those previously obtained from other females, and the problem of obtaining ripe fertilised eggs still remains unsolved.

When examining the ripe females that died in 1890 (three specimens) I noticed that they had lost nearly all the teeth, and that the bones of the head were soft and flexible. I afterwards made a careful comparison of two of the heads of these specimens preserved in spirit, with the fresh head of a conger bought on the fish-quay on January 6th, 1891. The latter specimen was 4 feet $5\frac{3}{4}$ inches in length, the total weight 14 lbs. $7\frac{1}{4}$ oz. I found the teeth in this specimen to be as follows:—They are all similar in shape, small, short, and obtusely pointed, and they are very numerous. In each jaw on each side there is one principal row situated on the narrow projecting edge of the jaw. These teeth are very close together, so that their points form a cutting edge. Along the inner side of the gums is a single row of smaller teeth, whose points project but slightly through the gums. At and near the anterior extremity of the premaxilla, on the outer side of the principal row of teeth, are other incomplete longitudinal rows, broadening out into a patch at the extremity of the bone. Similarly in the lower jaw there are incomplete rows on the outer side of the principal row, broadening out into a patch at the anterior extremity of the mandible. In the front of the upper jaw there is an oblong patch of teeth attached to the anterior part of the vomer. All these teeth are very sharp and strong, although small, and are very firmly fixed in the bones which bear them.

In the females which died with ripening ovaries there are only a few scattered teeth left; nearly all of them have disappeared. The few which remain are loose and blunt, held only by the skin, and not firmly fixed in the bones. The prominent ridges of the jawbones on which the principal rows of teeth are situated in the feeding conger have also disappeared, and the surface of the bones within the mouth are smooth and flat.

The condition of the bones of the head themselves in the conger which have died with ripening ovaries is still more remarkable. The bones are reduced in size, and are so soft and friable that they break easily in the fingers; they offer no resistance when bent, and can be cut with the finger-nail. In order to expose the teeth I cut down from the angles of the mouth with a large knife which was anything but sharp, and the knife cut straight through bones and tissues almost as if it were cutting cheese. In the head of the conger bought on the fish-quay it was impossible to cut through the bones; I had to find the joints, and use a good deal of force to separate the bones from one another.

I also examined the head of a ripe male, and found it was in the same condition, the teeth nearly all gone, the bones in a spongy and soft condition.

The reason of this is probably to be found in the fact that the breeding conger lives so long a time without food. No doubt much of the material of the body is absorbed into the blood and used up in the development of the ova, but probably some of the lime salts to which the bones owe their hardness are excreted.

In any case it is not to be wondered at, since tissues are always undergoing waste, that the bones should degenerate in a fish which takes no food for six months, and in which, further, a large weight of ova is developing at the expense of the rest of the body.

The following two tables give a synopsis of some numerical data related to the observations I have described.

TABLE I.—*Numerical data concerning Ripening Female Conger.*

Specimens examined by me at Plymouth.

Date of death.	*Length.*	*Weight.*	*Weight of ovaries.*	*No. of eggs calculated.*
Sept. 10th, 1889 .	?	?	7 lbs. 5 oz.	
March 24th, 1890 .	4 ft. 5½ in.	16 lbs. 2⅝ oz.	3 lbs. 4½ oz.	
April 22nd, 1890 .	5 ft. 11 in.	28 lbs. 9 oz.	4 lbs. 5 oz.	
Aug. 18th, 1890 .	5 ft. 4 in.	33 lbs. 8 oz.	7 lbs. 6½ oz.	7,925,280
Recorded by Hermes.				
? .	?	22 lbs. 8 oz.	8 lbs.	3,300,000
Recorded by Day.				
June, 1876 .	?	15¼ lbs.	7 lbs.	6,336,512

TABLE II.—*Showing the Numerical Relation of the Sexes in Conger under 2 feet 6 inches in length, examined by me at Plymouth.*

Date.	*No. of specimens.*	*Males.*	*Females.*
November 17th, 1887	11	3	8
December 20th, 1887	1	0	1
June 6th, 1888	2	0	2
June 14th, 1888	2	1	1
July 4th, 1888	2	0	2
July 21st, 1888	3	0	3
December 7th, 1888	2	1	1
December 20th, 1888	2	2	0
January 2nd, 1889	6	2	4
January 3rd, 1889	3	2	1
	34	11	23

III. *Discussion of Results of my Observations.*

Some of the conclusions which I have drawn from my observations are certain and others are only probable. Perhaps the most interesting of those which are certain, is that the males are distinguishable from females of the same size by slight but constant secondary sexual characters. The most important of these is the shape of the snout previously described, but I have found the pigmentation of the abdomen to be also a constant difference. The prominence of the eyes I have only noticed in males which were actually ripe. Perhaps careful comparative measurement would have shown that the eye is always larger in the male than in the female, but pressure of other work has prevented me making such measurements.

The largest male I have seen was only 2 feet 2 inches long, $3\frac{3}{5}$ inches less than that described by Dr. Otto Hermes. I conclude, therefore, that the latter specimen was unusually large, and that 2 feet 6 inches is the extreme limit of length of male specimens. The smallest ripe male I have seen was the first one I obtained, which was only 18 inches in length.

As shown in the table No. 2, according to my experience, even among specimens under 2 feet 6 inches long, the proportion of males is not more than 33 per cent. Brock found males and females about equal in number among 45 specimens. I have only recorded 34 specimens in my note-book, although in collecting living males I examined a larger number. I conclude that the males are less numerous than the females, for it must be remembered that all specimens over 2 feet 6 inches in length are females, and, therefore, if the sexes were approximately equal in number we should find the males more numerous than the females among the specimens under 2 feet 6 inches.

Another important conclusion I have drawn from my observations is that each conger only breeds once in its lifetime, or, in other words, that every specimen whether male or female dies after shedding its milt or ova. With regard to the males, I have shown that nothing is easier than to obtain them in the sexually ripe condition by keeping them in an aquarium until they ripen. Of the ripe males which I have had in captivity three have died. I never took out a dead male from the aquarium which was not ripe. Both males and females are very hardy, and during the time I have observed them in our aquarium only one specimen has died, excepting ripe males and females. The other ripe males which I had in 1890 were lost in the attempt to keep them in a box at the bottom of the sea. It may, of course, be argued that if the females were in natural conditions, and were able to extrude their ripe ova, they would again commence to feed and then breed again. We know that a considerable proportion of other animals die after breeding in consequence of exhaustion, although normally they produce young or eggs a great many times in succession. But, on the other hand, if the conger were able to recover in its normal free state in the sea, it is extremely unlikely that it would die so invariably in captivity, after attaining sexual maturity, especially considering that while its sexual organs are immature it is one of the hardiest, healthiest, and most voracious fishes in the aquarium.

Another objection which may be urged is the great variation in size among adult female conger. One of the gravid specimens which died in our aquarium was only 4 feet 5½ inches long, and just over 16 lbs. in weight, while the largest of those I have recorded was only 5 feet 4 inches long, and 33 lbs. 8 oz. in weight. And yet specimens are caught at sea which are much larger than this. Day, in his Fishes of Great Britain and Ireland, mentions one 6½ feet long, weighing 53 lbs., others weighing 84 lbs., 100 lbs., 104 lbs., and 112 lbs., and one measuring 8 feet 3 inches, and weighing 128 lbs. But this by no means invalidates my conclusion, for fishes of the same age vary wonderfully in size, as I know from flounders of the same age which I have myself reared in our aquarium. It is probable enough that the age at which in the female conger feeding and growth ceases, and the maturation of the ova begins, may vary in different individuals. It is also all but certain that females of the same age will reach very different sizes, some obtaining more food than others; even where the same supply of food exists, some probably are less voracious, and have less power of assimilation than others. Butterflies of a given species, although they breed only once, exhibit considerable variation in size.

The strongest evidence, however, in support of my conclusion is, I think, the loss of the teeth and the atrophy of the bones, which occurs during the ripening of the sexual organs. A conger, after it had shed its milt or ova, would in all probability be entirely incapable of feeding itself; without teeth it would be unable to hold its prey, and without food it could not recover its former condition.

Cases of animals dying after breeding once are, of course, not uncommon in the animal, any more than in the vegetable kingdom. Among insects it is rather the rule than the exception. But confining ourselves to the Vertebrata, to which the conger belongs, there are in that class cases of the phenomenon which are well established. The common eel is known to go down to the sea in order to breed, and the young elvers ascend the rivers in spring in countless multitudes, but no adults have ever been known to return. It is very probable that it will ultimately be found that all the members of the eel family (Murænidæ) produce eggs only at the cost of their own lives. Among the Cyclostomata my own investigations have shown conclusively that the hag-fish, *Myxine*, does not die after breeding. It breeds again and again, for I have taken, both on hooks and in baited traps, numbers of females with ovaries showing the collapsed follicles, from which the eggs had been recently discharged. In fact, in an old female *Myxine*, the *corpora lutea*, *i. e.* the old empty follicles in different stages of atrophy, belonging to successively discharged crops of eggs, can always be seen in the ovary. On the other hand, the river lamprey, *Petromyzon planeri*, has been shown to die after breeding once. In this last case there is a true metamorphosis from a sexually immature larva, the Ammocœtes, which feeds and grows, to the sexually mature adult, which feeds little or not at all, breeds, and then dies.

With regard to the season of the year at which the spawning of the conger takes place, my observations tend to show that it is not confined to a very short period, but extends over several months. It is impossible to decide how long a period would have elapsed before each of the ripening females I have mentioned shed its ova, if it had lived to do so. If we suppose that another month was required to bring the ova to perfect maturity, then the ova would have been shed in April, May, September, and October. Similarly the female which was observed at Southport would, perhaps, have spawned in July; whence it may be provisionally inferred that the female conger spawns in summer and autumn from about April to October. But, on the other hand, I have had ripe males in my possession from December to the end of August. If we infer from this that some females also become sexually ripe during the same period, then the spawning season is extended from December till October, eleven months in the year. If this inference is correct it becomes very improbable that the month of November should alone be excluded, and thus there is some ground for the conclusion that conger spawn at any season of the year. I shall have to refer to this question again before the end of this paper. It is at least certain that actually ripe males, or gravid females, have been observed in every month of the year except October and November.

The observed fact that both males and females cease to feed when their sexual organs begin to ripen, satisfactorily explains why it is that ripe specimens have never been obtained directly from the sea, but have only been found among conger kept for some time in captivity. For conger are usually caught by baited hooks, and of course can only be captured in that way when they seek their food. Occasionally they are taken in lobster pots, but they enter these also for the sake of the bait. Conger are frequently taken in the beam trawl, but as the gravid females in aquaria lurk constantly in holes and corners, it may reasonably be supposed that in the sea they remain in their hiding-places among the rocks, and that only those which are hunting for prey can ever be captured by the trawl.

The largest ova I have seen in newly-captured conger were ·7 mm. in diameter; these occurred in a specimen examined in March. In other large specimens the ova varied from ·2 to ·5 mm. in diameter. The larger the ova in such specimens taken directly from the sea the smaller the amount of fat-tissue; when the ova are small the fat forms the greater part of the mass of the ovary, but in more fully-developed ovaries the mass of the ova exceeds that of the fat. In the gravid females which died in the aquarium the ova when first shed were ·95 to a little over 1 mm. in diameter, and fat was entirely absent from the ovary. It is evident that the fat is deposited at first in the growing ovary in very great quantity, and is afterwards used up for the nutrition of the developing ova. Much of the fat is reabsorbed in this way before the female ceases to feed; the rest is exhausted during the period of fasting. The difference in size between the largest ova observed in conger from the sea, ·7 mm., and the ova of the gravid females from the aquarium, about 1 mm. before the formation of the perivitelline space, may seem small, considering that the ova of the gravid females have been developing for five or six months after the cessation of feeding. But in the feeding conger the large eggs are comparatively few, the rest are of all sizes, and the majority of them are quite undeveloped. In the gravid females all the eggs are of about the same size, so that the fasting period is devoted not so much to the increase in size of the few large eggs in the ovary, as to the development of the vast numbers of very young eggs which the immature ovary contains.

It was erroneously stated recently in *Nature** that a German naturalist had obtained a conger at Zanzibar containing eggs which were 2·5 mm. in diameter. I found that this statement was founded on a short paper published in the *Zoologischer Anzeiger*, 1890, p. 314, by a Dr. Voeltzkow, describing a gravid specimen, not of *Conger*, but of some species of *Muræna*. This specimen contained eggs which were 2·5 mm. in diameter and transparent. But the writer in *Nature* had misquoted the paper to which he alluded, and had written *Conger* instead of *Muræna*. The specimen of *Muræna* in question was probably more advanced towards sexual maturity than any conger yet described, because its eggs were transparent, and escaped on slight pressure from the genital aperture. But I have not been able to find any description of a female conger containing eggs larger than those described by me in this paper.

IV. *The Eggs of the Conger after Deposition.*

My own work has been confined to the study of the adult conger, my efforts having been directed towards the elucidation of the reproduction as the most satisfactory foundation for a future investigation of the development of the fish from the eggs. But there are a number of facts and probabilities concerning sundry stages of the development of the conger which have resulted from occasional observations made from time to time by other naturalists, and I think it will increase the interest of this paper if I add here a brief review of these.

To take the stages in order, we will begin with what is known of the eggs of the conger after they have been deposited by the female and been fertilised. No such developing eggs have yet been identified with certainty. It seems probable in the first place that the eggs are pelagic, that is buoyant and transparent, and each suspended separately and freely during development in the sea-water. One reason for supposing this is that eggs of the vast majority of truly marine fishes are pelagic. The eggs I have seen in gravid female conger are quite opaque and not buoyant; but these were not perfectly ripe, and it is usually the case that pelagic eggs in the ovary are opaque and heavier than sea-water up to the very last period of their maturation. In fact the eggs in an ovary (*e. g.* that of the sole) ripen in succession,

* See *Nature*, vol. xlii, p. 654, 1890.

and while a few are mature and transparent the rest are still opaque. Therefore it would not be at all surprising if the eggs of the conger were transparent and buoyant when perfectly mature and ready for fertilisation. This probability is made almost a certainty by the observation by Voeltzkow, already cited, on the ripe ova in a specimen of *Muræna* found at Zanzibar. The eggs in this case were perfectly transparent, and, therefore, probably after fertilisation would be pelagic.

The Italian naturalist Raffaele in his valuable paper on the *Pelagic Eggs and Larvæ of Fishes occurring in the Gulf of Naples*,* published in 1888, described five different kinds of pelagic eggs, which all resembled one another in certain common characters, and which could not be traced with certainty to the parent fish. Raffaele thinks it possible that these eggs belong to various species of the eel family (Murænidæ). He bases this suggestion on the form of the body, the form of the head, and the large number of muscular segments in the larvæ hatched from the eggs. The eggs all agree in having an extremely large perivitelline space, like that of the pilchard's egg, and in the fact that the yolk is not homogeneous but made up of separate vesicles, also like that of the pilchard. This similarity to the eggs of the pilchard is an important matter. For the family Clupeidæ is the only one among the Physostomi hitherto known to include species with pelagic eggs, and these eggs are distinguished from the eggs of Physoclisti by the two characters above mentioned. Therefore it is in the highest degree probable that Raffaele's eggs belong to some family of the Physostomi, and the Murænidæ is the only family among these in Europe whose eggs are not known.

We may consider it, then, as all but proved that the eggs of the Murænidæ are pelagic, and that to Raffaele belongs the credit of discovering them. In size the eggs described by Raffaele agree very well with those of the conger which I have measured. Unfortunately he only gives the diameter of the actual ovum inside the capsule in one case, in which it was 1·2 to 1·3 mm., scarcely larger than the unripe ova of the conger measured by me before the formation of the perivitelline space. The diameter of the external capsule in Raffaele's eggs was 2 to 3 mm., all the five kinds, except one, having a varying number of oil globules. I am not sure that the egg of the conger when ripe is without oil globules, but so far as I could judge it is so. In this case the egg without oil globules among those described by Raffaele is probably that of *Conger vulgaris*. The larvæ hatched from these eggs were, as I have said, all very similar. Besides the large number of body segments, they all agreed

* Mitt. Zool. Stat. Neap., Bnd. viii.

in the development, shortly after hatching, of peculiar long teeth in the jaws. After the fifth day from hatching the larvæ all died.

V. *The Larva of the Conger.*

The larval conger has been identified with certainty at a later stage, a transparent peculiar fish, whose nature remained for a long time doubtful, having been recently proved to be the young of the conger.

