









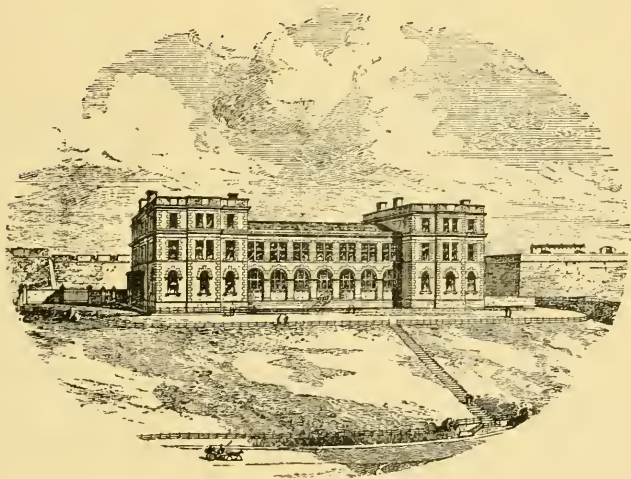








Journal  
OF THE  
MARINE BIOLOGICAL ASSOCIATION  
OF  
THE UNITED KINGDOM.



THE PLYMOUTH LABORATORY.

VOLUME I (N. S.).

1889—90.

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

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(NEW SERIES).

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*Naturalist.*—J. T. CUNNINGHAM, Esq., M.A., F.R.S.E.

*Assistant to the Director.*—W. GARSTANG, Esq., M.A.





# OBJECTS

OF THE

## Marine Biological Association of the United Kingdom.

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FOUNDED "for the purpose of establishing and maintaining Laboratories on the Coast of the United Kingdom, where accurate researches may be carried on leading to the improvement of Zoological and Botanical Science, and to an increase of our knowledge as regards the food, life-conditions, and habits of British Food-fishes and Molluscs."

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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 Marine Biological 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.

## TERMS OF MEMBERSHIP.

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	£	s.	d.	
ANNUAL MEMBERS . . . . .	1	1	0	per ann.
LIFE MEMBERS . . . . .	15	15	0	Composition Fee.
FOUNDERS . . . . .	100	0	0	" "
GOVERNORS (Life Members of Council)	500	0	0	" "

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

The special privileges of Governors, Founders, and Life Members will be found under the Regulations for the working of the Laboratory.

# BYE-LAWS.

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## MEMBERS.

1. The Association shall consist of Governors, Founders, Life Members, and Annual Members, from whom shall be chosen the Council, Officers, and not more than twenty Vice-Presidents.

2. A number of Associate Members, not exceeding fifty in all, may be elected from among persons connected with Marine Fisheries or interested in Marine Botany or Zoology.

## COUNCIL.

3. The affairs of the Association shall be conducted and its laboratories managed by a Council consisting of the Governors, the Officers, the Prime Warden of the Fishmongers' Company for the time being, and fourteen other Members to be chosen annually, who shall be eligible for re-election. Five shall be a quorum.

## OFFICERS.

4. The Officers of the Association shall consist of a President, a Chairman of Council (who shall be *ex officio* a Vice-President), an Honorary Treasurer, and an Honorary Secretary, all of whom shall be chosen annually from amongst the Members, but shall be eligible for re-election.

5. In the event of any vacancy occurring in the Council, Officers, or Vice-Presidents, the Council at their next Meeting after such vacancy has been made known shall elect some duly qualified person to the vacant office.

6. The President shall preside at the Meetings of the Association, and shall regulate the discussions and proceedings thereat.

7. In the absence of the President at any meeting of the Asso-

ciation, a Vice-President shall preside ; and, in the absence of all the Vice-Presidents, a Member of the Council shall preside ; and, if no Member of the Council be present at any Ordinary Meeting, the Members present shall appoint such Member as they shall think fit to be Chairman.

8. The Chairman of Council shall preside at the meetings of the Council, and shall regulate the discussions and proceedings thereat. In his absence the Members of the Council present shall appoint such Member of the Council as they think fit to be Chairman.

9. In case of an equality of votes at meetings of the Association, or of the Council, the Member presiding shall have a second or casting vote.

10. It shall be the duty of the Hon. Treasurer to receive all sums of money due to the Association, and to disburse all sums payable by the Association out of the funds in his hands.

11. No payment exceeding £15 (except for rent, taxes, or wages) shall be made by the Hon. Treasurer without the consent of the Council.

12. The Accounts of the Hon. Treasurer shall be audited previous to each Annual Meeting by a Committee of two Members of the Council and two Members of the Association, to be appointed by the Council at the last Council Meeting in the session, of which Committee three shall be a quorum.

#### DIRECTOR.

13. A Director of the Laboratory, who shall also act as Assistant Secretary of the Association, shall be elected by the Council at such a salary as shall from time to time be determined.

14. It shall be the duty of the Director to maintain the laboratories, aquarium, and library, and other property of the Association, in a state of efficiency ; to superintend and direct the scientific work at the laboratories ; to prepare and edit the Journal of the Association ; to keep a list of all the Members of the Association, together with their addresses ; to summon meetings of the Association and the Council ; to conduct all correspondence ; to take minutes of the proceedings of the Association and the Council, and generally to act under the direction of the Council in all matters connected with the affairs of the Association.

15. The Council may employ an Assistant to the Director, who shall receive such remuneration and shall be subject to such directions as they shall from time to time determine.



ELECTION, WITHDRAWAL, REMOVAL, AND PRIVILEGES  
OF MEMBERS.

16. Every candidate for election as a Member or Associate Member shall be proposed in writing by a Member, and such proposal shall be forwarded to the Director, who shall lay it before the Council at the next succeeding meeting.

17. The method of voting for the election of Members shall be by ballot, and a majority of the Council balloting shall elect.

18. The payments to be made by the Members shall be as follows :—A Governor shall pay £500, a Founder £100, and an Ordinary Member shall pay £1 1s. annually. The annual contribution may be compounded for at any time on payment of £15 15s. Any University of the United Kingdom, on the payment of £500 to the Association in the name of the University and for the purpose of acquiring the right herein specified, shall, if the Council of the Association assent thereto, become a Governor of the Association, and acquire the perpetual right of nominating annually one Member of the Council of the Association to serve for one year (from the Annual Meeting in one year to that in the following year), and any resident Member of the University subscribing £100 or more to such fund of £500 shall, in virtue of such subscription, become a “ Founder ” of the Association.

19. The annual contribution shall become due on the 1st June, in advance ; but any Member elected in the months of February to May inclusive will not be called upon for a second contribution until the 1st June in the year following his election.

20. Every Member having paid all sums due to the Association shall be at liberty to withdraw therefrom upon giving notice in writing to the Director.

21. Whenever written notice of a motion for removing any Member shall be delivered to the Director, signed by the President or Chairman for the time being on the part of the Council, or by five or more Members, such notice shall be sent by post to each Member seven days before the next Annual or Special Meeting of the Association, when such motion shall be taken into consideration and decided by ballot. If a majority of the Members balloting shall vote that such Member be removed, he shall be removed from the Association accordingly.

22. Whenever any Member shall be in arrear for two years in the payment of his annual contribution, notice thereof in writing shall be sent to him by the Hon. Treasurer ; and in case the same shall remain unpaid, the Hon. Treasurer shall give notice thereof to



the Council, who shall cause a similar notice to be sent to the Member, with an intimation that at the expiration of three months he will be liable to have his name erased from the list of Members. In default of payment the Council may order his name to be erased accordingly.

23. Members shall have the right to be present, to state their opinions, and to vote at all meetings of the Association ; to propose candidates for admission as Members ; to introduce visitors at meetings of the Association ; to have personal access and to introduce strangers to the laboratories, and to make use of the library, subject to such regulations as the Council may from time to time prescribe.

24. Members shall be eligible to any office in the Association, provided they are not more than one year in arrear in the payment of the annual contribution.

25. A Member shall not be entitled to vote on any occasion until he shall have paid his contribution for the year last past.

#### ASSOCIATE MEMBERS.

26. Associate Members shall not be required to pay any contribution to the funds of the Association, but are expected to communicate information to the Association on Marine Fisheries and on Marine Zoology or Botany, to supply specimens, and to otherwise advance the objects of the Association.

27. Associate Members shall not be eligible to any office in the Association, nor shall they be entitled to vote at any meeting.

28. Associate Members shall have personal access to the laboratories and library of the Association, subject to the regulations of the Council in force for the time being.

#### ANNUAL MEETING.

29. The Annual Meeting of the Association shall be held in June in each year, on such day and at such time as the Council shall from time to time direct.

30. The object of the meeting shall be to receive from the Council their annual report on the affairs of the Association, and to elect the Council, Officers, and Vice-Presidents for the ensuing year.

31. The Council shall cause to be prepared a list containing the names of Members whom they shall recommend to be elected as the Council, Officers, and Vice-Presidents for the year ensuing, and a

copy of such list shall be hung up in the office of the Association not later than the 15th May.

32. If any five or more Members shall desire to substitute for any of the names in the said list the names or name of any other Member or Members, they shall give notice in writing to that effect, specifying the names or name proposed to be substituted; such notice to be given on or before the 31st May to the Director, who shall cause the same to be forthwith hung up in the office of the Association.

33. If no such notice is given to the Director, the Members named in the list prepared by the Council shall be held to be elected as the Council, Officers, and Vice-Presidents for the ensuing year.

34. If any such notice is given, the election shall be by ballot at the Annual Meeting, and the President shall appoint two or more Scrutineers from the Members present, not being Members of the Council, to superintend the ballot, and to report the result to the meeting.

35. Any balloting list containing a greater number of names proposed for any office than the number to be elected to such office shall be rejected by the Scrutineers.

36. No ballot shall be taken unless five or more Members vote.

### SPECIAL MEETINGS.

37. Upon the requisition of any twenty or more Members presented to the Council, a Special Meeting of the Association shall be convened. A notice thereof shall be sent to every Member whose last known residence shall be in the United Kingdom, seven clear days before such meeting shall take place, and the general nature of any proposition to be submitted to such meeting shall be stated in the notice.

38. No vote shall be taken at any Special Meeting unless twenty or more Members shall be present.

39. Any of the Bye-Laws of the Association may be repealed or altered or others adopted in lieu thereof at an Annual or Special Meeting, but no resolution for effecting any such repeal or alteration shall be proposed at any Annual Meeting unless at least fourteen days' notice in writing specifying the terms of such resolution shall have been given to the Director.

## REGULATIONS FOR THE WORKING OF THE LABORATORY.

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At a Council Meeting, held on July 25th, 1888, the regulations with regard to the admission of Naturalists desiring to make use of the Plymouth Laboratory were amended and enlarged as follows :

1. Any Governor or Founder of the Association is entitled to occupy *in propria personâ* a table at the Plymouth Laboratory without payment. A Founder or Governor shall have the privilege, upon signifying to the Director his intention to forego permanently the right of personally occupying a table in the Laboratory, of nominating an eligible person to make use of a table for one month in each year free of charge.

2. The charge for a table shall be £40 a year, £25 for a half-year, and £5 for a month, to be paid in advance. No table shall be let for less than a month, and the monthly charge shall be as above for any number of months less than six.

3. Members of the Association have the first claim to become renters of tables.

4. Life Members of the Association are entitled to occupy *in propria personâ* a table at a reduction of one fourth from the above rates.

5. The Council of the Association may remit, in whole or in part, the payment of rent for a table in special cases. No charge will be made to a State-recognised authority for the use of a table.

6. Applications from Members and others desiring to occupy tables must be made in writing to the Director, and a notice of at least seven days will be expected before any table is ready for use.

7. The Association undertakes, so far as possible, to supply the material required for any investigation, and such facilities for obtaining it as may be at the command of the Association.

8. The Association supplies to the occupant of each table ordinary glass jars, dissecting dishes, bottles, pans, &c., not to be removed from the Laboratory, also the ordinary chemical reagents, and

ordinary methylated alcohol to the amount of two gallons per month. Absolute alcohol will be supplied to the extent of half a pound per month. Each Naturalist must pay for what he requires in excess of these amounts. The Association does not supply microscopes or other instruments. The more expensive reagents, as well as glass slips and covers and other portable apparatus, may be purchased of the attendant. Each Naturalist will be provided on arrival with a list of the free equipment supplied by the Association.

9. For the purpose of enabling the Director to draw up the half-yearly statement of the work of the Laboratory required by H.M. Government, and for the information of the Association, all Naturalists working in the Laboratory, at the completion of their work, or if not completed after three months then at intervals of three months, are expected to furnish the Director with a summary statement of the investigations carried on by them in a form suitable for publication in the Journal of the Association.

10. No Naturalist can be permitted to make zoological collections in the Laboratory. The Association undertakes to provide collections of marine animals, and to supply them at a fixed price to those who wish to buy them. This rule must be understood to apply only to general zoological collections. Every Naturalist is at liberty to collect and take away with him any material that is necessary for the prosecution of his special line of research on payment of the cost of bottles and packing-cases necessary for its removal.

11. The animals collected by the fisherman will be delivered to the Superintendent of the Laboratory, and distributed by him. The fisherman of the Association is prohibited from delivering specimens directly to the Naturalists.

12. Naturalists who are desirous of making use of the boats of the Association must apply to the Director for permission to do so.

13. A portion of the tank apparatus in the main Laboratory will be allotted to each Naturalist. Applications for small aquaria, glass vessels, caoutchouc and glass tubing must be made to the Laboratory Superintendent. Naturalists are not permitted to overcrowd the aquaria or contaminate the sea water in circulation.

14. There will be a collection of named specimens which may be used for reference and identification. Any Naturalist desiring to use the named specimens will be supplied with them on application to the Director. He will be required to return the specimens uninjured as soon as he has done with them.

15. Naturalists working in the Laboratory will have free access to the tank-room at any hour of the day, but they are not permitted to have access to the interior of the tanks without the permission of the Director. Facilities for conducting experiments on a large scale

will be granted as far as space permits, but each Naturalist will be held responsible for the consequences of such experiments.

16. Any Member of the Association is at liberty to view the Laboratory and tanks between the hours of 10 a.m. and 6 p.m. on presenting his card to the Director.

17. The Director has control of the Laboratory boats and apparatus of the Association. Persons are admitted as renters of tables solely on the condition that they accept this control, and agree to abide by the regulations drawn up by the Council of the Association.

*The Director regrets that, owing to delays in the execution of the plates, the issue of the present number has been retarded for more than a month.*

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ERRATA.

On Plates I, II, III, IV, V, VI, *for* Journal Mar. Biol. ass. *read* Journal Mar. Biol. Ass. ; *for* Planche *read* Plate ; *for* G. C. Bourne del *read* J. T. C. del.





## MARINE BIOLOGICAL LABORATORY.

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Received

June 1898.

Accession No.

1831

Given by

Marine Biol. Assoc.

Place,

\*\*No book or pamphlet is to be removed from the Laboratory without the permission of the Trustees.





# Journal of the Marine Biological Association.

## The Director's Report.—No. 1.

THE present number of the 'Journal of the Marine Biological Association' forms the first of a new series in which is intended to publish such scientific memoirs as have a direct or indirect bearing upon economic questions. In order that the illustrations, which are indispensable in zoological memoirs, may be conveniently large, the size of the journal has been increased to royal octavo. It is not intended that the Journal should enter into competition with any of the existing zoological or botanical periodicals. It is recognised that the Association is dependent on public support, and that, whilst it is its duty to supply scientific information in an easily comprehensible form to those who are interested in marine fisheries, it should confine itself to shorter accounts of work dealing with those questions in animal or vegetable morphology which are necessarily couched in very technical language. The Journal will be issued from time to time, according to the amount of work ready for publication, and will contain, besides the memoirs alluded to, abstracts of the scientific work done by the naturalists hiring tables in the Laboratory, notes and correspondence from other fishery and marine stations, abstracts of the most important results obtained by the fisheries commissioners of various Governments, and any correspondence addressed to the editor for publication.

In issuing the present number a brief sketch of the condition of the Association may conveniently be given.

Prior to the completion of the Laboratory at Plymouth it was impossible for the naturalists of the Association to do any great amount of practical scientific work; the means and appliances were wanting. A great deal of information on fishery matters and on the local Fauna and Flora was, however, collected and tabulated, and has been printed in the first two numbers of this journal. Mr. Cunningham, the naturalist of the Association, began to work on the development of bony fishes in August, 1887, and the memoir

from his pen which appears in this number is for the most part the result of the work done by him under great difficulties, when the Laboratory was still unfinished. Mr. Weldon, of St. John's College, Cambridge, was engaged from time to time before the completion of the building, when his work at Cambridge permitted him, on the study of the Crustacea of the Sound, and the results of his work will be published in due course. The Laboratory was not ready for work, and the tanks in the aquarium were not ready to receive marine animals before the spawning season of the majority of fish and Crustacea of economic value was over, and hence the subject of fish culture, to which great importance is attached, has practically been in abeyance since the apparatus necessary for it has been in place.

Immediately after the Laboratory was opened several inquiries were made by English naturalists as to the work that could be done at Plymouth, and several gentlemen, whose names are given in a Table below, came down to Plymouth for shorter or longer periods, and were engaged in zoological research, some of the results of which are given in the abstracts of this Journal. None of these gentlemen were able to extend their visit beyond September, and they had to experience the inconvenience of working in a new institution in which the necessary routine had not been formed by experience. At the present time, however, the organisation of the Laboratory is far in advance of what it was in September.

It is most unfortunate that the majority of English naturalists are so tied down by professional engagements that they cannot make lengthy visits to what may justly be called the National Marine Laboratory. In working out the life problems of any single animal, a single month's residence near its habitat is not sufficient, and when the research is extended to whole groups, many months, and even years, of patient study are required. Dr. Dohrn's famous station at Naples is tenanted year by year by naturalists from different countries, but chiefly from Germany, who are sent there to occupy one of the tables rented at a fixed annual charge by the **different Governments, universities, and learned societies.** Were this not the case the Naples Zoological Station, although its assured income is greatly in excess of that of the Marine Biological Association, would not have the means to keep together such a staff of naturalists as is required to produce the admirable scientific memoirs frequently published by that institution.

It is much to be desired that the universities, science colleges, and learned societies of Great Britain will similarly aid the Marine Biological Association by hiring tables at an annual rent,—fixed at

£40 per annum,—and sending their rising naturalists to Plymouth as yearly occupants of such tables. By doing this they will not only aid the progress of the Association and the extension of an accurate and reliable knowledge of all that concerns the denizens of the sea, but they will ensure to themselves a thoroughness and an enthusiasm on the part of those students on their return to scholastic or other duties, which can only be obtained by an extended study of the subject-matter of their science, free from the cares and interruptions of teaching work, and by constant communication with their fellow-workers in kindred branches of study. The effect of the enlightened patronage of the German States on the progress of zoological science in that country cannot be over-estimated, and the impetus that has recently been given to the same subject in France, America, Austria, and Holland by the foundation of marine stations in those countries is equally remarkable. It is to be hoped that now that a really efficient laboratory exists on the coast of England, means will be found to enable English naturalists to take advantage of its resources.

The Association is definitely pledged, in consideration of a grant from H.M. Government, to concern itself with economic questions relating to our fisheries. Mr. Cunningham's paper is a sufficient evidence that the pledge is being fulfilled. But it must be observed that practical investigations of this kind, whilst they differ from those which have a purely scientific object only in the end to be obtained, and not in the methods to be employed, require a more comprehensive survey of the phenomena under consideration, and therefore a more extensive experience of their occurrence.

The object of every "scientific" investigation is to trace certain effects to their causes, and whereas in the case of a non-practical question it may be permissible to study the influence of a *single* force upon a fish or other organism, neglecting for the time other forces of equal or perhaps of greater importance, the solution of a "practical" question depends on the sum of many influences, acting, it may be, with varying intensities for various periods on the organism which is being investigated. The organism, its structure, life-history, habits, and abundance is the resultant of many such intermittent, unequal, and sometimes antagonistic forces. A "practical" investigation, then, differs from a "theoretical" only in its greater complexity and in the larger amount of accurate knowledge required for its objects,—practical investigations are nothing but scientific investigations of the highest possible order. A scientific opinion upon fishery questions must be founded upon such a number and variety of observations as to be equivalent to a statement of fact, and those who act upon the opinion, whether

legislators, pisciculturists, or fishermen, have a right to expect an immediate advantage as the result of their following it. If a loss instead of a profit accrues, not only is that particular opinion set down as worthless, but the popular voice is apt to pass from a particular to a general statement, and to say that all scientific opinion on such matters is equally without value.

But perfect accuracy in any one detail requires long and laborious work, and many observations require many people to make them. Such work cannot be undertaken by a single man, nor even by two when one of them is subject to constant interruptions, with any prospect of immediate result. Several students are required who will interest themselves in the problems that concern marine life, and will divide the work between them in such a way as to keep a main object in view whilst they are working on separate details. This is being done with great success by the Commission appointed by the German Government for the investigation of the German seas, and may be done with equal efficiency at Plymouth if only the workers are forthcoming. As it is, Mr. Cunningham is fully engaged in the study of bony fishes and their development, and as much of my time as is not taken up with the duties of organisation and secretarial work is devoted to the study of the vast mass of living organisms which inhabit the surface waters of the seas—animals which are of great importance as forming the basis of by far the larger portion of marine life. But in addition to this, statistical, physical, and chemical, as well as other zoological work is required. The action of the tides and currents, the manner in which they are influenced by the weather, the temperature, density, and purity of the sea, are subjects which would take up the whole time of a single investigator, and they are of the greatest importance in the study of the migrations, spawning, and abundance of food-fishes. It is sincerely to be hoped that some gentleman will come forward as a volunteer in this department, and will spend at least a portion of his spare time at Plymouth.

In order that a thorough knowledge of the Fauna and Flora of the Devonshire and Cornish coasts may be obtained, it is requisite that several naturalists should spend long periods in investigating the different groups of the animal and vegetable kingdoms. Little can be done by an individual beyond the mere enumeration of the species with the date and locality of their capture. This work will naturally form part of the researches of renters of tables, but in order that it may be done well it is necessary that tables should be occupied for long periods.

By way of some remarks on the Fauna of Plymouth Sound it may be stated that the dredging and collecting done by the Association



during the past year shows that a great change has taken place within the Sound itself. Plymouth Sound is properly included within a line drawn from Penlee Point to the Mewstone. The breakwater divides it into two great areas, of which that lying within the breakwater is nearly a closed basin. During the months of July and August I explored the whole of this inner region very carefully, and extended my researches southward to the imaginary line which limits Plymouth Sound. Previous to my arrival there the same localities had been constantly dredged by Messrs. Heape and Cunningham, so that one may say that the Sound has been carefully explored throughout a whole year. The result is that we find that very many of the animals which were known to be plentiful in the Sound twenty years ago have migrated further out, and are no longer to be found within the breakwater. This is no doubt due to the great increase of the Three Towns, and to the largely increased outfall of sewage, the whole of which is poured directly into what I have already described as a nearly landlocked basin; in many places, indeed, the ground is so foul that no animal would have a chance of subsisting there. This is particularly the case northward of the Breakwater Fort, and along the line of buoys to the north of Drake's Island. It is not advisable to attempt to give a complete list of all the species recorded, but attention may be called to some of the more important forms which occur in the Sound.

The Protozoa have not been worked out. Of the Porifera, *Grantia ciliata* and *G. compressa* are very abundant. *Oscarella lobularis* is not uncommon, and *Clathrina clathrus* is abundant in certain caves beneath the Laboratory. The rocks are covered everywhere with *Halichondria panicea*. *Hymeniacion suberea* and *Isodictya lobata* are also found, the former in abundance, the latter rarely.

Of the Hydrozoa the most important is *Myriothela phrygia*, which is found on the underside of stones to the east of Drake's Island. *Tubularia indivisa*, common twenty years ago, can rarely be found now. *Clava carnea* and *C. multicornis* occur only in small colonies. *Eudendrium ramosum*, *Hydractinia echinata*, *Halecium halecinum*, several species of *Obelia*, *Clytia Johnstoni*, different species of *Sertularia*, *Sertularella* and *Plumularia*, with *Antennularia antennina* and *A. ramosa*, nearly complete the list. One hardly ever obtains a fine hydrozoon colony within the Sound, the large specimens come from deeper water and cleaner ground.

The Anthozoa are well represented in number, though not in variety. The most notable species is *Bolocera eques*, which occurs in the Cattewater. *Caryophyllia Smithii*, the common Devonshire coral, is tolerably abundant, and various species of *Sagartia*, *Bunodes*, and *Tealia* occur in the Sound. One of the most common forms is

*Anthea cereus*. *Alcyonium digitatum* and *Gorgonia verrucosa* are seldom found within the Sound, though they are common on rough ground in deeper water.

Of the Echinoderms *Antedon rosaceus* may be dredged in abundance close to the Mallard buoy. It appears to congregate in deeper holes during the winter months, and to spread itself along the shore during the summer. Echinids, Holothurians and Ophiurids are tolerably common, and *Asterias glacialis* is ubiquitous, *A. rubens* being common, but less frequent. *Asterina gibbosa* is found on every rock between tide marks.

Several Planarians have been found, but their species have not yet been accurately determined. The most common form is *Leptoplana tremellaris*.

Nemertines are tolerably common. *Lineus obscurus* is the most common form. *Micrura fasciolata*, *Nemertes Neesii*, *Amphiporus pulcher* and *lacteus* are not uncommon, and the palæonemertine *Carinella annulata* is found in the Cattewater.

Chætopod worms are found in great abundance and variety. The list given in the second number of the 'Journal' does not nearly enumerate the species which occur within the Sound. As a separate report on the Chætopoda may be expected in a future number, I will not attempt to give a list of the forms which we have collected, but will merely mention the discovery of *Pachydriulus* by Mr. Beddard in the sand at Jennycliff Bay, and the occurrence of the beautiful little *Gattiola spectabilis* near Bovisand Fort.

A note on Oligochæta by Mr. Beddard will be found at the end of the journal.

The Crustacea will form the subject of a separate memoir by Mr. W. F. R. Weldon, and I need not say more than that we have collected nearly all the species of Decapods enumerated in Mr. Heape's list, and have made some few additions. The Amphipods and Isopods have not yet received sufficient attention, and the same may be said of the Cirrhipedes and Ostracods. No mention is made of *Cladocera* in the list above mentioned, but *Podon* and *Evadne spinifer* are some of the commonest forms taken in the tow-net during the summer.

The Mollusca have received the attention of Mr. Walter Garstang, who gives the following account:

"The common littoral Gastropods are to be found in abundance on the rocks and beds of Fucus left bare by the tides (*Nassa reticulata*, *Murex erinaceus*, *Purpura lapillus*, *Littorina littorea* and *littoralis*, *Patella vulgata*, and several species of *Trochus*). Five or six species of *Chiton* occur, inhabiting the littoral and laminarian zones. *Helcion pellucidum* is very common on fronds of laminaria, and



*Cypræa europæa* can always be found. *Natica monilifera* and *nitida* occur on sandy bottoms, whilst their interesting allies, *Lamellaria perspicua* and *tentaculata*, are found on weeds, with colonies of *Botryllus*, *Didemnum*, and other compound Ascidians.

“ From deeper water come *Turritella terebra*, *Ovula patula*, *Eulima nitida*, *Emarginula reticulata*, *Aporrhais pes-pellicani*, *Scalaria Turtonis*, *Cerithium* and *Cerithiopsis*, &c. The palliate and non-palliate Opisthobranchs are well represented. *Aplysia hybrida* is fairly common, and especially so in its young stage of *nexa*. *Eolis papillosa* and *Doris tuberculata* can generally be obtained, while smaller species of each of these genera are abundant. *Goniodoris nodosa*, *Polycera quadrilineata*, *Dendronotus arborescens* and *Tritonia plebeia* occur in the Sound. The remarkable *Elysia viridis* is common at the mouth of the Yealm.

“ *Dentalium* is rare, but has been taken several times.

“ Of the Cephalopoda, *Eledone cirrhosus* has been taken occasionally in the Sound, and so has *Loligo vulgaris*. A specimen of *Loligo media* of Linnæus has been taken from Cawsand Bay, and one of *L. marmoræ* of Verany from off the Draystone. *Sepiolo atlantica* (D'Orbigny) is common everywhere. Many Lamelli-branchiata require to be specially searched for on account of their habits of life, and this work has not yet been done. *Teredo* is found rarely, while *Saxicava rugosa* excavates the rocks of limestone everywhere. Small species of *Pecten* are very abundant, as also of *Anomia*, specimens of which are found attached to roots and stems of *Laminaria*. I have found *Crenella marmorata* attached or buried in the tests of *Cynthia tuberosa* and *Styela grossularia*. A single specimen of *Pectunculus glyçimeris* has been taken from the Cattle-water, but in all probability had been thrown overboard from some trawler. Indeed, all the finer bivalves came from deep water outside the Sound.”

Polyzoa are found in great number and variety within the Sound. The most common forms are *Bowerbankia imbricata*, *Crisia eburnea*, *Acyonidium gelatinosum*, *Flustrella hispida*, *Scrupocellaria scruposa* and *reptans*, *Bugula flabellata*, *Cellaria fistulosa*, *Membranipora pilosa* and *membranacea*, *Lepralia foliacea*, and *Cellepora pumicosa* and *aricularis*. Both *Pedicellina* and *Loxosoma* are taken within the Sound. The former (*P. cernua* and *gracilis*) is very common in tide pools, the latter was brought in once during July.

Although the Brachiopoda *Terebratula* and *Argiope* are recorded in Mr. Heape's list, the Association has been hitherto unable to find either of these forms within or without the Sound.