The history of our knowledge of this stage of the larva is somewhat curious, and I will therefore give a comprehensive summary of it. About the year 1763 a specimen of an unknown transparent fish of small size was captured in the sea near Holyhead by a gentlemen named William Morris, by whom it was given to Pennant, a celebrated zoologist of the last century. Pennant sent it to Lawrence Theodore Gronow, a Dutch ichthyologist living at Leyden, and the latter published a description and figure of it in the first part, issued in 1763, of a work entitled *Zoophylacium.* Gronow or Gronovius, for he wrote his scientific works in Latin, gave the fish the name *Leptocephalus.* Pennant himself gave a description and figure in all respects similar to those of Gronovius in his *British Zoology,* vol. iii, published in 1769. Pennant calls the fish the Morris after the name of its discoverer, and *Leptocephalus* after Gronow. His definition is: "Small head, body extremely thin, compressed sideways; no pectoral fins." His description is to the following effect:—"The length was 4 inches, head very small, the body compressed sideways, extremely thin and almost transparent, about $\frac{1}{10}$th inch thick, and in the deepest part about $\frac{1}{3}$rd inch in depth, towards the tail the body grew more slender and ended in a point; towards the head it sloped down, the head lying far beneath the level of the back. Eyes large, teeth in both jaws very small. Lateral line straight, sides marked with oblique strokes that met at the lateral line. Aperture to gills large. It wanted the pectoral, ventral, and caudal fins; dorsal fin extremely low and thin, extending the whole length of the back very near the tail. Anal fin of the same delicacy and extending to the same distance from the anus."

In the later edition of the *British Zoology* of Pennant, which I have not seen, mention is made of the capture of other specimens of the *Leptocephalus,* one gentleman, a Mr. Hugh Davies, having seen four specimens, three of which were taken in the amusement of prawning below Beaumaris Green. But I believe no improvement of, or addition to, the description was made in this edition.

The next account from an actual observer which I have seen is that of Colonel Montagu in the Memoirs of the Wernerian Natural History Society vol. ii, 1818. This naturalist says he possessed two specimens taken by Mr. Anstice, of Bridgewater, in the river Pervet, one in 1810, the other in 1811. Both were caught in a hand-net near the surface of the water. Montagu says that Pennant's description is wrong in stating that pectoral and caudal fins were absent. He says his largest specimen was 6 inches long, $\frac{1}{2}$ inch broad, $\frac{1}{16}$th inch thick; jaws equal in length, teeth numerous and all inclining forwards. Dorsal fin does not extend the whole length of the back as Pennant stated, but commences one third the length of the body from the snout. Pectorals very minute. Pennant's description also omits mention of the minute black specks on the margin of the back and belly.

In Gmelin's edition of Linnæus's *Systema Naturæ*, 1788, the fish as described by Gronovius had been introduced under the binomial name *Leptocephalus Morrisii*, and this name is used by Montagu. In all probability Montagu is right in believing that Pennant's fish and his own were the same, and that Pennant's description and figure were erroneous. Montagu's description and figure have been shown by subsequent observers to be correct, and it is therefore rather from him than from Pennant that we should date our knowledge of the form which he calls *Leptocephalus Morrisii*.

In Loudon's Magazine of Natural History, vol. v, 1832, p. 313, there is a description from actual observation by R. Couch, the Cornish ichthyologist, of a fish which he calls *Ophidium pellucidum*, but which he says, in a second communication in the same volume, is undoubtedly the same as the *Leptocephalus Morrisii* of Fleming's British Animals. Fleming's account is simply taken from that of Montagu. Couch says he had seen four specimens and gives the length (presumably of the largest) as $5\frac{1}{2}$ inches, depth $\frac{1}{2}$ inch. There are only one or two points in which this description by Couch does not agree with that of Montagu. One is that the former does not mention the lateral compression of the fish, although he refers to its great transparency. Another is the statement that one specimen differed from the others in having two bifid teeth projecting forward from the under jaw; in proportion to the size of the fish they might be termed tusks. If we compare this statement with Raffaele's description of the teeth in the larvæ hatched from his unidentified pelagic eggs, we are at once led to conclude that the teeth observed by Couch were the remains of the more prominent and more numerous teeth of a still earlier stage of the conger larva, and Couch's observation confirms the hypothesis that Raffaele's eggs are those of the Murænidæ.

This hypothesis concerning *Leptocephali* is still more confidently maintained in Günther's *Introduction to the Study of Fishes*, published in 1880. The same hypothesis has been put forward in two other cases, namely, in that of the large *Phyllosoma* forms, known to be derived from the Loricate Crustaceans, such as *Palinurus*, and in that of large *Tornariæ*, known to be the larvæ of *Balanoglossus*. In the case of the *Tornaria* it was found on investigation that the

In 1833 another specimen of the *Leptocephalus Morrisii* was described in Loudon's Magazine (vol. vi, p. 530). The observer in this case was Mr. Henry Vietz Deere, of Slapton, Devon, who states that on April 29th, 1833, one of the local fishermen brought to him a small fish apparently dead, which he had carried in his pocket for three hours wrapped in a piece of brown paper. Nevertheless, the fish seemed to be alive, and was therefore placed in a tumbler of salt and water, where it lived for some hours. Mr. Deere identified his specimen as the *Leptocephalus* of Pennant, being unacquainted with other descriptions, and, like Montagu, he proceeds to correct Pallas's description. He says the body was $5\frac{1}{2}$ inches in length, $\frac{1}{8}$ inch thick, $\frac{7}{16}$ inch deep from back to belly. It was compressed laterally in a remarkable manner, and was pellucid, bright, and silvery. The head was small, $\frac{1}{4}$ inch long, but straight with the line of the back. The dorsal fin did not extend the whole length of the back, as Pennant said, but commenced $2\frac{1}{2}$ inches from the snout, and the pectoral fins were present, though small. Deere thought the fish to be allied to the launce, *Ammodytes tobianus*.

Yarrell's description in his *British Fishes*, 1st ed., 1836, is based on three specimens which he received from Couch; he does not add anything essential to previous accounts; he says it is usually found among seaweed.

Couch's description in vol. iv of his *Fishes of the British Islands*, 1865, is not very instructive, but he gives a good figure, which was doubtless drawn from one of his own specimens. It is a pity he does not say more about the habits and habitat of the fish. He merely says that its usual residence is in shallow water and rocky ground, but it also inhabits the deeper water.

Off the shores of England only this one kind of *Leptocephalus* has been found, but in the Mediterranean several species are defined by Kaup (*Apodal Fish*, Lond., 1856–8, and *On Some New Genera and Species of Fishes*, Ann. Mag. Nat. Hist., vol. vi, 1860). In the latter paper Kaup identifies the *L. Spallanzani* of Risso's *Hist. Nat. de l'Europe Meridionale* with the *Leptocephalus Morrisii*, and says that specimens vary in the development of the teeth, which are sometimes absent, and that in some the tail is longer than the body, in others *vice versâ*. He says that the species is common at Messina, where it lives in the open sea, not in the seaweed, and is caught in bottles by boys when bathing.

Prof. J. V. Carus was the first, in a pamphlet entitled *Ueber die Leptocephaliden*, Leipzig, 1861, to suggest that *Leptocephalus* and allied forms were the larvæ of other fishes; he concluded that *Leptocephalus* was the larva of *Cepola*, a genus of rather small, laterally compressed fishes, one of which, *Cepola rubescens*, is British.

But the identification of *Leptocephalus* with *Cepola* was obviously erroneous on anatomical grounds, and was completely rejected by other zoologists. An American ichthyologist, Gill, after examining the subject, came to the conclusion (Proc. Acad. Nat. Sc. Philadelphia, 1864) that the typical *Leptocephali* were the young of congers, and the one considered here, *Leptocephalus Morrisii*, the young of *Conger vulgaris*; he referred *Hyoprorus*, another genus of the Leptocephalidæ, to another genus of the Murænidæ, namely, *Nettastoma*, which lives in the Mediterranean.

Gill did not give the anatomical comparisons on which his conclusions were based. In his British Museum *Catalogue of Fishes*, vol. viii, 1870, Dr. Günther confirms Gill's conclusion so far as concerns the derivation of *Leptocephalus Morrisii* from the conger, but doubts whether the conger is developed from the *Leptocephalus*. Dr. Günther mentions as evidence for the connection between the two forms, the similarity in the form of the head and its parts, the coincidence in the number of vertebræ (156) and the geographical distribution. But he says the question arises whether the *Leptocephalus* is a normal stage in the development of the conger, or whether it is an individual arrested in its development at a very early period, yet continuing to grow to a certain size without a corresponding development of its internal organs, and destined to perish without attaining the characters of the perfect animal.

The reasons Dr. Günther gives for the latter view are three :—(1) That he has seen a specimen of a conger 4½ inches long, *i. e.* smaller than numerous specimens of *Leptocephalus Morrisii*. (2) Specimens showing apparently a more developed condition, an approach towards the conger, in the more cylindrical body and more elongated snout, nevertheless have still an undeveloped vertebral column; if *Leptocephali* are abnormally undeveloped forms, some individuals may be more developed than others in certain points. (3) The variations in the form of the body, dentition, &c., are so great that it is impossible to separate them into specific forms, and this great variability favours the supposition that they are individuals abnormally arrested in their development.

This hypothesis concerning *Leptocephali* is still more confidently maintained in Günther's *Introduction to the Study of Fishes*, published in 1880. The same hypothesis has been put forward in two other cases, namely, in that of the large *Phyllosoma* forms, known to be derived from the Loricate Crustaceans, such as *Palinurus*, and in that of large *Tornariæ*, known to be the larvæ of *Balanoglossus*. In the case of the *Tornaria* it was found on investigation that the larger specimens were the younger, and that the metamorphosis into *Balanoglossus* was accompanied by a considerable reduction in size. Such a reduction in size is, in fact, a very common feature in metamorphosis. I have found that the larval symmetrical flounder is considerably longer than the metamorphosed asymmetrical fish. It seems to me that the theory of an abnormal continued growth of larvæ, with arrested development, is at present entirely unsupported by evidence, and in any particular case can only be proved by the actual demonstration of the normal development and of the abnormal, together with proof that they are independent of one another.

However, to return to the case of the conger, I find that the French ichthyologist, Dr. Emile Moreau, in his *Poissons de la France*, tome iii, p. 568, claims to have satisfied himself by anatomical investigation that the *Leptocephalus Morrisii* is the young *Conger vulgaris*. Moreau does not refer to any publication of his anatomical researches, or even mention that he ever published his conclusion in any other place than that I refer to, but he states that M. Dareste appropriated his results in a *Note sur le Leptocéphale de Spallanzani* in the Comptes Rendus, tome lxxvi, 1873, p. 1304. Moreau asserts that Dareste examined his preparations of *Leptocephalus* and conger, but made no dissections himself.

If the evidence went no further than this, the conclusion that *Leptocephalus Morrisii* was the larval conger would rest merely on anatomical and zoological resemblances between the two forms. If it had been discovered that the *Leptocephalus* was developed from the eggs of the conger, proof would still be wanting that the former was a normal stage in the development of the latter, and Günther's theory of the abnormal growth of the larva would remain uncontradicted by observed facts. But the metamorphosis of a *Leptocephalus Morrisii* into a normal conger has actually been once observed. This observation was made by the distinguished French zoologist, Yves Delage, and is described briefly in the *Comptes Rendus*, tome ciii, 1886, p. 698. The particulars are as follows:— Two specimens of *Leptocephalus* were captured on February 7th, 1886, by the keeper of the Laboratory of Roscoff, in Normandy. One of them was damaged, and was preserved in alcohol The other was uninjured, and was kept alive in a tank of sea water. Unfortunately Delage, strange to say, omits to give the dimensions of these two specimens. On April 18th the living Leptocephalus was still ribbon-shaped and absolutely transparent, all its blood was colourless, and the air-bladder was not visible. On May 1st the skin began to get a little dark, the air-bladder appeared in the form of a silvery streak, the gills began to show a pink colouration. On May 9th the fish was examined alive under the microscope for a few moments, with such care that its health was not imperilled. It was found that the dorsal fin extended a little in front of the posterior extremity of the pectorals; in the skin scattered black chromatophores were seen, which gave it its general smoky tint; the blood contained chiefly colourless corpuscles. In the tail were seen colonies of red corpuscles, motionless, and unconnected with the blood-vessels. Little by little after this date the body became more cylindrical, the head grew proportionately larger and more square in shape, and at the commencement of July the transformation was complete, the *Leptocephalus*, originally ribbon-shaped and transparent, with a small head, had become a small conger, opaque and coloured, with a cylindrical body and a head like that of the adult conger. The young conger in July, at the completion of the transformation, was 9·3 cm. ($3\frac{7}{10}$ in.) in length. The specimen died from accident on September 5th, and it was then preserved and, together with the other larva preserved in February, presented to the Academy. Delage adds that the *Leptocephalus* is hatched below the limit of low water, and usually is not found on the shore until after its transformation. He says that it is devoured by the pollack (*Gadus pollachius*), in the stomach of which it is frequently found.

I will add here one or two remarks concerning Günther's arguments. He states in the Catalogue that he has seen a *Leptocephalus* 10 inches in length, but does not say it was a *Leptocephalus Morrisii*. We have seen that the maximum length of English specimens recorded is 6 inches. Of twelve specimens from Messina, whose measurements are given by Kaup, the longest is $5\frac{1}{3}$ inches (134 mm.), the smallest $4\frac{1}{5}$ inches. Again, Günther's theory supposes that the abnormal development is due to the fact that the ova and larvæ, which normally develop in the vicinity of the shore, have been carried out to sea far away from land. But we have seen that the *Leptocephali* captured in England and at Messina have been taken in shallow water near shore, and not in the open sea far from land.

I have found that young conger under 15 inches in length are usually not black or dark like the adults, but pink in colour. I believe this to be due, not to specially coloured pigment cells, but to the small number of black chromatophores which are present in the skin, and which are not sufficient to conceal the natural colour of the tissues of the skin. The smallest of such conger in my collection is $8\frac{2}{5}$ inches in length (21 cm.), and was taken in the beam trawl off St. Agnes Head, on the north coast of Cornwall, April 14th, 1890. Judging from the observation of Delage, this specimen was about a year and a half old, having been a *Leptocephalus* in the preceding spring, 1889, and hatched in the autumn of 1888.

It must be remembered that the young of the common eel, although not so different from the adult as the larva of the conger, is nevertheless perfectly transparent up to a length of about 3 inches, a length fairly corresponding to 6 inches in the case of the conger. These young eels or elvers are common enough in Plymouth Sound in spring from February to May or June, or even later. Unlike the *Leptocephalus,* they resemble the adult eel in shape, the body being cylindrical, the head like that of the adult, having the lower jaw prolonged, and the pectoral fins well developed. They also have red blood, visible as a small red spot at the throat, which is really the heart, the eyes are perfectly black, and there is a line of black pigment along the spinal cord; otherwise they are transparent as glass. They are often found in tide pools and under stones at low tide, and are caught without much difficulty with the hand.

I regret to say I have not met with any specimens of the *Leptocephalus* at Plymouth, and if any reader of this Journal can present me with some, alive or preserved, I shall be very thankful.

The Head Kidney of Teleostean Fishes.

By

W. L. Calderwood.

With Plate I.

Until the year 1881, when Balfour wrote on the subject,* the pronephros was generally believed to be a functional kidney, not only in the larval condition, but also in those adult forms described as possessing the organ.

Balfour, in his more detailed paper, published later,† states that in the fishes examined—pike, eel, smelt, and angler—although the pronephros had all the appearance, externally, of a true functional kidney, no uriniferous tubules were present, and that a minute examination only disclosed a degenerate trabecular tissue which he describes as lymphatic.

The angler (Lophius), it may be observed, is generally considered to possess only a head kidney. This organ Balfour found to be in a perfectly functional condition, but he declines to believe that it is a persistent head kidney, and argues from the highly modified structure of the fish that the organ in question is in reality the mesonephros shifted forward from its normal position. He also maintains that in adult Ganoids the head kidney has no longer a renal function. His general conclusion, therefore, is, that since the pronephros was only supposed to persist in Ganoids and Teleosteans, it must be now considered as non-existent except in the embryonic or larval conditions.

Parker‡ also supports the conclusions of Balfour by stating that in many instances the mesonephros has grown forward in front of the air-bladder and taken the place of the pronephros.

* *The Pronephros of Teleosteans and Ganoids*, Brit. Assoc. Reports, 1881, p. 721.

† Quart. Journ. Micros. Science, January, 1882.

‡ *On the Kidneys of Teleosteans*, Brit. Assoc. Report, 1882, p. 577.

When studying the extraordinary position of the air-bladder in Dactylopterus volitans* I was struck by the very pronounced head kidney, and by its peculiar position. In this fish the pronephros is entirely separated from the body kidney and is situated anterior to the abdominal cavity in the same transverse plane as the heart. In the paper referred to it is shown that the swimming bladder of Dactylopterus is divided, on each side, into two main portions, one large and muscular, the other thin-walled but surrounded by bone and situated above and anterior to the muscular portion. Below this secondary portion, and in front of the primary, there is a cavity of inverted pyramidal shape, formed entirely of bone except on the anterior aspect.

The pronephros fills this cavity, its anterior surface coming in contact with the extremely vascular membrane lining the posterior portion of the branchial chamber.