Of the Gephyrea *Thalassema Neptuni* is sometimes found in holes in stones within the breakwater, but it is much more common near

the Eddystone. *Sipunculus nudus*, though recorded from the breakwater, has not been found by us, but a *Phascolion* (sp. incert.) is not uncommon in shells of *Dentalium*, *Turritella*, and *Aporrhais*.

Ascidians are exceedingly numerous within the Sound, especially the composite forms. Of the simple Ascidians the beautiful *Clavellina lepadiformis* is not uncommon beneath rocks and in tide pools. *Styela grossularia*, a small red Ascidian not mentioned in Mr. Heape's list, covers rocks, stones, and wooden posts. Various species of *Ascidia*, *Cynthia*, and *Molgula* have been collected, and *Ciona intestinalis* has to be added to the previous list. The Ascidia compositæ are ubiquitous, and are being specially investigated by Mr. Garstang. The commonest form, *Aplydium fallax*, which covers stones and wooden piles with red fleshy masses, is not mentioned in the list published in August.

It is not necessary to enumerate over again the fishes given in Mr. Heape's list. The species there recorded have been taken, and most of them are commonly taken in Plymouth Sound, and there is nothing to add, except the occurrence of a peculiar *Siphonostoma*, one of the Lophobranchii, in zosteræ beds in Cawsand Bay. This little pipe fish is coloured bright green, and has the habit of holding itself upright amongst the waving leaves of the zosteræ, which it mimics to perfection.

This account does not pretend to be a complete list of everything taken in the Sound during the past year, it is only an indication of the animal forms which can with certainty be procured at a short distance from the Laboratory and in all weathers; for there may be days and even weeks when south-westerly gales prevent any dredging outside the shelter of the breakwater. Further to sea, and along the Devonshire and Cornish coasts, one meets with an abundance of marine life, unrivalled in any other part of the British coast. Were the Association possessed of a suitable steamboat these rich localities could be constantly visited, and what is more important, an enormous mass of evidence relating to the physical conditions of the Channel and to sea fisheries could be collected. A special fund for the purchase of a steamboat was started in July, and has reached the sum of nearly £500, chiefly through the generosity of a few individuals. But a sum of at least £1200 is required to purchase a boat strong and seaworthy enough to resist the heavy weather so frequently experienced in the Channel, and a further annual sum will be required to meet the annual cost of maintaining it. The experience of those resident at Plymouth shows how urgently a steamboat is required, and I would appeal to all those interested in marine biology and in our fisheries to give their assistance to the Association for this purpose.

Some of the most interesting catches of the past year have been made with the tow-net. In the summer months the surface of the sea swarms with minute organisms, many of which are the developmental phases of sand or shore-inhabiting animals. Thus the larva of *Balanoglossus*, an animal hitherto unknown to the British coast, was taken in August and September, and forms the subject of a memoir in this number. *Actinotrocha*, the larva of *Phoronis*, is common, and the larvæ of Echinoderms, Chætopods, Molluscs, Nemertines, and Polyzoa are equally abundant. Several specimens of larval *Amphioxus* were taken in the tow-net towards the end of October. In the summer months *Ctenophora*, *Medusæ*, and other interesting forms afford abundant material for research.

It is needless to say more of the natural advantages of the Devonshire coast. Special facilities for study are afforded by the Laboratory, and as soon as a competent body of naturalists can be established at Plymouth, it will be possible to attack the problems of marine life in a manner hitherto unknown in England, to the great advancement of biological knowledge and to the advantage of practical questions concerned with sea fisheries.

G. C. BOURNE.

*December 5th, 1888.*

Naturalists working at the Plymouth Laboratory during the six months ending December 31st, 1888 :

<i>Name.</i>	<i>Date of arrival.</i>	<i>Date of departure.</i>
W. F. R. Weldon, M.A., St. John's College, Cambridge.	... June 30	... Dec. 19
W. T. Hardy, B.A., Caius College, Cambridge.	... July 17	... Sept. 15
C. A. MacMunn, M.A., M.D. ... ..	... Aug. 14	... Sept. 12
F. E. Beddard, M.A., F.Z.S., Prosector of the Zoological Society.	... Aug. 3	... Aug. 30
Prof. Burdon Sanderson, M.D., F.R.S. } F. Gotch, M.A. }	... Sept. 3	... Sept. 29

In addition to the above, the Resident Director, Mr. Bourne, the Naturalist of the Association, Mr. Cunningham, and Mr. Garstang, Secretary to the Director, have been continuously engaged in zoological research.

## Studies of the Reproduction and Development of Teleostean Fishes occurring in the neighbourhood of Plymouth.

By **J. T. Cunningham, B.A., F.R.S.E.,**

Fellow of University College, Oxford; Naturalist to the Association.

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With Plates I, II, III, IV, V, VI.

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THE following is a detailed account of the results of my investigations concerning the breeding and the development, under natural and artificial conditions, of some of the fishes met with at Plymouth. These researches extended over the period from the beginning of August, 1887, to the end of August, 1888. I have given brief preliminary accounts of some of the results in No. II of the 'Journal,' issued in August, 1888. As I mentioned there, the laboratory work was carried on from August to November in a small room hired for the purpose near the fish quay; from November to June, 1888, in a single room in the Laboratory without a constant supply of sea-water; after that time the Laboratory being finished all its appliances were available.

### CAPROS APER.

This fish is abundant off Plymouth in the months of July and August, when it is taken in large numbers by the trawlers, who call it the "cuckoo." At this time it is sexually mature, and evidently approaches the shore for the purpose of spawning.

I obtained and artificially fertilized ova on August 15th, 1887, when on board a trawler which fished on the east side of the Eddystone, and found on my return to shore that the fertilization was successful.

The fertilized ovum of *Capros aper* is of a type which is common to a large number of marine species; it is buoyant, very transparent, and spherical; the perivitelline space is small, the egg-envelope has no markings on the external surface, and there is a single oil-globule which in the normal position of the ovum is at the uppermost pole,



*i. e.* the pole opposite to the centre of the blastodisc. But the oil-globule, as is usual in similar ova, is able to move freely at the surface of the vitellus at the early stages of development, that is, until the vitellus is completely enveloped by the blastoderm, and therefore when the ovum is placed on a slide in any position the oil-globule usually rises to the upper pole.

The ovum shown in fig. 1, at the stage when the blastoderm had just begun to spread, measured  $\cdot 97$  by  $\cdot 98$  mm. That shown in fig. 2, when the embryo was fully formed but the tail had not begun to grow out, measured 1.2 mm. in the shortest diameter, 1.5 mm. in the longest. The oil-globule is  $\cdot 19$  mm. in diameter. The ova were measured lying on a slide in sea-water without a cover-glass, the measurements being made by first tracing the outline of the ovum with Zeiss's camera, and then throwing the image of a millimetre scale on the tracing. In the later stage the increase in size is due to an expansion of the egg-envelope, the perivitelline space having increased. But ova of a given species are always, within narrow limits, variable in size.

The development was not carried to a later stage than that shown in fig. 2. At that stage black chromatophores had appeared at the sides of the embryo near the dorsal median line, as black specks.

#### TRIGLA CUCULUS.

I obtained some ova of this species on April 5th and 6th when on board a trawler south of the Wolf Rock, and also some milt, and thought I had effected artificial fertilization, but when I examined the ova on shore I found the fertilization had not succeeded. Another sample, this time successfully fertilized, was brought in by the Laboratory fisherman on April 28th; they were taken, together with eggs of the common sole and merry sole (*Pleuronectes microcephalus*), on April 27th, about forty miles north of the Longships Lighthouse. On May 13th the Laboratory fisherman returned from a trip on a trawler to the neighbourhood of the Wolf Rock, bringing one bottle of ova of this species fertilized on May 10th, and a bottle of ova of *Trigla gurnardus* fertilized on May 11th. A few more ova of *Trigla cuculus* I fertilized myself at the same locality on May 16th. The natural conditions to which these ova are exposed during development are thus the same as in the case of those of *Pleuronectes microcephalus* (see below), the period of spawning being the same for both species. *Trigla gurnardus* spawns also at the same time.

With regard to the experimental conditions I had not time to pay so much attention to this as to other species. My observations are

as follows:—The ova fertilized on April 27th were placed on the following day in a glass jar provided with a constant circulation of water, the jar having a layer of gravel at the bottom in which the lower end of a glass cylinder rested, the outflow passing through a siphon which took the water from the inside of this cylinder. The water supplied on this day was taken near the shore on the flood tide three hours before high water, and had a density of 1.025. The ova sank in this. On April 30th I procured some buckets of water from near the mouth of the Sound, at the Duke Rock, and this had a density of 1.026. As it replaced the other water in the circulation jar the ova rose to the surface. The specific gravity of the ova of this species is therefore about 1.0255. The temperature was 9.2° to 8.0° on May 1st, 8.9° on May 2nd, in the water passing through the jar. On May 4th the water brought in had a density of 1.024, and on account of small tides and continuous rain I could not get water any denser. The ova consequently sank to the bottom, and by May 7th all of them were dead. This case seems to show conclusively that death was due solely to the too low density of the water used. The circulation was nearly constant, and therefore the ova must have been sufficiently supplied with oxygen; and the temperature was very little higher than that of the open sea. However, the ova lived nine days. Of the ova brought in on May 13th, I placed the *T. gurnardus* in an apparatus like that described above, and left the *T. cuculus* in a jar of still water taken from the shore, having added common salt to it to cause the ova to float. On May 15th I went to sea on board the trawler "Lola." After my return, on May 19th, I found a single newly-hatched larva of *T. cuculus* in the jar, the rest of the ova being dead. This is somewhat surprising, namely, that an egg should live six days and finally hatch, in a small quantity of unchanged water to which common salt had been added. The temperatures of course had not been noted.

*Development and structure.*—I have given a figure of the ovum of *Trigla gurnardus* to show the early stage, not having drawn one of *T. cuculus* till the stage shown in fig. 4. The dimensions of the ovum in the two species are exactly the same; the diameter of the ovum is 1.45 mm., of the oil-globule .3 mm. There is but a single large oil-globule, which is as usual movable (see under *Scomber*) in the early stages. The stage shown in fig. 4 in *T. cuculus* was reached in five days three hours. Chromatophores of two colours were present at this stage, some black, the others orange; both kinds are present on the sides of the embryo, only the orange on the yolk-sac. The characters of the larva are shown in fig. 5, but the figure is not coloured. The black dendritic chromatophores are here as usual specially developed along the edges of the median fin-fold,

and both kinds are abundant on the surface of the yolk. The notochord is multicolumnar, and the anus immediately behind the yolk. But the most peculiar feature in the larva is the great size of the rudiment of the pectoral fin. As usual the mouth is not open, but there is an opercular opening leading to the gill-slits. The larva was 3·7 mm. in length.

#### PLEURONECTES MICROCEPHALUS.

I first got the eggs of this species, along with those of the sole and others, on March 5th and 6th, 1888, when I was on board a trawler which was fishing to the south of the Wolf Rock, which lies to the west of the Lizard Point in Cornwall. In the spring and summer, with few exceptions, all the Plymouth trawlers are accustomed to fish in that neighbourhood. They usually leave the port of Plymouth on Monday morning, about 8 a.m., and as a rule it takes about twenty hours to sail to the fishing ground, which is usually spoken of by the fishermen as Mount's Bay, although the fishing actually takes place some distance to seaward of any limit which could reasonably be defined for that bay. Several times I went on board one of the trawlers named the "Lola," and collected eggs of all the species of fish which were in a ripe condition amongst those brought on deck during the week's fishing. Each boat usually returns to Plymouth on Saturday, and starts again the following Monday.

My first trip lasted only from March 5th to March 8th, as we were obliged to return to Plymouth before the end of the week on account of bad weather. On that occasion I found one or two specimens of *Pl. microcephalus* which were partially ripe, and got a few ova and a little milt; but when I examined these ova afterwards on shore I found they were either dead, or still living and floating, but unfertilized. My next trip lasted from April 3rd to April 7th, when I again got some eggs of the same species, and found on my return that they were not fertilized. On April 11th the fisherman engaged for the collecting work of the Association was sent by me to go out in a trawler fishing on the Plymouth ground, and try to procure some fertilized ova. He returned on April 13th, bringing ova of *Pl. microcephalus* but of no other species. These ova I found were fertilized; they were taken four or five miles south of the Eddystone, the trawl being towed east and west. The Laboratory fisherman went out again in a trawler on April 23rd, the boat fished in the Irish Sea about forty miles north of the Longships Lighthouse. He brought back on April 28th ova of *Pl. microcephalus*,



and some other species, but those of the former were unfertilized. He went out again on May 8th, this time on board the "Lola," to the Mount's Bay ground, and returned on May 13th, bringing some fertilized ova of this species. I did not stay on shore to study these, as I was anxious to go out myself to procure soles' ova, and went to sea on May 15th for this purpose. On this occasion I did not get ova of *Pl. microcephalus*. On May 26th some healthy fertilized ova of this species were sent up by the captain of the "Lola;" they were taken near the Wolf Rock on May 24th. The Laboratory fisherman, William Roach, obtained more ova of the same species on May 29th on a trawler to the south of the Eddy-stone, and this was the last lot that I received.

It thus appears that the species we are considering spawns during April and May, the period, no doubt, extending in the case of a few individuals slightly beyond these limits in either direction.

A few data were obtained to indicate the physical conditions to which the ova are normally exposed. The density of the water in the neighbourhood of the Eddystone is 1·0267 to 1·0269 (see under Scomber).

On April 7th I brought a clean sample of sea-water from where we had been fishing, south of the Wolf Rock, in a stoppered bottle, and found its density when tested in the Laboratory was 1·0270. The temperatures observed were as follows :

April 4th.—South-east of Wolf Rock . . . . .	Surface . . . . .	7·5° C.
„ 12th.—5 miles south of Eddystone . . . . .	Surface . . . . .	7·2° C.
	Bottom, 40 fms. . . . .	6·6° C.
„ 16th.—Ditto . . . . .	Surface . . . . .	7·5° C.
„ 25th.—40 miles north of Longships Lighthouse . . . . .	Surface . . . . .	7·7° C.
	Bottom, 50 fms. . . . .	7·2° C.
May 10th.—10 miles south-east of Wolf Rock . . . . .	Surface . . . . .	10·0° C.
	Bottom, 45 fms. . . . .	8·9° C.
„ 29th.—6 miles south-west of Eddystone . . . . .	Surface . . . . .	9·4° C.
	Bottom, 40 fms. . . . .	8·8° C.

In describing the artificial conditions **under** which the ova were kept in the Laboratory, I shall consider **first** and more fully those obtained on April 12th about five miles south of the Eddystone, as **from** these all the figures and most of the description given below of the development were taken.

When these ova were brought in I transferred them to some water taken a short distance from the shore opposite the Laboratory; the density of this was 1·026, and the ova all floated in it without difficulty, remaining in a layer at the very surface. They were simply left in jars of the water, with no arrangement for continuous

aeration or circulation, but were transferred to clean water every day. On April 14th the temperature of the water in the jars was  $12.5^{\circ}\text{C}$ ., more than  $5^{\circ}$  higher than the surface temperature of the open sea where they were taken. The subsequent temperatures in the jars were: 16th,  $11.6^{\circ}\text{C}$ .; 17th,  $13.0^{\circ}\text{C}$ .; 19th,  $11.8^{\circ}\text{C}$ .

A large proportion of this lot of ova hatched, and some of the larvæ lived five days after hatching. The larvæ after hatching were placed in a jar with gravel at the bottom, supplied with a constant inflow of water, the outflow taking place from a cylinder whose base was inserted in the gravel.

On the 18th I found that water brought up from the shore had a density of 1.023, and in this ova of *Pl. microcephalus* rapidly sank.

The ova fertilized on May 24th were also left in still water, having a density of 1.026, and a temperature on the second day of  $13.7^{\circ}\text{C}$ . These hatched on May 30th. Another lot, fertilized on May 29th, were placed in a Chester apparatus (see under Scomber), made with a square wooden washing tray, and provided with a nearly constant supply of water from the shore. (All this time I was restricted to a single room, all water being carried up by hand.) The temperature of the water was  $12.4^{\circ}\text{C}$ . These ova were all dead on May 31st, the fatality being probably due to the impurity of the apparatus; the washing tray was fastened with white lead, and washed muslin was used over the bottom of the jars containing the ova.

It is thus shown that the ova of *Pl. microcephalus* are extremely hardy, and can be hatched without any difficulty in still water whose temperature and density differs considerably from those to which the ova are exposed under normal conditions. The next step is to make arrangements for collecting and hatching these ova on a large scale, and transferring the hatched young to the sea, in order to find if the supply of merry soles is thereby increased.

The specific gravity of the ovum of *Pl. microcephalus* is about 1.024; they floated in water having a density of 1.025, and sank in that of density of 1.023.

*Structure and development.*—The ovum of *Pleuronectes microcephalus* resembles that of other species of the same genus, and of many species of *Gadus* (cod, haddock, whiting, &c.) in having a perfectly homogeneous yolk without oil-globules, and a small perivitelline space. Its diameter is usually 1.36 to 1.44 mm., though individual ova may be a little smaller or a little larger than this. The external surface of the vitelline membrane (egg envelope) is not perfectly smooth, but shows a number of fine raised ridges forming two systems of parallel lines, which cross one another diagonally. Fig. 6 shows the appearance of the ovum under the

microscope when the blastoderm has almost entirely enveloped the yolk. In the ova fertilized on April 12th, at 1 p.m., and kept under the conditions already detailed, segmentation was completed on the first day, and on the second the extension of the blastoderm over the yolk took place. On the third day the differentiation of the optic vesicles and of the mesoblastic somites commenced. On the fourth day the lens and auditory vesicles were formed, and the first development of pigment appeared as black dots on the sides of the embryo. Fig. 7 shows the condition on the fifth day: the intestinal tube is formed, the notochord is present and already shows the multicolumnar arrangement of its vacuoles, and the cavity of the heart has appeared as a simple slit in the mesoblast below the neck. The black chromatophores are but little further developed. A number of the larvæ hatched out on April 19th at the end of the seventh and commencement of the eighth day after fertilization. The structure of the larva is shown in fig. 8. It is 3.8 mm. in length. There are now yellow chromatophores as well as black, and both are dendritic. They are present in the median fin-fold, on the sides of the body, and on the surface of the yolk, where they are situated at the surface of the periblast. The mouth is not open, the nasal pit is seen at the anterior end of the head, the heart is more developed and contracts regularly, but there are no red corpuscles. The anus is open and situated immediately behind the yolk. There is a large cavity (the venous sinus) in front of the yolk, between it and the anterior abdominal wall. The notochord is not altered. Besides the median fin-fold there are rudiments of the pectoral fins in the form of a semicircular fold of membrane on each side behind the auditory vesicle. The cavity of the intestine is plainly visible. The larva four days after hatching (fig. 9) is considerably more developed. The mouth is not opened, but its cavity is large and only separated from the exterior by a thin membrane, and three or four gill-slits are open leading from the pharynx to the exterior. The yolk is almost absorbed, and the abdominal region therefore does not protude so much. The venous sinus is still large and its communication with the posterior end of the heart is plainly seen. Red corpuscles are still absent, but white corpuscles or leucocytes are to be seen moving in the venous sinus and passing into the heart. In front of the remnant of the yolk is seen the liver, as a bulbous follicular outgrowth from the wall of the intestine. The urinary bladder is visible behind the rectum. The head is much shortened, so that the auditory vesicle is much nearer to the eye. The pectoral fin is considerably developed, but no fin rays are present in it. The pigment is much more abundant, and has a definite arrangement. The yellow

pigment is confined to the body of the larva and the surface of the yolk; on the former it is abundant, especially about the head. The black chromatophores form a fringe at the edges of the median fin, and others are also present on the body and the yolk-sac. The larva is still perfectly symmetrical; no indication of the asymmetry of the eyes and skull is yet apparent. The larva at this stage has a total length of 4.6 mm.

#### SOLEA VULGARIS.

Observing that the ovaries of soles brought in by the fishermen were approaching maturity, I went out in a trawler on February 6th, 1888, to obtain, and to artificially fertilize, some ripe ova. On this occasion, as on many others when I was similarly engaged, the trawl was brought on deck after darkness had set in, and I had to carry on operations by the dim light of a lantern. From one specimen I got a few ova, but could get no milt. The ova, when examined on shore next day, were found to be unfertilized, though two or three were floating. On this occasion the boat, when the trawl was hauled, was about nine miles west by south of the Eddystone.

My next attempt was on March 6th, when I was on board the "Lola," south-east of the Wolf Rock. At one haul of the trawl I got, out of about thirty-five soles, two or three which yielded a few ripe ova on squeezing, but I could obtain no milt from any of them. On opening those which I judged to be males I found small testes in the usual position, and these I cut out and divided into small pieces, and placed these in the water with the ova, hoping that sufficient spermatozoa for fertilization would thus be obtained. This difficulty in obtaining the milt of the sole, an unexpected obstacle to the investigation of the development of the species, occurred constantly on every subsequent occasion when I tried to obtain fertilized ova. The cause of it I have not yet discovered. There is no such difficulty in the case of other flat-fishes; the ova of the merry sole were fertilized with ease, sufficient milt could almost always be obtained by squeezing males, and at other times I have fertilized the ova of *P. flesus* (the flounder), *P. limanda* (the dab), *P. cynoglossus* (the witch, or pole flounder); but I was not able during the whole of last season ever to squeeze any milt out of a male sole. The probable reason is that the testes of the sole are extremely small.

On March 7th I examined the soles of another haul with the same result. On my return to Plymouth on March 8th I found only about a dozen of the ova floating, and of these only two or three showed a blastoderm, that is, were fertilized. Thus the pieces of the testes placed in the water had effected fertilization only in a few



ova of the whole number. The few I had were used up for microscopic examination.

In my next trip to Mount's Bay on April 3rd to 7th, I took some sole's ova as before, using entire testes cut into pieces to fertilize the ova. But on my return I found that this time not a single ovum was fertilized. At this time only a few soles were taken at a haul on the Plymouth ground, and it was necessary to go to Mount's Bay in order to have a chance of getting ripe specimens at all. But after this nearly all the trawlers went round the Land's End and fished on the north coast of Cornwall, so that it was difficult to arrange a trip unless one was prepared to stay out a fortnight, which would have made it impossible to get any results from the material obtained. I sent the Laboratory fisherman on one of these long trips, April 23rd to 28th, but the sole's ova he brought back were unfertilized. He went again to Mount's Bay, May 8th to 13th, and was again unsuccessful. I went myself May 15th to 18th, when I found a good many of the female soles spent, but again failed to get milt; I employed the testes as before, and on my return on May 19th I found a few of the ova fertilized.

The common sole thus spawns in March, April, and May. The temperatures of the open sea during the last two months are given under *Pleuronectes microcephalus*. Off the Wolf Rock on March 6th the temperatures were: surface  $7.7^{\circ}$  C., thirty fathoms  $7.5^{\circ}$  C. I found that sole's ova sank in water of 1.026 specific gravity and floated at 1.027, so that their specific gravity is between these numbers.

*Structure and development.*—The ovum of *Solea vulgaris*, after extrusion and fertilization, is of considerable size; of two that I measured one was 1.47 the other 1.51 mm. in diameter. It is distinguished from the greater number of the pelagic ova of other genera by two peculiar characters, both connected with the yolk. One is that instead of having a single large oil-globule, or a small number of these, it has an immense number of very minute size. These are arranged in groups of irregular shape, the globules of a given group being all in contact with one another. At the early stages most of these groups are near the edge of the blastoderm, but without any constant arrangement (fig. 10). The other character is that the yolk is not perfectly continuous and homogeneous, but co-extensive with the blastoderm there is a single superficial layer of separate yolk-masses, or yolk-segments, having a somewhat rounded outline, but not spherical (*y. s.* in figs. 10, 11, &c.) This layer of yolk-segments extends with the blastoderm, so that when the latter has enveloped the yolk the layer of yolk-segments also envelops it completely, forming a superficial layer over the whole surface of the yolk as seen in fig. 11. When the embryonic rudiment

becomes distinct, and especially after the yolk is completely covered by the blastoderm, the groups of oil-globules are mostly aggregated on each side of the embryo, though there are a few groups at other parts of the surface of the yolk (fig. 11).

I have only, on account of the great scarcity of my material, been able to examine two stages in development from artificially fertilized eggs. Fig. 10 shows a living but unfertilized ovum, drawn on March 8th. The development of a fertilized ovum examined on the same day had evidently been very slow, owing to the low temperature to which it had been exposed; the temperature of the surface sea-water in which the ovum was fertilized was  $7.7^{\circ}$  C., and as the jar had been kept on board the trawler until shortly before the time when the ovum was examined, the temperature of the water containing the ovum was probably even lower than this during the two days.

Fig. 11 is taken from another ovum fertilized on May 16th, and drawn three days afterwards, the temperature at fertilization having been about  $10^{\circ}$  C., and in the jar containing the ovum during the time it was on board the boat probably somewhat higher. At this stage the enclosure of the yolk by the blastoderm has been completed, the embryo is distinctly formed, the optic vesicle is present, and the vesicle at the posterior end, known as Kupffer's vesicle, is fully developed; this vesicle is unusually large. Black chromatophores have appeared on the sides of the embryo and on the surface of the yolk, the former being still in the form of dots, the latter dendritic or stellate in shape.

It is evident that the peculiarities of the sole's egg enable it to be easily recognised when taken in the open sea in the tow-net. Twice I obtained specimens in this way. The first time was on March 16th, 1888, from a tow-net worked between the Tinker and the Knap buoys just outside Plymouth Breakwater, just after high water, when the temperature at the surface of the water was  $6.6^{\circ}$  C. There were three ova altogether, one of which is shown in fig. 12. The diameter of this was 1.47 mm. The individual oil-globules and the vitelline segments were of somewhat larger size than in the artificially fertilized ova, but this is probably a mere individual variation, and there can be little doubt that the ova belonged to *Solea vulgaris*.

The second time was on April 18th from a tow-net worked on the east side of the Sound, when I found only a single ovum, which is figured in fig. 13. This ovum was in the same stage as the artificially fertilized one shown in fig. 11, but it is figured in a different position. It agrees in structure exactly with the ova taken directly from the parent fish, but its apparent size in the figure is greater. It was drawn under a cover-glass, and in this condition measured

1.67 mm. in diameter, the difference being due partly to the flattening caused by the pressure of the cover-glass, and partly perhaps, to individual variation, as the eggs of a given species always vary in size within certain limits. The position of the groups of oil-globules at the sides of and beneath the embryo is clearly shown in this figure.

*Historical and comparative.*—Imperfect as is the foregoing account of the ova of *Solea vulgaris* and their development, it is the first definite information yet afforded concerning the eggs of this species. Certain facts concerning the structure of the ova in the genus *Solea* have been published by Dott. Fed. Raffaele in a paper on the eggs and larvæ of Teleostean fishes in the Gulf of Naples,\* which appeared in March, 1888; but Raffaele has only described fertilized developing ova obtained by the tow-net from the surface of the sea, and did not identify any of these ova with a definite species. He ascertained the peculiarities of the ova in the genus by examining mature ovaries of *Solea impar*, *vulgaris*, and *Kleinii*, and says that these peculiarities, although distinguishing the ova of *Solea* from any other pelagic ova, render the ova of the different species so similar that they cannot, when obtained at random (*i. e.* from the open sea) be distinguished easily from one another. These peculiarities are those I have described, namely, the groups of minute oil-globules, and the superficial layer of yolk-segments, which Raffaele calls “vescicole vitelline,” speaking of the whole layer as the “zona esterna vescicolare.”

Raffaele describes two kinds of ova of *Solea* obtained by the tow-net, and not having been able to determine their species, he calls them Species A and Species B. Species A was 1.06 mm. in diameter, and was obtained in January. He gives two figures of this ovum, which are both indistinct, and also six figures of the larva at different stages, which are much better. Species B was larger, 1.23 mm. in diameter; of this he gives no figures of the ovum, but three figures of the larva. Neither of these species probably belonged to *Solea vulgaris*, as the largest of them is .2 mm. smaller than the ovum of the latter according to my measurements.

Raffaele notices the change in the relative position of the groups of oil-globules as the blastoderm grows over the yolk, attributing it to the fact that they are situated in the cortical protoplasm which divides the vitelline segments, and therefore take part in the movement of the latter. I cannot say whether the oil-globules in the sole's ovum are freely movable at first like the single globule in Scomber, Trigla, &c.

\* *Le Uova galleggianti e le Larve dei Teleostei nel golfo di Napoli*, Mittheilungen aus der zoologischen Station zu Neapel, Bd. viii, Heft 1.



The layer of separate vitelline segments is not exclusively confined to the ova of *Solea*; it is the combination of this character with the peculiar arrangement of the oil-globules which distinguishes this genus. The external segmental layer of the yolk was first noticed by Agassiz and Whitman\* in a species of ovum which they ascribe to *Temnodon saltator*, Linn., known in America as the blue-fish. *Temnodon* belongs to the same family as the boar-fish, *Capros aper*, whose ova have been described above, namely, the Carangidæ. Agassiz and Whitman state that when the blastoderm has enveloped the yolk the yolk-segments are absent immediately beneath the embryo, but I have not verified this in *Solea*. In the ova described by these authors there is but a single oil-globule of considerable size, and judging from the figures which show the globule in different positions it is mobile at the early stages.

Raffaele describes a perfectly similar superficial layer of segmented yolk in *Mullus surmuletus*, L., the red mullet. He informs us, moreover, that in the ovarian ovum of *Mullus* when it is approaching maturity the yolk-segments are in the centre of the ovum, and are nothing but a portion of the vitelline segments which at an earlier stage make up the whole mass of the yolk. Most of these segments fuse together to make up the homogeneous part of the yolk; the remainder pass to the surface and take up a position beneath the germ or blastodisc, persisting during development. The partitions enclosing the segments Raffaele believes to be protoplasmic and continuous with the protoplasm of the germ, by which he explains the fact that the yolk-segments are involved in the movement of the blastoderm. The explanation is in all probability correct.

The superficial layer of segments is also described by Raffaele in the ovum of *Callionymus festivus*, and in an unidentified ovum (Species No. 2 in his paper) with a diameter of .75 mm. which he says resembles that of *Callionymus*. He states that in *C. festivus* the layer of segmented yolk extends all round the ovum from the beginning, even in the mature ovum before fertilization, and undergoes no movement during the extension of the blastoderm. He refers to a description by McIntosh of the ovum of *C. lyra* (Ann. Mag. Nat. Hist., vol. xvi, 1885), in which it is stated that the surface of the vitelline membrane in this species exhibits a hexagonal mosaic of raised lines, and says that nothing of the kind being visible in the ovum of *C. festivus*, McIntosh probably saw the follicular epithelium attached to the ovum when it was taken from the ovary, and mistook this for a marking of the vitelline membrane.

\* *Pelagic Stages of Young Fishes*, Memoirs of Museum of Comp. Zoology, vol. xiv, No. 1, pt. i, Cambridge, 1885.

But I am able to confirm entirely McIntosh's statement with regard to *C. lyra*. I examined ripe ova squeezed from a mature female, and saw the hexagonal reticulum figured by McIntosh, and further, I took in the tow-net in the Firth of Clyde in 1886 an ovum well advanced in development, which showed exactly the same marking, and which agreed in all characters with the ripe ovum of *C. lyra*. Moreover, I saw no layer of yolk-segments in this species. At Plymouth I again met with the same ovum on February 1st, 1888, inside the Sound; two views of it are shown in figs. 26 and 27; the former shows an optical section, the latter the surface of the vitelline membrane. This ovum measured in one case .90 mm., in another .97 mm. Raffaele gives as the diameter of the ovum of *C. festivus* .56 to .60 mm. The Italian author speaks as if he had taken the ova directly from the parent fish, and thus it would seem that there are great differences between the ova of these two species of the same genus, but they agree in having no oil-globules.

The other kind of ovum with a peripheral layer of yolk-segments is briefly described by Raffaele (No. 2 of his unidentified species). This has a diameter of .75 mm., and has a number of rather large oil-globules scattered separately over the yolk; it was obtained by the tow-net in January.

As it seems not quite certain that the identification of the ovum of *Temnodon* by Agassiz and Whitman is correct, and there is some doubt about *Callionymus festivus* and the other species, *Mullus* and *Solea* are left as the only genera whose ova undoubtedly have the peripheral layer of yolk-segments. It is interesting to notice that these ova present a condition of the yolk intermediate between that characteristic of non-pelagic ova and that seen in typical pelagic ova. Oil-globules occur equally, either singly or in numbers, in both kinds of ova, but in all adhesive ova the yolk is made up of a number of minute yolk-spheres, and in nearly all pelagic ova the yolk is one mass, continuous and homogeneous, a single yolk-sphere. The adhesive ova are characteristic of nearly all shore fishes from the large *Cyclopterus* to the minute Goby, and also of the greater number of *Physostomi*, *i. e.* of the more primitive fishes with an opening to the air-bladder. But certain Clupeoids, *e. g.* the pilchard, although belonging to the *Physostomi*, have pelagic ova, and in these ova the subdivision of the yolk is retained at all stages; then in *Solea* and *Mullus* the central part of the yolk is fused into one mass, while a peripheral layer continues segmented; and finally in most pelagic ova the segments disappear altogether, and there is no subdivision of the yolk at all. It is possible that the peculiar character of the ovum of *Solea* indicates that there is no close affinity between this genus and *Pleuronectes*; the adaptation to the

habit of lying on one side may have brought about a superficial similarity in fishes originally derived from distinct families. I hope to decide this question by a careful comparison between soles and other kinds of flat-fish in all points of adult structure.

#### SOLEA VARIEGATA.

I did not devote much attention to this species, as my time was occupied with others; the following notes are therefore very meagre. Until May 30th I had not been able to find any of this species in a ripe condition. On that day the Laboratory fisherman brought me a few ripe ova which he had taken from a fish on board a trawler six miles south-east of the Eddystone. He had not been able to get any milt. When I examined the ova they were all at the bottom of the jar apparently dead, and all I could make out was the size and a large group of numerous oil-globules, individually larger than those of *Solea vulgaris*. These all collected at the highest point of the ovum when placed on a slide. The diameter was 1.36 mm. The appearance of the ovum is shown in fig. 14.

On July 17th, I obtained from a tow-net worked by the Laboratory fisherman from a mackerel boat south-east of the Eddystone a peculiar kind of pelagic ovum which is shown in fig. 15. This had a superficial layer of yolk-segments, like *Solea vulgaris*, but the oil-globules, though rather numerous, were of rather large size, and were scattered singly at nearly equal distances over the surface of the yolk. The diameter measured 1.36 mm. Thus the size of the ovum and of the individual oil-globules agreed closely with the dimensions noticed in the unfertilized ovum of *Solea variegata*. I conclude provisionally that the ovum shown in fig. 15 belongs to this species. Raffaele examined the ovarian eggs of only three species, *S. impar*, *vulgaris* and *Kleinii*. *Impar* is considered by Day in his Fishes of Great Britain and Ireland as synonymous with *lascaris*, which is Couch's lemon sole, and occurs occasionally on the coast of Devonshire; *Kleinii* occurs only in the Mediterranean. Thus there is nothing to show that *Solea variegata* may not have separate oil-globules; and although in the dead unfertilized ovum I observed them all in one group, this does not prove that they are not in the later stages of the living egg fixed at a distance from one another. Moreover, Raffaele describes and figures among his undetermined species an ovum which agrees in all respects with that shown in fig. 15 except that it is 1.4 mm. in diameter instead of 1.36. This difference may be due to the conditions of measurement or to individual variation. Raffaele thinks his ovum belongs to

another species of *Solea*; it seems to me probable that it belongs to *Solea variegata*.

*Other species of Pleuronectidæ.*—It will be useful here to summarise the present state of our knowledge concerning the reproduction of other species of the flat-fish family. I have already mentioned that Day considers *Solea lascaris* and *Solea impar* of Günther's British Museum Catalogue to be one and the same species, and that Raffaele has examined the mature unfertilized ovum and finds it has the same peculiarities of structure as *Solea vulgaris*. The species occurs occasionally at Plymouth, but I have never met with a specimen, and it is too rare to be of any importance for practical hatching. Day also unites *Solea lutea* and *Solea minuta* of Günther. This is a very small and practically unimportant species which also is rare at Plymouth, and I have not seen a specimen.

Of Pleuronectes I have previously\* described the ova and development of *P. flesus*, the flounder; *P. limanda*, the dab; *P. platessa*, the plaice, and *P. cynoglossus*, the witch, or pole flounder. These, with *P. microcephalus*, are the only British species of the genus. The eggs and larvæ of all these species are closely similar and differ only in size. The eggs and larva of *P. Americanus* described by Agassiz and Whitman in Pelagic Stages, &c., have the same characters.

*Rhombus maximus*, the turbot, and *R. lævis*, the brill, both occur at Plymouth. I have not been able to get ripe ova of either, but Raffaele considers certain ova which he obtained from the tow-net, which had a diameter of 1·33 mm., a homogeneous yolk, and a single large oil-globule, as belonging to *R. lævis*. He also figures larvæ of this species. Wenckebach describes the mature ova of *R. maximus* as having a diameter of ·75 mm.

*Arnoglossus* includes two species which occur at Plymouth, of which *Arnoglossus laterna*, the small scald-fish, is of no importance in the fish market. Concerning this species I have some incidental remarks to make. It is very common at Plymouth, and inside the Sound, especially in Cawsand Bay, young specimens of all sizes from three quarters of an inch long up to the full size of about six inches, are taken in numbers by the small trawls used for catching shrimps. It is constantly reported by fishermen that the shrimpers catch numbers of young soles, but the report is simply founded on a mistake, these young scald-fish being erroneously taken for soles. On August 15th, 1888, I went, with Mr. Bourne, on purpose to test this matter, and after trawling for a long time in Cawsand Bay we got large numbers of young scald-fish, but only one young specimen

\* *The Eggs and Larvæ of Teleosteans*, Trans. Roy. Soc. Edinb., vol. xxxiii, pt. 1, 1887.



of *Solea vulgaris*. In one point the descriptions and figures of *Arnoglossus laterna* given by Day in his British Fishes, and by Günther in his Catalogue of the British Museum Collection are a little too vague. The latter author does not of course give a figure for each species, and he speaks of the anterior curve of the lateral line in this species is subsemicircular. The former describes it as almost semicircular, and figures it as a rounded curve much like that of Zeugopterus. The anterior part of the lateral line in reality forms almost three sides of a square, and has another smaller curve still farther forwards, as shown in outline in fig. 39.

Raffaele states that the mature ova of *Arnoglossus* are .60 to .70 mm. in diameter, with a homogeneous yolk and a single oil-globule, and cannot be distinguished from those of *Rhomboidichthys* and *Citharus*, genera of Pleuronectids occurring in the Mediterranean, but not in Britain. It would seem therefore that the ova of *Arnoglossus* only differ from those of *Rhombus* in size.

Two species of *Zeugopterus* occur at Plymouth. I have met with a specimen of *Z. punctatus* taken in a lobster pot. They have no value in the market and their ova are not known.

#### SCOMBER (the Mackerel).

My first examination of living mackerel was made on board a boat called the "Prima Donna," on May 24th, 1888. On this occasion the nets were shot on the east side of the Eddystone, about fourteen miles from Plymouth Sound; and when they were hauled at day-break in their whole length of nearly two and a half miles only about fifty mackerel were taken. Several of these were males in a perfectly ripe condition, but only one ripe female was found, from which a number of ova were taken and fertilized. The skipper and the men having seen performed the simple operations necessary to obtain and fertilize the eggs, I left a basket of collecting bottles on board, and they supplied me with fertilized ova almost every time they went to sea. In fact, by this skipper and another, who was also taught how to collect them, more ova were sent to me than I could deal with, and I had to tell them not to send any until I gave them notice. The spawning continued from the end of May till the middle of July, and throughout this time I was studying and making experiments with mackerel ova. I received the last of the season on July 17th. It follows from this that mackerel in the neighbourhood of Plymouth spawn principally in June and the first half of July, that the ovaries and testes of all the adult fish become ripe within this period, and that all the reproductive products in a given fish are matured and shed within a short space of time. The process of spawn-

ing, that is to say, as usual in species of fish that swim in shoals and have migratory pelagic habits, is approximately simultaneous in all the specimens in a given locality, proceeds very rapidly when once begun, and is limited definitely to one short period of the year.

*Physical conditions during development.*—I have collected a few data concerning the density and temperature of the water at the surface of the sea, some miles from the Sound, that is where mackerel ova are shed under natural conditions.

March 23, 1888.—Water brought in from 2 miles outside the breakwater	Density . . .	1·0268
	Temp. when tested	8·2° C.
April 7.—Water from 7 miles south of Wolf Rock . . .	Density . . .	1·027
	Temp. when tested	7·5° C.
June 1.—Water in which mackerel ova were floating when brought in; that is, water taken from the surface at the place where the mackerel were caught.	Density . . .	1·0267
June 2.—Water in which mackerel ova were brought in from sea.	Density . . .	1·0268
July 17.—Ditto . . . . .	Density . . .	1·0269
	Temp. when tested	15·0° C.
May 31st.—Temperature of the sea 2 miles outside the breakwater.	Surface . . .	9·44° C.
	Bottom, 12 fms. . .	10·0° C.
June 12.—Temperature of sea at 7 miles south-west of the Eddystone, taken with Casella's reversing thermometer in the "Scottish" frame.	Surface . . .	11·6° C.
	Bottom, 40 fms. . .	10·0° C.
July 10th.—Temperature of sea in middle of Plymouth Sound, Melampus Buoy.	Surface . . .	13·3° C.
	Bottom, 7½ fms. . .	12·7° C.

With regard to the temperature of the sea at places where spawning mackerel were caught, that is in the neighbourhood of the Eddystone, it is certain that it could not have been higher than the temperature in the Sound and a short distance south of the breakwater. This temperature therefore between June 12th and July 10th rose from the temperature observed at the mackerel ground on the former date, namely, 11·6° C., to something less than that observed in the Sound on July 10th, namely, 13·3° C. With regard to density, the specific gravity of water from the mackerel ground was ascertained on shore three times, and was 1·0267 on June 1st, 1·0268 on June 2nd, and 1·0269 on July 17th. The temperature of the sample at the time when the density was observed was only once ascertained, on July 17th, when it was 15·0° C. The temperature of a small quantity of water in a bottle carried on a fishing boat, and examined in the Laboratory in June and July, must of course be somewhat higher than its temperature when taken from the sea, but we see that the greatest difference of



temperature between the sea and the observed sample of sea-water was that between  $11.6^{\circ}$  C. and  $15.0^{\circ}$  C., or  $3.4^{\circ}$ . Thus the density of the water at the surface of the sea was slightly greater than that observed in the samples, allowing for the expansion of the water caused by a rise of temperature of two or three degrees. But this difference of density would be scarcely appreciable, and we may therefore conclude with certainty that the density of the surface water of the sea was not less than 1.0267 and very little higher than 1.0269. The temperature on June 12th, seven miles south-west of the Eddy-stone, was  $11.6^{\circ}$  C., and on July 10th less than  $13.3^{\circ}$  C.

The following data of the conditions of temperature and density to which the ova were exposed during the Laboratory observations are to be compared with the natural conditions ascertained above. The first lot of ova I got, namely, those taken on May 24th, I placed in a glass jar of water provided with a slow circulation; at the bottom of the jar was a layer of gravel, and a glass cylinder with its base in the gravel surrounded the siphon through which the outflow took place. Thus the ova were prevented from approaching the exit siphon, while the water passed through the gravel up into the inside of the cylinder. This apparatus was arranged at 10 a.m. on May 24th, and on the following day I found that all the ova had sunk to the bottom of the jar, and were in a dead or dying condition. A few of the ova which had been left in the water brought in from the sea were still alive and developing. The water supplied to the circulation apparatus was brought up from the shore, as at this time I was restricted to my single room in the Laboratory, and the aquarium apparatus was not built. The result showed that the water from the shore, although constantly supplied in a pure condition to the eggs in the circulation apparatus, was rapidly fatal, while in the water from the open sea, although perfectly still and unchanged, the ova lived.

On May 26th more ova were sent up by the crew of the "Prima Donna." I had some clean water brought up from the shore, and found that its density was 1.0260, and its temperature  $13.7^{\circ}$  C. In this water the mackerel ova slowly sank, although the ova of *Pleuronectes microcephalus*, which I had at the same time, rose to the surface in it as soon as they were introduced. It is remarkable that there should be so considerable a difference in the specific gravity of the ova of the two species, the more so as the mackerel ovum has a large oil-globule, and the merry sole none, and yet the former is a good deal the heavier. As these mackerel ova were in perfectly clean water when brought in I did not transfer them to

the water from the shore, but only added a little of the latter to the water containing them, taking care not to decrease the density so much as to cause them to sink. I discarded the circulation method this time, and left them in bottles of still water.

On the 27th I was obliged to transfer them to shore water, in which they sank, but I brought them to the surface again by adding common salt. I found on testing I had raised the density to 1030, which was excessive.

On the 28th I found the temperature of the water containing the ova was  $12.1^{\circ}$  C. I changed them again into clean water made denser with salt. Many of them were still doing well.

On the 29th the water was again changed, and the temperature of the old water was  $12^{\circ}$  C., of the new  $11^{\circ}$  C.

On the 30th I fitted up an apparatus on the principle invented by Captain Chester, of the Fish Commission of the U.S.A., and described by A. Ryder in the Commissioner's Report for 1885, p. 499 (Washington, 1887). I procured a wooden washing tray with a hole bored in one side near the top, in which hole, by means of a cork, I fitted a glass siphon with its shorter leg inside the tray. In the tray I placed a glass cylinder open both at the top and the bottom; over the lower opening a piece of muslin was fastened. The eggs were placed in the cylinder, and a supply of water allowed to run at a constant rate into the tray. In consequence the water rose in the tray and the glass cylinder to the height of the hole in the side of the tray when the siphon commenced to act, and the water was drawn off until the level was lowered below the short leg of the siphon, when it commenced to rise again. Clean water in such an apparatus is thus constantly flowing over the eggs, while the latter are only subjected to very gentle motion.

But it would have been better if I had not been tempted to try circulation again. On the 31st a great number of the ova were dead, and by the evening of this day I could find none alive, and they all had to be thrown away. The damage may have been partially or wholly due to impurities derived from the wooden tray or the muslin, but the probable meaning of the result is that density is an essential condition; the ova lived and developed four days in still water in which they floated without motion at the surface, although the water for three of these days was shore water made denser with common salt, and when placed in a current of shore water to which no salt was added they died in twenty-four hours.

In this case the temperatures to which the ova were exposed during the first four days as observed were  $13.7^{\circ}$  C.,  $12.1^{\circ}$  C.,  $12^{\circ}$  C., and  $11^{\circ}$  C. The densities were 1.0267 to 1.030. The temperature of the open sea on May 31st was not more than  $9.44$  C., and the

density 1·0267 or a little more. The temperature of the water on the last day in the Chester apparatus was 12·4°, while its density was not greater than 1·0260. Thus the ova were not injured during the first four days by a temperature more than 4° higher than that of the open sea, and a density increased on one occasion by ·0033, but they died on the fifth day in a circulation in which the temperature was the same as before, and the density decreased by ·0007 or somewhat more. Unless the motion or impurities from the apparatus killed them, it must be concluded that they died because they sank in the water.

My next experiment was still more unsuccessful. Ova were brought in on June 1st, and I transferred them to water fetched from near the breakwater; the density of this was 1·0255. I added salt to it till the density was 1·0265. On June 2nd the temperature was 14° C. I then changed the water, and placed half the ova in a glass jar provided with a circulation, the outflow being protected by muslin; but on June 3rd both halves, that in the still water and that in the circulating, were dead.

On June 12th I received a number of healthy fertilized ova from the "Prima Donna," taken seven miles south-west of the Eddystone. I placed these in a Chester apparatus, made with a perfectly clean wooden tub instead of the tray formerly used, and placed them in the tank-room, as the aquarium apparatus was all but complete and the pumps were working. By placing the tub under one of the jets I expected to obtain a constant supply of water to the apparatus, which was impossible in my single room, where each bucket of water had to be carried up by hand. But the pumps had to be stopped and all the ova died.

On June 29th I received a fresh supply, and as the aquarium pumps were now working continuously I kept these in a Chester apparatus on the shelf below the small tanks in the main laboratory, water being supplied to the tub by means of a siphon from the tank above. Some of these ova lived well for some days, but they sank in the water because its density was not great enough. And as some of the ova died the living and dead were all mixed together in a mass lying on the muslin at the bottom of the jar, a condition which was obviously unhealthy. The water in circulation in the aquarium system of the Laboratory varied somewhat in density, because frequently some water had to be run off from one of the large reservoirs to allow some slight defect in the arrangements to be attended to, and then more water was pumped up from the shore to make up the loss. On June 8th the density of the circulating water was 1·0260, on August 15th it was 1·0250; it varied between these two limits. On July 4th the temperature of the water in the



tanks in the main laboratory was 14.5° C. The temperature of the open sea at this time was not much above 12° C. Thus, in this last experiment with mackerel ova the temperature was only about 2° higher than that of the open sea, and the density was 1.0250 or 1.0260 instead of 1.0267.

Some of these ova hatched on July 4th, on the sixth day after fertilization, but these were few in number, all the rest being dead; the larvæ were also half dead and had not strength enough to survive more than a few seconds when placed on a slide; consequently I was unable to get a drawing of them. On July 5th there were neither larvæ nor ova left alive. I got another sample of mackerel ova subsequently, but they were only partially fertilized and soon died.

It is difficult to say whether the death of the ova in the experiment conducted from June 29th to July 5th under the most favorable conditions, was partially due to the presence of impurities derived from the new apparatus, but it has generally been observed that in a new aquarium the animals die in considerable numbers notwithstanding all care. It was so to a certain extent in ours,—there were more deaths at first than subsequently; and the fact of the system having been so newly arranged may have had an unfavorable effect on the mackerel ova; but I believe the chief cause of failure was the insufficient density of the water. Apart from the question whether buoyant ova will develop normally in water of such low density that they sink in it, it is certain that in the apparatus used for floating ova the conditions become unfavorable if the ova sink. They are insufficiently supplied with oxygen, and it is impossible to separate the dead ova from the living. Some pelagic ova have been found near or on the bottom in the Baltic, where the density of the water is below that of the open seas. The observations I refer to were made at Kiel by V. Hensen,\* a member of the Commission for the Investigation of German Seas, and they refer only to plaice, flounder (*Pleuronectes flesus*), dab (*Pl. limanda*), and cod. By fishing with a fine net attached to a dredge at the bottom, at a depth of nine fathoms, about eighteen miles from Kiel, at the mouth of Kiel Bay, he obtained ova of the three species of *Pleuronectes* mentioned, and these afterwards hatched in captivity. The specific gravity of the water at the place mentioned has an average for the year of 1.0128, and the maximum observed during several years was 1.0201, and the average temperature in April, when the ova were taken, was 6.11° C. Hensen found that the ova of the plaice, after having been shed into sea-water had a specific gravity of 1.01496;

\* *Ueber das Vorkommen und die Menge der Eier einiger Ostseefische*, 4ter Bericht der Commiss. zur Unters. der deutschen Meere, IIte Abtheil., 1883.

and found that in eleven years, in March three times, in April three times, in May seven times, the maximum specific gravity of the water off Kiel Bay was lower than that of the plaice ovum. Thus in these years the ova of *Pleuronectes* species would have to develop on or near the bottom. Hensen does not give any details of the apparatus in which he hatched the ova artificially, but I infer from his remarks that he hatched them when they sank in the water of the vessels containing them.

But of course it does not follow that mackerel ova will develop healthily in water of less specific gravity than themselves. And it is certain that it was a constant result in my experiments that mackerel ova floating at the surface in still water, even when the density was artificially increased with common salt, lived some days, while those provided with a circulation of water in which the ova sank died in a much shorter time. The same thing was observed also with the ova of *Pleuronectes microcephalus* and others. But these experiments are not sufficiently rigid to prove that the too low density of the water, *i. e.* the sinking of the ova, was the sole cause of the death of the ova in unsuccessful experiments. It may, however, be pointed out that in my experiments the ova were first fertilized in water much denser than themselves, and remained in this some time before they were transferred to water of less specific gravity in which they sank, and a change of density like this after fertilization may possibly be fatal, when if the ova were shed and fertilized at the beginning in water in which they sank they would live and develop normally. This can only be decided by further experiments directed specially to this point.

The specific gravity of mackerel ova fertilized in the water of the open sea where the parents were captured is 1.0265 at the maximum. In water of a specific gravity of 1.0263 a few out of a large number of ova remained at the surface; at a specific gravity of 1.026 the ova remained suspended at various depths for some time, and one or two rose to the surface, while at 1.0257 all the ova sank rapidly. Thus the specific gravity of different individual ova varies slightly within narrow limits; a few were observed to have a specific gravity of less than 1.026, but the great majority are heavier than 1.0263, and none are heavier, at least at early stages of development, than 1.0265, or lighter than 1.0259.

*Development.*—The ovum of the mackerel after fertilization is spherical and transparent, and has a diameter of 1.22 mm. In the early stages of segmentation the ovum is not perfectly spherical, because the principal diameter, passing through the centre of the blastoderm, is a little longer than the others, owing to the slight pressure of the prominent blastoderm on the envelope (fig. 16). The yolk is

homogeneous and colourless ; at its surface is a large oil-globule, also colourless, having a diameter of  $\cdot 32$  to  $\cdot 33$  mm. The blastodisc, and the blastoderm at the commencement of segmentation, has a slightly yellow colour, which disappears later. The envelope is thin, and I have not noticed any sculpturing or inequalities on its outer surface. The perivitelline space is small, at the stage referred to, consisting as usual of only a ring-shaped cavity in the depression between the blastoderm and the yolk ; the rest of the ovum is in contact with the inner surface of the envelope.

The oil-globule moves with perfect freedom at the surface of the yolk, which proves that the latter substance is a liquid of very slight tenacity. When the ovum is floating freely in water the blastoderm is at the lowest pole, and the yolk at the uppermost. When the ovum is placed upon a slide, whatever be the position of the blastoderm, the oil-globule rises to the uppermost pole ; the blastoderm is the heaviest portion of the ovum, the oil-globule the lightest. On the slide the position of the blastoderm is proved to be fixed in relation to the position of the egg envelope, but the oil-globule remains free and rises to the pole which is vertically highest under the action of gravity. Even when the blastoderm is placed uppermost the oil-globule passes freely beneath it and rests below its centre. Thus it is evident that the yolk is to be regarded as a liquid enclosed within a layer of protoplasm continuous with the blastoderm, and at the surface of this liquid next to the protoplasmic layer moves the oil-globule.

The blastoderm spreads out, and the segmentation cavity, embryonic rudiment, and embryonic ring are formed in the usual way. At the temperature of about  $13\cdot 5^{\circ}$  C. the sixteen-cell stage is reached in about seven hours, and the segmentation cavity is formed before the end of the first day (twenty-four hours). On the second day the growth of the blastoderm over the yolk takes place. During all this time until the envelopment of the yolk is completed the oil-globule remains movable (figs. 17 and 18), but as soon as the yolk is completely covered by the blastoderm the oil-globule becomes fixed in a position ventral to the posterior end of the embryo (figs. 19, 22, 24). This fixture is effected by the periblast, and is a fact which deserves the greatest attention. The oil-globule seems to belong entirely to the yolk, and the periblast grows with the blastoderm outside the yolk. Why then should it grow in between the oil-globule and the yolk, separating the two and fixing the former in one position ? In its new condition the oil-globule projects slightly beyond the general surface of the yolk, which is depressed in its immediate neighbourhood. Thus there is a cavity round the projecting part of the oil-globule. This projecting part



comes into contact with the blastoderm, which is here composed only of epiblast; the cavity belongs, of course, to the segmentation cavity. The question arises whether the periblast furnishes a covering to the outer surface of the oil-globule as well as to the deeper side. It probably does, but I cannot say with certainty.

The time when the enclosure of the yolk is completed varies of course with the temperature, but in my experiments it was effected before the end of the second day. The differentiation of the organs in the dorsal part of the embryo begins before it is complete, and proceeds rapidly during the third day. Fig. 20 shows the stage reached about the middle of the third day; seven mesoblastic somites are distinctly seen, the eyes are indicated, and Kupffer's vesicle has appeared. On the fourth day (figs. 21, 22, 23) the crystalline lens, the auditory vesicle, the heart, the intestine, and the notochord are formed, and pigment appears in the skin. This pigment is confined to the sides of the embryo, and to the deep surface of the oil-globule; there is none on the surface of the yolk; the pigment consists entirely of black dendritic chromatophores. The development of these chromatophores in the periblast covering the oil-globule on its deeper surface is another fact in connection with the oil-globule which deserves special attention. I have described the development of chromatophores in the periblast covering the anterior part of the yolk in *Pleuronectes microcephalus*, and these connected with the oil-globule in the mackerel are in homologous relations, but it is curious that they should be confined to the surface of the oil-globule and absent from the rest of the yolk.

Fig. 24 shows the condition reached on the fifth day; all the organs are more developed, and the notochord is seen to be multi-columnar. Pigment is still absent from the periblast covering the surface of the yolk, except over the surface of the oil-globule. But green chromatophores have appeared in addition to the black, and are confined to two small groups on each side, one behind the eye, the other at the base of the tail. The latter organ has begun to grow out at the posterior end of the embryo.

Some ova fertilized on June 29th, hatched on July 4th, the sixth day, at a temperature of  $14.5^{\circ}$  C. I have not been able to give a figure of the larva for reasons stated above, and can only give a few notes of its characters. The distribution of the pigment is much the same as in fig. 24; the notochord is multi-columnar, the mouth not open, the anus is immediately behind the yolk.

The special development of chromatophores round the oil-globule is not a peculiarity of the mackerel, but seems to occur to a great or less extent in all ova which contain oil-globules, especially if there

is only a single one present. But so far as I am aware, attention has not hitherto been called to the peculiar position of this pigment on the deeper side of the oil-globule, though it probably has the same relative position in other species.

*Historical and Comparative.*—Some valuable information and deductions concerning the life-history of the mackerel are contained in a report made by Prof. G. O. Sars to the Department of the Interior of the Norwegian Government. Prof. Sars carried on investigations of the Norwegian fisheries for a series of years from 1864 to 1878, at the request of the Government, and his reports have been officially published from time to time at Christiania. The whole series was finally published in one volume in 1879. But to the English reader they are more easily available in the translations published in the Report of the United States Commissioner of Fish and Fisheries for 1877. In the report of Prof. Sars for 1875 he states that he made some preliminary investigations of the spawning of the mackerel during a zoological tour in the summer of 1865. He says that this fish spawns at the surface of the water, near or far from the coast, and that the roe floats near the surface and there goes through all the stages of its development; that the spawning period is as a general rule the first half of July; that the ova when shed are small beads as clear as crystal, which float near the surface as long as they are alive; that the ova are of about the same size as those of the cod or a little larger, but are distinguished from these by a large and very distinct and clear oil-bladder near the upper pole; that he obtained the fertilized ova from the sea by means of a fine net, and was able to keep these during development until they hatched. He believes that by the end of one year the young fish are about as long as the finger, that in two years they grow to the size of a common herring, and at the end of three years are full-grown and spawn themselves; that during the first two years they remain near shore, roaming about in the open water.