The body kidney is situated behind the large muscular portion of the swimming bladder, and receives in a concavity the rounded posterior end of the bladder.

Communication between the two is, however, maintained by a canal formed in the ventral surfaces of the anchylosed first four vertebræ of the spinal column. This canal tunnels through what would otherwise be the bases of the transverse processes, and so is protected from any movements of the bladder which surrounds, and lies largely above the spinal column in this region.

The appearance of the pronephros when sectioned is represented in fig. 1. It is apparently a functional kidney. Sections of the body kidney give an exactly similar appearance, only in the majority of sections a greater number of uriniferous tubules are present, and no doubt this organ is capable of secreting more urine than the other. In comparing the organs, I took at random, ten sections from slides of head kidney sections, and ten from slides of body kidney, and used a lens with a wide angle (Zeiss D). I counted 87 sectioned tubules for the head kidney, and 144 for the body kidney; *i.e.* a majority of 57 for the body kidney.

This difference between the two organs may go to show that in Dactylopterus the degeneration of the pronephros is only commencing, but I think the conditions justify me in believing the organ to have a renal function.

In attempting to follow the course of degeneration I examined *Cyclopterus lumpus*. Here the pronephros, although joined to the mesonephros, is yet easily distinguishable from it. The single body kidney somewhat resembles an elongated cone in form, the apex

* *On the Swimming Bladder and Flying Powers of Dactylopterus volitans*, Proc. Roy. Soc. Edin., vol. xvii, 1890.

being posterior. At its broadest or anterior end it suddenly divides, each branch becoming constricted and then again dilating to form the large head kidney. The appearance of sections taken at this constricted part in no way differs from that of the body kidney proper, but in the fully-grown adult, the part where the dilatation to the head kidney begins shows an altered condition ; uriniferous tubules have become fewer in number, blood-vessels have disappeared, and the cells of the surrounding matrix seem to have multiplied. Still further forward, hardly any trace of tubules remains. This condition is shown in fig. 2.

Here, elongated empty spaces alone denote the former position of tubules, and the granular matrix forms almost the entire organ ; whereas in sections of the body kidney, the convoluted tubules lie so thickly together as to leave room for little surrounding substance. As to the nature of this matrix, which Balfour considers to be lymph, I am not prepared to make a positive statement. Looked at with a very high power, the granules are seen to be nucleated, and to possess a more or less irregular outline, but they are extremely small, and it seems to me the entire organ presents a singularly solid mass to be analagous to a lymph gland. Capillaries do not appear to exist, nor can I find any adenoid reticulum.

The very early condition of the pronephros is seen in fig. 3—a thirteen days' embryo. Here the tubules are still few in number, but large in proportion to the size of the organ, and there is a considerable mass of granular tissue. As development proceeds the tubules multiply, and there is consequently less granular substance, but a Cyclopterus three quarters of an inch long shows little difference in the condition of its pronephros, from the figure of the thirteenth day embryo.

I have preserved almost a complete series of specimens from the fertilization of the egg onwards, but find that not till Cyclopterus has become sexually mature does its head kidney commence to degenerate. Fig. 4 shows a section of the pronephros of what may be described as a half grown or small adult fish, but owing to the specimen having been preserved in strong spirit, great shrinkage has taken place. This figure is in strong contrast to the condition in the old fish as seen in fig. 2, yet it is very similar to the figure showing the old state in Dactylopterus, fig. 1.

Returning now to the statement of Balfour that, in some instances, the mesonephros grows forward so as to take up the position formerly occupied by the pronephros, and again considering the case of Dactylopterus, two objections suggest themselves. First, in the developing embryo, the segmental duct and pronephros are developed at a much earlier period than the mesonephros, and must be permanently separated from all abdominal viscera before the completion of the mesonephros. Second, from the manner in which the head kidney is encased in bone, it appears that if what I am naming head kidney is in reality a part of the body kidney grown forwards (since it is functional), it must, to have taken up its position in the head, have penetrated both the air-bladder and the scapular arch.

Again, does the similar condition of the pronephros in a small adult Cyclopterus and an old adult Dactylopterus, not indicate that in some fishes (*e. g.* Dactylopterus) the degeneration of the organ in question has not yet reached that point demonstrable in many? This seems to me to be a more natural view than to suppose that any functional kidney occupying a position in the head is merely the whole or part of the true body kidney translated from its normal position.

If, then, I establish the fact that the head kidney in Dactylopterus is in reality a functional pronephros persisting in the adult, the statement of Balfour that such an organ does not exist must be modified, and a compromise made between it and the older hypothesis of Rosenberg, who first demonstrated that the head kidney was the persistent pronephros.

I think the above evidence, therefore, favours the conclusion that in adult Teleosteans the renal function is performed in some instances by the body kidney only; in others by the head kidney only; and in others—probably a very limited number—by both the body and head kidneys. Besides Dactylopterus, I am aware of only one instance where the head kidney is described as possessing tubules and Malpighian bodies, viz. in Fierasfer. (Carlo Emery, Le Specie del Genere Fierasfer nel Golfo di Napoli, Leipzig, 1880).

EXPLANATION OF PLATE I.

Illustrating Mr. Calderwood's paper on "The Head Kidney of Teleostean Fishes."

FIG. 1.—Transverse section of head kidney of an adult Dactylopterus. Zeiss' D, oc. 2.

FIG. 2.—Transverse section of head kidney of adult Cyclopterus. Zeiss' D, oc. 2.

FIG. 3.—Longitudinal section of pronephros of Cyclopterus embryo at thirteenth day. Zeiss' D, oc. 2.

FIG. 4.—Transverse section of head kidney of young adult Cyclopterus. From spirit specimen. Zeiss' D, oc. 2.

Fig. 1.

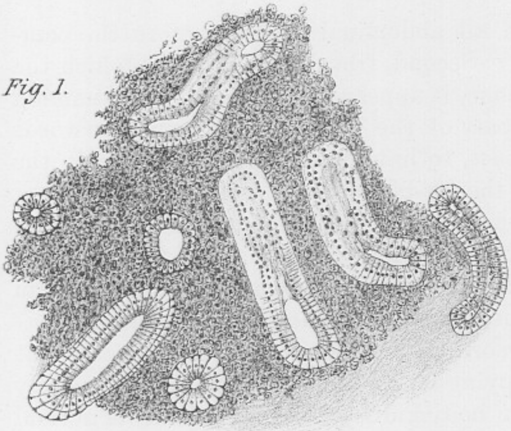


Fig. 2.

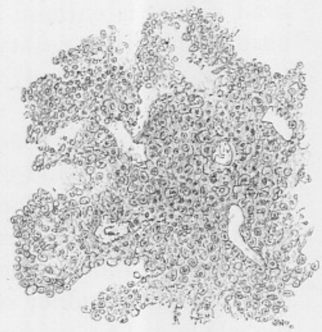


Fig. 3.

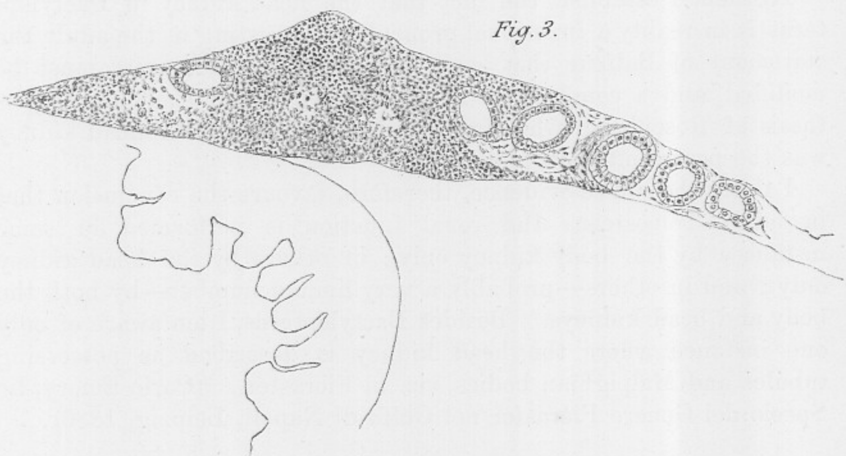
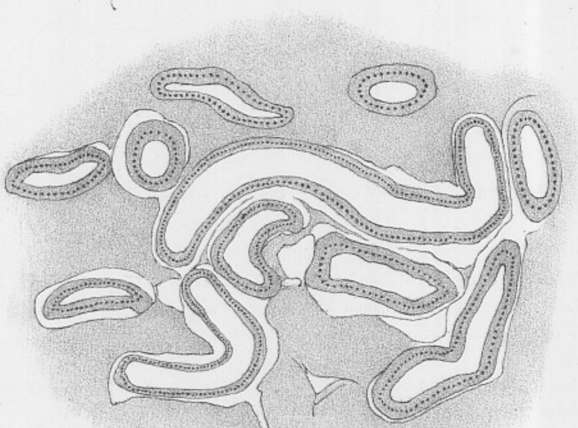


Fig. 4.



W. L. Calderwood del.

F. Huth, Lith^r Edin^r

Report on the Tunicata of Plymouth.

By

Walter Garstang, M.A.,
Jesus College, Oxford;
Berkeley Fellow of The Owens College, Manchester.

With Plate II.

Part I.—CLAVELINIDÆ, PEROPHORIDÆ, DIAZONIDÆ.

The southern shores of the English Channel have long been famous for the wealth of their Tunicate fauna, having furnished material in abundance for the classical researches of Milne-Edwards, Giard, and Lacaze-Duthiers. The Channel Islands also have been repeatedly visited by English zoologists, and have amply supplied those among them who have been in search of Tunicate treasures. Probably the peculiar tidal conditions of this part of the Channel are especially favourable to a rich development of littoral forms; but, as the work of Montagu, Couch, Clark, Alder, Gosse, Cocks, Bate, and Norman sufficiently testifies, the Devon and Cornish coasts of England can lay claim to an almost equally luxuriant shore fauna, the rocky bays and long sheltered estuaries being especially wealthy in this respect. During my residence at Plymouth I found that the Tunicata were among the best represented groups of the fauna, and, as I devoted considerable attention to the search for rare or new, as well as for well-known forms, I trust that a classified report upon the local representatives of the group will not be without its usefulness to other investigators.

The absence of any work at all approaching the character of a monograph of the British Tunicata is a serious want which has long been felt by marine zoologists generally. Such a work has several times been commenced by some of our most eminent naturalists, by Forbes and Goodsir, by Alder and Hancock, and by Professor Huxley; but various causes have hitherto conspired to delay its production. It is now very satisfactory to be assured that the preparation of the Monograph is in the hands of the experienced author of the Reports on the "Challenger" Tunicata. In the meantime a more or less detailed account of the forms with which I have met at Plymouth may be of some service as a contribution towards an improved knowledge of the British representatives of the group.

In the neighbourhood of Plymouth I found the rocks under the Hoe, the north and east sides of Drake's Island, the wooden piles of the docks and wharves in Millbay and the Cattewater, the rocks and tidal pools of the Mewstone and Wembury Bay, to be all good hunting-grounds for the littoral species of composite Tunicata; the best dredging-grounds for Ascidians generally were undoubtedly the neighbourhood of the Duke Rock, the Queen's Grounds, and the deeper waters off the Eddystone, the Mewstone, and Bigbury Bay, while some forms were most common upon *Zostera* in Cawsand Bay; but it was almost impossible to use any of the ordinary methods of collecting within Plymouth Sound without obtaining numbers of Ascidians of various species. Very few simple Ascidians were to be found inhabiting the tidal zone; they were most plentiful in the deep water of the trawling grounds and on the rough ground off the Mewstone.

In reporting upon the Ascidians of Plymouth, I have taken *Clavelina* and its allies as my starting-point, since this genus includes the forms which are in many respects probably the least modified descendants of the earliest Ascidiacea. But I am met at the outset by the problem which is now engaging the attention of every Ascidiologist: What taxonomical value must be attributed to the possession of the power of budding and of the formation of colonies? A full discussion of this question I cannot give here, but since the matter bears directly upon the classification which I shall employ, I am bound to admit that the division of the Ascidiacea into the sub-orders *Ascidiæ simplices, Ascidiæ compositæ,* and *Ascidiæ salpiformes* so completely disregards the admitted inter-relationship between various sections of these groups, that its adoption seems to me to involve the rejection of any morphological, and therefore genetic, meaning in classification altogether. The term "composite Ascidians" is in practice a very convenient one, but this is not a sufficient reason for retaining it as the symbol of a natural group, when the group in question is in reality no natural group at all, but an "artificial assemblage" composed of several quite unrelated phyla. The primary subdivision of the *Ascidiacea* into these three sub-orders will therefore not be adopted in my Report; the various genera will be grouped into families upon morphological grounds pure and simple, and will be taken as far as possible in the order of their affinity. From the nature of the case it is impossible to do this with perfect satisfaction, because the families of Tunicates, as of other orders of animals, do not form a single series; but upon completing the description of the species I will present a scheme of classification in which the various families will be bound together according to their most probable phylogenetic relationships.

I desire here to express my warm thanks to Professor Herdman for the assistance which he has liberally given me from time to time; as regards the present paper, I am particularly indebted to him for his kindness in rendering me various information concerning still unpublished work of his upon members of the *Clavelinidæ* and upon Tunicate classification* generally. I am equally indebted to Professor Milnes Marshall for the excellent facilities and help which he has afforded me in his Laboratories.

Order ASCIDIACEA.

Family 1.—CLAVELINIDÆ.

Body consisting of a thorax and abdomen connected by a slender, more or less elongate, œsophageal region. Stolonial tubes arising from the posterior end of the abdomen, rarely from its lateral walls.

Test gelatinous or cartilaginous; forming either distinct sheaths round the stolonial tubes or a common mass investing them; common test never extending above the abdominal region; apertures circular, not lobed, placed near together, terminal.

Musculature consisting almost exclusively of longitudinal bundles; transverse muscles rare.

Branchial sac not folded; horizontal membranes well developed, without papillæ or internal longitudinal bars; dorsal lamina consisting of a series of languettes flattened antero-posteriorly and continuous with the horizontal membranes; stigmata straight.

Tentacles simple, filiform.

Genitalia in the loop of the intestine; oviduct and vas deferens present.

Reproduction by gemmation as well as from ova.

The family, as thus defined, includes the genera *Clavelina*

* Professor Herdman's views upon the classification of the Tunicata will form the subject of a comprehensive memoir in the Transactions of the Linnæan Society, to which Society they were recently communicated.

(Savigny), *Podoclavella* (Herdman), *Stereoclavella* (Herdman), and a new genus, *Pycnoclavella*, described below.

I believe there is abundant reason for dividing the family Clavelinidæ, as regarded by Herdman, into several groups; *Perophora*, indeed, was excluded by Giard in 1872 and by von Drasche in 1883, while still more recently Lahille (1890) has emphasised the differences between *Clavelina* and *Perophora* by placing the former genus in the Distomidæ and the latter in the Ascidiidæ. Von Drasche's family Clavelinidæ includes *Diazona*, but although a near relationship between *Clavelina* and *Diazona* is generally admitted, it must be remembered that the new forms discovered in recent years have rather emphasised than reduced the gap between the two genera; I have therefore excluded *Diazona* from the Clavelinidæ altogether. As above defined, this family includes a number of forms about whose close mutual affinity there can be no doubt.

1. Clavelina, *Savigny*.

Ascidia, *O. F. Müller*. Zoologia Danica, vol. ii, 1788. In part.
— *Bruguière*. Hist. Nat. des Vers, Encycl. Méthodique, Paris, 1792, p. 141. In part.
— *Turton*. Linné's General System of Nature, London, 1802, vol. iv, p. 92. In part.
Clavelina, *Savigny*. Mémoires sur les Animaux sans Vertèbres, Paris, 1816, IIe Partie, pp. 87 and 109. In part.
— *Savigny*. Tableau systématique des Ascidies, p. 171. In part.
— *Fleming*. Molluscous Animals, Edinburgh, 1837, p. 202. In part.
— *M. Edwards*. Observations sur les Ascidies des Côtes de la Manche Mém. de l'Acad. des Sci., Paris, xviii, 1842, p. 50. In part.
Clavellina, *Alder*. Cat. Moll. of Northumberland and Durham, Trans. Tyneside Nat. Field Club, 1848, p. 108.
Clavelina, *Forbes and Hanley*. Hist. Brit. Moll., i, 1853, p. 26.
Clavellina, *Adams*. Genera of Recent Mollusca, London, 1858, vol. ii, p. 595. In part.
Clavelina, *Giard*. Recherches sur les Synascidies, Arch. Zool. Exp., i, 1872, p. 613.
— *Herdman*. Prelim. Report on Tunicata of "Challenger," Proc. Roy. Soc. Edin., x, 1880, p. 717. In part.
— *Herdman*. Rep. on Tunicata, "Challenger" Reports, vol. vi, pt. xvii, p. 245. In part.
— *R. von Drasche*. Die Synascidien der Bucht von Rovigno, Wien, 1883, p. 8.
— *Carus*. Prodromus Faun. Mediterr., Stuttgart, 1890, vol. ii, pt. ii, p. 476.
— *Herdman*. On the Genus Ecteinascidia and its Relations, with Descriptions of two new Species, and a Classification of the Family Clavelinidæ, Trans. Biol. Soc. Liverpool, vol. v, 1890, pp. 160, 161.

Body oblong, more or less clavate, not provided with a post-abdominal peduncle.

Stolons distinct, delicate and branched.

Professor Herdman has quite recently* subdivided this genus as it was defined in his "Challenger" Report. The difference recognised by Savigny between the types *borealis* and *lepadiformis*, in regard to the presence or absence of a well-developed post-abdominal peduncle of test-substance, is raised by him into a criterion of generic value (*Podoclavella*), while the rudimentary "common test" enclosing the stolons of the "Challenger" species constitutes the salient character of his new genus *Stereoclavella*. These changes have been rendered desirable by an increase in the number of species and the apparent† distinctness of the three types. As the table in Professor Herdman's paper shows, the restricted genus now includes the species *lepadiformis* (O. F. Müller), *rissoana* (M. Edwards; variety only?), *pumilio* (M. Edw.), *producta* (M. Edw.), *Savigniana* (M. Edw.), and *nana* (Lahille).

Is not Müller's *Ascidia gelatina* (Zool. Dan., iv, 26, plate 143) also probably a species of *Clavelina*?

1. CLAVELINA LEPADIFORMIS, *O. F. Müller*. (Pl. II, fig. 1.)

ASCIDIA LEPADIFORMIS, *O. F. Müller*. L. c., p. 54, pl. lxxix, fig. 5.
— — *Bruguière*. L. c., pp. 142, 151, 152; pl. lxiii, fig. 10.
— — *Turton*. L. c., p. 95.
CLAVELINA LEPADIFORMIS, *Savigny*. Tableau systématique, p. 174.
— — *Fleming*. L. c., p. 202, pl. xvi, fig. 57.
— — *Milne-Edwards*. L. c., p. 267, pl. i, fig. i; ii, fig. 1.
— RISSOANA, *Milne-Edwards*. L. c., p. 267.
— LEPADIFORMIS, *Thompson*. Rep. on Fauna of Ireland, Rep. Brit. Ass., 1843, p. 264,
CLAVELLINA — *Alder*. L. c., p. 108.
CLAVELINA — *Forbes and Hanley*. L. c., p. 26, pl. E, fig. 1.
— — *Dickie*. Rep. on the Mar. Zoology of Strangford Lough, Brit. Ass. Rep., 1857, pp. 105, 111.
— — *Mennell*. Rep. of Dredging Expedition to Dogger Bank and Coasts of Northumberland, Trans. Tyneside Nat. Field Club, 1862, p. 12.
— — *A. M. Norman*. Last Rep. on Dredging among Shetland Isles, Rep. Brit. Assoc., 1868, p. 303.
— — *Giard*. Recherches, l. c., pp. 613—615, pl. xxi, figs. 2, 5; xxiii, fig. 2.

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* *On the Genus Ecteinascidia*, &c., loc. cit.

† One of the individuals in Milne-Edwards' figure of *Clavelina producta* (l. c., pl. ii, fig. 3) exhibits a post-abdominal peduncle of some extent.

CLAVELINA LEPADIFORMIS, *McIntosh.* Marine Invertebrates and Fishes of St. Andrews, 1875, p. 54.
— — *Herdman.* Fauna of Liverpool Bay, vol. i, 1886, p. 296, and Proc. Biol. Soc. Liverpool, vol. iii, 1889, p. 245.
— — *Carus.* L. c., p. 476.

Colonies compact, zooids numerous.

Zooids more or less stout, moderately clavate, slightly compressed from side to side, without well-marked external differentiation into thoracic and post-thoracic regions; average height from a half to three-quarters of an inch.

Test gelatinous, perfectly hyaline and transparent.

Thorax one third of the total body-length; œsophageal region short; conspicuous opaque bands of a yellow, brown, or white colour mark the position of the dorsal, ventral and anterior peri-branchial sinuses.

Branchial sac with about thirteen transverse rows of stigmata; horizontal membranes broad.

Habits.—Attached to rocks and stones (rarely to algæ and the backs of crabs, Müller) at the bottom of the tidal zone; seldom extending into 10 fathoms water.

At Plymouth fine colonies of this species have been found at extreme low water on the north side of Drake's Island, near the "Bridge" under Mount Edgcumbe Park, in tide-pools among the Renny Rocks, and in a few other localities. A few isolated zooids have also been dredged occasionally in 4 to 5 fathoms water near the Duke Rock, and, very rarely, in 10 to 15 fathoms off the Mewstone and Penlee.

On Pl. II, fig. 1, I have represented part of the series of languettes which extends along the dorsal median line of the branchial sac, in order to display their method of connection with the horizontal membranes. The languettes themselves are comparatively narrow and slender; they are compressed antero-posteriorly and are not connected with one another by any trace of a longitudinal lamina.

The horizontal (interserial or transverse) membranes are thin but well-developed, and may project sufficiently for each one to completely cover the row of stigmata immediately behind it. The free margins of these membranes are perfectly even; they are not in the least degree scalloped (festooned), and they show no trace of marginal papillæ.

2. PYCNOCLAVELLA, *gen. nov.*

Der.—πυκνος, closely united.

External appearance.—Zooids small and delicate, clavate, arising by slender stalks from a more or less thick, basilar mass of test-substance.

Body consisting of a small thorax, a slender, often greatly elongate œsophageal region, and a more dilated abdomen, the greater part of which is imbedded in the basilar mass of common test.

Test thin and delicate around the thorax, thicker and firm in the foot-stalks, dense and cartilaginous throughout the basilar mass; the latter is traversed in all directions by stolonial tubes, some of which even extend and branch in the œsophageal region of the zooids, where they remain sterile or, more rarely, give rise to new buds.

The partial imbedding of the posterior ends of the zooids in a basal mass of test is a character which is common to this genus and the genus *Stereoclavella*, as recently defined by Herdman (l. c., pp. 160, 161); but although this is the only character by which *Stereoclavella* has been as yet distinguished, a comparison of *Pycnoclavella aurilucens* with the described species of *Stereoclavella* shows that marked differences exist between the two genera. In *Pycnoclavella* the zooids arise by slender stalks from the common basal test, and there is a definite demarcation between the two regions; while in *Stereoclavella** it is almost impossible to speak of the common test as a distinct structure. The elegant and regularly clavate form of the free portions of the zooids, together with their delicacy and small size, are also points clearly separating the former genus from the species of *Stereoclavella*. It appears to me to be very probable that the chief character common to these two genera has been attained independently in each case, *Stereoclavella* having arisen from a species of *Clavelina* resembling *C. lepadiformis* in form and size, while *Pycnoclavella* is more akin to *C. producta*.

2. PYCNOCLAVELLA AURILUCENS, *sp. nov.* (Pl. II, figs. 2 and 3.)

Colonies very variable in shape and size, as regards both the thickness and extent of the common test and the length of the free portions of the zooids.

Zooids with thorax slightly compressed from side to side, almost as broad as long, connected with the basal test by a slender cylin-

* The preliminary description given by Professor Herdman of *S. australis* has no reference to the exact character of its common test.

drical foot-stalk of varying length; thorax $\frac{1}{20}$ inch in length; foot-stalk from twice to ten times as long. Abdomen elongate, deeply embedded in the common basal test.

Colour.—A band of golden-yellow pigment extends along the ventral side of the thorax and is continued into the œsophageal region; it is absent from the dorsal side; this band gives a conspicuous colouration to the zooids, when seen alive with the naked eye.

Test of a pale green colour, semi-transparent; thin around the thorax, thicker and firm in the œsophageal region, cartilaginous in the basilar mass; traversed by stolonial tubes in the basal, abdominal, and even œsophageal regions; in the latter region (that of the foot-stalk) the tubes are generally sterile.

Apertures circular, proximate, in the median sagittal plane; branchial terminal, cloacal subterminal.

Branchial sac with seven to nine rows of stigmata; horizontal membranes well developed, broad; dorsal languettes borne on the horizontal membranes, long and stout; endostyle of great size; aperture of hypoganglionic gland simple, circular.

Cardiac structures (pericardium, epicardium) as in *Clavelina;* pericardium not recurved.

Habits.—Irregularly attached along with masses of Polyzoa (*Bugula, Scrupocellaria*, &c.), calcareous sponges (*Leucosolenia*), and compound Ascidians (*Botryllus, Didemnum*) to varied objects from rough ground in 10—20 fathoms water (*e. g.* cases of tubicolous Annelids, *Gorgonia* stems, shelly débris); rarely forming a thin carpet on the stems of red weeds, such as *Delesseria*.

I first noticed this beautiful little Tunicate in the winter and early spring of 1889, when it was dredged several times on rough ground off the Mewstone, on one occasion to the west of it, but generally from half to two miles south or south-west of the rock. This is certainly the best locality for the species at Plymouth, although curiously enough the first specimen was dredged on January 26th in shallower water inside the Breakwater, north-west of the chequered buoy. This first colony was attached to the stem of a *Delesseria*, and formed a thin crust over its surface, the zooids having very short stalks (see Pl. II, fig. 3); the colony was unusually free from adventitious foreign bodies, and the configuration of its parts, especially of the basal test, was much more obvious than in specimens dredged off the Mewstone. These latter colonies are almost inextricably bound up with Polyzoa, Botryllids, Sponges, and other organisms, forming tangled masses in which usually only the brightly gleaming heads of the zooids are visible, the basal test being hidden beneath numerous other organisms and foreign bodies. It is a very interesting fact that the stalks of the zooids are elongated in direct proportion to the abundance and height of the foreign organisms competing with them for space and oxygen, resembling in this respect numerous epiphytes and other vegetable growths in a thick Brazilian forest.

If the smaller zooids of a living colony be touched with a needle, the bright yellow thorax frequently withdraws itself completely from the greenish test of that region and disappears within the stalks or below the level of the corm. The larger zooids contract upon irritation, but do not completely withdraw in this way. On contraction they give, as it were, a stoop or bend towards the dorsal side—away from the side with the line of yellow pigment; this is due to the fact that the longitudinal muscle-bundles are somewhat more numerous in the dorsal than in the ventral section of the body. Very rarely, if the irritation be continued, the larger zooids may also behave like the smaller ones.

Since I made these experiments with *Pycnoclavella* I have found that Forbes and Goodsir* noticed a precisely similar reaction in the case of their *Syntethys hebridicus*. Indeed, there are several interesting resemblances between the genera *Diazona* (*Syntethys*) and *Pycnoclavella*, the chief of which I may mention as being the greenish colour of the test and the embedding of the abdominal regions of the zooids in a thick basal mass of common test, the thoracic portions remaining free; in *Diazona* this process is more complete than in *Pycnoclavella*.

With regard to the relations of this species to *Clavelina*, I have stated above that although there can be no doubt that both *Stereoclavella* and *Pycnoclavella* are closely allied to that genus, and, indeed, almost certainly derived from it, I believe others will agree with me that this species is more closely related to *Clavelina* itself than to the species of *Stereoclavella*; its nearest ally seems to be Milne-Edwards' species *Clavelina producta*.† This species produces buds from the lateral walls of the abdomen as well as from the basal stolonial tubes, a fact hitherto without parallel in the Clavelinidæ. *Pycnoclavella aurilucens*, however, exhibits occasionally the same phenomenon (see Pl. II, fig. 2), and there can be little doubt that the stolonial tubes traversing the foot-stalks in this species, whether they remain sterile or produce buds, are the direct homologues of the fertile stolonial tubes of the abdominal walls in *Clavelina producta*. The only other "social Ascidian" possessing morphologically similar structures is *Sluiteria rubricollis* (Van Beneden‡

* Trans. Roy. Soc. Edin., xx, 1853, p. 308.

† Milne-Edwards' Observations, l. c., p. 267, pl. ii, fig. 3.

‡ E. van Beneden, *Les genres Ecteinascidia, Rhopalæa et Sluiteria; note pour servir à*

ASCIDIA, *Fleming*. Molluscous Animals, Edin., 1837, p. 202.
PEROPHORA, *Forbes and Hanley*. Brit. Moll., 1853, p. 28.
— *Adams*. Genera of Mollusca, 1858, ii, p. 596.
— *Giard*. Recherches, l. c., p. 615.
— *R. von Drasche*. Die Synascidien, 1883, p. 8.
— *Herdman*. Tunicata, Encycl. Brit., 9th edit.
— *Carus*. Prodr. Faun. Med., 1890, ii, pt. ii, p. 476.
— *Herdman*. On the Genus Ecteinascidia, l. c., p. 161.

Zooids quadrangular or oblong, rarely pyriform, never cylindrical, generally compressed from side to side.

Test thin, membranous, without sterile stolonial tubes; apertures apart.

Branchial sac rarely provided with rudimentary horizontal membranes; interserial papillæ triangular or tubular; papillæ simple or and Sluiter), whose transparent test is traversed by several sterile stolonial tubes, branching dichotomously and terminating in a few delicate papillary prolongations on its surface.

These three species illustrate the probable manner in which the "vessels of the test" in Ascidiidæ arose phylogenetically; at first few, short and completely fertile (*e. g. Clavelina producta*), they subsequently increased somewhat in number and extent, dividing dichotomously in the thickness of the test, and became less fertile (*e. g. Pycnoclavella aurilucens*); at a still later stage (represented by *Sluiteria rubricollis*) the tubes became completely sterile, and, though still not numerous, were essentially organs of the test. The loss of the power of blastogenesis altogether would now bring us to the stage occupied to-day by the species of *Ciona;* while an increase in the number of the vessels would lead to the condition found in the greater number of simple Ascidians.

It is interesting to note also that these forms furnish confirmatory evidence of the view enunciated by Della Valle* that the sterile ectodermic tubes of the test have essentially a "palliogenic" function. In *Pycnoclavella aurilucens* the part of the test traversed by them is much thicker and firmer than the thoracic portion, and in *Sluiteria rubricollis* the test is, according to Van Beneden, thicker and more resistant than in *Ecteinascidia*. The test of "social Ascidians" generally is characteristically thin and soft, and this can be referred directly to the absence or very slight development of sterile "palliogenic" tubes. The softness and delicacy of the test of *Ciona* as compared with that of *Ascidia* is also a further confirmation of Della Valle's view.

A fully illustrated account of the anatomy of *Pycnoclavella* will appear in another journal later in the year, and with it will be published coloured sketches of the living colony.

Family 2.—PEROPHORIDÆ.

Body undivided into thorax and abdomen; viscera on the left side of the branchial sac.

Test transparent, for the most part thin and membranous, rarely traversed by a few sterile stolonial tubes; never investing the stolons in a common basal sheath; apertures generally well apart, the branchial terminal and the cloacal dorsal, lobed, or rarely proximate, terminal and only indistinctly lobed.

la classification des Tuniciers, Bull. Acad. Roy. des Sci., &c., Bruxelles (iii), xiv, 1887, pp. 43, 44.

* See Arch. Zool. Exp., x, 1882, *Notes et Revue,* p. xli.

Musculature consisting almost exclusively of transverse fibres; longitudinal fibres rarely present except around the apertures.

Branchial sac not folded, horizontal membranes absent or feebly developed, replaced or surmounted by interserial rows of papillæ; papillæ simple and unbranched or supporting incomplete or complete internal longitudinal bars; bars papillate or not papillate; dorsal lamina a longitudinal membrane or represented by a series of slender languettes; languettes rarely compressed from before backwards; stigmata straight.

Tentacles simple, filiform.

Genitalia in the loop of the intestine; oviduct and vas deferens present.

Reproduction by gemmation as well as from ova.

This family includes the genera *Perophora* (Wiegmann), *Perophoropsis* (Lahille), *Sluiteria* (E. van Beneden), and *Ecteinascidia* (Herdman, sens. strict.). In a complete system of classification it should be placed very near to Roule's group "Phallusidées," which embraces the genera *Ascidiella, Ascidia,* and *Phallusia.*

A species of *Ecteinascidia* (*E. Moorei*), quite recently described by Herdman, appears from his figures to possess dorsal languettes flattened antero-posteriorly, and this is implied, though not directly stated, in the text of his paper. This condition of the languettes is unique within the family, and affords an approach towards the genera *Rhopalopsis, Rhopalæa,* &c.

3. PEROPHORA, *Wiegmann.*

ASCIDIA, *Lister.* Some Observations on the Structure and Functions of Tubular and Cellular Polypi and of Ascidiæ, Phil. Trans., pt. ii, 1834, pp. 378—382.
PEROPHORA, *Wiegmann.* Jahresbericht, Archives, 1835, p. 309.
ASCIDIA, *Fleming.* Molluscous Animals, Edin., 1837, p. 202.
PEROPHORA, *Forbes and Hanley.* Brit. Moll., 1853, p. 28.
— *Adams.* Genera of Mollusca, 1858, ii, p. 596.
— *Giard.* Recherches, l. c., p. 615.
— *R. von Drasche.* Die Synascidien, 1883, p. 8.
— *Herdman.* Tunicata, Encycl. Brit., 9th edit.
— *Carus.* Prodr. Faun. Med., 1890, ii, pt. ii, p. 476.
— *Herdman.* On the Genus Ecteinascidia, l. c., p. 161.