With regard to the habitat, the home of the mackerel, Prof. Sars, rightly no doubt, considers that it extends in the eastern part of the North Atlantic along the whole western coast of Europe from the Orkney Islands and the north coast of Scotland to the Mediterranean and southward to the Canary Islands. It occurs on the southern and western coasts of Norway, on all the other coasts of the North Sea, on the western coast of Great Britain, round Ireland, in the Channel, on the coasts of France, Spain, and Portugal, and in the Mediterranean as far as the Black Sea. It also occurs on the Atlantic Coast of North America from Labrador to Cape Hatteras (see: *Materials for a History of the Mackerel Fishery*, U.S. Fish. Comm. Report for 1881). Prof. Sars rightly condemns the

erroneous notions that have been held concerning the habits of the mackerel. Some have supposed that there is an enormous annual migration for spawning purposes from the sea round the North Pole; others, especially the fishermen, that the fish in winter remained at the bottom in a torpid condition, and, what is still more strange, blind. Prof. Sars believes, as is now generally held for all pelagic fish, that they approach the coast chiefly in order to spawn, and at other times are scattered at greater distances from the shore, or in the ocean, but always in an active pelagic condition. He thinks it probable that not all the mackerel taken on the coasts of the North Sea pass their whole life in that area, but that many enter it from the north or through the Channel. It is certain that in the neighbourhood of Plymouth mackerel are often caught in greater or less numbers all the year round, though there is generally little fishing immediately after the spawning time, *i. e.* at the end of July and the beginning of August.

It is stated in the paper already referred to, "Materials for a History of the Mackerel Fishery," that the spawning season on the Coast of New England coincides with that observed on the British Coasts, occurring in May and June in Massachusetts Bay, and in June in the Gulf of St. Lawrence. As we have seen, Professor Sars states that the spawning of the mackerel does not begin on the west coast of Norway until the beginning of July, and that it is finished about the middle of that month. He may not have been able to make sufficient observations, as at Plymouth the spawning period lasts more than one month.

It may well be that the season is a little later off Norway, for I find that the surface temperature on July 22nd in the Foldenfjord, 64° 34' N. latitude., in 1880 was 11.4° C., which is slightly less than the temperature off the Eddystone on June 12th, 1888. Thus the spawning season of the mackerel is doubtless inseparably connected with a certain range of temperature, though the connection may be an indirect one, through the relation of the temperature of the sea to the mackerel's food.

In the family Scombridæ, besides the mackerel are included the various genera of tunnies, which are mostly of very large size, and the tropical sucking-fish, *Echeneis remora*. Of these, so far as I know, the ova and development have not been investigated, but in all probability their ova are buoyant and pelagic. On the Atlantic coast of North America another species of the family besides the common mackerel occurs, and is the object of a regular and valuable fishery in Chesapeake Bay, at Sandy Hook, Southern Long Island, and Narragansett Bay. This species is the *Cybium maculatum* (Mitchel), Agass. It is chiefly captured in fixed gill-nets, not in

drift-nets or seines to so great an extent. Its spawning and development have been investigated by J. A. Ryder, a naturalist of the United States Fish Commission, and an account of its fishery is given by R. Edward Earll. Its ova are pelagic and closely similar in all respects to those of *Scomber scomber*, but somewhat smaller. On the coast of Virginia (Mobjack Bay, Chesapeake Bay) it spawns in July. Ryder does not mention the mobility of the oil-globule; he states that it is fixed and to its position ascribes the buoyancy of the egg, and the position of the egg when floating. Probably the oil-globule is movable nevertheless, and there are several floating eggs which have no oil-globule. Ryder describes the subsequent formation of a mantle of cells, "apparently of hypoblastic origin," round the oil-globule, and says that by the time the young fish is ready to hatch, the covering of the oil-sphere is found to be more or less covered with pigment which seems to have been developed in the cellular mantle. This refers to the same processes in the history of the oil-globule as I have described in the mackerel, but the mantle round the globule is certainly not made of hypoblastic cells, but of the periblastic syncytium, from which the pigment-cells are developed. The development in *Cybium* is extremely rapid, hatching taking place about twenty-four after fertilization; the temperature of the water in which the eggs were kept artificially, or of the sea in which they are shed naturally, is not stated by Ryder. The mouth was formed about twenty-four hours after hatching, by which time the yolk was almost entirely absorbed. Some of the larvæ were kept alive till the sixth day after hatching.

#### BLENNIUS OCELLARIS.

On July 10th I received at the Laboratory a large hollow bone, probably the femur of an ox, affixed to the sides of the cavity of which was a single layer of adhesive ova of an orange-red colour; this was forwarded by Mr. Dunn, of Mevagissey, who had obtained it from some fishermen. It was brought up by a long line fifteen miles south of Deadman Point, Cornwall, having been caught by one of the hooks. In the letter sent at the time Mr. Dunu stated that the fishermen said that when the bone was taken there was a fish in the cavity of the bone, supposed to be guarding the eggs, but that the fish had escaped and fallen overboard. The next day, however, Mr. Dunn forwarded a fish which he said was the one that had been seen in the cavity of the bone, the fishermen having found it at the bottom of their boat and recognised it as the same. This fish was a specimen of *Blennius ocellaris*, L., and in all probability the ova belonged to it.



The character of the ovum is shown in Fig. 25. Its diameter, measured in a direction parallel to the surface of attachment, is 1.2 mm. The embryo was distinctly formed and somewhat advanced in development, the heart having begun to beat; but this organ lying on the surface of the yolk anterior to the embryo is not shown in the figure. The yolk is of an orange-red colour and made up of separate minute yolk-spherules; it also contains near the tail of the embryo a number of oil-globules of different sizes. The tissues of the embryo were very transparent. The chromatophores are limited in number, intensely black in colour, and confined to the dorsal portion of the yolk-sac near the tail of the embryo.

*Blennius galerita*, and *Blennius pholis* are stated by Day to have adhesive ova, the former depositing them on stones, the latter in holes in rocks, on the authority of Couch (Zoologist, 1846). *Centronotus gunnellus* has adhesive ova which adhere together and form a free round mass. *Zoarces viviparus* hatches its ova in its ovary and produces about fifty young at a time all alive and similar to the parent except in size (see my paper in Trans. Roy. Soc. Edin., 1886). Shore fishes, like fresh-water, fishes have usually adhesive ova, or in some cases heavy ova which sink to the bottom. Such ova usually have oil-globules, either a single one or several, and the yolk is always made up of minute yolk-spherules.

#### CALLIONYMUS LYRA (the Dragonet).

I have already referred to the ova of this species in connection with my observations on *Solea vulgaris*, and have stated that I identified the ova taken by the tow-net shown in figs. 26 and 27 as the ova of *Callionymus lyra*. I also mentioned that Raffaele denies altogether the existence of the hexagonal marking of the vitelline membrane in the Mediterranean species *C. festivus*. On the other hand, Raffaele found an exactly similar reticular marking of hexagonal meshes on the vitelline membrane of the fertilized ova of *Uranoscopus scaber*, and in the ovarian ova of *Saurus lacerta*. It is certainly somewhat inconsistent on the part of the Italian zoologist that he should assume that McIntosh mistook an epithelium for a marking of the vitelline membrane in *C. lyra*, and should affirm the existence of the marking in *Saurus* on evidence exactly equivalent to that on which McIntosh relied. *Saurus* is a genus of the Scopelidæ, which family belongs to the order Physostomi.

Leaving the question of *Saurus lacerta* entirely aside for the present, the similarity between the ova of *C. lyra* and *Uranoscopus*

suggests some interesting possibilities with regard to the true systematic affinities of these two genera. *Callionymus* belongs to a group, *Callionymina*, which is classed by systematists in the family *Gobiidæ*, but which certainly forms an aberrant group of that family. *Callionymus* is extremely different from any of the typical *Gobiidæ*; it has a depressed form, no ventral sucker, has the eyes close together at the top of the head, in accordance with its habit of lying always on the sea-bottom on its flat ventral surface, and has a multiradiate spine resembling a riding spur directed backwards from its preoperculum. *Uranoscopus* similarly belongs to an aberrant group of the *Trachinidæ*, to which our common weevers, *Trachinus draco* and *vipera*, belong. All the *Trachinidæ* with few exceptions have a backward-pointing spine on the operculum. *Uranoscopus* possesses this spine, but whereas most *Trachinidæ* are compressed from side to side, *Uranoscopus*, as its name implies, is depressed from above downwards and has the two eyes directed upwards and placed on the upper flat surface of the head. The families *Trachinidæ* and *Gobiidæ* are widely separated by Günther, the former being placed among the *Gobiiformes*, the latter among the *Cotto-scombriformes*. Yet considering that the eggs have a rare peculiarity in common, and that there are several similarities of adult structure, it seems probable that *Callionymus* and *Uranoscopus* are closely allied, and that either the *Callionymina* ought to be included among the *Trachinidæ* instead of among the *Gobiidæ*, or that the *Callionymina* and *Uranoscopina* together form a single family, distinct both from the *Gobies* and the *Weevers*.

In support of this suggestion it is to be noted that the ova of typical *Gobiidæ* are adhesive, not pelagic like those of *Callionymus*, and that, although the ova of both *Uranoscopus* and *Trachinus* are pelagic, those of the former have the reticulate marking and no oil-globules, those of *Trachinus* have no marking and numerous oil-globules. The ova of *Trachinus* have been described and figured by George Brook in *Lin. Soc. Journ.*, vol. xviii, 1884, and also by Raffaele in the paper so often cited.

#### CLUPEA PILCHARDUS (the Pilchard) AND CLUPEA SPRATTUS (the Sprat).

The ovum of the pilchard has never yet been obtained directly from the parent fish and artificially fertilized, and therefore the absolutely certain knowledge based on the examination of ova so obtained is still wanting. But it will be shown in the following that a definitely characterised ovum is known, which I have traced



with all reasonable certainty to this species. The history of our knowledge on this subject is of much interest, and is an excellent example of the difficulty which may unexpectedly occur in the attempt to solve an apparently simple problem.

The question of the ova of the pilchard is closely connected with that of floating Clupeoid ova in general, and I will therefore give a brief summary of the history of this larger question. Some years ago the only species of Clupea whose eggs were known with certainty was the herring, *Clupea harengus*. The eggs of the herring are heavy and adhesive, and when expelled from the body of the fish they stick fast to anything they happen to fall upon. A detailed account of their structure and development was published by Prof. Kupffer in 1878 in the Jahresbericht der Commission zur Untersuchung der deutschen Meere for 1874-76. But before that herring spawn had been dredged from the sea-bottom near the Isle of May in the Firth of Forth. I myself studied the ova in the years 1883 and 1884, and published a paper on them in 1885.\* In 1882 Alexander Agassiz described† a pelagic ovum (*i.e.* a floating one) which had a yolk entirely divided into small segments, and which produced a larva 5 mm. long, having a great resemblance to a larval herring. Agassiz at first thought these eggs must belong to some Clupeoid, but afterwards identified the larva as the young of *Osmerus mordax*, Gill. But the American *Osmerus mordax* is the same as the British *Osmerus eperlanus*, and this species was discovered by myself‡ to have adhesive ova with a peculiar method of adhesion, and to spawn in almost fresh water in the upper parts of estuaries. V. Hensen§ in 1883 described a similar ovum, which he took in the tow-net in the Baltic near Kiel. This ovum, like that of Agassiz, had a segmented yolk and no oil-globules; its diameter was 1.24 mm., and the larva which hatched from it resembled a herring larva and had a length of 3.7 mm. In 1886|| I described a very similar ovum taken by the tow-net in the Firth of Forth; this likewise had a segmented yolk, and produced a herring-like larva. The dimensions of the ovum were .94 by .97 mm. diameter, and the larva was 3.63 mm. long. I concluded that this ovum came from the same species as Hensen's. The latter informed me by letter that he believed the ovum to belong to the sprat, *Clupea sprattus*, but I did not succeed in obtaining fertilized ova of the sprat for

\* *On the Significance of Kupffer's Vesicle, &c.*, Quart. Journ. Micr. Sci., 1885.

† *Young Stages of Osseous Fishes*, part iii, Proc. Amer. Acad. Arts and Sci., vol. xvii.

‡ Proc. Zool. Soc. Lond., 1886.

§ Vierter Bericht der Comm. Unters. deutschen Meere, II Abtheilung, Berlin, 1883.

|| Trans. Roy. Soc. Edinb. for Session 1885-86.

comparison. Lately, in 1887,\* Hensen has stated that he obtained ova taken from the sprat and artificially fertilized, and found they agreed in all respects, both in size and structure, with the ova he got in the tow-net. There can be little doubt that my ova from the Firth of Forth were of the same species as Hensen's; my measurement of the ovum was somewhat smaller than his, but the length of the larva was almost exactly the same in the two cases. And it is also pretty certain that Agassiz' ovum found off the American coast belonged to some species of *Clupea*.

With regard to *Clupea pilchardus*, Couch long ago in 1865, in his *Fishes of the British Islands*, stated that the pilchard spawned at the surface of the sea. His account is as follows: "In April and May they are habitually prepared to shed their spawn, which they now do at a further distance from land and over deeper water than is the case at the warmer season of autumn, when again, early or later, they perform the same function, although we do not feel assured that they are the same fishes which thus perform the duty of procreation on both occasions." "I have reason to suppose that the spawn is shed at the surface, and mingled with it a large quantity of tenacious mucus in which it is kept floating while it is obtaining the vivifying influence of the light and warmth of the sun. My notes on this subject are that presently, after spawning, a sheet of jelly, enclosing myriads of enlarging grains of spawn, has been seen to extend several miles in length, and a mile or more in breadth over the surface of the sea." We shall see how far Couch was from a knowledge of the real spawn of the pilchard.

In a Report by Frank Buckland and Spencer Walpole, Commissioners for Sea-Fisheries, on the sea-fisheries of England and Wales, presented to Parliament and officially published in 1879, evidence concerning the spawning of the pilchard, given by Mr. Dunn, of Mevagissey, is recorded. In Appendix No. III to that Report, by Frank Buckland, the following quotation is given from a letter from Mr. Dunn: "On the 28th of May, 1871, I took a pilchard alive, and in the act of spawning, about twenty miles from land. With the help of my hands the fish deposited the remaining spawn into a bucket of sea-water. Immediately the spawn rose to the surface of the water with the buoyancy of cork, and instantly the eggs separated from each other. By the candle-light the globules appeared bright and almost transparent. After a few minutes they lost their buoyancy save just dipping under the surface, others floating an inch or two further down. In this state they continued for two hours, then a white speck showed itself in each globule,

\* Fünfter Bericht der Comm. Unters. deutschen Meere, Berlin, 1887.

and all sank to the bottom of the vessel." The eggs in this experiment were unfertilized, no milt was added to them.

In Day's work, *Fishes of Great Britain and Ireland, 1880-1884*, it is stated that Mr. Dunn observed that the pilchard appears to breed at two seasons of the year, May and June, and also in December, and the young are first seen in September, three or four inches in length. On January 16th, 1882, Mr. Dunn observed the fish returning to the bays shotten.

On the 15th October, 1887, in reply to inquiries of mine, I received a courteous letter from Mr. Dunn, in which he said he was certain that some pilchards spawn late in December and early in January, and even up to March, the winter spawning extending thus over some months. He said that in summer some pilchards spawn in May, the majority in June, and others in August. He also said that in some seasons spawn, which he believed to come from the pilchard, was seen floating in immense tracts on the surface of the sea.

This continuous sheet of spawn mentioned by both Couch and Mr. Dunn, can only be the spawn of *Lophius piscatorius*, the angler or devil-fish, whose spawn is known to be contained in an extended sheet of gelatinous material. It is fully described by Agassiz and Whitman in their memoir already cited, on the Pelagic Stages of Osseous Fishes. I have not myself met with this spawn of *Lophius* off the coast of Devon and Cornwall, but as the angler is common enough in the neighbourhood, I have no doubt that it has been seen by fishermen and erroneously identified by Couch and Mr. Dunn as the spawn of the pilchard.

Meanwhile, before any naturalist had identified ova of the pilchard the eggs of another species of the family Clupeidæ, namely, the anchovy, *Engraulis encrasicolus*, were examined and found to be pelagic. This discovery was made by K. F. Wenckebach, of Amsterdam,\* and published only in 1887. I have not seen the original paper, but the Italian zoologist Raffaele gives a description, with figures, of the ova of the anchovy and the young stages of the fish, from studies he was able to make upon them at the Zoological Station at Naples. Fortunately, there is no danger of confounding the eggs of the anchovy with those of the pilchard or sprat. The egg of the anchovy, like the others, has the yolk divided into segments, but instead of being spherical like the others it is much elongated, so as to have the shape of a sausage.

Raffaele gives a description and figures of two other kinds of floating eggs, which, having a segmented yolk, are recognised by him as belonging to species of the herring family; he obtained these

\* *De embryonale ontwikkeling van de Ansjovis (Engraulis encrasicolus)*, Verh. Akad. Amsterdam, Deel 26, 1887.

from the open sea by means of the tow-net, and has not taken directly from the fish, eggs that could be identified with them. He therefore speaks of them as *Clupea* species A, and *Clupea* species B. The first of these he believes to be the ovum of the pilchard. It is well known that the pilchard and the sardine are the same fish at different sizes, and sardines are common enough in the Gulf of Naples. This species, A, is an ovum of spherical shape varying from 1.50 to 1.70 mm. in diameter. Compared with the majority of floating ova, it has this peculiarity, that the space between the egg proper and its envelope is exceedingly large; the egg itself inside this space has a diameter of only .80 to .90 mm. In the yolk is a single oil-globule .16 mm. in diameter. The segments of the yolk have a polygonal form due to their mutual pressure. The egg hatched in four or five days at a temperature of 9° to 12° C., and the larva resembled that of other pelagic Clupeoid ova, *e. g.* the sprat, but its length is not given.

The ovum of species B differs very slightly from that of species A. It is a little smaller in the diameter of the egg envelope, which is 1.20 to 1.40 mm. It has, like the other, a segmented yolk containing a single oil-globule which is .121 mm. in diameter, slightly smaller than in the previous case. The oil-globule has a slightly yellow colour, the yolk and embryo have a faint smoky tint, which colours are absent in species A. The only other difference is that in the newly-hatched larva of species B the oil-globule is in the centre of the lower margin of the yolk, in species A it is at the posterior end of the yolk. Species A was found in the winter, Species B in summer and autumn.

*My own Inquiries.*—From the beginning of September, 1887, I examined at Plymouth the pilchards landed by drift-net boats from time to time, but never found any generative organs which were quite ripe or very nearly ripe from that time till the following summer. In October, 1887, the ovaries and spermaries seemed to be about half developed in a few specimens, and it is possible, even probable, as will be seen, that some individuals spawn late in the autumn. I found no change in the condition of the fish up till the end of January: the fish were usually 7½ to 8½ inches in length. In the early part of 1888 I was too much occupied with other fish to pay a great deal of attention to pilchards, but there was no regular fishing for them going on, and scarcely any were caught. I was told by a pilchard fisherman that these fish were found in spawning condition in April and May, but he did not think at any other time of the year. Afterwards I was told by mackerel fishermen that they often in summer got large pilchards which were meshed along with mackerel in their mackerel drift-



nets, and that these were always soft and ripe, with spawn and milt running out of them. I found by actual experience that this was perfectly true. On June 2nd, 1888, two pilchards were brought up to me from a boat which had caught them in mackerel nets five miles south-west of the Eddystone. These were perfectly ripe, the whole ovary, as in the herring, containing nothing but ripe eggs which escaped on the slightest pressure. These eggs were, of course, dead, and as these were the only two pilchards taken it was impossible to fertilize any of them at the time of capture. But the eggs were fresh enough to show in some degree their structure, and I made a drawing of one which is shown in fig. 28. This shows that there is but a single oil-globule, and that the yolk is made up of spherical vesicles. The diameter measures  $\cdot98$  mm., that of the oil-globule  $\cdot16$  mm. Of course the envelope in the ovarian egg is everywhere in contact with the yolk. Several times in June and July one or two pilchards were taken by mackerel fishermen who were endeavouring to get fertilized pilchard spawn for me, but they never succeeded in getting ripe males and ripe females at the same time. Sometimes they got a single ripe male, at others two or three ripe females. One boat shot at my request two pilchard nets, which have a smaller mesh, with its fleet of mackerel nets, but even this did not succeed. One of these occasional ripe specimens, a female, was caught as late as October 17th, and the skipper who took it pressed the ripe ova into a bottle of clean sea-water, and gave them to me the next day when he returned to port. But when I got them the ova were already dead and lying at the bottom of the jar, and on examination I found that the yolk was decomposed. I could form no conclusions from these as to the normal extent of the perivitelline space.

In 1887 I had taken pelagic ova in the tow-net, which, from the probability of the ovum with segmented yolk taken in the Firth of Forth being that of *Clupea sprattus*, I guessed were those of the pilchard. The structure of these ova is shown in fig. 29. I took some in Whitsand Bay, August 11th, and did not meet with them again till November 9th, when I found a few in a tow-net worked from a trawler to the south-east of the Eddystone. On both occasions there were only five or six specimens of this particular ovum. Its diameter measured in one case  $1\cdot72$  mm., in another  $1\cdot65$ , including the envelope. The space between the latter and the yolk was extremely large, and the yolk itself measured  $\cdot85$  mm. in diameter in the first case,  $\cdot95$  mm. in the second. The yolk was composed of polygonal segments divided by curved surfaces, and contained a single oil-globule  $\cdot16$  mm. in diameter. This ovum, therefore, agrees in every respect both of size and structure with



Raffaele's *Clupea* species A. Of those taken on November 9th I was successful in hatching some, and the appearance of the larva produced is shown in fig. 30. This larva was 3·8 mm. in length, and the oil-globule was at the posterior and lower side of the yolk, thus also agreeing with the larva of Raffaele's species A. There can be no doubt that these ova of mine and those described by Raffaele as species A belong to the same species of fish, and the character of the unfertilized ovum taken directly from the pilchard, having a diameter corresponding to that of the yolk in the tow-net specimens, and an oil-globule of exactly the same size as that in the latter, is sufficient evidence that these ova from the tow-net are the ova of *Clupea pilchardus*. Fig. 30, then, shows the structure of the larva of the pilchard. Like that of the herring and sprat it has a unicolumnar notochord, that is, a notochord with a single linear series of cubical vacuoles. At the time of hatching, pigment, as in the herring, is altogether absent, even in the choroid of the eyes. The intestine extends far behind the yolk, and the anus is near the end of the tail. A comparison of figs. 28 and 29 shows that the ovarian ovum of the pilchard is more closely similar to the fertilized ovum of the herring than the pilchard ovum in its pelagic state after fertilization; in the ovarian ovum the yolk elements or segments are still spherical vesicles as in the herring, while in the fertilized ovum these segments have come into close contact with one another, and so become more polygonal.

These observations show, as was previously stated by Mr. Dunn, that pilchards spawn far out at sea, and that the pilchard fishery consists exclusively in the capture of fish which are not spawning, of fish in which the generative organs are not even approaching the ripe condition. The shoals of pilchards which are caught in drift-nets not far from shore in autumn, winter, and spring, approach the coast to feed and not to spawn; they are either shotten fish or young fish which have never spawned. It is otherwise with the mackerel and the herring; mackerel are, as I have shown in this paper, caught as abundantly during their spawning period as at any other time, while the winter fishery for herrings near Plymouth and all the other great herring fisheries that I know of consist chiefly in the capture of spawning shoals, although there are productive fisheries of immature herring which remain some time in shore waters for the purpose of feeding.

My evidence, as far as it goes, does not favour the theory that there are two separate periods in the year at which pilchards spawn; it shows that ripe specimens occur to the south of the Eddystone occasionally from the beginning of June to the middle of October, and as it is reasonable to suppose that the pilchard, like

the herring, spawns in shoals, we must conclude that these shoals of ripe fish are to be sought at greater distances from shore than the region a few miles south of the Eddystone where the isolated individuals were taken. This conclusion is supported by the paucity of the pilchard ova taken in the tow-net, and it does not permit very sanguine hopes of the practicability of artificially propagating the pilchard on a large scale. But it must be mentioned that, according to the positive statements of the mackerel fishermen, the number of spawning pilchards taken in their nets was extraordinarily small last season; that it is not unusual for fifty or more ripe specimens to be taken among a single catch of mackerel.

Another kind of buoyant Clupeoid ovum occurs near Plymouth. This is shown in fig. 31. It is 1.01 or 1.02 mm. in diameter, and has the small perivitelline space characteristic of the majority of pelagic ova. The yolk has the same segmented structure as that of the pilchard ovum but has no oil-globule. At the stage shown in fig. 31 black chromatophores were conspicuous near the dorsal median line of the embryo. The larva hatched from one of these ova is shown in fig. 32. Its length was 3.07 mm., which is less than that of the pilchard larva and less than that of the larva previously described by Hensen and myself. But as the length of a hatched larva probably varies, I think that in all probability this ovum and larva belong to *Clupea sprattus*, the sprat, which regularly occurs in Plymouth Sound in winter. This kind of ovum was taken in small numbers just outside the Sound, to the east of Penlee Point, on January 28th and 30th, 1888.

#### PELAGIC OVA TAKEN IN THE TOW-NET.

Some of these, identified as those of the pilchard, sprat, sole, and dragonet, have already been described, but besides these many other kinds were obtained which could be identified with more or less certainty from the descriptions and figures already published by myself and others of artificially fertilized ova taken directly from the parent fish. Some ova taken near the Rame Head on February 6th, 1888, measuring 1.36 in one diameter, 1.44 in another, and having an entirely homogeneous yolk, were probably the ova of *Pleuronectes microcephalus*, of which some specimens probably begin to spawn in February.

#### PLEURONECTES PLATessa (the Plaice).

An ovum of Pleuronectid type of very large size, obtained January 21st, 1888, eight miles south of the Mewstone, probably

came from this species. It measured 2·13 mm. in diameter, had a number of dendritic black chromatophores on the body of the embryo; the tail was fully developed and the larva almost ready to hatch. The ovum of the plaice was described in my paper in the *Trans. Roy. Soc. Edin.*, vol. xxxiii, part 1; the measurement I there gave was 1·95 mm., but 2·13 mm. is not beyond the limit of individual variation.

#### GADUS MERLANGUS (the Whiting).

Ova obtained February 6th, 1888, off the Rame Head at the entrance to Plymouth Sound. Their size was 1·23 mm. in diameter, they had a homogeneous yolk without oil-globules. I gave a description of the ova of this species in 1885\* from artificially fertilized ova, and stated their diameter as 1·25 mm. I did not figure the hatched larva in that paper, and therefore now give figures of one stage of the ovum, and of the larva which hatched from one of these tow-net specimens. The larva is 3·67 mm. long, and the dendritic chromatophores are confined to the body of the fish absent from the median primordial fin, and from the surface of the yolk. The rectum, as in all species of *Gadus*, does not extend to the edge of the ventral part of the median fin, but ends blindly close to the body. Figs. 33, 34.

I found the whiting perfectly ripe at Mount's Bay on March 7th, although I did not take any artificially fertilized ova, and there is no doubt that off Plymouth the species spawns also in February.

#### GADUS LUSCUS (the Pouting).

Another ovum similar to the previous, but measuring 1·13 mm. in diameter, was obtained eight miles south of the Mewstone on January 20th. From it a larva hatched on January 23rd, which obviously belonged to a species of *Gadus*, having similar characters to the one assigned to the whiting. It is represented in fig. 35. Its length was 2·97 mm. I have identified it provisionally as the larva of *Gadus luscus*, the eggs of which species I have never taken directly from the fish.