Zooids quadrangular or oblong, rarely pyriform, never cylindrical, generally compressed from side to side.

Test thin, membranous, without sterile stolonial tubes; apertures apart.

Branchial sac rarely provided with rudimentary horizontal membranes; interserial papillæ triangular or tubular; papillæ simple or each provided near its extremity with an anterior and posterior longitudinal process; processes rarely fusing to form complete internal longitudinal bars; dorsal lamina, a rudimentary or well-developed longitudinal membrane, supporting interserial languettes compressed from side to side.

Stigmata usually in four, rarely six, transverse rows.

Stolons delicate, distinct, creeping; branches generally alternate in position.

The species included within this genus are at present four in number —*Listeri* (Wiegmann), *Hutchinsoni* (Macdonald), *viridis* (Verrill), and *banyulensis* (Lahille). Of these, *P. banyulensis* may prove not to be distinct from *P. viridis*, as Herdman believes, while *P. Hutchinsoni*, despite Macdonald's careful description and figures, will probably be found on re-examination to present some structural characters not included in the above generic diagnosis.

In his recent paper on *Ecteinascidia* and its allies, Professor Herdman has anticipated me in a description of the interesting condition of the interserial papillæ in *P. viridis*. I can quite confirm his account by my observations on a number of specimens of a *Perophora* which Professor Weldon collected in the Bahamas and gave into my hands some time ago for description. Professor Herdman rightly interprets the bifid or trifid papillæ of *P. viridis* as "rudimentary or imperfect internal longitudinal bars," but so far, I believe, no perfect bars have been discerned in the branchial sac of *Perophora*. In some specimens, however, sent to me from the Zoological Station at Naples, and labelled "Perophora Listeri" I discovered some months ago that numerous perfect internal longitudinal bars actually existed, being supported upon the ends of flat triangular "connecting ducts" precisely as in *Rhopalopsis crassa* or *Ecteinascidia Moorei*, with this difference only, that small papillæ were frequently present at the points of junction. The existence of papillæ on the bars renders the affinity between *Perophora* and *Sluiteria* still closer than has been already believed. It is very probable that a new species must be created for the Naples type, but that is a matter to which I hope to refer in a subsequent paper on the anatomy and variation of the genus. (See *Postscript*, p. 64.)

3. Perophora Listeri, *Wiegmann*. (Pl. II, figs. 4, 5, 6.)

Ascidia, sp., *Lister*. Phil. Trans., 1834, pp. 378—382, pl. xi.
Perophora Listeri, *Wiegmann*. Archives, 1835, p. 309.
Ascidia, n. sp., *Fleming*. Moll. Anim., 1837, pp. 202—209, pl. xvii, fig. 59 (2).
Perophora Listeri, *Forbes and Hanley*. L. c., p. 28, pl. E, fig. 2.
— — *Giard*. Recherches, l. c., pp. 615, 616, pl. xxi, figs. 3, 6 to 11, 13 to 15, pl. xxiv.

Perophora Listeri, *Herdman*. Second Report, Proc. Biol. Soc. Liverpool, iii, 1889, p. 246.

— — *Herdman*. On the Genus Ecteinascidia, l. c., pp. 158—161.

Zooids quadrangular, compressed from side to side, colourless, transparent.

Apertures widely separated, branchial with six lobes, cloacal with five.

Tentacles forty in number, of three sizes.

Branchial sac always provided with unbranched digitiform or slightly triangular interserial papillæ; no rudiments of internal longitudinal bars; rudimentary horizontal membranes; stigmata in four transverse rows, two between each pair of interserial papillæ.

Musculature feebly developed; transverse fibres few, widely separate from one another, extending from the dorsal region to the middle of each side; also forming a weak sphincter round each aperture; longitudinal fibres almost as well developed as the transverse, extending from the oral sphincter as far as the level of the first interserial bar of the branchial sac; several longitudinal fibres arising anteriorly between the oral aperture and the anterior end of the endostyle, extending with the longitudinal fibres of the oral sphincter to the same distance; longitudinal fibres of the cloacal sphincter short.

Habits.—Attached to stones or algæ in shallow water.

At Plymouth *Perophora Listeri* has been dredged in the estuary of the Yealm, and in 4 to 5 fathoms water off the Duke Rock. Mr. Heape recorded it as abundant on the rocks below the Hoe.

There can be very little doubt that the name given by Wiegmann to Lister's *Perophora* has been also applied to forms specifically distinct from it. Lister, in his admirable paper, remarks upon the existence of "finger-like processes, about eight in a row, that project nearly at right angles into the central cavity" [of the branchial sac], and these are shown in some of his figures.

Giard also mentions these papillæ and compares them with the papillæ which were figured by Savigny in his account of *Diazona violacea*. These papillæ are simple and digitiform, so that Giard's species probably did not differ from Lister's with respect to these structures.

On the other hand the species found at Naples and, as I gather from Professor Herdman's paper, at Banyuls also (by Lahille) present considerable differences from this simple arrangement. It is probable, therefore, that *Perophora Listeri* does not occur in the Mediterranean but is confined to the Atlantic shores of northern Europe.

The condition of the papillæ in Plymouth specimens is shown on

Plate II, fig. 6, in a drawing taken from preserved material. These structures are seen to have a flattened triangular shape and are connected at their bases by very low and rudimentary horizontal membranes (cf. fig. 7). In life, these papillæ assume a more extended digitiform shape, as Lister long ago stated. If these papillæ were to be connected by internal longitudinal bars (as frequently occurs in the Naples species), meshes would be formed, each containing two stigmata.

The opening of the duct of the hypoganglionic gland (fig. 7, *c. v.*) is simply circular. It is situated in front of a raised triangular area, whose apex is posterior; this constitutes what is undoubtedly the homologue of the epipharyngeal groove. A precisely similar structure has been figured by Roule for *Rhopalæa nepolitana*,* and observed in *Sluiteria rubricollis* by E. van Beneden.† From the posterior apex of this area arises the dorsal lamina (fig. 7, *d. l.*) as a low membrane which increases slightly in height as it extends posteriorly. At the level of each horizontal membrane it rises up into a curved triangular languette (*l*), and occasionally there is a small projection from its edge between each pair of interserial languettes (fig. 8, *i. p.*). An examination of fig. 7 also shows that the horizontal membranes really are continued upon the lateral faces of the dorsal lamina, although they do not extend along the languettes.

The structure of the dorsal lamina in this species approaches closely in essential features that described by van Beneden in *Sluiteria rubricollis*, in which form there is a continuous longitudinal membrane whose border is cut into festoons in correspondence with the number of transverse (interserial) bars. The lamina is provided with fourteen oblique ridges which also correspond in number with the horizontal bars. Although in his diagnosis of the genus *Sluiteria*, Professor van Beneden denies the presence of horizontal membranes (*l. c.*, p. 43), he admits in his description of *S. rubricollis* that the connecting ducts of the internal longitudinal bars "spring by an enlarged base from little interserial folds traversing the length of the transverse bars" (p. 34). This is precisely the condition I have found in the Naples *Perophora*, and it is essentially similar to what is here described for *P. Listeri*; interserial membranes are in each case present, but rudimentary. The ridges on the lamina of *S. rubricollis* are therefore undoubtedly of the same nature as the less conspicuous elevations formed in *P. Listeri* by the continuation of the horizontal membranes upon the sides of the lamina (see fig. 7).

* Roule, *Rev. des Esp. de Phallusiadées de Provence*, Rec. Zool. Suisse, iii, pl. xiv, fig. 14.

† Ed. van Beneden, Sur les genres Ecteinascidia, &c., l. c., p. 35.

Further the lamina of *Sluiteria rubricollis* is described as being enrolled, the concavity being to the right; my figure also shows that the marginal languettes of *P. Listeri* are bent over in a precisely similar way.

In *Ecteinascidia turbinata* (Herdman) and *diaphanis* (Sluiter) the dorsal lamina is represented by tentacular languettes unconnected by a longitudinal membrane. This membrane is present in *E. Thurstoni* (Herdman), while horizontal membranes are quite absent, and with them also every trace of interserial ridges on the sides of the dorsal lamina. In *E. Moorei* (Herdman) all the horizontal structures are well developed, but the longitudinal lamina is absent.

Family 3.—DIAZONIDÆ.

Body large, consisting of a thorax and abdomen connected by a slender, more or less elongate œsophageal region; stolonial tubes arising from the posterior end of the abdomen.

Test gelatinous or semi-cartilaginous, greatly developed around the basal stolonial tubes, with formation of a thick common test, in which the abdominal portions or the entire bodies of the zooids are imbedded; apertures terminal, each divided into six lobes, rarely smooth.

Musculature consisting of both longitudinal and transverse fibres, which for the most part anastomose freely; longitudinal fibres especially well developed.

Branchial sac large; with or without festooned horizontal membranes; interserial papillæ always present, supporting complete or rudimentary internal longitudinal bars; longitudinal bars not papillate; dorsal lamina represented by a series of languettes with long tapering ends; dorsal tubercle a large, longitudinally ovate slit surrounded by broad raised margins; branchial sac not folded.

Heart recurved upon itself.*

Genitalia in the loop of the intestine, or extending considerably behind it; oviduct present or absent.

Reproduction by gemmation as well as from ova, with formation of colonies of great size; colonies without systems.

This family, including the genera *Diazona* (Savigny) and *Tylobranchion* (Herdman), has relations both with the Cionidæ, Distomidæ, and Polyclinidæ. To Lahille belongs, I believe, the credit of first emphasizing the resemblances between *Diazona* and *Tylobranchion*, the latter being one of the most interesting of the "Challenger" forms made known to us by Professor Herdman's researches. As

* This has not yet been established for *Tylobranchion*, but is probably the case.

I gather from Professor Herdman's remarks upon Lahille's system of classification, this zoologist groups together, along with *Diazona* and *Tylobranchion*, the genera *Ecteinascidia*, *Rhopalæa*, and *Ciona*. I believe, however, that *Ecteinascidia* is much more closely related to *Sluiteria* than to any of these genera, and while Roule has established the relationship of *Rhopalæa* and *Ciona* beyond doubt, the equally close affinity of *Diazona* to these forms is still a matter of some uncertainty. That the mere formation of a huge common mass of test enclosing the abdominal regions of the zooids is not of itself a point of great systematic importance is demonstrated by *Pycnoclavella*, which is in every other structural respect a true *Clavelina*. Therefore on this head I am quite in accord with Lahille in his efforts to break up the group "Ascidiæ compositæ," and to classify the Ascidians upon morphological grounds only or in the main. Yet I cannot but regard the definite position of *Diazona* and *Tylobranchion* among the Cionidæ as too forcible a disregard of the ties which also bind them to the Polyclinidæ and Distomidæ.

4. Diazona,* *Savigny*.

DIAZONA, *Savigny*. Tableau systématique, l. c., pp. 174, 175.
— *Dujardin*, in *Lamarck*. Hist. Nat. des Anim. sans Vertèbres, 2nd ed. (par Deshayes and M. Edwards), t. iii, 1840, pp. 498, 499.
SYNTETHYS, *Forbes and Goodsir*. On some Remarkable Marine Invertebrata new to British Seas, Trans. Roy. Soc. Edin., xx, 1853, p. 307.
— *Forbes and Hanley*. Brit. Moll., iv, p. 244.
DIAZONA, *Alder*. Observations on British Tunicata, Ann. and Mag. of Nat. Hist. (iii), xi, 1863, p. 169.
— *Lahille*. Comptes Rendus, cii, 1886, p. 1574, and civ, 1887, p. 240.
— *Giard*. Comptes Rendus, ciii, 1886, pp. 755, 756.
— *R. von Drasche*. Die Synascidien, p. 8.
— *Carus*. Prodr. Faun. Med., 2, ii, p. 480.

Colony gelatinous, sessile; the zooids superior, their thoracic portions freely projecting.

Musculature with longitudinal fibres united into well marked bundles.

Branchial sac with festooned horizontal membranes, supporting complete, rarely incomplete, internal longitudinal bars, not papillate at the point of junction; dorsal languettes triangular, compressed from before backwards.

Genitalia in the loop of the intestine; oviduct (always ?) and vas deferens present.

* I greatly regret that my efforts to obtain a copy of Della Valle's Contribuzioni have been unsuccessful up to the time of going to press, and I must express the same regret with regard to Lahille's Recherches sur les Tuniciers.

In 1853 Professors Forbes and Goodsir announced the discovery of a composite Tunicate allied to Savigny's *Diazona violacea*, but differing from it in the possession of the following characters: Plain undivided orifices, non-pedunculated abdomen, meshes with "one ciliated opening" only, and apple-green colour. Their genus *Syntethys* was established upon these grounds, but Alder subsequently wrote to show the generic identity of the two forms, basing his criticisms upon an examination of specimens dredged near Guernsey and possibly upon a re-examination of a portion of one of the original specimens of Forbes and Goodsir. Alder satisfactorily showed that the difference of colour was one due entirely to the action of the spirit used in preservation, and also that the pedunculation of the abdomen is very variable in its extent. He also noted that, after preservation, the division of the apertures into lobes was generally difficult to make out. His conclusion in regard to the generic identity of *Diazona violacea* and the so-called *Syntethys* is probably correct, although, as I shall endeavour to show below, his identification of the Guernsey species with that of Forbes and Goodsir from the Hebrides is extremely doubtful.

4. Diazona violacea, *Savigny*. (Pl. II, figs. 7, 8.)

Diazona violacea, *Savigny*. Mémoires, pp. 35—38, 175, 176, pl. xii.
— — *Fleming*. Moll. Animals, 1837, p. 211.
— mediterranea, *Dujardin*. L. c., pp. 499, 500.
— hebridica, *Alder*. L. c., p. 169.
— violacea, *Carus*. L. c., pp. 480, 481.

Colony massive, irregularly rounded, attached by a short, thick pedicle or base; total diameter about 7 inches, total height 5 or 6 inches; of apple-green colour when alive, semi-transparent.

Zooids often 2 inches long, with oral and cloacal orifices each six-rayed.

Branchial sac with sixty to eighty transverse rows of stigmata; meshes each containing three, rarely four stigmata; internal longitudinal bars for the most part completely formed, but here and there represented by T-shaped interserial papillæ, as in *Tylobranchion*; dorsal tubercle a large deep groove, elongate antero-posteriorly, with thickened walls.

Habits.—Attached to rocks or stones in deep water.

Dredged at Plymouth on rough ground off Stoke Point, and off the Eddystone in 20—40 fathoms of water.

There are two remarkable statements in the original description of the structure of *Syntethys Hebridicus* by Forbes and Goodsir

assumption he endeavoured to find out what structural differences there might be between this form and the *Diazona violacea* so admirably described by the great French anatomist. His researches were not very fruitful of result: "The only difference I can find is that the papillæ of the branchial sac in the latter (*Syntethys Hebridicus*) are stout and obtuse, very different from the slender pointed form represented by Savigny; I have therefore determined to consider them distinct until further observations decide the point."

Now Alder's Guernsey specimens are certainly identical (specifically) with the forms investigated by myself, and they are both from practically the same region of the English Channel; there is further no appreciable difference between the Plymouth forms and

* Herdman, "Challenger" Report, vol. xiv, pt. xxxviii, p. 155.

which have not, to my knowledge, received the attention which they deserve. They are involved in the following account given by these naturalists of the branchial sac in their specimens:

"Branchial chamber with thirteen transverse rows of oblong openings, fringed with ciliated epithelium; hooked fleshy tubercles at the intersections of the branchial meshes, each mesh presenting one of the ciliated openings; the tubercles give the internal surface of the chamber a dotted appearance." (Trans. Roy. Soc. Edin., 1853, p. 307, cf. also Forbes and Hanley, l. c., p. 244.)

Now, in the specimens of *Diazona violacea* dredged at Plymouth, the number of transverse rows of stigmata greatly exceeds that given by the eminent naturalists who described *Syntethys Hebridicus*; the number is usually about sixty, seventy, or even more! Further, the stigmata in each mesh are invariably three or four, the latter number agreeing with the description and figure given by Savigny.

Were Professors Forbes and Goodsir mistaken? Such a theory is unlikely, for one of their figures (l. c., pl. ix, fig. 4 *d*) shows in outline some of the appearances which they recorded in the words quoted above. Indeed, this figure is too precise to admit of any doubt as regards the approximate number of *transverse* bars (and, therefore, rows of stigmata) in their specimens, and a difference in this respect between *Diazona violacea* and *Syntethys Hebridicus* must, I think, be admitted.

But the more remarkable statement is that "each mesh presents one of the ciliated openings." That Forbes and Goodsir should have made a mistake in the observations which gave rise to this statement seems inconceivable, but it is surprising that they pass no reflection upon so unusual a condition of the branchial sac. There was plainly no error in the identification of the "meshes," for "hooked fleshy tubercles" are stated to be present at the "intersections of the branchial meshes" (a somewhat confused but quite intelligible statement). Still, the fact of one stigma alone being included in each mesh has either to be accepted or explained away.*

It is conceivable that the appearance of one "ciliated opening" corresponding to each mesh was due to a great transparency of the "trame fondamentale" of the branchial sac, and that while the meshes were observed, the true stigmata were not noticed; but I cannot reconcile this hypothesis with the assertion, so definitely made, that the "oblong openings" were "fringed with ciliated epithelium." It is also impossible, and for the same reason, to imagine that the

* This condition exists in *Polyclinum sabulosum* (Lahille, Comptes Rendus, cii, p. 1574), and is approached in *Tylobranchion speciosum*.

meshes were totally devoid of stigmata, as in *Pharyngodictyon mirabile* of the "Challenger" collection, described by Herdman.*

I am obliged, therefore, to conclude that *Syntethys Hebridicus* actually possessed, as Forbes and Goodsir stated it to possess, a branchial sac containing about thirteen transverse rows of oblong stigmata, and presenting a "hooked fleshy tubercle" at the junction of every longitudinal and horizontal bar.

It should be noticed that in the original description there is nothing irreconcilable with the view that the branchial sac of *Syntethys Hebridicus* may in reality have been quite destitute of true internal longitudinal bars, and possibly of horizontal membranes; the "hooked fleshy tubercles" may have been such rudimentary connecting ducts and bars as Herdman has described and figured for *Tylobranchion speciosum* (l. c., p. 161). In this connection I may state that I find the internal longitudinal bars of *Diazona violacea* to be by no means rarely incomplete in portions of the branchial sac; they are then represented by structures which could well be described as "hooked fleshy tubercles."

I will not maintain that this new view of Forbes and Goodsir's very "remarkable invertebrate" is probable, but it is at least possible. If it should prove eventually to be correct, a very interesting connection between *Diazona violacea* and *Tylobranchion speciosum* will have been established.

By admitting the above-named differences between the branchial sacs of *Diazona violacea* and *Syntethys Hebridicus*, it will be noticed that I do not accept Alder's identification of his Guernsey specimens of *Diazona* with Forbes and Goodsir's species. From Alder's account I have been led to believe that he assumed this identity too hastily. He states that his specimens were "at once recognised as the *Syntethys Hebridicus* of Forbes and Goodsir," and upon this assumption he endeavoured to find out what structural differences there might be between this form and the *Diazona violacea* so admirably described by the great French anatomist. His researches were not very fruitful of result: "The only difference I can find is that the papillæ of the branchial sac in the latter (*Syntethys Hebridicus*) are stout and obtuse, very different from the slender pointed form represented by Savigny; I have therefore determined to consider them distinct until further observations decide the point."

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* Herdman, "Challenger" Report, vol. xiv, pt. xxxviii, p. 155.

Fig. 2.

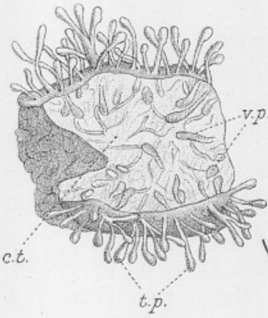


Fig. 1.

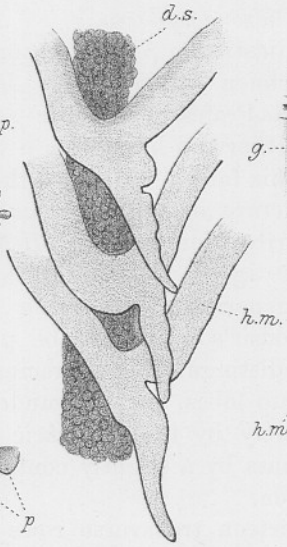


Fig. 5.

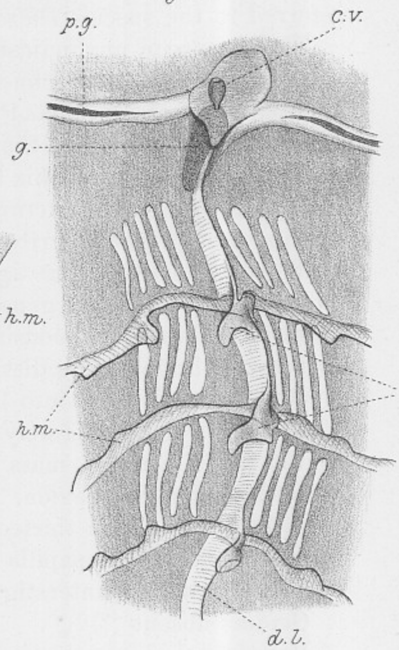


Fig. 4.

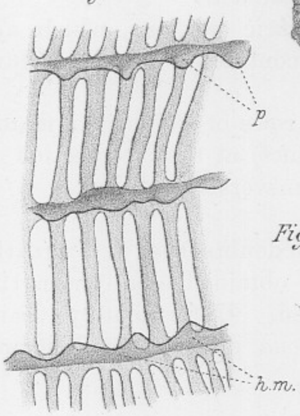


Fig. 3.

Fig. 6.

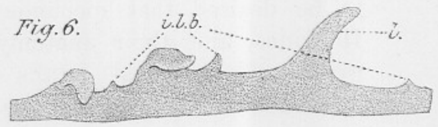


Fig. 7.

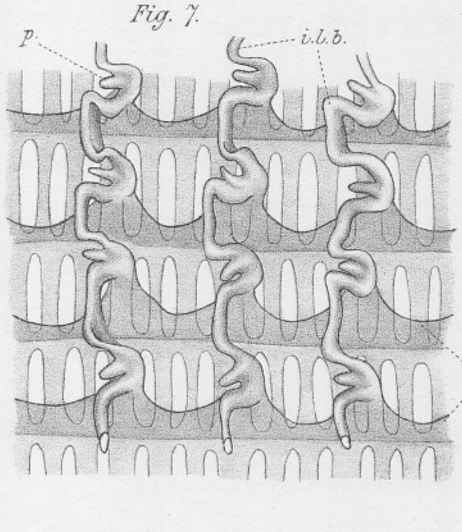
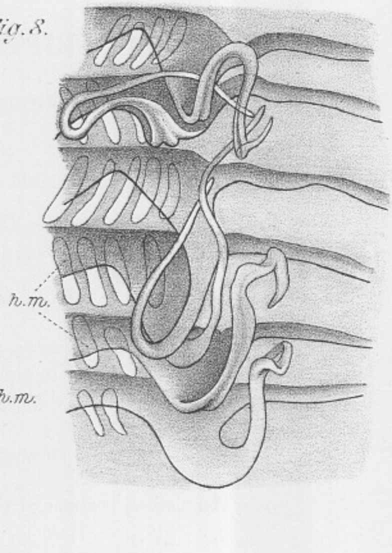


Fig. 8.



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Savigny's species. Therefore Alder's examples must also be referred to the species *Diazona violacea.*

The absence of any indication in Alder's paper that he re-examined the "portion of a specimen (of *Syntethys Hebridicus*) from the original habitat" which Professor Goodsir sent to him, renders intelligible what would otherwise have been a very strange omission on his part. I refer to his failure to notice the remarkable discrepancy between the structure of the branchial sac in the Channel specimens and that described for *Syntethys Hebridicus.*

Thus, although I quite agree with Alder that there is as yet no sufficient ground for generically separating these two forms, I believe Forbes and Goodsir's species to be perfectly distinct and to possess the following distinguishing characters:

Orifices not divided into lobes, evenly rounded.

Zooids projecting freely by their thoracic portions, which are united to the common mass by a slightly contracted but not pedunculated œsophageal region.

Branchial sac with thirteen transverse rows of oblong stigmata; a hooked interserial papilla (connecting duct) at the intersection of every longitudinal (interstigmatic) and transverse bar.

Oviduct absent (?)

But the whole matter is so beset with doubts that it is greatly to be desired that specimens should be obtained again from the Hebrides, and their anatomy re-described. Unfortunately Giard gives no anatomical details of the *Diazona* dredged by him and described in Comptes Rendus, ciii, p. 755.

DESCRIPTION OF PLATE II.

Illustrating Mr. W. Garstang's "Report on the Plymouth Tunicata," pt. 1.

N.B.—Where not otherwise stated all the figures were drawn from preserved material.

FIG. 1.—*Clavelina lepadiformis*, O. F. Müller. Three of the dorsal languettes of the branchial sac. Zeiss, A, Oc. 2, Cam.

d.s. = Dorsal sinus.

h.m. = Horizontal membrane.

FIG. 2.—*Pycnoclavella aurilucens*, gen. et sp. nov. Portion of a colony. A section has been taken through the colony in order to show the common test and the imbedded portion of the zooids. Nat. size; slightly diagrammatic.

c.t. = Common test.

t.p. = The free portions (thoracic and œsophageal) of the zooids projecting from the common test.

v.p. = The visceral portions of the zooids imbedded in the common test.

FIG. 3.—*Pycnoclavella aurilucens,* gen. et sp. nov. The free portion of a zooid from a colony growing on the stem of a *Delesseria.* Drawn from life, enlarged.

FIG. 4.—*Perophora Listeri,* Wiegmann. Portion of the branchial sac. Zeiss, A, Oc. 2, Cam. luc.

h.m. = Rudimentary horizontal membranes.
p. = Interserial papillæ (= rudimentary connecting ducts).

FIG. 5.—*Perophora Listeri,* Wiegmann. Dorsal wall of pharynx, showing dorsal lamina and aperture of hypoganglionic gland, seen from inside. Zeiss, A, Oc. 2, Cam. luc.

p.g. = Pericoronal groove.
c.v. = Ciliated vesicle, opening on the surface of a shield-shaped pad.
g. = Ganglionic mass.
d.l. = Longitudinal membrane of dorsal lamina.
l. = Marginal languettes.
h.m. = Rudimentary horizontal membranes.

FIG. 6.—*Perophora Listeri,* Wiegmann. Dorsal lamina of another individual, seen from the right side. Zeiss, A, Oc. 2, Cam. luc.

l. = Marginal languettes, interserial in position.
i.p. = Small marginal projections intermediate between the languettes.

FIG. 7.—*Diazona violacea,* Savigny. Portion of branchial sac, seen from inside. Magnified, slightly diagrammatic.

h.m. = Horizontal membranes.
i.l.b. = Internal longitudinal bars.
p. = Papillæ of the connecting ducts. (See *Postscript.*)

FIG. 8.—*Diazona violacea,* Savigny. Six dorsal languettes. Zeiss, A, Oc. 2, Cam. luc.
h.m. = Horizontal membranes.

Postscript.—By Professor Herdman's kindness I have recently been enabled to consult Lahille's important *Recherches sur les Tuniciers.* Lahille points out that the appearance of papillæ on the internal longitudinal bars of the branchial sac of *Diazona violacea,* as previously described by Savigny and Della Valle, is a false one, produced by the thickened remains of the "primitive branchial languettes." I had myself, like Alder, failed to find any such vertical papillæ as were represented by Savigny for this species, and was struck by their apparently recumbent position in mounted preparations (see fig. 7); but a re-examination by means of dissecting needles has convinced me that Lahille is quite correct in denying their existence altogether. The necessary correction has been made in the text of my paper, but the diagram given on fig. 7 is in this respect misleading. Lahille also states that the horizontal membranes are very little developed, but this is by no means the case in the Plymouth specimens.

I have stated above (p. 55) that my discovery of internal longitudinal bars in the Naples *Perophora* will probably necessitate the creation of a new species; but from Lahille's description this species would appear to be identical with his *P. banyulensis.* The Naples species differs widely from *P. viridis* as regards its musculature, a fact which thus militates against Professor Herdman's suggestion that *P. banyulensis* is a synonym of *P. viridis.*

W. G.

On some Larval Stages of Fishes.

By

J. T. Cunningham, M.A.,
Naturalist to the Association.

With Plates III and IV.

The six drawings reproduced in Plates III and IV were made at sundry times from stages that I succeeded in obtaining in the years 1889 and 1890. The three stages of the common sole were procured after my quarto book on that fish was completed, and they enable me to supplement the account of the life-history of the species given there.

Fig. 1 represents a larva of *Solea vulgaris* four days after hatching. The drawing reproduced was made from the living larva on April 26th, 1890; the larva was hatched on April 26th from an egg artificially fertilized on April 14th on board a trawler off the north coast of Cornwall. The temperature of the surface water of the sea in which the eggs were fertilized was 9·7° C., of the water in the Laboratory in which the eggs were kept 10·8° C. The variations of temperature in which the eggs were carried while on board the trawling smack were not observed. I can only, therefore, give an approximation to the relation between temperature and the period of development of the egg, namely, that at a mean temperature of about 10·0° C. the eggs of the sole hatch in eight days.

The condition of the larva of the sole immediately after hatching is described and illustrated in my Treatise on the species. The changes which have occurred in the stage represented in fig. 1 are the following: The yolk, *yk*, is much reduced in bulk, about half the quantity present at hatching having been absorbed. Three groups of oil globules are still visible on the surface of the yolk, the individual globules being larger than in the newly hatched larva, doubtless because some coalescence has occurred. In the newly-hatched larva the intestine is straight, and lies in a depression of the dorsal surface of the yolk, while in the present stage the intestine shows the commencement of a convolution above the yolk, and the latter does not project dorsalwards on each side of the gut. The whole of the anterior part of the body is now straightened out, while at the time of hatching it was bent downwards towards the anterior extremity. Accordingly the region of the fore-brain and olfactory organ is now at the anterior extremity of the axis of the body. The position of the olfactory organ is indicated by *ol.* in the figure, although the organ itself was not distinct enough to be represented in the figure when the drawing was made. The intestine or alimentary tube has now grown forwards beneath the brain to meet the skin beneath the fore-brain and eyes, and the lumen or cavity of the tube, open in the posterior part, is faintly indicated anteriorly by a line; the mouth, however, is not yet open, although the lumen of the gut extends to the exterior at the anus. The heart, *ht.*, has the usual structure in larval fish at this stage; it consists of a tube beneath the gullet having an aperture posteriorly, by which it communicates with the perivitelline sinus. The heart is surrounded by a cavity, which is separated from the perivitelline sinus by a delicate membrane, and which is afterwards extended to form the body-cavity. Pigment has begun to appear in the eye, *i. e.* in the choroid membrane, as separate dots. The mid-brain, *m. b.*, projects dorsally. The primordial membranous fin of the larval sole is characterised by its irregularity of outline anteriorly. The edge of this fin forms a projection over the mid-brain, and another behind the head. The pigmentation of the skin consists of black and yellow dendritic (*i. e.* branched) chromatophores. On the fin these chromatophores form four not very definitely marked spots on the dorsal portion, and one posteriorly on the ventral portion. At later stages these spots become more definite and conspicuous. The total length of the larva represented in fig. 1 was 4·35 mm.

Fig. 2 shows an older larva from the same lot. It was drawn on April 28th, that is, six days after hatching. The mouth is now fully developed, although a remnant of the yolk is still unabsorbed, and the larva has not yet begun to feed. The eye is now completely pigmented, the choroid membrane being black and opaque. The auditory vesicle, in the previous stage a simple spherical capsule with two calcareous nodules inside it, is now much enlarged, and exhibits the commencement of the semicircular canals within it. The olfactory organ, *ol.*, has the form of a spherical capsule just beneath the skin, opening to the exterior by a circular aperture. There is, of course, one of these on each side of the snout; the division of each aperture into the two nostrils which exist on each side in the adult takes place later. The convolution of the intestine, although still simple, is much larger and more conspicuous in consequence of the increase of the intestine in length. The heart has the same relations as in the previous stage. The pectoral fin is visible as a somewhat quadrangular membranous fold projecting from the side of the body behind and below the auditory organ. The great bluntness of the anterior edge of the head is very characteristic of the larval sole at this stage. The mid-brain is still very prominent dorsally. The dorsal edge of the primordial fin still presents the two rounded projections described in the previous stage. The pigmentation of the skin is now more developed than before. The length of the larva from which fig. 2 was prepared was 4·2 mm., rather less than that of the specimen represented in fig. 1. Fig. 2 represents the appearance of the larva as seen partly by reflection, partly by transmission of the light; the light was partly excluded from the aperture of the stage of the microscope, so that the specimen was seen against a somewhat dark background, as shown in the figure.