#### MOTELLA, SP. ? (the Rocklings).

The ova and larvæ shown in figs. 36, 37 I find it difficult to identify, but they probably belong to the genus *Motella*. The blind rectum,

\* *Relations of Yolk to Gastrula in Teleosteans*, *Quart. Journ. of Micr. Sci.*, 1885.

terminating before reaching the edge of the primordial fin, shows that the larva is one of the cod family. The hake, *Merluccius vulgaris*, has been found to have a single oil-globule, but the present ovum has a diameter of  $\cdot 78$  mm., that of the hake is larger,  $\cdot 94$  to  $1\cdot 03$  mm. *Motella tricirrata* has, according to Raffaele, an ovum measuring  $\cdot 74$  mm., while the ovum of *Motella mustela*, according to George Brook (Journ. Linn. Soc., 1884), measures  $\cdot 65$  to  $\cdot 73$  mm. Another feature characteristic of *Motella* and present in the ovum under consideration is the presence in the earliest stage of several oil-globules which afterwards fuse into one. This ovum was obtained in considerable numbers to the east of Penlee Point on January 28th and 30th, 1888. Some of those taken on the latter date hatched on February 2nd. The length of the larva was  $1\cdot 98$  mm., and it had black pigment only which was confined to the body of the fish, and absent from the fin and the yolk-sac. It is not unlikely that these ova really are those of *Motella tricirrata*; the difference between their size and that given by Raffaele is very slight. On May 31st I obtained in the tow-net two specimens of a young fish  $17$  mm. long, which agrees with descriptions given of the young *Motella tricirrata*. The chief characteristic of this young fish (fig. 39) is the great length of the ventral fins which extend back to the anus, and the intense black colour of their terminal third. Another curious point is that the caudal fin, although it has apparently attained its final form, is almost completely homocercal, being supported by fin rays which have a symmetrical relation to about eight terminal vertebræ. The sides of these little fish had a very bright silvery glitter. There was a small barbel on the symphysis of the lower jaw. This young fish is identical with that described by Couch (vol. iii, p. 113) as Thompson's Midge, which together with the *Couchia argentata* of Günther (Catalogue, vol. iv, p. 363), is identified by Day as the young of the three-bearded rockling *Motella tricirrata*. Agassiz (Young Stages of Osseous Fishes, pt. 3) describes stages of a young fish very similar to the one I have described, and identifies it as *Motella argentea*, Rhein., but I do not know if this species is the same as *Motella tricirrata*. The young of *Motella mustela*, the five-bearded rockling, is known as the mackerel midge, which has already five barbels, but its younger stages may well be indistinguishable from those of *Motella tricirrata*. These young *Motella* are said to form the principal food of the mackerel in May, but I have not verified this at Plymouth.

I found one specimen of hake perfectly ripe on July 6th, so that this species spawns at Plymouth in summer; Raffaele found it spawning at Naples in May.

I have taken other kinds of ova in the tow-net, but have not been



able to identify them with any certainty. The ova most difficult to identify are those which have a homogeneous yolk with a single oil-globule, because there are so very many species which have ova of this character differing only, in the early stages, in size, and sometimes not even in that respect. Further and more minute study of the larvæ will probably enable us to distinguish the species to which they belong, but before hatching this is almost impossible. It has been seen already in this paper that this type of ovum is common to the families Scombridæ (mackerel), Carangidæ (cuckoo), many Gadidæ (hake, rockling), many Pleuronectidæ (Arnoglossus, Rhombus). And Raffaele describes ova of the same kind from the bass, *Labrax lupus* (Percidæ), and from some of the sea-brems *Pagellus erythrinus*, &c. (Sparidæ); some of the wrasses (Labridæ), namely, *Coris* and *Julis*, have also similar ova.

It is evident that a great deal still remains to be done before an adequate knowledge of the development and growth of the Plymouth fishes is obtained. But the researches I have described in this paper have been, and future work will be, greatly facilitated by Raffaele's admirable memoir so often quoted in the preceding pages. The extent to which the Italian naturalist's results apply to the fish-fauna of Plymouth, shows how closely connected fauna-logically are the south coast of Britain and the Mediterranean.

#### A HYPOTHESIS CONCERNING OIL-GLOBULES IN PELAGIC TELEOSTEAN OVA.

In considering the question why some pelagic ova have separate oil-globules in their yolk while others have none at all, I have noticed a connection between the presence of these separate masses of fatty matter and the normal quantity of oil in the body of the parent fish. Whenever the adult has a large quantity of oil in its tissues the ova possess one or more oil-globules in the yolk. At least this seems obvious in some cases. In both the herring and the pilchard the yolk is completely vesicular; this is a character common to all species of the genus *Clupea*; but the pilchard ovum has a large oil-globule, the herring ovum has none; and it is certain that the adult pilchard possesses more oil in its tissues than the herring. The mackerel also is a rich oily fish, and its ovum has an oil-globule, while the species of *Pleuronectes* and *Gadus* have comparatively dry flesh, and their ova have no oil-globules. The sole is richer in oil than the plaice, and the former has oil-globules while the latter is destitute of them.

There are two ways of regarding this fact if it be one. We may suppose that the excess of oil runs over as it were into the ova,



without having any great importance to the latter ; or we may suppose that as the tissues of the adult are oily, it is necessary that the tissues of the embryo should be supplied with abundance of oil in order to develop normally. But perhaps the truth lies in the union of these two suppositions, that the excess of oil in the tissues of the parents extends into the ovum, and during the development of the latter supplies the embryo with an abundance of fat which is necessary to its constitution. But none of these hypotheses explain why in many cases ova provided with oil-globules have a greater specific gravity than those that are without them ; a difference which must depend on a greater density of the protoplasm and of the yolk.

#### THE DEVELOPMENT OF THE VASCULAR SYSTEM AND CÆLOM IN PELAGIC OVA OF TELEOSTEI.

In a great many pelagic Teleostean embryos at the time of hatching the heart consists of a tube which opens posteriorly out of a wide space between the yolk, or more accurately between the surface of the periblast and the wall of the yolk-sac, which wall consists solely of a layer of epiblastic cells. The heart itself is surrounded by another cavity which is separated from the space first mentioned by a thin membrane, which passes on the one hand into the lips of the posterior aperture of the heart, and on the other into the body wall ventrally, into the tissue beneath the pharynx dorsally. The space out of which the heart opens contains blood, *i. e.* a colourless fluid containing at first colourless corpuscles, which at a later stage become red corpuscles. The blood is carried by the pulsations of the heart out of the space round the yolk into the cavity of the heart.

The cavity round the periblast, which communicates with the heart, exists at an earlier stage, before hatching, as a space between the epiblast of the anterior part of the yolk-sac and the periblast. And this is the same space which exists at a still earlier stage before the yolk has been enveloped by the blastoderm, between the epiblast and the periblast in the central part of the blastoderm, that is, over all the region of the latter which is not occupied by the embryonic rudiment and the embryonic ring. This space, in fact, is the earliest to appear in the ovum, and is nothing more or less than the segmentation cavity.

To consider now the space which surrounds the heart, and which is entirely separated from the space which communicates with the heart. This cavity round the heart is simply a portion of the true body-cavity or cœlom. The heart with this cavity develops shortly

before hatching out of a solid mass of mesoblast cells situated below the pharynx, and continuous on either side with the lateral mesoblastic plates which lie on either side of the notochord. I have not studied the histological process by which the heart itself is formed. Suffice it to say that it is produced by the formation of the central mesoblastic cells into a tube, which, as soon as it has a lumen, communicates with the space between the ventral epiblastic body wall and the periblast. The cavity in which the tubular heart is contained is due to a splitting of the mesoblast, and is continuous superiorly and posteriorly with the cavity formed on each side of the embryo by the splitting of the lateral mesoblastic plates. The cavity containing the heart is in reality the first part of the ventral region of the body-cavity to be formed. A section farther back, through the centre of the yolk-sac at the stage immediately after hatching, shows a cavity on each side of the embryo in the mesoblastic plates; the splanchnic mesoblast forms the roof of the cavity between the periblast and the wall of the yolk-sac. The mesoblast only extends a little way from the embryo, so that laterally and ventrally the wall of the yolk-sac is formed solely of epiblast. The lateral body-cavities communicate anteriorly with the ventral body-cavity which contains the heart.

What then does the blood space between periblast and wall of yolk-sac correspond to in those Teleostean ova which possess a vitelline circulation? Obviously the vitelline veins and their tributaries communicate with the posterior end of the heart, just as does the single extensive blood space in pelagic ova. This blood space corresponds, and in a sense is homologous with the cavities of the vitelline veins. Suppose the vitelline veins and their capillaries to open out sufficiently so as to coalesce, and we have a single space extending over the surface of the yolk and communicating with the posterior end of the heart. This supposed continuous space would then correspond with the venous space in the pelagic ovum in a general way; but would it correspond exactly? The vitelline veins, where they exist, are canals running through a layer of splanchnic mesoblast covering the periblast. Now, in a pelagic ovum the mesoblast is, as far as we can judge from our present knowledge, limited to the embryo and the embryonic ring, and at a later stage to a narrow region at the sides of the embryo, which region is derived from the embryonic ring after the latter has disappeared as such. The space, therefore, over the rest of the yolk between the periblast and the epiblast, *i. e.* the segmentation cavity, can only close at these early stages by contact occurring between the epiblast and periblast. Now, such contact seems to occur at the stage immediately after the enclosing of the yolk has taken place, but it is certain that at a

slightly later stage the space is again open beneath the anterior end of the embryo, between the yolk and the epiblast forming the wall of the yolk-sac; and this space becomes the venous sinus out of which the heart opens. Thus it would seem that the venous sinus in the pelagic ovum, which corresponds to the vitelline veins in other ova, is bounded internally by the periblast, and externally by a layer of epiblast, and that it is a persistent segmentation cavity.

But if we look at the living newly-hatched larva of *Pl. microcephalus* (fig. 8) we see over the surface of the yolk black and yellow dendritic chromatophores. As these are continued over the anterior surface of the yolk-mass, and are not visible in the wall of the yolk-sac in front of the yolk, it follows that these chromatophores exist on the surface of the periblast and not on the inner surface of the epiblastic wall of the yolk-sac. Chromatophores are of course mesoblastic, and these in particular are, in all probability, developed *in situ* from the periblast, the nucleated protoplasm surrounding the yolk. It has been shown in various Vertebrate ova that the nucleated protoplasm of the yolk at early stages buds off cells which join the mesoblast. At this later stage in the Teleostean ovum the periblast forms mesoblastic pigment-cells, and also, as shown by Ryder and others, *blood-corpuscles*. But there is no evidence that there is any mesoblast on the internal surface of the wall of the yolk-sac; the venous sinus is bounded internally by periblast with a few chromatophores on its surface, externally by a layer of epiblast. It is obvious, on reflection, that all the yolk, with its periblast, after the formation of the definite hypoblast, is a part of the splanchnic mesoblast. But the interesting morphological peculiarity about the venous sinus in the Teleostean embryo is that it is the persistent segmentation cavity. The segmentation cavity may partially disappear by the contact of its walls, but it is not, as usually represented in the frog, obliterated by the growth of the mesoblast; and thus, when the sinus venosus appears it is not as a cavity or system of veins entirely surrounded by splanchnic mesoblast, but is the old segmentation cavity between the epiblastic ventral wall of the yolk-sac and the periblast. This periblast develops chromatophores on its surface, a process which is peculiarly well illustrated by the formation of pigment-cells round the oil-globule in the mackerel; and at a later stage, no doubt, the sinus venosus acquires mesoblastic walls all round it, but this is not till the yolk has been absorbed.

The opening of the posterior end of the heart into the cavity round the yolk looks very surprising at first sight, and as it is very conspicuous has attracted the attention of all who have studied the development of pelagic Teleostean ova. I have figured it myself in

my paper on Teleostean eggs and larvæ published in the Transactions of the Royal Society of Edinburgh. Ryder described it in the cod larva (Ann. Rep. Comm. of Fisheries of U.S. for 1882), but gave what was a very natural but erroneous interpretation of it. He called the space round the heart the pericardiac space, which is true if taken etymologically but not morphologically. The venous cavity he called the segmentation cavity, which is partially true, and stated it was the same as the body-cavity, which is erroneous.

Lastly, Mr. A. E. Shipley has described the development of the heart in *Petromyzon* (Quart. Journ. Micros. Sc., Jan., 1887). His description of the development of the heart from mesoblast beneath the pharynx agrees with what I have described in Teleostei. He also states that the heart communicates posteriorly with the space beneath the ventral yolk-cells and the epidermis, and that such a space would be equivalent to part of the segmentation cavity. Thus the condition of things in *Petromyzon* is similar in these respects to that in pelagic Teleostean ova. But when Mr. Shipley says, "From the fact mentioned above that the mesoblast behind the heart has not split into somatic and splanchnic layers nor united ventrally, it will be seen that the cavity of the heart communicates posteriorly with the space between the ventral yolk-cells and the epidermis," I do not follow him. It seems to me to be a *non sequitur*,—the heart might remain closed posteriorly until the ventral mesoblast had developed in the region behind it.

Moreover, although in *Petromyzon* it may be true that the mesoblast behind the heart has not split into somatic and splanchnic layers, my preparations show that the proposition is not true for Teleostean larvæ, for I find that the mesoblastic plates behind the heart have split so as to form a cœlom, and the splanchnic layer forms a horizontal partition dorsally between the cœlom on each side and the blood space surrounding the yolk. And although it may be true in *Petromyzon* that the yolk-cells form the immediate boundary of the venous sinus internally, it is also possible that some mesoblastic cells exist on the surface of the yolk in that form, for Mr. Shipley has drawn his conclusions from the study of sections, and I was not at first able to perceive in sections the dendritic chromatophores I have described in the larva of the pelagic Teleostean ovum. My observations concerning this subject have been chiefly but not exclusively made on the ova and larvæ of *Pleuronectes microcephalus*.



## DESCRIPTION OF PLATES I—VI,

Illustrating Mr. J. T. Cunningham's paper on the "Reproduction and Development of Teleostean Fishes occurring in the neighbourhood of Plymouth."

*Reference Letters.*

*au.* Auditory vesicle. *p.* Body-cavity. *e.* Eye. *ht.* Heart. *int.* Intestine. *k. v.* Kupffer's vesicle. *n.* Notochord. *s. v.* Sinus venosus. *o. g.* Oil-globules. *y. s.* Yolk-segments.

All the figures, except figs. 38 and 39, are drawn from living ova or larvæ, with the help of Zeiss's camera lucida, and, except where otherwise stated, with Zeiss's objective A and ocular 2. Sometimes the object was, when drawn, covered with a cover-glass, sometimes not, as specified in the description of each figure.

FIG. 1.—Ovum of *Capros aper*, fertilized August 15th, 1887, 6 p.m. Drawn August 16th, 10 a.m. (16 hours).

FIG. 2.—Same species, fertilized same time. Drawn August 17th, 1 p.m. (1 day 19 hours), without cover-glass.

FIG. 3.—Ovum of *Trigla gurnardus*, fertilized May 11th, 1888. Drawn May 13th, without cover-glass.

FIG. 4.—Ovum of *Trigla cuculus*, fertilized April 27th, 1 p.m. Drawn May 2nd, 4 p.m. (5 days 3 hours); cover-glass.

FIG. 5.—Same species, fertilized May 10th. Hatched and drawn May 19th (9 days). Zeiss  $a_3$ , oc. 2, camera, no cover-glass.

FIG. 6.—Ovum of *Pleuronectes microcephalus*, fertilized April 12th, 1 p.m. Drawn April 14th, 4.30 p.m. (2 days 3½ hours).

FIG. 7.—Same species, fertilized same time. Drawn April 17th, 6 p.m. (5 days 5 hours); cover-glass.

FIG. 8.—Same species, fertilized same time. Hatched and drawn April 19th (7 days). Zeiss  $a_3$ , oc. 2, camera, without cover-glass.

FIG. 9.—Same species, fertilized and hatched same dates. Drawn April 23rd (4 days after hatching), Zeiss  $a_3$ , oc. 2, camera, cover-glass.

FIG. 10.—Ovum of *Solea vulgaris*, living but unfertilized. Drawn March 8th, 5 p.m. cover-glass.

FIG. 11.—Same species, fertilized May 16th, 4 p.m. Drawn May 19th (3 days), without cover-glass.

FIG. 12.—Same species, taken in tow-net at surface outside the end of Plymouth Break-water, March 16th; cover-glass.

FIG. 13.—Same species, taken in tow-net on the east side of Plymouth Sound, April 18th; cover-glass.

FIG. 14.—Ovum of *Solea variegata*, pressed from the fish May 29th, unfertilized. Drawn after death, May 30th, without cover-glass.

FIG. 15.—Probably the same species, taken in tow-net south-east of Eddystone Light, July 17th; without cover-glass.

FIG. 16.—Ovum of *Scomber scomber*, fertilized May 24th, 3 a.m. Drawn same day, 10.30 a.m. (7½ hours; 13.5° C.), without cover-glass.

FIG. 17.—Same species, fertilized June 1st, 3 a.m. Drawn June 2nd, 11 a.m. (1 day 8 hours), without cover-glass.

FIG. 18.—Same species, fertilized May 26th, 2 a.m. Drawn May 27th, 5 p.m. (1 day 15 hours); no cover-glass.



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FIG. 19.—Same species, fertilized May 24th, 3 a.m. Drawn May 25th, 1.30 p.m. (1 day 10½ hours); no cover-glass.

FIG. 20.—Same species, fertilized May 26th, 2 a.m. Drawn May 28th, 11.30 a.m. (2 days 9¼ hours); no cover-glass.

FIG. 21.—Same species, fertilized same time as above. Drawn May 29th, 11 a.m. (3 days 9 hours), without cover-glass.

FIG. 22.—Same species, fertilized same time. Drawn May 29th, 5 p.m. (3 days 15 hours), with cover-glass.

FIG. 23.—Same species, fertilized same time. Drawn May 29th, 1.30 p.m., with cover-glass.

FIG. 24.—Same species, fertilized same time. Drawn May 30th, 5 p.m. (4 days 15 hours), with cover-glass.

FIG. 25.—Ovum of *Blennius ocellaris* adhering to ox-bone. Drawn in living condition, without cover-glass, July 10th, 1888.

FIG. 26.—Ovum taken in tow-net in Plymouth Sound, February 1st, 1888; no cover-glass. Optical section. Probably *Callionymus lyra*.

FIG. 27.—Same ovum, surface view, showing the marking of the vitelline membrane.

FIG. 28.—Ovum pressed from a ripe female pilchard when the fish was dead.

FIG. 29.—Ovum of the pilchard at an advanced stage of development, from tow-net August 11th, 1887.

FIG. 30.—Newly-hatched larva of same species, from an ovum taken in tow-net November 9th, 1887.

FIG. 31.—Ovum of the sprat, taken in tow-net January 28th, 1888.

FIG. 32.—Newly-hatched larva of same species, from an ovum taken in tow-net January 30th, 1888.

FIG. 33.—Ovum taken in tow-net February 6th, 1888. Drawn February 9th, 1888. Zeiss a<sub>3</sub>, oc. 3, camera; no cover-glass. Identified as *Gadus merlangus*.

FIG. 34.—Larva hatched from same kind of ovum on February 8th. Zeiss a<sub>3</sub>, oc. 3, camera; no cover-glass.

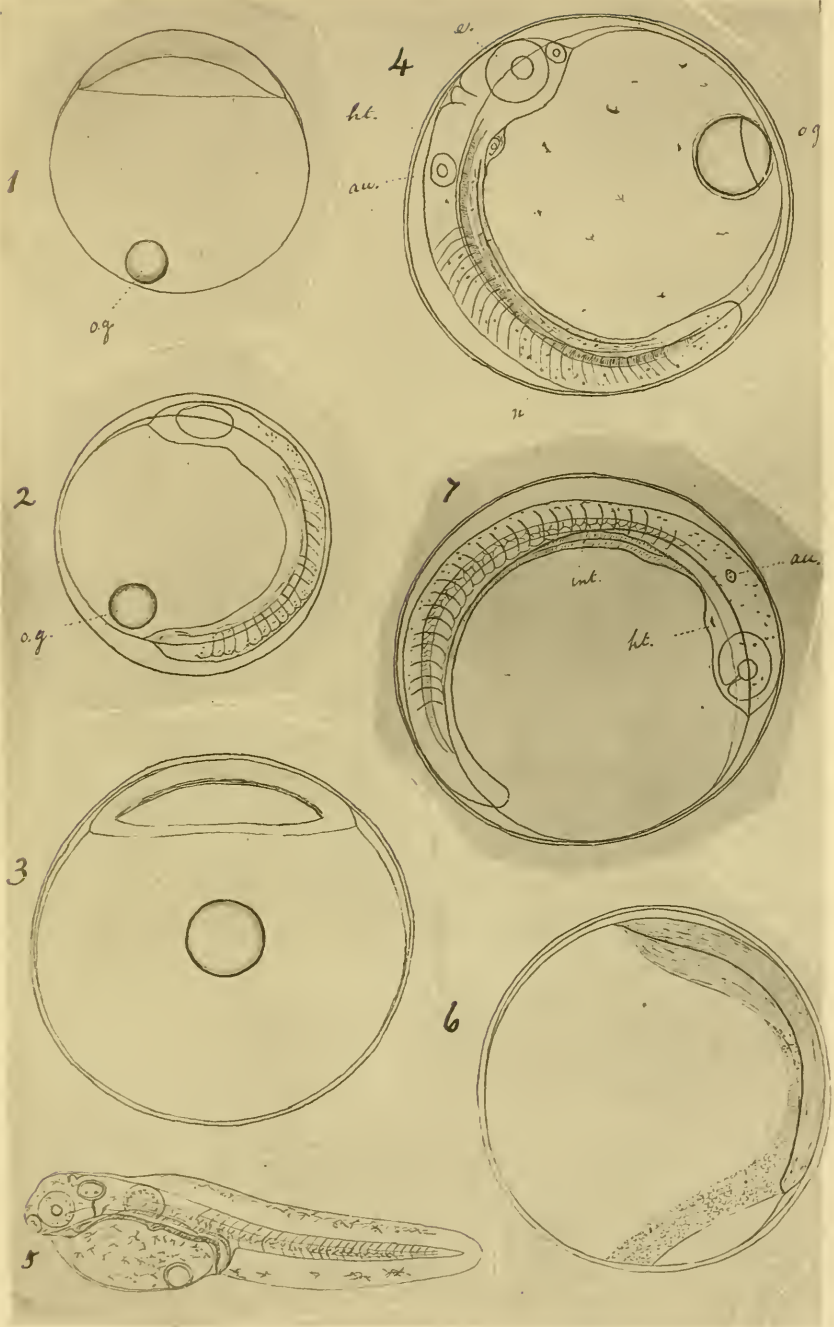
FIG. 35.—Gadoid larva hatched from ovum, taken in tow-net January 20th. Probably *Gadus luscus*.

FIG. 36.—Ovum taken in tow-net January 28th; 8-cell stage.

FIG. 37.—Larva hatched from ovum of same species, collected January 30th. Hatched and drawn, February 2nd, without cover-glass.

FIG. 38.—Young *Motella*, 17 mm. long, from tow-net, May 31st. Drawn without the microscope.

FIG. 39.—Outline sketch of *Arnoglossus laterna*. Natural size. February 9th.

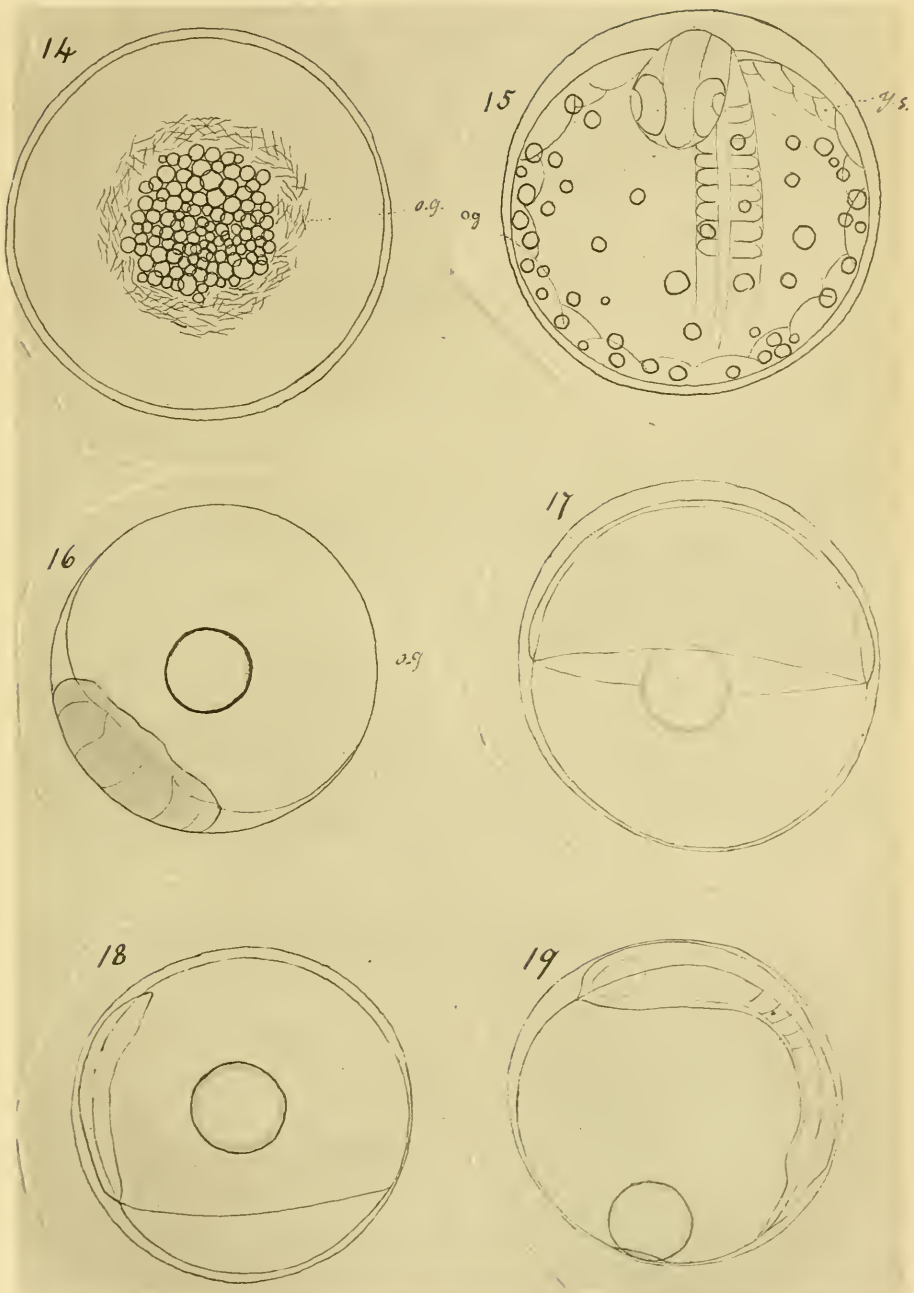




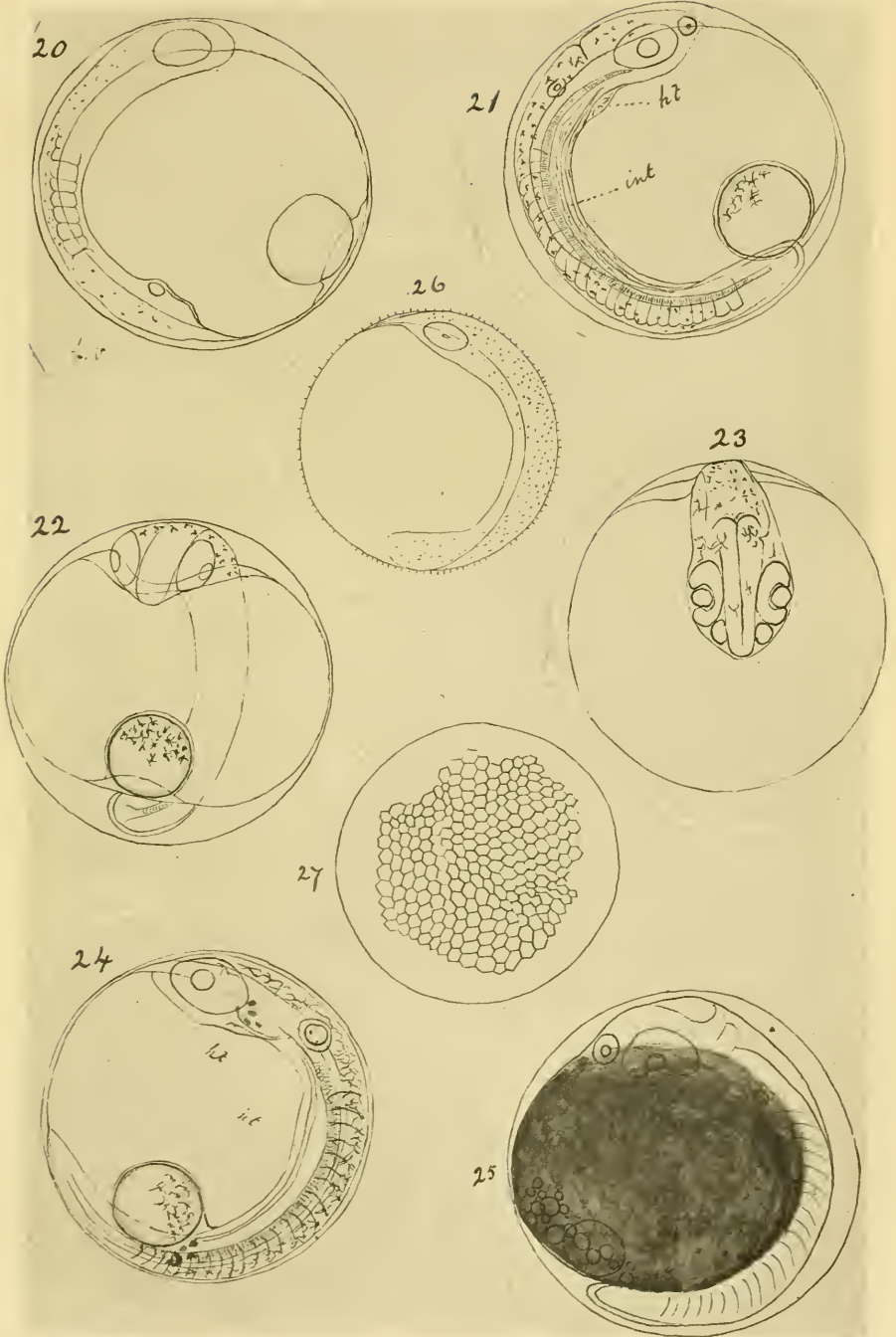






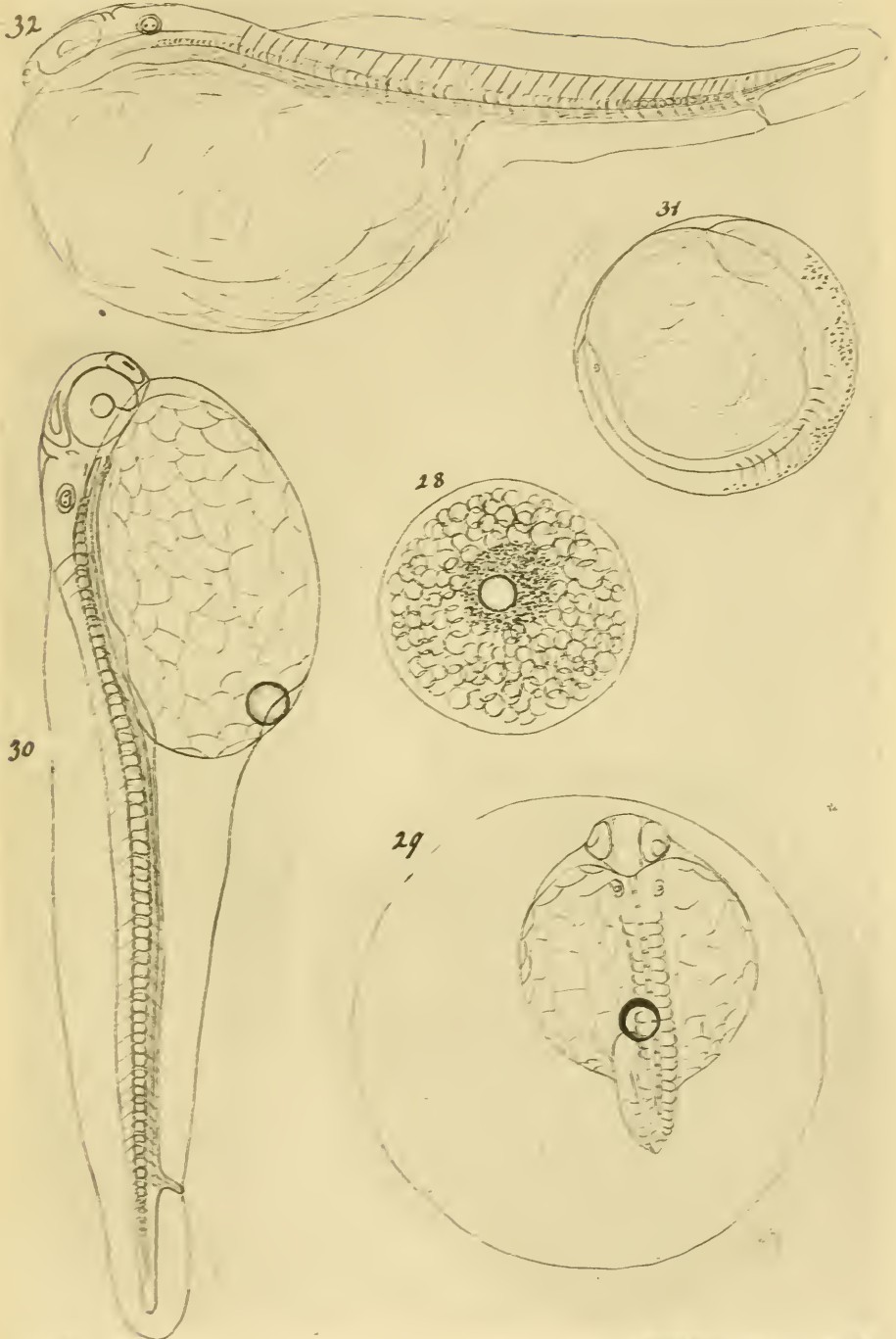




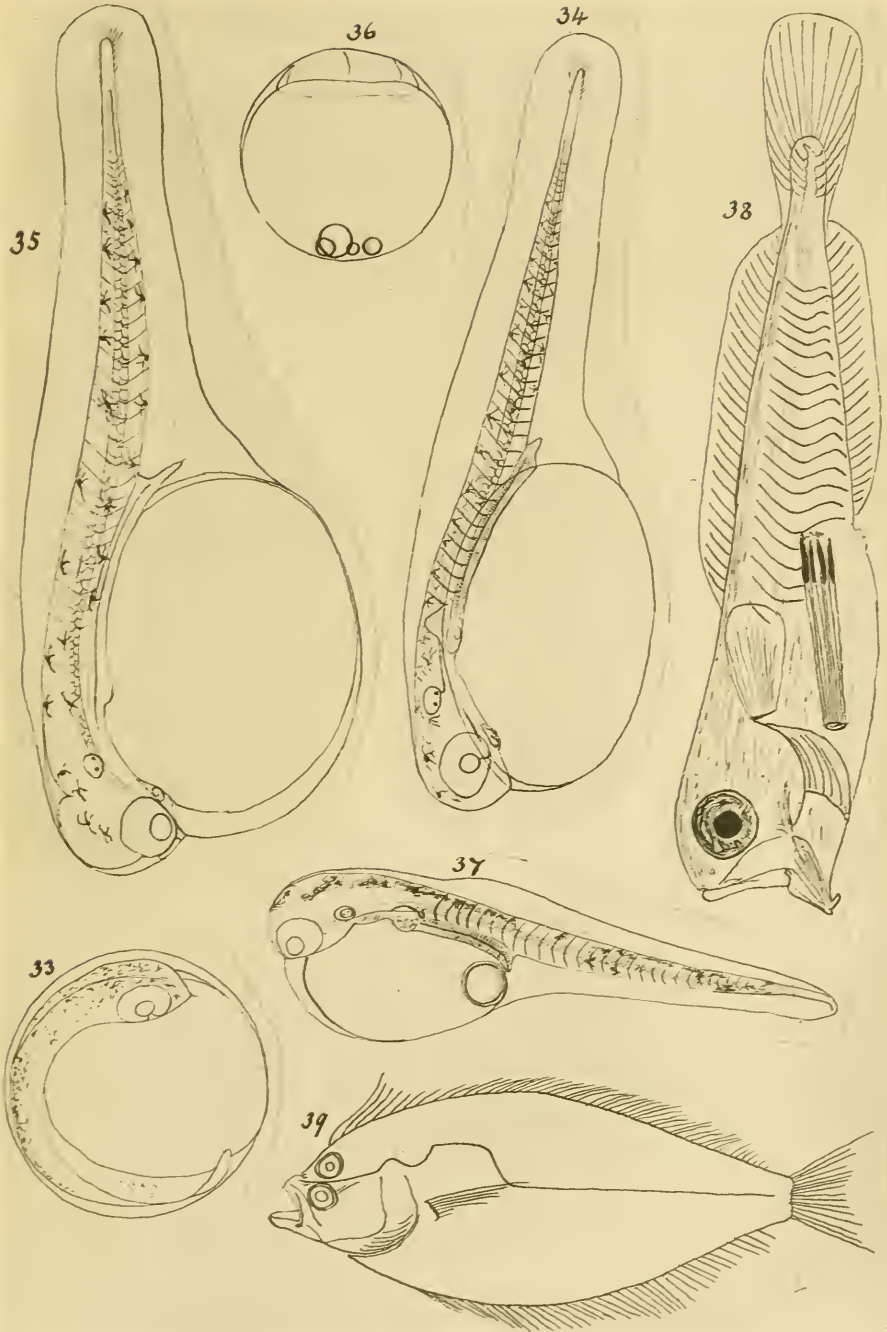














Notes on some Animal Colouring Matters examined at  
the Plymouth Marine Biological Laboratory.

(Brief Abstract.)

By

C. A. MacMunn, M.A., M.D.

THE following is a list of the Invertebrates which I had an opportunity of examining. Their pigments were not in all cases thoroughly studied, partly because the Laboratory had been opened but a short time before my arrival, and was not yet fully provided with the necessary chemical apparatus, partly through want of time.

CELENTERATES.

*Chrysaora hysocella.*  
*Tubularia indivisa.*

*Corynactis viridis.*

ECHINODERMS.

*Antedon rosaceus.*  
*Asterias glacialis.*  
*Goniaster equestris.*  
*Solaster papposa.*

*Asterina gibbosa.*  
*Holothuria nigra.*  
*Ocnus brunneus.*

VERMES.

*Arenicola piscatorum.*  
*Terebella.*  
*Cirratulus.*  
*Nereis.*  
*Pontobdella.*

*Polynoe.*  
*Chætopterus insignis.*  
*Nemertes neesii.*  
*Phyllodoce viridis.*

TUNICATES.

*Styela grossularia.*  
*Botryllus violaceus.*  
*Botrylloides.*

*Ascidia virginea.*  
*Clavellina lepadiformis.*

BRYOZOANS.

*Lepralia foliacea*

And one Mollusc—*Doris.*



The results arrived at will be published *in extenso* in the Quart. Journ. Micros. Sc., but I may here briefly refer to the most important facts which I came upon.

*Does the spectroscope support the supposition that symbiotic Algæ are present in Antedon rosaceus?* The answer is decidedly no, as neither chlorophyll nor chlorofucin is present in any of the extracts of this Echinoderm. I found that if the stomach with its contents was removed before the extraction with alcohol, ether, &c., the above result was obtained, but if allowed to remain then chlorophyll (from the food) was present. This decides the question. Krukenberg has figured a chlorophyll band in his map of the alcohol extract of *Antedon* which led me to suppose that I should also find it, but the result was as described. Dr. P. Herbert Carpenter\* has come to the same conclusion, by studying the morphology of the supposed algæ and the pyriform oil-cells of Wyville-Thomson, which Vogt and Yung† took to be the amœboid spores of these algæ. Apart from spectroscopic proof the latter were found neither to possess a cellulose wall nor to contain starch, and as they are easily seen to grow out from the surface of the integument, being attached to it by their narrower parts, it is not easy to see how they can have been mistaken for anything else but what they are. The red pigment of *Antedon* I found not to be identical with Moseley's antedonine, and in the complete paper the points of difference are referred to at length.

The ether extract was found to contain a lipochrome‡ probably allied to Kühne's xanthophan.

The red pigment itself easily goes over into glycerin, alcohol, and partially into water. It gives no well-marked bands; its colour is destroyed by acids, and more or less changed by alkalies.

Krukenberg's paper, *Ueber die Farbstoffe von Comatula mediterranea*, will be found in his *Vergleichend-physiologische Studien*, zweite Reihe, dritte Abth., 1882.

*Other Echinoderms.*—The fine violet colour of *Asterias glacialis* can be extracted by fresh water, but the solution gives no bands; the colour is diminished by ammonia and by caustic potash, and is not much affected by hydrochloric acid. Alcohol extracts from the integument a lipochrome allied to Kühne's rhodophan,§ but ether

\* *Notes on Echinoderm Morphology*, Quart. Journ. Mic. Sci., Jan., 1887.

† *Traité d'Anatomie Comparée Pratique*, Livr. 7, 8, pp. 519—572.

‡ The lipochromes (Krukenberg), or fat-pigments, include those formerly known as luteins, also tetronerythrin and the chromophanes of the retina, &c. They give bands in the violet half of the spectrum, and become in the solid state blue or green by H<sub>2</sub>SO<sub>4</sub> and HNO<sub>3</sub>, and in some cases blue or green with I dissolved by means of KI. The last test often fails in the case of animal lipochromes. All lipochromes are soluble in such solutions as ether, chloroform, bisulphide of carbon, &c.

§ Kühne, *Unters. a. d. physiol. Inst. d. Univ. Heidelberg*, Bd. i, 1878; Bd. iv, 1882.

fails to extract it. The violet colouring matter could not be extracted by glycerin, and no hæmatoporphyrin could be obtained by extracting the integument with alcohol and sulphuric acid, whereas in *Uraster rubens*, especially in brownish specimens, that pigment is present as I have shown.\* Nor was any found in *Goniaster*, *Solaster*, *Asterina*, nor in *Holothuria nigra* and *Ocnus brunneus*. The integuments of the first three yield lipochromes, which are described in the full paper. *Holothuria nigra* contains within it, and colouring its ovaries, its blood, its digestive gland, &c., one or more lipochromes. The polian vesicle contains what may be described as a lipochromogen, and in the blue ovaries of *Ocnus brunneus* a similar substance is found which, under the influence of alcohol, ether, &c., as in the case of the beautiful blue pigment of the larval lobster and the "cyano-crystals" of other Crustaceans, becomes changed into a reddish lipochrome. Enterochlorophyll† is present in *Goniaster*, *Solaster*, and *Asterina*, and in these, as well as in many other Echinoderms, notably in *Holothuria nigra*, there is reason for supposing that its yellow or red lipochrome-constituent is built up in the digestive gland, from whence it is carried to the integument. In the last-mentioned species it is present in the blood. It may be remembered that Dr. Halliburton‡ has detected a lipochrome in the blood of various Crustaceans, in which also it is prepared in the "liver." So that we may consider the digestive gland of these animals not only an organ in which digestive ferments are prepared, but also as discharging a chromatogenic function. In *Holothuria nigra* a yellow pigment can be extracted from the integument by alcohol, which possesses a magnificent emerald-green fluorescence. This has been described by Krukenberg§ as a "Uranidine," and it has also been described by Prof. Jeffrey Bell.|| To the latter I am indebted for a solution of the colouring matter which I have described in full in the paper referred to.

*Cœlenterata*.—The discovery of polyperyrthrin (which I have shown to be identical with hæmatoporphyrin) in many Cœlenterates by Prof. Moseley,¶ led me to hope that in the brown pigment of *Chrysaora* I might see a banded spectrum, but I could not see any bands whatever, and my further results have confirmed exactly those of Prof. McKendrick,\*\* who examined this jelly-fish.

In the beautiful little *Corynactis viridis*, when it has a red colour,

\* JI. Physiol., vol. vii, No. 3; see also vol. viii, No. 6.

† See Proc. Roy. Soc., vol. xxxv (1883), p. 370, *et seq.*; also Philos. Trans., Pt. i, 1886.

‡ JI. Physiol., vol. vi, No. 6.

§ Vergl. physiol. Stud., II Reihe, 3 Abth., 1882, S. 53.

|| Proc. Zool. Soc., Dec., 1884, p. 563.

¶ Quart. Journ. Mic. Sci., vol. xvii, N.S., 1877.

\*\* Journ. Anat. and Physiol., vol. xv.

I find actinohæmatin present, differing in no essential respect from that colouring matter as I have described it elsewhere.\*

In *Tubularia indivisa* the bright red colour of the polyp heads was found to be due to a lipochrome.

*Vermes*.—In *Arenicola*, as in *Lumbricus terrestris*, the glandular tissue surrounding the intestine was found to contain a lipochrome, as well as the integument. From the latter situation the black pigment could be extracted by caustic potash, but in solution it gave no bands. Hæmoglobin is present in this worm, as is known by Prof. Ray Lankester's researches.

In *Terebella*, besides the hæmoglobin (Lankester), to which, and not to tetronerythrin the colour of the tentacles is due, the integument contains a lipochrome. In *Cirratulus* the tentacles also owe their colour to oxyhæmoglobin, but they also yield a lipochrome to solvents, as does the integument.

In *Nereis* a lipochrome is also present besides the hæmoglobin. The blood of *Nereis Dumerilii* showed one broad band like that of reduced hæmoglobin. In some parts of the worm only one band like the first one of oxyhæmoglobin was seen. An aqueous solution of the blood, however, gave two bands, but on adding ammonium sulphide they disappeared, and did not seem to be replaced by the single band of reduced hæmoglobin.

In *Pontobdella* an undescribed colouring matter bearing a remote resemblance to chlorophyll can be extracted from the integument by absolute alcohol. This comes from the large green-coloured corpuscles situated in the deeper parts of the integument.† The green solution showed no red fluorescence, nor did it show all the chlorophyll bands. With hydrochloric acid it became a deeper blue colour, but did not show the phyllocyanin spectrum.

In *Polynoe* a phosphorescent area was noticed surrounding the head ganglion, which latter was of a red colour, and gave a band situated approximately in the same part of the spectrum as that of reduced hæmoglobin, but in no part of the worm could I see the spectrum of oxyhæmoglobin. In one specimen the cerebral ganglion showed one band like the first of oxyhæmoglobin, and in another this ganglion was yellow and showed no band.

I have examined the green colouring matter of *Chætopterus insignis* (Baird) and can confirm Professor Lankester's statement that it is chlorophyll. The alcohol solution possesses a fine red fluorescence and gives all the chlorophyll band and yields "modified" and "acid" chlorophyll as well as phyllocyanin by suitable treatment.

\* Philos. Trans., Pt. ii, 1885.

† See A. Gibbs Bourne's paper, Quart. Journ. Mic. Sci., July, 1884.

I could detect no hæmoglobin in *Nemertes Neesii*, nor did the integument yield hæmatoporphyrin to acidulated alcohol.

In *Phyllodoce viridis* a special green pigment occurs which is not chlorophyll. This pigment is described at length in the complete paper. It may be remembered that P. Geddes\* exposed this green polychæte Annelid to sunlight and failed to get any evolution of oxygen. Of course the above result explains why.

*Tunicates*: In *Styela grossularia* the brilliant red pigment surrounding the exhalent and inhalent orifices was found to be a red lipochrome, which by Merejkowski† would doubtless be taken for tetronerythrin, but in this, as well as in many other instances, it is more closely related to Kühne's rhodophan than to anything else. The ether solution was at first a fine red colour, but soon changed to greenish, and although it did not show a red fluorescence it gave a chlorophylloid spectrum. But the pigment present was not chlorophyll; it seemed to possess characters, however, which should class it among the lipochromes and which show that the step from one to the other is not a great one.

*Botryllus violaceus* yields to solvents such as alcohol and ether a yellow lipochrome, which in a deep layer of alcohol solution showed a band in red like that of chlorophyll. It is probable that in this instance also a colouring matter is present possessing some of the characters of chlorophyll and being yet a lipochrome.‡

In *Botrylloides* an allied pigment is present.

In *Clavellina lepadiformis* some bluish colouring matter occurs which showed some shading at the blue end of green and a feeble shading at D, but I was unable to examine it further.

In *Ascidia virginea* a reddish pigment was noticed which gave two shadings in the green and strongly absorbed the violet end of the spectrum, but I failed to get it into solution. It is probably, however, related to the lipochromes.

*Bryozoans*: The examination of *Lepralia foliacea* yielded interesting results. It contains abundance of chlorophyll mixed with a lipochrome, to which latter the fine orange of this species is due. The chlorophyll is also accompanied by a second pigment, probably chlorofucin,§ if so, the latter must be due either to symbiotic algæ or to brown marine algæ. The ether solution shows the bands of the latter pigment well marked, and has a red fluorescence, which is

\* Proc. Roy. Soc. Edin., vol. xi, 1881-82.

† Bullet. de la Société zoolog. de France, 1883, p. 81 *et seq.*; cf. Dr. W. Wurm in Jahreshefte des Vereins für vaterl. Naturkunde in Württ., 1885, S. 262-265.

‡ Cf. Krukenberg, Verg. physiol. Stud., 2 Reihe, 3 Abth., 1882, Tafel v, 7.

§ Sorby, Proc. Roy. Soc., No. 146, vol. xxi, 1873; see also my paper in Quart. Journ. Mic. Soc., vol. xxvii.



not so well marked in the case of the alcohol solution. Water extracted from *Lepralia* a little reddish yellow colouring matter, showing some shading at the blue end of green, and glycerine a little yellow. The acetic acid solution was brownish yellow, and in deep layers absorbed all the spectrum except the red, while in a thin layer it showed a band at the blue end of green.\*

I formerly found chlorophyll in *Flustra foliacea*, where it is evidently due to the presence of the brown bodies, the remains of the atrophied Zooids.

The only mollusc which I had time to examine roughly was *Doris*, but in this I found evidence of the presence of a hæmochromogen-like spectrum, resembling exactly that of the pigment which I have named enterohæmatin, and which Sorby found in several snails and slugs, and I found in *Patella* and *Astacus*.† This pigment is, as I have shown, connected with the histohæmatins, which have a very wide distribution throughout the animal kingdom.

*Remarks.*—It was evident to me that every pigment which I met with, in this somewhat rough and unfinished series of observations, could be classified under groups which have already been described by others and myself; but they are not on that account the less interesting, as the distribution of these pigments is of great importance.

To morphologists the study of animal chromatology may seem trivial, but the pigments are of great importance from a physiological point of view, and the discovery of hæmoglobin, hæmocyanin, the histohæmatins, echinochrome, and other respiratory colouring matters, has thrown much light on the respiratory processes in animals.

With regard to the lipochromes, it is difficult to understand what rôle they play. I cannot think that they can be of much use in respiration, as they are unaffected by oxidizing and reducing agents as are other respiratory substances. And I therefore differ from Merejkowski with regard to tetronerythrin being respiratory, as it—as I said before—has been shown to be a lipochrome. It is significant that such widely separated structures as the eye-spot of a starfish and the rods of the Vertebrate eye should each yield lipochromes; it would seem that in such cases they are concerned in the absorption of light-rays.‡ Probably their simple chemical constitution, as they all consist of only three elements, carbon, hydrogen, and oxygen, has been taken advantage of for such purposes, as they can be built up with the minimum expenditure of energy. It is interesting also to note that they have a very strong absorptive power for the violet end of the spectrum.

\* Cf. Krukenberg, *Verg. physiol. Stud.*, 2 Reihe, 3 Abth., S. 29.

† *Philos. Trans.*, Pt. i, 1886, p. 239, and *Ibid.*, p. 268.

‡ Cf. Sir J. Lubbock in *The Senses of Animals*, *Internat. Sci. Series*, p. 3, *et seq.*



Their very intimate association with chlorophyll, and the actual change of that substance into them, which I have sometimes observed, teach that the step from one to the other colouring matter is not a great one. When we also consider that they are widely distributed throughout the vegetable kingdom, it no longer becomes difficult to understand why chlorophyll should be built up by animals. I am quite convinced that Prof. Lankester's contention that true animal chlorophyll exists can no longer be contradicted.

Krukenberg\* has shown that the lipochromes are connected closely with the lipochromoids and melanoids, and through the latter with the melanins; if so, they furnish the radicals for the construction of many black and brown pigments (such as we find in *Holothuria nigra*, whose interior is, as said before, pigmented, to an extraordinary degree, by lipochromes).

The narrow view that all or nearly all the pigments of the vertebrate body are formed from hæmoglobin, held by many human physiologists up to a very late period, is shown to be erroneous by a study of the chromatology of the lower forms. Thus there are other mother-substances such as the histohæmatins, which are of as great importance to many Invertebrates as hæmoglobin is to the higher forms, and it is only by a knowledge of this fact that we can explain the occasional occurrence of such pigments as hæmatoporphyrin in the integument of a starfish, in slugs, and in *Solecurtus strigillatus*,† as I have shown, or of biliverdin in *Actinia mesembryanthemum*, as I have also shown, or in the shells of various molluscs, as Krukenberg has pointed out.‡

These histohæmatins and others, such as the enterohæmatin of snails, slugs, the common limpet, the crayfish and *Doris*, actinohæmatin, and Lankester's chlorocruorin, may possibly, and probably do, represent immature kinds of hæmoglobin on their way, as it were, to form that complex body, but they certainly are not metabolites of hæmoglobin.

The view that modified myohæmatin from pigeon's muscle is hæmochromogen, which Herr Ludwig Levy holds, and endeavours to prove in a recent paper,§ cannot be maintained by anyone who extends his observations to invertebrate animals. Levy further states that it is derived from hæmoglobin, but where is the hæmoglobin from which it comes in a bee, a wasp, a butterfly, a slug, a snail, a crayfish, or a lobster, or in many others in which not a single trace of hæmoglobin can be detected by the most careful spectroscopic

\* Centralb. f. d. medic. Wissensch., 1883, S. 785—788.

† Jl. Physiol., loc. cit.

‡ Centralb. f. d. medic. Wissensch., loc. cit.

§ *Über den Farbstoff der Muskeln*, Inaug. Dissert. Strassburg, 1888.

observation?\*

I am quite aware of the near relationship of these pigments to hæmatin, and I know that modified myohæmatin and enterohæmatin are very like hæmochromogen : it was for that reason that I gave them their present names ; but apart from the fact that, as I have just stated, no hæmoglobin can be found in some animals where they occur, there remains the no less important one, that they do not behave chemically, as they ought to do, if they were metabolites of hæmoglobin.

\* Philos. Trans., loc. cit.

## On a *Tornaria* found in British Seas.

By

**Gilbert C. Bourne, M.A., F.L.S.,**

Fellow of New College, Oxford, and Resident Director of the Association.

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With Plates VII, VIII.

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BEFORE 1888 no specimen of *Tornaria*, the well-known pelagic larva of *Balanoglossus*, had been taken off the English Coast. But on August 9th of the past year Mr. Weldon, using the surface net near the Eddystone Lighthouse, took several young specimens of *Tornaria*, and subsequently the same gentleman, during a cruise of a week's duration towards the end of August, captured many larger and more mature specimens of the same larva. Other specimens were taken by us up to September 21st, and in the month of August Mr. Rupert Vallentin found several specimens in the vicinity of Falmouth.

The specimens taken on these occasions form the subject of the present memoir, and their anatomy is detailed at some length, both because of the interest attached to a form hitherto unknown to England, and because it is in some respects of morphological importance.

The specimens taken by us came from the offing, and were not taken within four miles of the shore; Mr. Vallentin's *Tornaria* were found close to the shore at Falmouth. As he was able to bring his back alive and preserve them at leisure in his laboratory, they are better preserved than those taken by us, since we were obliged to preserve our catch in a somewhat rough manner out at sea. An examination of Mr. Vallentin's specimens leaves me no doubt that the larva is *Tornaria Kröhnii*, a species found in the Mediterranean. The different forms of *Tornaria* have not been with certainty referred to their adult forms, but *T. Kröhnii* must belong to one of the Mediterranean species of *Balanoglossus*, that is to say, to *B. Kowalevskii*, *B. minutus*, or *B. claviger*, species which have not hitherto been recorded from the English Channel, unless we suppose that the larva of *B. salmoneus* v. *sarriensis*, which occurs in the Channel Islands and at Roscoff, is identical with *Tornaria Kröhnii*.

The larvæ found on August 9th were of minute size, the largest

measuring not more than .33 mm. in length. In the same surface net I found a few specimens of a younger larva which is identical with Johannes Müller's figure of the youngest *Tornaria* found by him. One of these larvæ is shown in fig. 1. It has a pre-oral ciliated band and a longitudinal band, but the circumanal band is not developed. The anus is terminal and the mouth opens on the ventral surface. A longitudinal section of this larva is shown in fig. 2. The segmentation cavity is large, and in its anterior portion are several scattered amœboid cells, which will form the walls of the anterior body-cavity. The mouth leads into a stomodæum which is not yet in communication with the gut. The gut is divided into two regions, an anterior mid-gut and a posterior hind-gut, the latter opening to the exterior by the anus. The opening of the anus is shown in fig. 3. It seems probable from the condition of the larva that the posterior division of the gut is not a proctodæum, as might be supposed from an examination of the perfect *Tornaria*, and that the blastopore persists as the anus without being pushed further inwards by a secondary invagination of ectoderm, *i. e.* a proctodæum.

The next stages observed have all the characters of a *Tornaria*. The circumanal ciliated ring is now fully developed, but has not the same importance that it acquires at a later stage. The pre-oral and longitudinal bands retain the same arrangement, but are more marked than they were in the earliest stage (fig. 4). The gut is increased in size and is more distinctly differentiated into a mid-gut and a hind-gut. The anterior body-cavity is formed, probably from the amœboid cells described in the earlier larva, and is connected by a muscular thread with the now conspicuous apical sense organ. It opens on the dorsal surface by a pore, which eventually becomes, as Spengel\* has shown, the proboscis pore of the adult. Anticipating its fate I shall refer to this pore as the proboscis pore. Fig. 12 shows a longitudinal section through a *Tornaria* of this age. It can be seen that the œsophagus opens into the gut, the point of junction between the two being sharply defined. The cells of the œsophagus are columnar and richly ciliated. In larvæ of this age the opening from the mid-gut into the hind-gut is very small and difficult to find in specimens contracted by reagents. At first I was led to believe that no communication between the two exists at this stage, but further examination showed me that an opening exists as shown in fig. 5. No traces of the so-called heart (the proboscis sac of Bateson) nor of the collar- and body-cavities are to be found at this stage. The third stage shown in fig. 13 represents the perfect *Tornaria*. The larva has increased greatly in size, the specimen from which the figure was drawn was as much as a millimetre in

\* *Bau u. Entwicklung von Balanoglossus*, Tagebl. d. Naturf. Vers. München, 1877.



length; but in this respect there is great variety among individuals. The pre-oral and longitudinal bands have undergone considerable changes both in their arrangement and in histological characters. In the earlier larva the pre-oral band was triangular, the base overhanging the mouth, and the apex touching the apical sense organ. In this stage the external angles of the triangle are drawn out on either side into long loops which are turned upwards towards the apex, the remainder of the figure appearing as a third median loop which touches the sense organ. The lower edge overhanging the mouth has not undergone any change. The longitudinal band forms a sort of cross the head of which touches the sense organ, the arms are turned upwards like those of pre-oral band. Ventrally the angle beneath the mouth is larger and more sharply defined, but otherwise no important change has taken place. In section, both the pre-oral and longitudinal bands are seen to be composed of numerous densely-crowded, deeply-stained nuclei, the cell outlines of which are not distinguishable. In the earlier stage the cells of the bands were columnar and fewer in number. The cilia have nearly disappeared in the later stage, but a few fine patches may be distinguished. The circumanal band on the other hand has increased in size and importance, and is now the chief if not the only organ of locomotion. Its long and powerful cilia are borne on long columnar cells arranged in oblique rows of three, as is shown in fig. 11. Above and below the ciliated cells are supported by packing cells, and numerous spots of bright brown pigment mark the course of this as well as of the pre-oral and longitudinal bands. Each ciliated cell is long and columnar, slightly contracted in the middle of its length, with a large nucleus. The cilia can be traced as fine fibrillæ inwards as far as the nucleus, but I could not determine whether they entered the nucleus or not.