The stage shown in fig. 2 is the oldest which I have examined in larvæ reared in confinement from artificially fertilized ova; all the larvæ I reared last year, died soon after this stage was reached. Fig. 3 shows the appearance during life of an older larva which I obtained in Cawsand Bay, Plymouth Sound, on May 14th, 1890. It was captured in a small trawl made of cheese-cloth and worked on a sandy bottom in three to five fathoms of water. I think there can be no doubt that this larva belonged to *Solea vulgaris*. I identify it by the distribution of the pigment in the skin, especially the spots on the dorsal and ventral fin, and by the shape of the head. The tissues of the body, though still translucent, were no longer transparent enough at this stage to show the internal organs so clearly as at the stages previously described. The chief features to notice at this stage are as follows. The notochord is bent upwards at its posterior extremity, and the caudal fin-rays are beginning to appear beneath the bent portion. The lateral muscles of the body are defined dorsally and ventrally by a distinct margin, between which and the base of the median fin-membrane is a region in which the interspinous bones, *is. b.*, have begun to appear. The liver, *l.*, is visible as a large mass towards the anterior margin of the abdominal cavity. Behind the intestine, *int.*, is seen the urinary bladder, *u. b.* The prominence of the mid-brain and the projections of the outline of the longitudinal fin over the head have disappeared, but the fin membrane still extends forwards in front of the eyes. The eye has a blue colour, probably due to iridescence of the choroid membrane. The auditory vesicle is very large, and extends dorsalwards far above the level of the eyes. The pigmentation of the skin is characterised by the development of very definite spots along the sides of the dorsal and ventral fin membrane. In the centres of these spots as well as over the sides of the body there are small orange spots in addition to the yellow and black of the earlier stages. Judging from what I have seen in the skin of the adult plaice and sole, I believe that the orange is not a new pigment, but the same pigment as the yellow in a more concentrated form; in fact I have reason to conclude that there are only two pigments in the skin of flat fishes, the black and the yellow, the latter being yellow when spread out, orange or even red when concentrated into a thicker globule. It will be seen on comparison that my fig. 3 differs very greatly from the figure of a larval sole of about the same size, 5 mm., given by Professor McIntosh in Plate III of the seventh Annual Report of the Scottish Fishery Board. We do not know the whole development of the sole with sufficient completeness to justify a definite assertion on the matter, but I cannot help doubting for the present whether Professor McIntosh's figure represents a stage of the larval sole at all.

In my paper published in this Journal March, 1889, I was unable to describe the larva of the mackerel. In the summer of that year I succeeded in hatching some artificially fertilized ova of the species, but could not keep them alive for any length of time. Pressure of other work has prevented me since from devoting much attention to the mackerel, and all I have to add now is a figure of the newly hatched larva, fig. 4. The drawing reproduced in this figure was made on July 2nd, 1889. The egg, from which the larva hatched, was one of a number artificially fertilized for me by mackerel fishermen on board their own boats. The length of the larva was 4·23 mm. In structure the larva does not differ essentially from other species belonging to the Physoclisti, or Teleosteans with closed air-bladders.

As in most other larvæ of that division, the rectum is immediately behind the short oval anterior yolk-sac. The notochord is as usual multicolumnar, composed of several columns of cells. The mouth is not open, and the eye (choroid membrane) is unpigmented. The slender elongated form of the larva is characteristic. But the chief distinguishing feature is the pigment of the skin and its distribution. The pigment consists of chromatophores of two colours, black and green, as in the adult. There is no pigment at all on the primordial median fin membrane. Black chromatophores occur over the sides of the body and head, especially along the edges of the body. The green chromatophores, mingled with black, occur only in five spots in the neighbourhood of the yolk-sac. The largest of these is not in the skin, but on the surface of the yolk-mass over the oil-globule, which is situated at the posterior end of the yolk. Another is at the base of the rudiment of the pectoral fin, *pe. f.* Another is just behind the eye, and two others are at the anterior end of the yolk-sac.

The larva represented in fig. 5, Plate IV, is that of *Cottus bubalis*, a species extremely common on the shore at Plymouth. The eggs of this species are adhesive and are deposited in small rounded clumps of about one and a half to two inches in diameter attached to stones or rocks on the shore. There are usually numbers of the fish in our tanks, where they regularly deposit their eggs. The deposition of the eggs takes place in January, February and March. The single egg is 1·7 mm. in diameter, and is characterised by the presence of rounded protuberances all over the external surface of the envelope. The yolk when the egg is first laid has usually several rather large oil-globules, but during development these coalesce into a single globule. Fig. 5 shows the appearance and structure of the living larva immediately after hatching. The larva is in a much more advanced condition than those of species hatched from pelagic eggs. Its length is 5·7 mm. The mouth is open and the cartilaginous branchial arches are already formed. The choroid of the eye is fully pigmented, and has a deep blue colour by reflection. Some of the yolk still remains and the oil-globule is situated at its anterior surface. The condition of the heart is quite different from that seen in newly hatched pelagic larvæ ; instead of a continuous perivitelline blood sinus, there are numerous definite vitelline vessels, *v. v.*, and in these, circulates fully developed red blood, containing numerous red corpuscles. These vitelline vessels lead to the posterior end of the heart, and in the opposite direction are seen to be continuous with the vessels of the liver *l*. On the dorsal side of the liver, in the figure, is seen the gall-bladder, conspicuous from the green colour of its contents. Above the liver is seen the enlargement of the intestinal tube forming the stomach, but the tube is without convolutions. The notochord is multicolumnar, and below it are seen the caudal artery and vein, *c. v.*, in which the blood is seen in the living larva coursing in opposite directions. The pectoral fin, *pe. f.*, is large and membranous, with a semicircular outline. The auditory vesicle with its two calcareous nodules, and developing semicircular canals, is a conspicuous structure behind the eye. The distribution of pigment in the larva is peculiar. Black pigment only is present, yellow not being developed till a later stage. Pigment is altogether absent from the caudal region ; the black chromatophores are almost entirely confined to the dorsal region of the peritoneum, where they are closely aggregated in a saddle-shaped area over the region of the stomach and rectum. There are also a few chromatophores in the skin behind the base of the pectoral fin. Professors McIntosh and Prince* give a figure of a later stage identified by them as belonging to *Cottus scorpius ;* the latter species is abundant on the Scottish coast, but I have not yet met with it at Plymouth. Their figure shows little detail, and they do not note the fact that the characteristic saddle of black pigment is situated in the peritoneum and not in the skin. In the larva figured by them yellow pigment is present on the head and abdominal region.

Fig. 6, Plate IV, represents an advanced larval stage identified as belonging to the grey mullet *Mugil chelo.* The little fish was taken in Mevagissey Harbour and sent to our Laboratory alive by Mr. Matthias Dunn, on May 10th, 1890. I have identified it by the shape of its head and snout, and by comparison with more advanced young of the same species which occur abundantly near Plymouth in summer. It was 10·5 mm. in length. The yolk is entirely absorbed, and the body opaque and pigmented. But the fins still retain their larval membranous character, the formation of the fin-rays having only commenced in the caudal region beneath the upturned extremity of the notochord. The air-bladder, *a. b.*, is conspicuous ; the pectoral fins are large. The pigmentation of the skin is a general yellow ground with numerous black chromatophores scattered over it ; the yellow colour would, of course, also be resolved into chromatophores under a higher magnifying power.

Raffaele in his paper in the *Mittheilungen* of the Zoological Station at Naples, vol. viii, gives figures of the ovum, and the newly-hatched larva of a species of *Mugil* or mullet. The ovum is pelagic and small, it has a single large oil-globule. There is little that is characteristic in the figure of the newly-hatched larva, except that the yolk is ellipsoidal instead of spherical, and the pigment is yellow and black as in the stage I have above described.

* *Development of Teleostean Fishes,* Trans. Roy. Soc., Edinb., vol. xxxv, pt. iii, 1890.

DESCRIPTION OF PLATES III AND IV,

Illustrating Mr. Cunningham's paper "On Some Larval Stages of Fishes."

Reference Letters.

a. b. Air bladder. *au.* Auditory organ. *c. v.* Caudal blood-vessels. *ht.* Heart. *int.* Intestine. *is. b.* Interspinous bones. *l.* Liver. *m. b.* Mid-brain. *pe. f.* Pectoral fin. *u. b.* Urinary bladder. *v. v.* Vitelline blood-vessels. *yk.* Yolk.

PLATE III.

FIG. 1.—Larva of *Solea vulgaris,* from egg artificially fertilized. Hatched April 22nd, drawn April 26th, 1890. Zeiss, a_3, oc. 3, camera.

FIG. 2.—Larva of *Solea vulgaris,* hatched same date, drawn April 28th. Zeiss, a_3, oc. 3, camera.

FIG. 3.—Larva of *Solea vulgaris,* caught in Cawsand Bay, May 14th, 1890.

PLATE IV.

FIG. 4.—Larva of *Scomber scomber* (mackerel), newly hatched. Zeiss, a_3, oc. 3, camera.

FIG. 5.—*Cottus bubalis,* newly hatched. Zeiss, a_3, oc. 3, camera.

FIG. 6. Larva of *Mugil chelo* (grey mullet). Zeiss, a_3, oc. 2, camera.

Fig. 1.

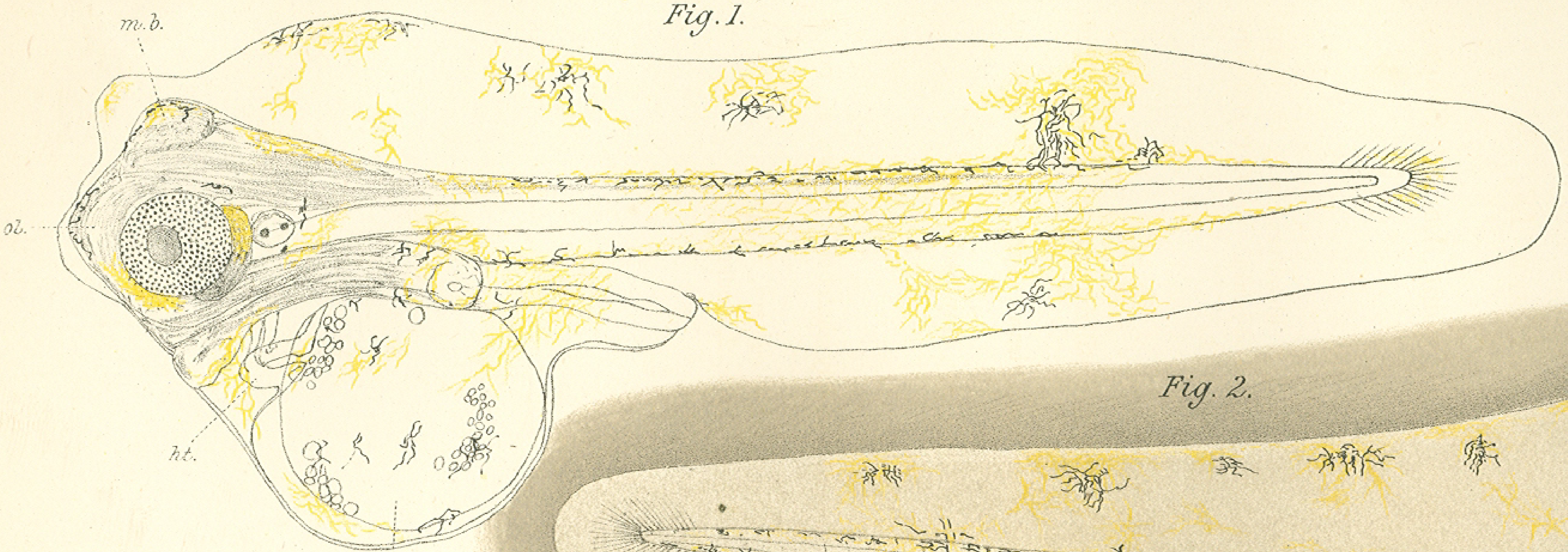


Fig. 2.

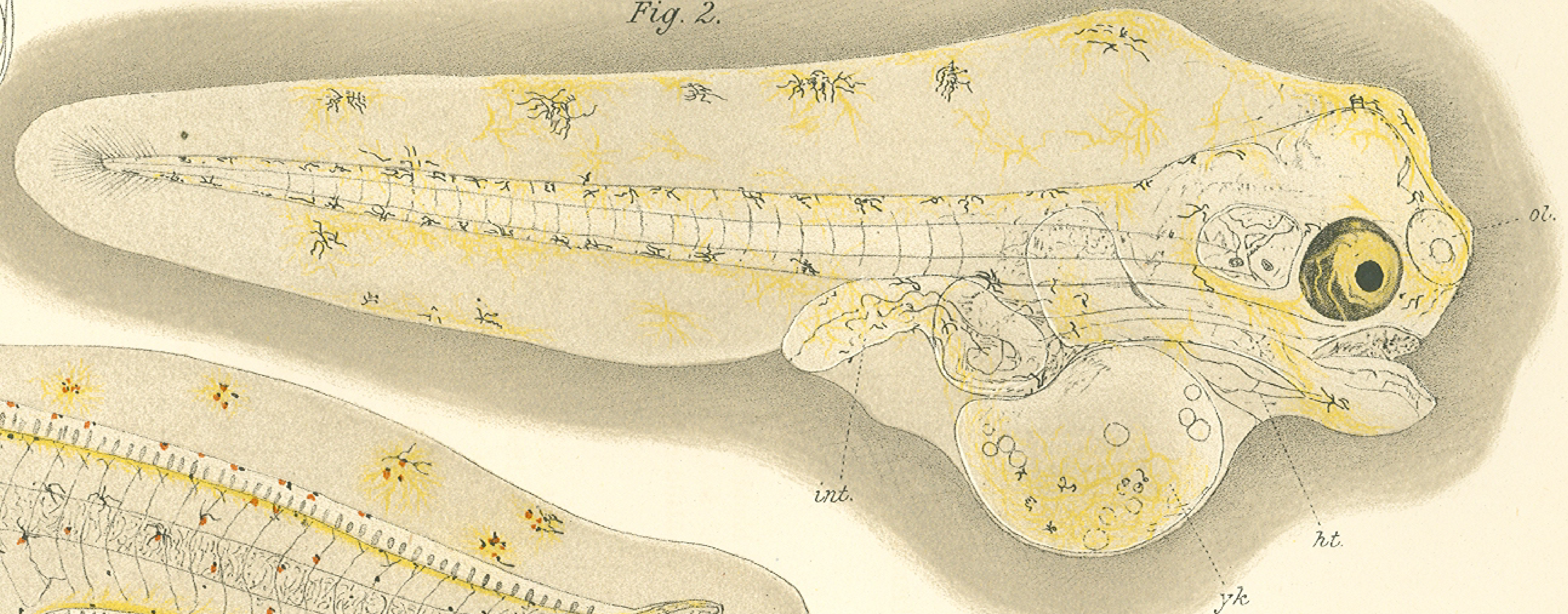
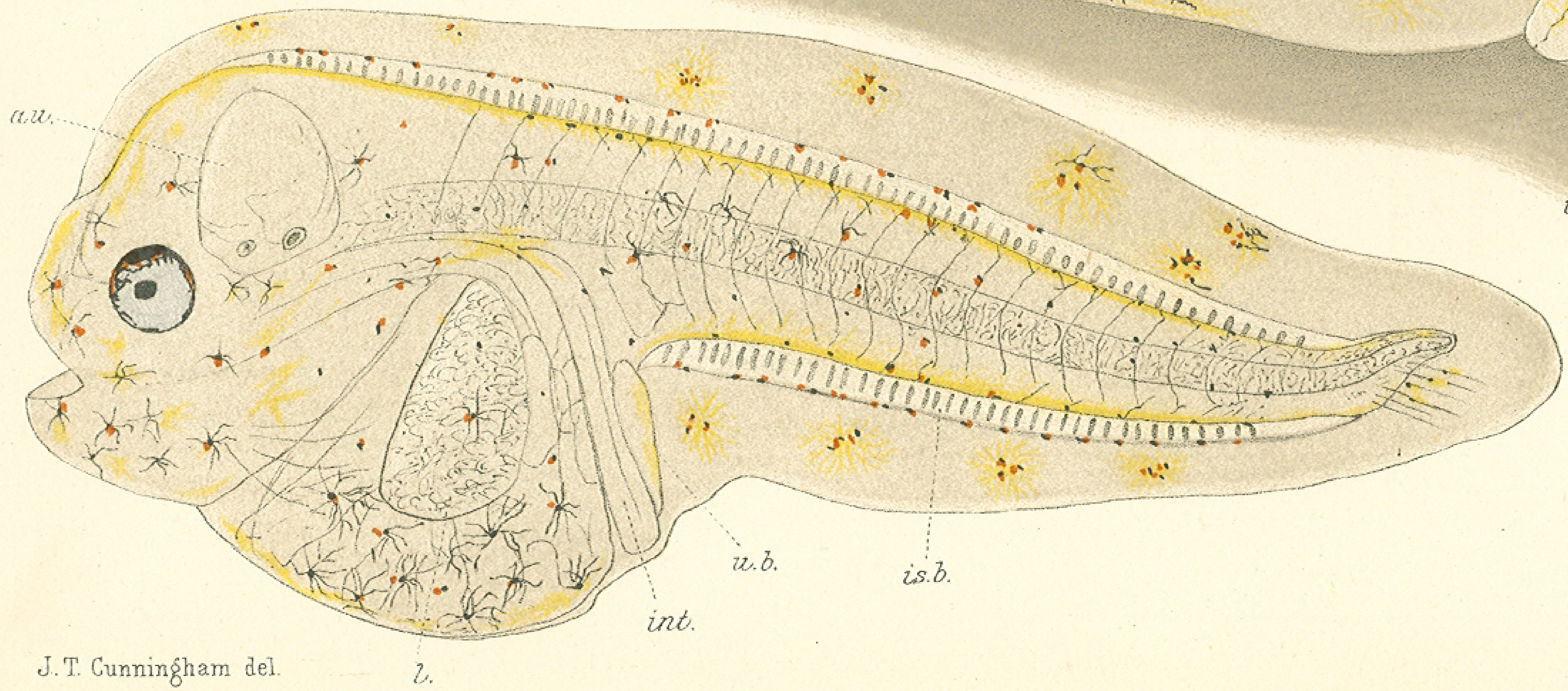


Fig. 3.



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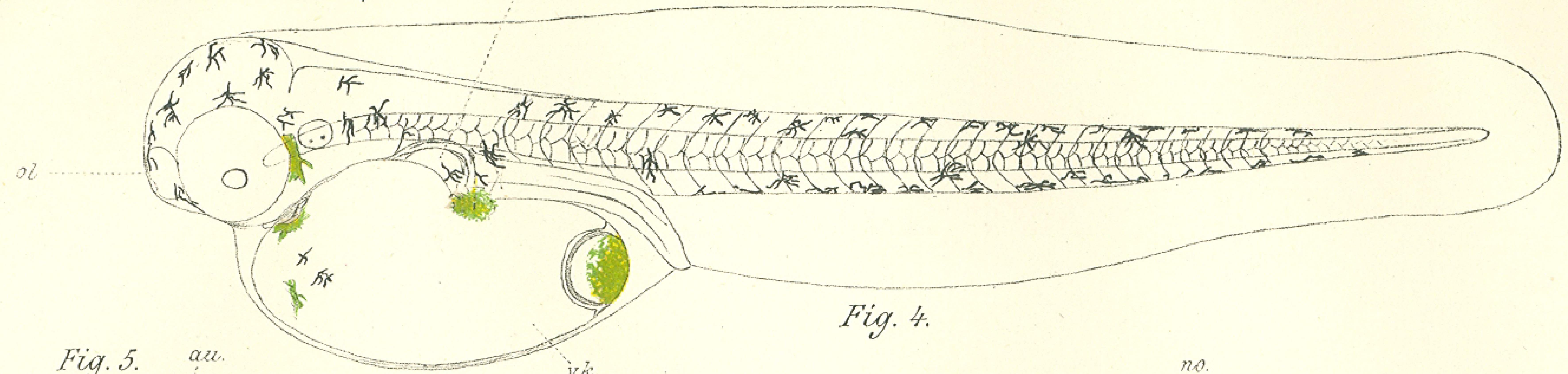

Fig. 4.

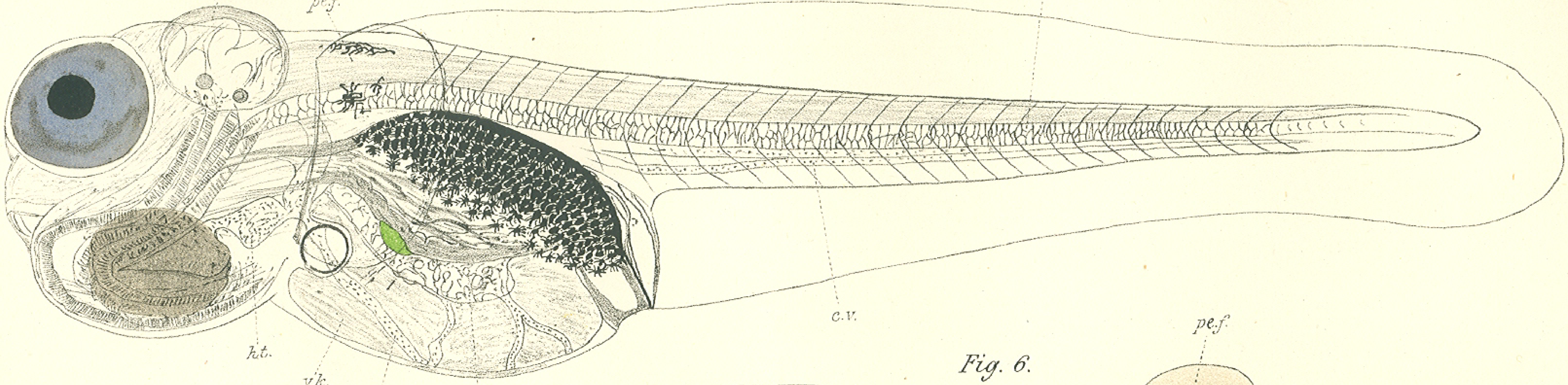

Fig. 5.

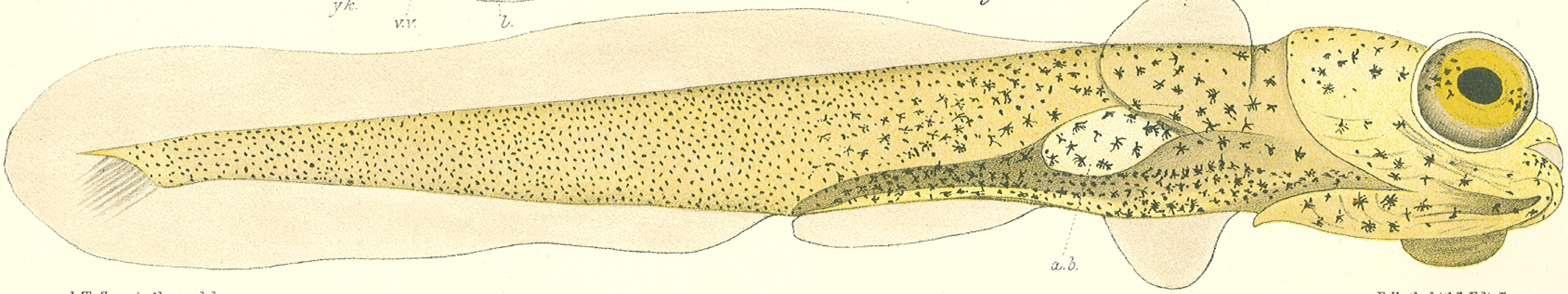

Fig. 6.

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NOTES AND MEMORANDA.

1. Hermit Crabs and Anemones, &c.—It is often so difficult to make systematic observations on the inter-relations of animals, that a bare record of the merest fact may prove eventually to be of use. These few lines, on one or two small occurrences in the aquarium and elsewhere, are printed here, not from any intrinsic interest, but in the hope that they may be useful to some future worker.

Upon the relations existing between certain Actinians aud Crustacea, observations are much needed. In a tank containing several *Pagurus Bernhardus* and *Adamsia Rondeletii* (*Sagartia parasitica*), which are habitually associated in a form of commensalism, most of the Paguri for one reason and another died, and their anemones in some cases crawled off the shell and throve independently (this has been noticed also in the case of *Adamsia palliata*). One of three specimens of *Maia squinado* living in the same tank, presently appeared bearing first one, then two, finally three *Adamsia Rondeletii* on its walking legs ; one, if I remember right, was placed on the first walking leg of each side, the third on the second leg of the right side. The limbus of the anemone was in all cases firmly clasped round the leg, the edges meeting closely in the manner of *Adamsia palliata*. The anemones remained in this position for some days, but only one was left after about a month. Though the crab was not actually seen to place the anemones on his legs, there can be little doubt that such was the case, both because the anemone's power of locomotion is but small, and because of the well-known habit of Maia to "dress" itself with anything available. On the other hand cases are known where the anemone, whether as embryo or adult, selects its own habitat. Last summer in the aquarium a particularly fine specimen of *A. Rondeletii* was fixed on the back of a large live *Buccinum undatum ;* and under the same head probably fall the *Rondeletii* on the cephalothorax of *Carcinus mœnas,* instances of which are occasionally dredged in the Sound. In another tank where *Pagurus Bernhardus* with Adamsia were stored, when the anemones were fed the hermit-crabs were frequently observed to insert a chela into the stomatodæum of the anemone associated with another crab, and to drag out and devour the plunder. Mr. Bateson recorded some time ago in this Journal that he had noticed a prawn rob an *Anthea* in this way, and the observation has been since repeated.

Among the foes of shrimps, which seem to include nearly every animal in the sea, I am not aware that the common prawn has ever been recorded. Where a tub full of shrimps has been emptied into a tank for food, the prawns collect round the spot, and seize and devour at leisure live shrimps, despite their struggles. It would hardly be anticipated that the prawn would prove so deadly an enemy to an animal which seems almost as swift and as strong as itself. Shrimps are almost the only animals eaten alive in the tanks; very few of the creatures even attack each other.

The commonest Plymouth star-fish, *Asterias glacialis,* was observed to eat, not only the Mollusca supposed to form its chief food, but also *Asterina gibbosa* (Aquarium and Wembury Bay), *Echinus miliaris* (Aquarium), and small Crustacea such as *Porcellana platycheles* and *Portunes,* sp. (Wembury Bay); the latter were sometimes found reddened as if boiled, apparently by the action of the digestive juices. In all these cases the stomach was more or less everted round the food.

Like the oyster, *Pecten maximus*, when surprised, can punish an invader by nipping him tightly between its valves till he dies; an intrusive Conner (*Ctenolabrus rupestris*) was caught in this way by the head in the aquarium, and in the morning was dead.

G. H. Fowler.

2. Grayling and Loch Leven Trout in Salt Water.—Some time ago I received a consignment of the above-mentioned Salmonidæ from O. Greig, Esq., who has recently built large fish-ponds at Holdsworthy, N. Devon. The fish were all young, averaging about 4½ inches in length; they were transported in a conical tank of the Howietown pattern, and arrived, with one exception, in a perfectly healthy condition.

One grayling and one trout were first of all taken, and, as an extreme experiment, transferred to pure salt water. They immediately darted off with great rapidity, swimming now round the tank, now with sudden zig-zag bounds after the manner of Mysidæ. If at any time they came to rest they floated quickly to the surface, owing to their bodies being unaccustomed to so dense a surrounding medium.

Their breathing can only be described as violent spitting, and a slight quiver of the body was occasionally noticeable. Both fish soon showed signs of sickening, their motions becoming slower, and their power of keeping below the surface in a normal position less. In about two hours the grayling died, but the trout, with greater tenacity to life, remained alive for four hours.

The rest of the fish were put into water only slightly salt, and were treated with care, the density being allowed to increase very gradually. For some days it was found that whenever the hydrometer registered 15°, the fish showed signs of distress. On the fresh water tap being alone allowed to run the majority revived, but four died even with this amount of salinity. The snow storm of March 10th occurred at this juncture, and for four days our fresh-water supply was entirely cut off. I aërated the water and only introduced small jets of salt water at intervals, but the mortality became seriously high, and the renewal of the water-supply left me with only three fish, all trout. The trout have all along proved more hardy than the grayling.

The fish commenced to feed first of all on small earthworms, but by soaking marine worms in fresh water previous to feeding, I have managed gradually to accustom them to a sea-animal diet.

The remaining trout were successfully kept alive while the water was increased in density. They are now in ordinary sea water of 26° sp. gr., and still they appear to be perfectly healthy, and are feeding well. The gradual transition from fresh water into salt has occupied just fifteen days. If they continue to thrive it will be instructive to observe their development, although we can scarcely hope that they will propagate their species.—DIRECTOR.

3. **Eels and Sticklebacks in Sea Water.**—Three eels and quite a number of sticklebacks, caught in the brackish water at the mouth of the Cattewater, are now thriving perfectly amongst the marine animals in the large exhibition tanks of the Aquarium.—DIRECTOR.

4. **Phoronis at Plymouth.**—Since *Phoronis* is not usually considered to be at all common on the British coasts, it may be useful to record the fact of its occurrence in Plymouth Sound. *Actinotrocha,* the larva of *Phoronis,* has been frequently taken here by means of the surface net (see Mr. Bourne's report, this Journal, N.S., vol. i, 1889, p. 9), but the adult animal was not observed until October last. While looking over some stones dredged near the Duke Rock, I was struck by the appearance of a number of delicate, membranous, sand-covered tubes, attached in crevices of some of the stones, and slightly projecting from the general surface. Upon placing these stones in a vessel of sea-water, the inhabitants of the tubes extruded the anterior portions of their bodies and displayed each the beautiful lophophore characteristic of *Phoronis.* The number of tentacles slightly exceeded sixty, and the lophophore was in all cases hippocrepian in form ; there were no young individuals. The species was *Phoronis hippocrepia,* Str. Wright.

About the same time, Mr. Rupert Vallentin informed me that he had found *Phoronis* in abundance at Falmouth, and kindly sent me several specimens. Mr. Vallentin's specimens closely agree with those taken at Plymouth and are undoubtedly of the same species.

Thus, *Phoronis hippocrepia* has been taken at the following parts of the British coast:—Ilfracombe (Strethill Wright), Tenby (Dyster), Sheerness (Shrubsole, species ?), Millport (Kölliker), Falmouth (Vallentin), and at Plymouth. If *P. ovalis* is an immature condition of the same species, then the Firth of Forth must be added to this list.

The larva *Actinotrocha* is recorded from Plymouth (G. C. Bourne), Cromarty Firth (J. T. Cunningham), Arran (Herdman, Carpenter, and Claparède), Portobello (Spencer Cobbold), in and off the Firth of Forth (McIntosh).—Walter Garstang.

5. **Oyster Culture in the River Yealm.**—With regard to the observations on oyster culture in the river Yealm, to which reference has been made in a previous number of the Journal, a report has been furnished by Dr. G. H. Fowler to Lord Revelstoke, who had generously placed the river at the disposal of the Association, and had provided a stock of parent oysters. As a result of these experiments it appeared that (1) as regards food, the river is well adapted for the production of a fat and well-flavoured oyster; (2) that the purity and salinity of the water are also favourable; (3) that a large part of the present bottom and sides of the river are unusually well-fitted for oyster farming, and a good deal of ground, at present unfit for the purpose, could be brought into cultivation without great trouble; (4) that the considerable movement of the water in ebb and flow is a less favourable factor in the problem, but is not so extensive as to nullify the other advantages of the river for oyster farming.

6. **Ray's Bream.**—On March 28th Mr. Dunn, of Mevagissey, sent to the Laboratory a specimen of Ray's bream, *Brama Raii*, Bl. Schn. It was 50·4 c.m. in length and in a quite fresh uninjured condition. Mr. Dunn stated that it was seen swimming at the surface of the water off the beach at Portseathoe near Falmouth, and was captured with a gaff. This fish is rarely taken, and its normal habits are not well known. The occasional specimens which have been taken have been thrown up on the shore after storms, or found in an exhausted condition in shallow water. It has occurred on various parts of the British and Irish coasts. The last specimen found on the south coast was captured on June 12th, 1875, near Penzance, and is recorded by Mr. Cornish in the *Zoologist* for that year.—J. T. C.

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.

Professor HUXLEY, the President of the Royal Society, took the chair, and amongst the speakers in support of the project were the Duke of ARGYLL, Sir LYON PLAYFAIR, Sir JOHN LUBBOCK, Sir JOSEPH HOOKER, the late Dr. CARPENTER, Dr. GÜNTHER, the late Lord DALHOUSIE, Professor MOSELEY, Dr. ROMANES, and Professor 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, in particular, 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, at the expense of a small rent for the use of a working table in the Laboratory and other appliances, and have made valuable additions to zoological and botanical science. 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. The gentleman holding this post receives £200 a year and a residence. A naturalist has also been appointed at a salary of £250 a year, whose duties are confined to the study of food-fishes, and provision has been made for an assistant to the Director. THESE ARE THE ONLY SALARIED OFFICERS OF THE ASSOCIATION: its affairs are conducted entirely by voluntary service.

The Association has at present received some £15,000, of which £5000 was granted by the Treasury. The annual revenue which can be at present counted on is about £950, of which £500 a year for five years is granted by the Treasury, whilst £180 is in the uncertain form of Annual Subscriptions.

The admirable Marine Biological Laboratory at Naples, founded and directed by Dr. Dohrn, has cost about £20,000, including steam launches, &c., whilst it has an annual budget of £4000.

The ASSOCIATION URGENTLY NEEDS ADDITIONAL FUNDS FOR THE PURCHASE AND MAINTENANCE OF A SEA-GOING STEAM VESSEL, by means of which fishery investigations can be extended to other parts of the coast than the immediate neighbourhood of Plymouth; for the maintenance and completion of the library; and in order to increase the permanent staff engaged at Plymouth. 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. II, 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 ann.	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, M. B. A. Laboratory, Citadel Hill, Plymouth.