The alimentary tract does not require a detailed description. The chief distinction between this stage and the last consists in the large circular aperture between the mid-gut and hind-gut. The anus remains relatively small.

The anterior body-cavity, which from its fate may conveniently be spoken of as the proboscis cavity, shows the same relations as in the previous stage. The whole cavity is larger, and its walls are further differentiated, the anterior wall being considerably thickened. Between the thickened portion and the point of insertion of the œsophagus on the mid-gut a few scattered cells may generally be distinguished.

The "heart" of Agassiz, Metschnikoff, and Spengel makes its appearance at this stage as a vesicle lying just above and to one side of the proboscis pore. Figs. 6—10 are a series of sections



through the region of the proboscis pore in a perfect Tornaria. In fig. 6 two canals may be seen lying side by side. Of these, one marked *ant. b. c.* is the canal of the proboscis cavity leading to the proboscis pore. The other, marked *v.*, is the heart in question. An examination of figs. 7 and 8 shows that it is formed as an invagination of the ectoderm just above and to one side of the proboscis pore (*d. p.*). Prof. Spengel, who has investigated the whole development of many species of Tornaria, has been good enough to send me proofs of the illustrations of his forthcoming monograph on *Balanoglossus*, and from his figures and from the account given in his preliminary paper (*d*) it appears that this vesicle is destined to form the "heart" in the adult animal, the proboscis sac of Bateson.

By permission of Mr. Weldon I reproduce a drawing (fig. 19) of the proboscis gland in a later stage of the Tornaria found by him in the Bahamas. In this the heart or proboscis sac (*v.*) is seen as a sac lying in the proboscis gland. It is completely closed, and does not communicate with the blood system nor with the proboscis cavity. The most plausible explanation of this structure is that the anterior body-cavity of *Balanoglossus* may primitively have been a paired structure, and that this sac may be a member of the pair and the degenerated fellow of the proboscis cavity. But the development of a mesoblastic pouch as an invagination of the ectoderm lands us in a great morphological difficulty.

The development of the posterior mesoblastic pouches can be followed up to a certain point in this stage. It has already been shown by Metschnikoff and Agassiz that a plate is budded off from the posterior region of the gut on each side, which subsequently undergoes division, and forms, as shown by Spengel, the collar-cavities and body-cavities of the adult. My sections show that right and left of the body a plate of cells is budded off from the upper edge of hind-gut on either side. At first continuous with the hind-gut (fig. 14), each plate subsequently separates from it, and becomes so closely applied to the mid-gut as to look as if it had originated from it (fig. 15). The cells composing these plates multiply, and a cavity is formed in them, as shown in fig. 16. No later stages were observed in our Tornaria, but in other forms these pouches become each divided into an anterior and a posterior portion, the anterior moiety on each side giving rise to the collar-cavity of the adult, the posterior moiety to the general body-cavity. This further development is figured in the drawings which Prof. Spengel has sent me, and I was able to follow it in the series of preparations of the Bahamas Tornaria lent me by Mr. Weldon.

Bateson, in his account of the development of *Balanoglossus*

*Kowalevskii*, describes the collar- and body-cavities as arising from separate pairs of archenteric pouches. The account given above, which was first given by Metschnikoff and has since been proved by Spengel, is in accordance with Batesou's observations, if I am right in considering that the hind-gut is in reality a portion of the true gut and not a proctodæum. But although I believe that the evidence at my disposal is opposed to the view that this region of the alimentary tract is a proctodæum, Prof. Spengel informs me that he is inclined to think that it is, and should he prove to be correct, the origin of the mesoblast from such a source would be without parallel in the animal kingdom. I expect to find that my view is correct, because a widely different origin of the mesoblast in two species of the same genus is in itself hardly credible, and would present most serious morphological difficulties.

The apical sense organ in our *Tornaria* is shown in section in fig. 18. Its central portion is composed of columnar sense-cells bearing cilia. Outside of these are larger cells, with large nuclei surrounding a pair of deeply pigmented pits. These pits are the "eye-spots" of previous authors, the large cells surrounding them are probably ganglion-cells. Beneath the sensory cells is a thin layer of nerve-fibres. The structure of the sense organ and its relation to the muscular band which connects it with the proboscis cavity can readily be seen in fig. 18. The paired invaginations forming sense pits, suggest a comparison with similar organs in the unarmed *Gephyrea*.

Unfortunately, the account of the British *Tornaria* must stop here. No specimens older than that described were taken during the year. Possibly if we had brought back our *Tornaria* alive we might have succeeded in rearing the further stages as was done by Metschnikoff and Agassiz, but owing to the distance we had to traverse in a small sailing-boat, and that often in calm weather, we found it always expedient to preserve our catch on board. Very probably the *Tornaria* ceases to lead a pelagic life, sinks to the bottom, and undergoes its further development there, which would explain our taking no later stages in the tow-net.

In conclusion, I have to thank Prof. Spengel for his kindness in sending me proofs of his forthcoming illustrations of the development of *Balanoglossus*. From these it appears that he has already anticipated anything that is new in this paper, such as the formation of the "heart" and the structure of the sense organ. I am also indebted to Mr. Weldon for lending me numerous drawings and preparations of the two forms of *Tornaria* found by him in the Bahamas, and to Mr. Rupert Vallentin for the specimens taken by him at Falmouth.

## DESCRIPTION OF PLATES VII, VIII,

Illustrating Mr. G. C. Bourne's paper on "A Tornaria found in British Seas."

FIG. 1.—Lateral view of a very young Tornaria (?).

FIG. 2.—Longitudinal section through the same specimen, showing the relation of the stomodæum to the gut.

FIG. 3.—Posterior part of the next section to 2, showing the blastopore persisting as the anus.

FIG. 4.—Young Tornaria, older than fig. 1. Actual size .33 mm.

FIG. 5.—Frontal section through the posterior region of a Tornaria of the same age as fig. 4, to show the communication between the mid-gut and the hind-gut.

FIGS. 6, 7, 8, 9, 10.—Five consecutive sections through a perfect Tornaria in the region of the proboscis pore, showing the opening of the latter (*d. p.*) and the canal (*ant. b. c.*) which connects it with the proboscis cavity. In figs. 6, 7, 8, the mode of origin of the so-called heart (*v.*) may be seen.

FIG. 11.—Surface-view of the circumanal ciliated ring, showing the nuclei of the ciliated cells, the supporting cells, and the pigment spots.

FIG. 12.—Sagittal section through a Tornaria of the same age as fig. 4, showing the proboscis cavity and pore.

FIG. 13.—Lateral view of a perfect Tornaria, showing the complication of the ciliated bands. Actual size 1 mm.

FIG. 14.—Longitudinal section through the posterior region of a Tornaria of the same age as fig. 3, showing the origin of the mesoblast from the hind-gut.

FIG. 15.—Longitudinal section through a somewhat more advanced larva, showing the mesoblast separate from the hind-gut, and closely applied to the wall of the mid-gut.

FIG. 16.—Transverse section of a larva somewhat older than fig. 15. A cavity has been formed in the mesoblast.

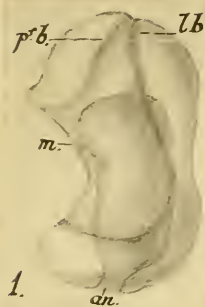
FIG. 17.—Surface view of the ectoderm in a perfect Tornaria.

FIG. 18.—Frontal section through the apical sense organ, showing the sense pits (*s. p.*), the ganglion-cells and layer of nerve-fibres, the proboscis cavity, and the muscle band connecting the latter with the sense organ.

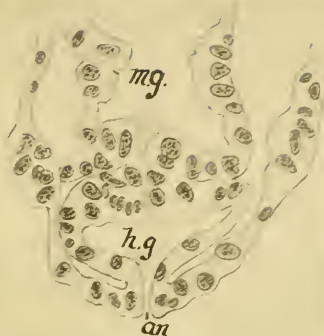
FIG. 19.—Section through the proboscis gland of an advanced larva of a *Balanoglossus* from the Bahamas, showing the relations of the so-called heart (proboscis sac) to the proboscis gland. Copied from a drawing by Mr. Weldon.

*Lettering in the above figures.*

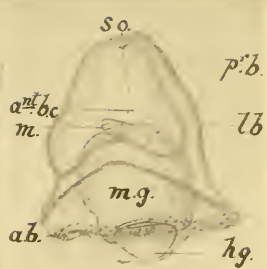
*a.* Lateral loop of the pre-oral band. *a'*. Median loop of the pre-oral band. *a''*. Lateral loop of the longitudinal band. *a'''*. Median loop of the longitudinal band. *a. b.* Circum-anal ciliated band. *am. c.* Amœboid cells. *an.* Anus. *ant. b. c.* Proboscis cavity. *d. p.* Proboscis pore. *ect.* Ectoderm. *end.* Endoderm. *g. c.* Ganglion-cells. *h. g.* Hind-gut. *l. b.* Longitudinal band. *m.* Mouth. *m. b.* Muscular band. *mes.* Mesoblast. *m. g.* Mid-gut. *n. f.* Layer of nerve-fibres. *œs.* Œsophagus. *pr. b.* Pre-oral band. *proc.* Proctodæum. *p. s.* Pigment spots. *s. c.* Supporting cells. *s. o.* Apical sense organ. *s. p.* Sense pits. *v.* "Heart," or proboscis sac.



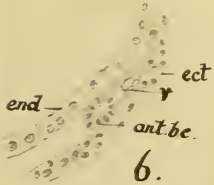
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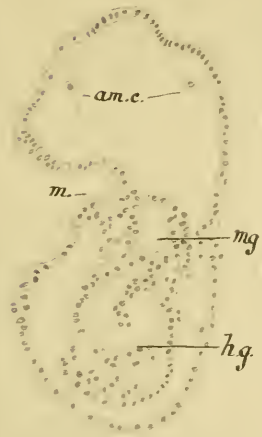
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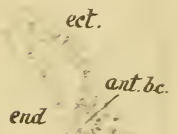
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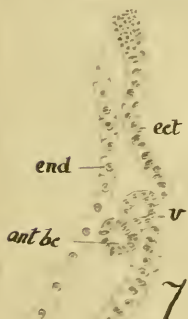
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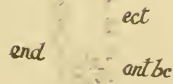
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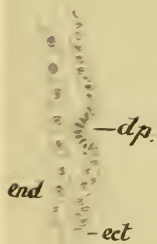
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## Notes on the Marine Oligochæta of Plymouth.

By

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THE Oligochæta form a division of the Annelida, of which the most familiar type is the common earthworm (*Lumbricus terrestris*); the group comprises also a great number of smaller worms, which are for the most part inhabitants of ponds and streams, such as the red River worm (*Tubifex rivulorum*). The Oligochæta were at one time believed to be entirely terrestrial or inhabitants of fresh water, and to be distinguished thus from the Polychæta, which were supposed to be exclusively marine in their habitat. Although the progress of research has not broken down the structural distinctions between these two divisions of the *Annelida chætopoda*, it has been proved that no absolute line of demarcation can be drawn between the Oligochæta and the Polychæta as regards their habitat; on the one hand Polychæta have been found in fresh water, and, on the other hand, certain species of Oligochæta are now known to inhabit the mud and gravel of the seashore.

There are three species common in the Sound at Plymouth, which are apparently identical with certain species described by Claparède\* from the shores of Scotland and France.

One of these is a small whitish worm about half an inch in length, which is abundant in gravel between tide marks in Rum Bay. It belongs to the genus *Pachydrilus* of Claparède, but I have not yet satisfactorily determined to which of the several known species of the genus it should be referred.

The two remaining species are found in mud at Drake's Island and on the shores of the Sound, where they are extremely abundant. They can be distinguished from each other by a slight difference in the transparency of the body wall. One worm is much more transparent than the other, and is therefore of a brighter red colour, this colour being, of course, due to the blood-vessels; this species appears to be Claparède's *Clitellio arenarius*. The other worm has a more dusky appearance, caused by the presence of a

\* Mém. Soc. Phys. Geneve, 1862.

quantity of minute papillæ, filled with a greyish-green pigment, which cover the body except at the anterior and posterior end, and on the clitellum when developed. The opacity of the body walls renders the contained blood-vessels less conspicuous. I identify this worm with Claparède's species *Clitellio ater*; it is probably also identical with d'Udekem's\* *Tubifex Benedii*.

The preliminary list of the Marine Fauna of Plymouth, published in the second number of the 'Journal of the Marine Biological Association,' contains a single Oligochæt—*Tubifex lineatus*.

*Tubifex lineatus* is, however, a most mysterious species; it was originally described by Hoffmeister;† but there is nothing in Hoffmeister's description which renders its identification possible, unless he is right in stating (by implication) that there are no hair-like setæ in the dorsal fascicles; in this case it cannot be a *Tubifex*; but the generic name *Sænuris*, which Hoffmeister applied to it, includes several species which are now assigned to different genera. I should be inclined myself (at least provisionally) to regard "*Sænuris lineatus*" as being the same form as *Clitellio arenarius*, for in that Annelid also, as Claparède stated, there are no hair-like setæ.

Another marine species, found on the coasts of the North Sea, is *Tubifex hyalinus*, d'Udekem. Vejdovsky‡ considers it probable that this is a *Limnodrilus*, since it only possesses bifid setæ. This is, however, as already stated, no reason against regarding the species as a *Clitellio*, inasmuch as all the species of *Limnodrilus*, which have been adequately described, are fresh-water forms; it is more probable, though of course by no means certain, that *Tubifex hyalinus* is a *Clitellio*, and perhaps also identical with *Cl. arenarius*. Claparède was unacquainted with d'Udekem's paper when he described *Clitellio arenarius*.

*Clitellio* also agrees with *Limnodrilus* in the presence of a pair of "hearts" in each of segments 8 and 9. It is in fact only to be distinguished from that genus by (1) the absence of "prostate" glands, (2) the shortness and breadth of the vasa deferentia, and (3) the structure of the spermathecæ, which are composed of two sacs united by a very narrow tube; in the lower sac lie the spermatophores.

The species which Claparède termed *Clitellio ater*, and only very briefly described, cannot be referred to the genus *Clitellio* at all. The peculiar papillæ, already referred to, distinguish the species,

\* *Nouvelle classification des Annelides Sétigères Abranches*, Bull. Acad. Roy. Belg., T. xxii, Pt. ii (1855).

† Die bis jetzt bekannten Arten aus der Familie der Regenwürmer.

‡ System u. Morphol. d. Oligochæten.

and lead me to infer its identity with d'Udekem's *Tubifex Benedii*, which appears from the woodcut in Udekem's\* paper to possess similar papillæ ; this has been already urged by Vaillant. Claparède does not mention the presence of hair-like setæ ; these indeed are present in some individuals and absent in others ; when present they exist only in the dorsal fascicles. The only genus of Tubificidæ in which this capricious arrangement of the setæ occurs is Eisen's genus *Hemitubifex* ; † but the only species of that genus is fresh water. *Clitellio ater* furthermore agrees with *Hemitubifex* in the dilatation of the termination of the vas deferens connected with the atrium ; I am not, however, convinced that this species is an *Hemitubifex*, though there does not appear to be any other genus to which it can be unhesitatingly assigned.

I have already communicated to the Zoological Society of London a fuller account of the anatomy of these two Tubificidæ.

\* Loc. cit., p. 544.

† *Oligochatological Researches*, Report of the (U. S.) Commissioners for Fish and Fisheries for 1883.



## The Mackerel Fishery in the West of England.

By

**R. J. Ridge.**

THE mackerel fishery began off Plymouth in January, and boats from Yarmouth, Lowestoft, Newhaven, Brighton, Eastbourne, Hastings, Plymouth, together with a considerable number of Mount's Bay boats (Porthleven, Newlyn, and Mousehole) were engaged in the above fishery. Fish were found about the 13th January fifteen to twenty-five miles south-west of the Start Point, of a very fine quality, and were caught in considerable quantities for some few nights, catches from two lasts (20,000) down to few hundreds per boat. Westerly and south-west winds prevailing (strong breezes), very stormy weather set in, and fishing operations were interrupted for three weeks, when the boats got to work again, meeting only with light catches for some weeks, February and March were not very successful months, easterly winds set in and continued throughout above months, and practically nothing was done till latter part of March and beginning of April, when boats fell in with fish south-west of Eddystone fifteen to twenty-five miles. There fish were not so fine in quality as those of January, and appeared to be quite distinct from the latter. Some good hauls were secured, one last (being about the largest catch) to few hundreds per boat. The fishing continued up to May, and boats did fairly well, a good average earnings was obtained; prices kept up, especially during Lent.

The spring fishing off the Lizard was practically a failure, no doubt the result of strong east winds; generally the Mount's Bay boats meet with good catches of fish during March and April from five to twelve miles south-west to west of the Lizard. In 1887 it was late in April before they were met with in any considerable quantities, but this year (1888) very few indeed were secured on this ground.

A few nights' good fishing were secured twenty-five to thirty miles south to south-south-east of Lizard, and the quality very clearly indicated them to be of the usual Lizard spring shoal.

The commencement of May Bay-boats\* shifted nets (took on

\* The fishing boats belonging to Mount's Bay are usually spoken of in the West of England as the "Bay-boats."—ED.

board a large mesh net), and as usual went to the ground off Scilly. During first part of the month very unsettled weather set in and very little could be done. The month, however, closed with a very good fishing and some very fine hauls were taken and the quantity excellent.

During May the greater part of the Lowestoft boats continued to find fish in considerable quantities forty miles south of Mount's Bay, and the quality also was very fair though not equal to those from the Scilly ground.

The fishing during June off Scilly was fairly well maintained, and mackerel kept in capital condition, maintaining a flavour somewhat superior to ordinary June fish.

The season held on till the very end of the above month, and even several boats continued fishing the whole of July, getting catches of 1000 to 200 per boat.

Owing to prevalence of light winds Scilly fishing was closed in June, and the fishing during July was prosecuted off Mount's Bay twelve to twenty miles.

September.—Bay-boats met with fish again off the Bay in fair quantities, the quality being most excellent.

December.—The fleet fitted out again for the mackerel fishing off Plymouth, and the first that were taken was on the night of Friday, December 7th, nine miles south-west Start, by the "Mizpah," of Porthleven, 1000 fish being her catch.

Tuesday, 11th December, five boats landed from same ground 3000, 2900, 2600, 500, and 300 respectively, quality most excellent.

13th inst., catches from 2700 down to 100 per boat were landed.

During the week the very bright moonlight has somewhat been against good fishing.

The year's fishing has been above the average during the last nine years financially for the fishermen, as prices have been rather higher on the whole.\* Quantity a little below. Quality very satisfactory.

\* The high prices of mackerel, and consequent high returns to the West of England fishermen, are due to the failure of the Kinsale mackerel fishery, which has been unprecedentedly bad during the past year.

## Further Investigations on the Function of the Electrical Organ of the Skate.

By

**Prof. Burdon Sanderson, M.D., F.R.S., and F. Gotch, M.A.**

DURING the month of September, 1888, we availed ourselves of the facilities afforded by the Laboratory for the purpose of continuing the investigations began by us the year before, of the function of the electrical organ of the skate. In the record of the work done by us in 1887 at St. Andrews, published in the *Journal of Physiology*, vol. ix, p. 137, we indicated several new lines of investigation which we hoped to pursue if the opportunity offered. Two of these indications we have now been able to fulfil satisfactorily, namely, those relating to the electromotive force of the shock, and to the way in which the function of the electric organ is controlled and influenced by the central nervous system. In the first of these inquiries, we used apparatus which was brought from the Oxford Physiological Laboratory, and temporarily fitted up in the room at Plymouth, which is set apart for physiological researches, and which we found well adapted for this purpose. For the second, a large number of experiments and consequently a considerable number of fish were requisite. Forty skates of various species (*Raia Batis*, *R. clavata*, *R. microcellata*, and *R. maculata*) were supplied to us and used in our researches, of which the result will shortly be ready for publication.

We desire to express in the strongest terms our appreciation of the advantages afforded by the Laboratory for physiological researches. We would also record our personal obligation to the Director for his uniform courtesy and untiring zeal in obtaining for us, in spite of considerable difficulties, the material required for our work.

## The Scientific Work of the Fishery Board for Scotland.

By

**T. Wemyss Fulton, M.B.,**

Scientific Secretary, Fishery Board for Scotland.

UP to 1882 the control of the Scottish Fisheries was vested in the Commissioners of British White Herring Fishery. This body, which was instituted in 1808, had for its functions the general superintendence of the herring fishery, the branding of herring barrels, the collection of trade statistics, and the administration of an annual grant from the Government for the construction and repair of fishery harbours. Later on, the cod and ling fisheries were also brought under its care. But the duties of the Commissioners were strictly limited to the fish cured, no cognisance being taken of the fish landed and used in a fresh state.

It was therefore scarcely to be expected that a Fishery Board whose operations were thus circumscribed would concern itself much about the scientific aspects of fishery questions. It is only in recent years that the full value of systematised knowledge concerning such questions has been generally recognised. Occasionally, however, the Commissioners, yielding to the petitions of fishermen or others connected with the industry, instituted inquiries of a scientific character into such points as the distinction between sprats and herrings, the destruction of immature herrings by sprat fishers, or of their spawn by trawlers.

Such investigations were, however, desultory and spasmodic. So soon as the temporary agitation which gave them birth had died away the inquiries lapsed; and from this lack of continuity little of value was accomplished.

In 1882, in response to the growing feeling that the effective management of fisheries should be based upon more extensive and accurate knowledge, and should include every branch and detail of the industry, the old Fishery Board was dissolved, and the present organisation was established in its stead. All the duties of the old Commission were relegated to the new Board, which, in addition, had to take cognisance of the coast and deep sea fisheries, and the salmon fishery; and it was further empowered

to "take such measures for their improvement as the funds under their administration might admit of." While the traditions of the old Board to some extent survived, and regulated in many ways the operations of its successor, the infusion of new blood, and the presence of one or two scientific men who fully recognised the importance of scientific investigations in connection with the fisheries, led to important departures in the consideration and treatment of fishery questions. It is needless here to defend the value of the application of scientific methods and inquiries in reference to the fisheries; but Professor Cossar Ewart and Sir James Gibson-Maitland had to contend with much official inertia and unenlightened obstruction before such methods and inquiries could be made fruitful of results. The lack of funds and of suitable appliances also at the outset hampered the scientific investigations; but means were found to gradually extend their scope as their value became more and more recognised.

A word must be said as to the means at disposal and the methods adopted for carrying on the scientific fishery work of the Scottish Board. The staff of Fishery Officers, gradually formed by the old Board, was utilised as far as possible in the collection of scientific statistics, &c., and the fishery cruisers were also made use of, so far as their defective qualities allowed, in carrying on the investigations. Temporary laboratories were established for the purpose of prosecuting systematic inquiries; but owing to financial difficulties their utility was somewhat interfered with, and even the use of the large tanks in the Rothesay Aquarium had to be discontinued. At the present time the Marine Laboratory of the Board at St. Andrews is the only one in active operation. As a matter of fact, however, a considerable amount of the scientific work in connection with the Fishery Board has been carried on in the Natural History Department of the University of Edinburgh. Two years ago the Board bought a small steamer (the "Garland"), which has been employed, so far as the annual grant permits, in active investigations into the condition of the fishing grounds, the influence of different modes of fishing in the inshore waters, the habits of the food-fishes, &c. Hitherto the results of the scientific inquiries have been incorporated with the Report on the commercial aspects of the fisheries, but arrangements have now been made for publishing the scientific portion of the Annual Report separately.

The scientific work of the Board may be grouped under three heads:

(1) Inquiries into general fishery questions, such as the influence of beam trawling, especially in inshore grounds, and of other methods of fishing; the destruction of immature fish; the supplies of bait;



the collection of special statistics ; the survey of fishing grounds, the preservation of fish, &c.

(2) Biological investigations into the marine Fauna, the structure, distribution, migrations, food, habits, &c., of the edible fishes, crustacea and molluscs.

(3) Physical inquiries into the temperature, salinity, and composition of the waters around the coast.

It is not always easy to draw a line of distinction between the first and second classes, but this division will be enough for practical purposes.

### GENERAL FISHERY INQUIRIES.

It would be out of place here to enter into details as to many of the general questions connected with fisheries which have received scientific treatment. One important investigation has been into the influence of beam trawling, especially in the inshore waters. While these inquiries have shown that a great increase of fish, and especially of flat-fish, has occurred in the waters protected from this mode of fishing, they have been the means of throwing light upon the distribution of the edible fishes, their relative abundance at different times of the year, the proportions of immature and adult fish, and other questions of practical and biological interest. These observations were made on board the "Garland" at various parts of the coast. The precise localities and the methods adopted are described in the Report for 1886,\* the results being discussed more fully in the Report for 1887,† where all the details will be found. From these observations it is evident that by continuing them for a year or two a great deal will be learned of the habits and migrations of the food-fishes. Abstracts of several papers relating to the spawning of fishes will be found below ; and a system has been devised by which continuous observations will be made throughout the entire year as to the condition of the reproductive organs and the stomach in different sized specimens of each kind of fish. By this means we shall discover (a) the minimum size of mature individuals of both sexes, (b) the duration of the spawning period, (c) the nature of the food in different seasons, (d) whether there is any variation in the amount of food taken during the period of reproduction, &c.

The collection of special scientific statistics has been particularly attended to. Besides the Tables of the amounts and values of the different kinds of fish landed, supplied by the Fishery Officers, a scheme has been adopted by having correspondents at the chief

\* Fifth Ann. Rep. Fishery Board for Scotland, Appendix F, p. 43, 1887.

† Sixth Ann. Rep., Part iii, p. 25, 1888.

fishing villages in most districts along the east coast, who furnish details regarding the daily catch, the number of boats fishing, the relative size of the fish, whether got in the inshore or offshore waters, the bait used, the condition of the weather, &c. Above forty East Coast fishermen have also been supplied with books, and keep records of their daily catches, with particulars as to state of weather and tide, depth, bait, quality and size of fish, &c., and by supplying them with charts divided into areas of square miles it will be possible to localise with greater precision the most productive localities. These statistics are given in a large number of Tables,\* and have been discussed in last year's Report.†

Another point which requires notice is the study of the appliances used in fishing, especially in relation to the capture of immature fish. Experiments are at present being carried on with specially devised trawls with the object of lessening the great destruction of young fish by this mode of fishing. Professor Ewart published a paper last year giving the results of his investigations into the kinds of herring nets used around the Scottish coast, and showing how, by the substitution of light cotton nets for the old hempen ones, and the diminution in the size of the mesh, combined with the earlier commencement of the herring fishing and the greater prevalence of surface fishing, a vastly greater proportion of young herrings are now captured than was previously the case. Other general questions regarding the sprat and herring fisheries are considered in several of the papers referred to below.

The question of bait is one of increasing importance to Scottish fishermen from the growing scarcity of supplies. The common mussel is the chief bait used, and it has been shown‡ that the East Coast line fishermen are put to great expense in order to procure the requisite supplies, and that the total yield of Scotch mussels is rapidly diminishing. The cultivation of mussels is recommended, and experiments have been begun, under the direction of Professor Ewart, with this object in view.

The condition of the shore fisheries is also demanding attention. In a paper in last year's Report§ on the *Scottish Lobster Fishery* it is shown by Professor Ewart and the writer, that the numbers of this crustacean are rapidly diminishing, and that there is a corresponding reduction in the average size of those taken.

The best modes of preserving fish have been made the subjects of exhaustive investigation by Professor Ewart, but as this is closely

\* Fifth Report, p. 82, *et seq.*, 1887.

† Sixth Report, pp. 95—188, 1888.

‡ The Scottish Mussel Fishery. J. C. Ewart. Edin., 1888.

§ Sixth Report, Part iii, p. 189.

linked with certain scientific researches referred to below it will be better to consider them together.

The Report for 1885 contains a short paper by Mr. Wilson, the Fishery Officer of the district, on the *Fisheries of the Solway Firth*;\* a similar paper on *The Fishing Grounds of the Stonehaven District*, by Mr. J. Murray, is given in last year's Report; † Professor Stirling, of Owens College, has a suggestive paper in the Report for 1885 on *Some Economic Products from Fish*, ‡ a subject which deserves far more attention in this country than it has yet received; and in the Report for 1886 Mr. C. E. Fryer, Inspector of Fisheries for England and Wales, furnishes an account of much practical value on *The Preparation of Sprats and other Fish as Sardines*.§

#### BIOLOGICAL INVESTIGATIONS.

One of the earliest questions which engaged the attention of those conducting the scientific investigations was the natural history of the herring. Several papers have appeared in the annual reports on this subject. In that for 1886 there is a long and elaborate memoir by Mr. Duncan Matthews *On the Structure of the Herring and other Clupeoids*,|| which is illustrated with four plates, and contains the fullest description of the skeleton of the herring which has yet appeared. The skeletons of the shad, the pilchard, and the sprat are also described. It is scarcely possible to give an abstract of this paper, which consists of minute descriptions of every part of the skeleton; but it forms a valuable contribution to the osteology of the Teleostean fishes. In the Reports for 1885 and 1886 Mr. Matthews has given the first and second parts of a report dealing with the question of *Variety among the Herrings of the Scottish Coasts*.¶ These papers embody the results of the examination and measurement of a very large number of herring from both the east and west coasts in winter, spring, and summer, and some idea of the extent and minuteness of this research may be obtained when it is stated that about 16,000 measurements were made. A large number of Tables are included in the report, giving the ratios of the positions of the fins, the relative length of the body and head, the

\* Fourth Report, p. 255, 1886.

† Sixth Report, p. 223, 1888.

‡ Fourth Report, pp. 256—260, 1886.

§ Fifth Report, pp. 218—221, 1887.

|| Fifth Report, Appendix F, pp. 257—292, pls. xv—xviii, 1887.

¶ Fifth Report, Append. F, pp. 61—98, 1886; Fifth Report, Append. F, pp. 295—316, 1887.

number of fin-rays, &c. The general conclusions of the author are : (1) That there is no true racial distinction between the herrings at different parts of the Scottish coasts ; (2) That the only difference in favour of a distinction between the summer and winter herring consists in the more posterior position of the dorsal, pelvic, and anal fins, the doubtfully smaller head, and the slightly lesser size of the summer herring ; but although this holds for the majority of each season, all the extremes of every variation are repeated among the herrings of both seasons.

In the Report for 1883 Mr. Matthews gives the results of his investigations into the *Difference between Herrings and Sprats*.\* Considerable differences existed among the specimens of each species examined. Various external differences are described, such as the general shape and curve of the body, the position of the operculum and suboperculum, the length of the jaw, &c. These variations are, however, slight and not always easily detected. The best distinctions are the position of the fins and the presence or absence of ventral serration. The scales of the ventral margin have the posterior termination of the median keeled portion sharp and projecting in the sprat, and scarcely developed in the herring. The number of these scales also differs in the young herring and sprat, as does also the number of the scales of the lateral line (fifty-six to fifty-eight in herring and forty-eight in sprat) and the transverse scales (sixteen and eleven or twelve respectively). In the sprat the pelvic fin is anterior to the first ray of the dorsal, but posterior in the young herring. The variations in the position of the other fins is considerable but inconstant ; and the number of rays in the fins varies, except in the pelvic, which has seven in the sprat and nine in the herring. Mr. Matthews states that the distinction based upon the presence of yomerine teeth in the herring and their absence in the sprat is difficult to determine in practice. The chief internal or structural differences are : (1) forty-eight vertebræ in the sprat and fifty-six in the herring ; (2) a less number of gill rakers and branchial filaments in the sprat ; (3) seven or eight pyloric cæca in the sprat, and eighteen to twenty-four in the herring, and they are differently arranged ; (4) in the herring each of the two anterior ducts passing forwards from the swim bladder to the head becomes spindle-shaped and bifurcates, each tubular bifurcation terminating at the ear in a spherical capsule, but in the sprat the spindle-shaped dilatation and subsequent bifurcation are absent. Thus there are four anterior spherical capsules in the herring and only two in the sprat. The most certain distinction, of course, is the presence of ripe milt or roe in the sprat. In winter the reproductive organs in young herrings

\* Second Report, Append. F, pp. 48—60, pl. iii, 1884.



and sprats could not be differentiated, but about March in many sprats they were larger, and in June the sprats were nearly all "full" and ripe, while the specimens identified on the above characters as young herring showed no signs of increasing maturity, even when eight inches long. The spawning of the sprat thus occurs in May and June on the east coast of Scotland.\* The largest sprat obtained by Mr. Matthews was six inches, the smallest one and three quarter inches, the average size being four to four and a half inches.

The intermixture of sprats with shoals of young herrings, and the great destruction of the latter by sprat fishers, are then discussed. The proportion of young herrings varied from 3 to 80 per cent. In the winter sprat fishing of 1883 along the east coast of Scotland close upon 150,000,000 young herrings were taken by sprat fishers, 98 per cent. of the total being used as manure.

I may here refer to a paper in the Fourth Report, *On the Nature of Thames and Forth Whitebait*, by Professor Cossar Ewart and Mr. Duncan Matthews.† The question whether "whitebait" forms a distinct species of *Clupea* has been often discussed. The authors, after referring to the diverse views held on this subject at various times, give the results of an examination of several thousand specimens of whitebait. Of about 6000 from the Thames, procured in monthly samples between February and August, almost every individual was either a young herring or a young sprat. The percentage of sprats varied from 95 in March to 13 in June. In the Forth the percentage of sprats was 99·5 in the winter. In both the Thames and Forth samples less than 1 per cent. consisted of other small fish, such as gobies and sand launces. In the Report for 1882 Professor Ewart published a paper on the *Natural History of the Herring*,‡ dealing with the supposed existence of varieties, the migrations, the character of the spawning ground, and the spawning process, and describing the artificial fertilization and hatching of herring ova. In regard to the first point it is shown that there is as much difference between specimens caught at the same time and place, as between the spring and autumn varieties of the Baltic herring, established by Heincke. The migrations of the herring and the causes most likely to influence them are discussed. The most important part of the paper deals with the spawning of the herring. The famous spawning grounds at Ballan-

\* This agrees with the observations of Dr. Hensen, of the Kiel Commission, who has also shown that the herring and sprat differ markedly in the mode of depositing their ova. In the sprat the eggs are translucent, dispersed and buoyant, floating freely in the water. (*Vide Fünfter Bericht der Kommis. z. wissenschaft. Untersuchung d. deutschen Meere*, p. 40, 1887.)

† Fourth Report, Append. F, pp. 98—100, 1886.

‡ Second Report, Appendix F, pp. 61—72, pls. iv—ix, 1884.



trae were surveyed, and the spawn was found in greatest abundance in the hollowed gravel-covered areas, where for many square yards it formed a layer nearly half an inch thick. The depth at the banks is from seven to thirteen fathoms, while around it, where the bottom is muddy or sandy, it is about twenty fathoms. The relations of salinity and temperature are described, and it is shown that a probable cause of the desertion of spawning grounds may sometimes be the loss of full trammel nets, which were found during the survey filled with putrefying fish. The spawning process, and the mode of fertilization, are fully described. It is shown that while the great spawning periods are spring and autumn, spawning goes on to some extent in nearly every month of the year. It is not known how long herring frequent the banks before spawning begins, but they probably remain several days after its commencement; and the males longer than the females. The appearance of the spawn as naturally deposited is described; by transferring ripe herring to the tanks in the Rothesay Aquarium, the whole process of spawning was fully studied, and a number of experiments were made as to the influence of currents, light, &c. Professor Ewart artificially fertilized and hatched herring ova, hatching occurring in from eighteen to twenty-two days; a full account of the process is given, and of the habits of the liberated fry.\*

In the Report for 1884, and in that for 1885, Mr. George Brook gives an account of his investigations *On the Development of the Herring*.† The first part consists of a *résumé* of what was already known on the subject, with especial relation to the labours of Kupffer, several of whose figures are reproduced. Kupffer's paper, *Ueber die Entwicklung des Herings im Ei*, is discussed *seriatim* chapter by chapter, notes from other papers being added. In the second paper the results of the investigations carried on at the Rothesay Aquarium with artificially fertilized ova are described. The retention of vitality by sperms and ova after the death of the adult is discussed, and a full description of the developmental phenomena is given.

In the Report for 1885, Professor Ewart gives an account of experiments carried on as to the *Development of Herring Ova in Deep Water*,‡ a subject of importance in relation to offshore fishing banks. Herring may spawn normally on the gravel-coated grounds in the North Sea in water from 60 to 100 fathoms deep; but these banks have never been well examined or surveyed. Professor Ewart

\* See also a paper *On the Natural and Artificial Fertilization of Herring Ova*, by J. C. Ewart, M.D., Proc. Roy. Soc., London, 1884.

† Third Report, pp. 32—50, pl. i, 1885; Fourth Report, pp. 31—41, pls. i, ii, 1886.

‡ Fourth Report, pp. 43—46, 1886.

experimentally proved that artificially fertilized ova can be hatched in water 98 fathoms deep, although the process is slower than in shallower water, and that the fry would have no difficulty in reaching the surface waters.

In the same Report there is a paper by Mr. Brook *On the Herring Fishery of Loch Fyne and the Adjacent Districts during 1885*.\* Many questions connected with this fishery are discussed, —the migration of the herring, its food, spawning times and places, &c. It is stated that there are probably at least two migratory races of the herring in the Firth of Clyde.

There are several papers dealing with the food of fishes. In the Report of 1885 the result of the inquiries into the food of the herring, haddock, and cod are given by Mr. Brook and Mr. W. L. Calderwood,† and in the Report for 1886 the food of the whiting is described by Mr. Duncan Matthews‡ and that of *young Gadidæ* by Mr. Brook.§ In the Sixth Report there is a paper by Mr. Thomas Scott on the *Food of the Herring and Haddock*.|| In regard to the *herring* the researches show (1) that the nature of the food varies considerably in different districts and in different seasons ; (2) that although it is probable that during the spawning time very little or no food is taken, such abstinence does not appear to be confined to the spawning season ; (3) that on the east coast most food is taken in winter and spring, and on the west coast in summer. The food comprises almost all of the smaller pelagic organisms ; and hence a study of the food of a widely distributed fish like the herring may furnish a clue to the relative abundance and distribution of the pelagic Fauna at different times of the year, on the assumption that the fish does not exercise much selection. On the east coast the chief food during winter and spring is furnished by *Hyperia galba* (a rare species on the west coast), especially in the region lying between the Firths of Forth and Cromarty. Two Schizopods supply a large amount of the herring's food, namely, *Nyctiphanes norvegica* and *Boreophausia Raschii*. On the east coast *Nyctiphanes* gradually replaces *Hyperia* after February, and it is most abundant in those areas where *Hyperia* is most scarce ; on the west coast it is widely distributed, the Schizopods forming the main diet of the herring during winter. Copepoda furnish the chief food during summer, especially on the west coast, and notably in Loch Fyne, but in autumn they are gradually replaced by Schizopods. Ostra-

\* Op. cit., pp. 47—61.

† Fourth Report, pp. 100—147, 1886.

‡ Fifth Report, pp. 317—325, 1887.

§ Op. cit., pp. 326, 327.

|| Sixth Report, Part iii, p. 225, 1888.

cods and embryo molluscs were rare, larval Decapods frequent, and *Sagitta* was abundant on the east coast in winter. At certain times and places the food consists largely of sprats or of the ova or young of the herring. On the north-east coast sand-eels form a fair proportion of the herring's food.

The food of the *haddock* was found to consist chiefly of Echinoderms, especially the common brittle-star (*Ophiothrix pentaphyllum*), but Asteridea were very rare. Crustacea came next, principally Anomura (*Pagurus*, *Galathea*), but also Brachyura (particularly *Hyas coarctatus*), Macrura and Amphipoda. Only one species of Cumacea and one of Isopoda were obtained. Twenty-one species of Mollusca were identified, almost all being young. Annelids were well represented, especially *Aphrodite* and others of the Errantia group, and Hydrozoa occasionally occurred. In eight stomachs of the ninety examined, fish remains were found, and herring ova in four, three being full of them.

About 300 stomachs of *cod* were examined, almost all from the east coast, and representing a period from January to June inclusive. These investigations demonstrate the great voracity and gastronomic impartiality of this fish. In one part of a sea-fowl was found, in another the whole of a lark. In 247 stomachs the remains of fish were found, chiefly haddock, young flat-fish (mostly flounders), herring, and whiting; in 184 there were Crustacea, almost exclusively Decapods, especially *Hyas coarctatus*, *Pagurus Bernhardus*, and *Crangon Allmanni*; in sixty-seven Annelids were present (*Aphrodite*); in forty molluscs, of which ten species, including *Eledone cirrosa*, were identified. From thirty stomachs the remains of Echinoderms were obtained, the brittle star, as in the haddock, forming the greater proportion, but no Asteroids occurred. The general conclusions in regard to the food of the cod are thus stated: (1) The cod feeds chiefly and constantly on Crustacea, Gadidæ, and Pleuronectidæ; (2) *Aphrodite* forms an important part of the food in the spring and summer in districts where this form is plentiful; (3) in the winter the cod is attracted to our shores by the large shoals of herring seeking their spawning ground, and at this time herring and herring ova form the staple food material; (4) Echinoderms and Mollusca do not contribute an important part of the food supply; (5) the cod feeds much more on fish and much less on Echinoderms than is the case with its ally the haddock.

Of the *whiting*, 400 stomachs were examined, obtained mostly during autumn and winter, and from the east coast. The food of the whiting is almost limited to small fish and Crustacea; no Echinoderms were found, and of molluscs only a few fragments of the common mussel, probably nibbled from the hooks of line fishermen.

The Crustacea (found in 53 per cent. of the stomachs) were almost wholly confined to shrimps and prawns, but they were not quite so abundant as the small fish (in 57 per cent.), chiefly young cod and haddocks and sprats. The above papers contain a large number of Tables giving full details.

The food of *young cod and saith* (which were found frequenting the *Zostera*-beds in Loch Fyne in enormous numbers) was investigated. In the case of the young cods—measuring from one and a quarter to three inches in length—the smaller specimens contained almost nothing but Copepods, and the larger ones also Amphipods, Mysidæ and Isopods. The stomachs of the young saith (two and a half to five inches long) contained Copepods, *Sagittæ*, young Gasteropods, Amphipods, Schizopods, and Isopods.

In the Report for 1884 there is a paper by Professor Ewart and Mr. Brook on the *Spawning of the Cod*\* in which an account is given of the natural process as observed in the tanks at the Rothesay Aquarium, and of experiments which were conducted in artificial fertilization. It appears that the process of spawning occurs chiefly at dusk and in the early morning, the spawn being shed while the fish are freely swimming about, and fertilized as they rise towards the surface.

Tables giving the *Spawning Period of the British Food-fishes*, compiled by Mr. Brook from various sources, will be found in the Report for 1885;† and an account of the *Spawning of the Pike*, by the same author, in the Report for 1886.‡

The *Artificial Hatching and Rearing of Sea-fish*, is dealt with by Professor Ewart in a paper in the Report for 1886.§ The fundamental problems connected with this subject are discussed in the light of the knowledge acquired by the culture of the Salmonidæ, and the operations which have been carried on in the United States, Norway, and Germany, in the cultivation of edible fish. Various apparatus for the hatching and rearing processes are described and figured; and it is pointed out that by systematic hatching and rearing of marine forms, such as the more important flat-fishes, lobsters, &c., a great deal might be done to recruit the inshore fisheries. Professor Ewart also contributed a *Report on the Progress of Fish Culture in America* to the Report for 1884,|| which contains a full account, based upon personal observation, of the methods adopted in the United States and of the results accomplished up to 1884.

\* Third Report, pp. 52—55, 1885.

† Fourth Report, pp. 242—254, 1886.

‡ Fifth Report, pp. 347—349, 1887.

§ Op. cit., pp. 230—244, pls. vii—x, 1887.

|| Third Report, pp. 78—91, 1885.



In the Report for 1883, Professor Stirling gives a paper on the *Chemistry and Histology of the Digestive Organs of Fishes*,\* which contains an account of the digestive processes in the herring, cod, haddock, and skate, and of the histology of the alimentary tract of the herring. The reactions of the various parts of the digestive canal were found to agree with those in mammals. In the herring peptic extracts were obtained from the stomach; a stronger one from the crop or "cardiac sac," and a weaker one from the gizzard-like "pyloric sac." The pyloric appendages yielded a tryptic ferment, *i. e.* were pancreatic in function, and they probably also secrete a diastatic ferment. The bile was neutral or faintly alkaline and contained a diastatic ferment. In the cod and haddock the gastric extract was purely peptic; trypsin was present in the pyloric appendages, and the bile contained a diastatic ferment. In the skate also pepsin was demonstrated in the stomach, a diastatic ferment in the bile, and glycogen and sugar in the liver. The histology of certain portions of the digestive tract in the herring is fully described.

The results of an elaborate research by Professor Ewart into the phenomena of *rigor mortis* in fish, and its relation to putrefaction,† and of another on the presence of bacteria in living fish,‡ have been recently published. In the former the gradual onset of rigor, the conditions which accelerate or retard it, and its relation to the subsequent processes of putrefaction, are set forth in detail, and a large number of experiments are described. In the latter the occurrence of bacteria in the blood and tissues of living fresh-water and marine fish is described; the causes and results of their presence being considered. In a third paper,§ Professor Ewart goes fully into the practical consequences of these researches, and gives the results of his researches into the action of various reagents and processes in the preservation of fish, together with many details and suggestions as to the best mode of applying them in practice.

Professor Stirling, in the Report for 1885, furnishes a paper on the *Red and Pale Muscles in Fishes*.|| After summarising our knowledge concerning the dark and pale muscles in animals belonging to various groups, and referring to the anatomical disposition of the muscles in an osseous fish, the arrangement and microscopical appearance of the red and pale muscles in the herring, whiting, mackerel, haddock, and plaice are described.

Dr. W. D. Halliburton, in the same Report, gives the results

\* Second Report, pp. 31—46, pls. i, ii, 1884.

† Proc. Roy. Soc., vol. xliii, p. 438, 1887.

‡ Proc. Roy. Soc. Edin., 1887.

§ The Preservation of Fish, London, 1887.

|| Fourth Report, pp. 166—170, pls. iii—v, 1886.



of an investigation on *The Blood of Nephrops norvegicus*.\* The appearance and properties of the blood when shed, the process of coagulation, the composition, the proteids of the plasma and serum, and the nature of the colouring matters are described in detail.

In the Reports for 1885 and 1886, Mr. John Wilson furnishes an account of his studies on *The Development of the Common Mussel*.† The reproductive organs, spermatozoa, and ova are described; the method adopted for artificial fertilization explained; and, especially in the second paper, a full account of the development of the embryo, so far as observed, is given.

In a series of papers read before the Royal Society, Professor Ewart has given the results of his investigations into the structure and development of the curious electric organs in the skate.

The first‡ deals especially with the development of the organ in the common skate, each step in the process of the conversion of simple muscular fibres into the highly complex electric discs having been followed. The development of the discs is very fully explained. In a second paper§ the electric organ of *Raja circularis* is fully described and compared with the corresponding organ in other species. In another paper|| the structure and development of the electric organ in *Raja radiata* are explained in detail and compared with the organs in *R. batis* and *R. circularis*, and the author shows that the less complex structure of the organ in *R. radiata* must be looked upon as evidence that it is in a state of progressive development rather than in a stage of degeneration.

Mr. R. D. Clarkson contributes a paper to the Report for 1886, *On the Nutritive Value and Digestibility of Fresh Fish*,¶ which contains a review of what has been done on this subject, the labours of Atwater, Chittenden, and others being discussed. It would appear, from the variation in the methods employed by different investigators and the diversity of the results obtained, that there is much yet to be done on this subject.

Scattered throughout the Annual Reports are several papers dealing with the marine Fauna of special localities.

Mr. W. L. Calderwood has given a list of the Copepoda obtained in Loch Fyne, with brief descriptions of each species.\*\* Twenty-eight species were collected by the tow-net, ten belonging to the

\* Op. cit., pp. 171—176, 1886.

† Op. cit., pp. 218—222, 1886; Fifth Report, pp. 247—255, pls. xii—xiv, 1887.

‡ Phil. Trans., vol., 179, p. 399, 1888.

§ Op. cit., p. 410.

|| Phil. Trans., vol. 179, p. 539.

¶ Fifth Report, pp. 221—229, 1887.

\*\* Fourth Report, pp. 147—154, 1886.

Calanidæ, fifteen to the Harpacticidæ, two to the Artotrogidæ, and one to the Cyclopidæ. The list has been since extended.

In the same report the Rev. Canon Norman supplies descriptions of *A Crangon*, some *Schizopoda*, and *Cumacea* new to, or rare in, the British Seas.\* A new species of Schizopod (*Siriella Brooki*) from Loch Fyne is described. Species here first recorded as British are: *Crangon (Cheraphilus) neglectus*, G. O. Sars; *Erythrops pygmæa*, G. O. Sars; *Mysidopsis gibbosa*, G. O. Sars; *Leptomysis lingvura*, G. O. Sars; *Siriella Clausii*, G. O. Sars; *Lamprops fasciata*, G. O. Sars; *Diastylis rugosa*, G. O. Sars; *Pseudocuma cercaria* (van Beneden). All were obtained in Loch Fyne.

Also, in the Fourth Report, there is a *List of the Marine Fauna collected at the Tarbert Laboratory (Loch Fyne) during 1885*,† by Mr. Brook and Mr. Scott. This list includes fifty-seven species of fishes, 147 species of Mollusca, 127 species of Crustacea (exclusive of Amphipods), twenty-three species of Echinoderms (exclusive of Holothurians), and forty species of Foraminifera. Those which are known to furnish food to fishes are specially indicated.

Dr. Brady, in the Report for 1886, supplies *Notes on Entomostraca*.‡ A list of fifteen Ostracoda is given, including a new variety (*Cypris virens*, var. *monilifera*, nov.) and a form (*Cypris Browniana*, Jones) previously known only in the fossil condition. In describing the occurrence of *Peltidium purpureum*, Philippi, for the first time in British seas, Dr. Brady points out that this species is not synonymous with *Peltidium depressum*, Baird (as it was doubtfully made in his classical Monograph on the British Copepoda), but that the two species are separated by characters of generic importance. Hence the three species referred to *Peltidium* in the monograph must henceforth take Baird's generic name, *Alteutha*. A full definition of the genus *Peltidium* is given.

In the Report for 1887, Dr. Brady gives a description and figures of a new Copepod, *Cyclops Ewarti*;§ and Mr. Thomas Scott of another, *Artotrogus papillatus*.|| Mr. Scott also furnishes a *List of the Crustacea of the Firth of Forth*,¶ by far the fullest yet published, several species new to Britain being described.

Mr. W. L. Calderwood, in the Report for 1885,\*\* contributes *Notes on the Greenland Shark (Læmargus microcephalus)*, em-

\* Op. cit., pp. 155—166.

† Op. cit., pp. 231—242.

‡ Fifth Report, pp. 328—330, pl. xix, 1887.

§ Sixth Report, p. 232, pl. viii, 1888.

|| Op. cit., p. 232, pl. viii.

¶ Op. cit., p. 235.

\*\* Fourth Report, pp. 228—231, pl. x, 1886.

bodying the results of his dissections of two specimens. The same gentleman, in last year's Report, furnishes *Notes on an Intra-uterine Specimen of the Porbeagle*.\*

A *Note on the Ova, Fry, and Nest of the Ballan Wrasse (Labrus maculatus)*, by Mr. Duncan Matthews, appeared in the Report for 1886.† The very curious nests of this species, the ova, and the appearance and remarkable habits of the embryo, are carefully described.

Descriptions of new or rare fishes, which have been obtained by the Fishery Officers or otherwise, have been given from time to time. Thus a new British blenny (*Lumpenus lamprætiformis*) has been described and figured by Dr. Francis Day;‡ and *Torpedo nobiliana*, *Rhombus maximus*, and *Lampris luna* have been described, and the two first figured by Professor Ewart.§ Among the rarer fishes obtained may be mentioned *Carelophus ascanii* (Walb.); *Ctenolabrus rupestris*, L.; *Centrolabrus exoletus*, L.; *Motella cimbria*, L.; *Zeugopterus unimaculatus* (Risso)—which is figured—*Pristiurus melanostomus* (Raf.), &c.|| Mr. Brook gives an account of the remarkable chromatic changes in the Dragonet (*Callionymus lyra*).¶

Several papers have appeared in the Reports dealing with pathological conditions in fish, and with the presence of micro-organisms in river-water.

Dr. Barret gives *A Note on the Liver of a Haddock, in which a Sand-eel was partly Embedded*,\*\* describing the naked-eye and microscopic appearances; and Dr. Woodhead gives an account of *Caseous Tumours found in the Muscles of the Hake*.††

There are three papers by Professor Greenfield (who was assisted in this research by Dr. Griffiths, Dr. Woodhead, and Dr. J. Gibson), *On the Examination of River-Waters for Micro-organisms*.‡‡ The object of this investigation was to discover and describe the various forms of minute fungi, and especially bacteria, which are present in river water, and which form an important factor in its impurity in relation to fish life. Specimens of water from important salmon rivers such as the Tweed, the Dee, and the Tay, were examined. Full details are given as to the methods adopted in

\* Sixth Report, Part iii, p. 263, 1888.

† Fifth Report, pp. 244—247, pl. xi, 1887.

‡ Second Report, p. 78, pl. x, 1884.

§ Op. cit., pp. 79, 80, pls. xi—xiii.

|| Fourth Report, pp. 222—227, pl. ix, 1886.

¶ Third Report, p. 68, 1885.

\*\* Op. cit., p. 70, with three plates.

†† Op. cit., p. 76.

‡‡ Op. cit., pp. 73—76; Fourth Report, pp. 176—188, 1886; Fifth Report, pp. 331—347, 1887.

obtaining the samples and in carrying on the research, and a large number of micro-organisms are described.

The results of a bacteriological investigation of "red" cod, by Dr. Alexander Edington, are given in the Report for this year,\* and a *Note on the Nature of Red Cod*, by Professor Ewart.†

In each Annual Report Prof. McIntosh has supplied a number of brief but interesting notes dealing with a great variety of topics concerning marine life, such as the ova, development, and young of fishes, the diseases of fishes, new or rare forms, &c. These notes are, as a rule, so brief and numerous that it is not possible to make an abstract of them. In this year's Report Prof. McIntosh refers to the use of Annelids as bait, and shows how pressing the question of bait is becoming.

#### PHYSICAL INVESTIGATIONS.

The investigation of the physical conditions of the sea forms an important part of the scientific work connected with fisheries. It is not, however, always easy to carry on such inquiries as thoroughly as might be desired, for it is a matter of great importance that they should be continuous, and conducted at as many points as possible. The measures adopted by the Fishery Board have consisted (1) in utilising as far as possible the fishery cruisers in the service of the Board; (2) in instituting special cruises to investigate the physical conditions of particular areas; (3) in carrying on series of observations on board the "Garland" during the trawling experiments. The data supplied from the first source have not as yet been published, owing chiefly to want of space for the extensive Tables; the "Garland's" observations have been given in the Tables in connection with the trawling reports, and the investigations into particular areas are referred to below. The system of physical inquiries is now in process of reorganisation, and it is to be hoped that it may be found possible to carry on continuous observations at several parts of the Scottish coast. Arrangements have been completed with the Northern Lighthouse Board by which daily observations on the temperature and density of the sea will be recorded by the officers on board the lightships and at the various lighthouse stations in the area embracing the estuary of the Tay, St. Andrew's Bay, and the Firth of Forth. Since this area includes that in which the principal biological investigations are going on,

\* Sixth Report, p. 207, pls. vi, vii, 1888.

† *Op. cit.*, p. 204.



and is from its conformation and the position of the observing stations singularly well adapted for obtaining data to bring the phenomena of atmospheric meteorology and marine physics into relationship with those of marine life, these observations will furnish very valuable results.

In 1883 special physical work was carried on by Dr. Gibson during a cruise of the "Jackal" in the Moray Firth. The methods and results are given in the Report for 1883,\* the paper being illustrated by a chart; several Tables showing the temperature, the density, and the ratio of total halogen to density at different depths at the various stations. In 1886, during a cruise of the "Garland" in the Moray Firth, physical observations were made by Dr. Gibson and Dr. H. R. Mill, who has done so much in the study of marine temperature. The results of these investigations are embodied in two papers in last year's Report,† which are illustrated by four plates and furnished with many Tables. In the same Report there is a paper by Drs. Mill and Gibson describing the apparatus required for marine physical observations;‡ and another by Dr. Mill (illustrated by a chart and two plates) dealing with the physical conditions of the sea to the west of Lewis.

To the Report for 1886 Dr. Mill contributed a paper *On the Physical Condition of the Firth of Forth*,§ which is accompanied by a Table giving the density, salinity, and alkalinity of the water, three plates showing the curves of salinity and temperature, and a large bathymetrical chart.

During September last H.M.S. "Jackal" was engaged in a cruise of physical investigations, under the charge of Dr. Gibson, along the east coast of Scotland, and across the North Sea to Bergen and Copenhagen. A large number of stations were formed, at which vertical series of temperature, density, and alkalinity observations were made, the gaseous constituents determined, and samples of water collected for analysis.

\* Fourth Report, pp. 189—201, pls. vi, vii, 1886.

† Sixth Report, Part iii, pp. 313—347, pls. xi—xiv, 1888.

‡ Op. cit., pp. 309—312, pls. ix, x.

§ Fifth Report, pp. 349—354, pls. xx—xxiii, 1887.



## NOTES AND MEMORANDA.

The Vernacular Names of Common Fishes.—If confusion is to be avoided it must be borne in mind that very often a vernacular name is applied to a different species at almost every different fishing port. The following analysis is intended to show the applications of vernacular names which have come within my own experience or reading.

*Names used by Plymouth Fishermen.**Acanthopteri :*

Capros aper .....	Cuckoo.
Trigla lyra .....	Piper.
Trigla hirundo.....	Tub.
Trigla cuculus.....	Red gurnard.
Trigla gurnardus .....	Grey gurnard.
Zeus faber .....	John Dorey.
Pagellus centrodontus .....	Bream (when young, Chad).
Pagellus erythrinus.....	Snapper.
Labrax lupus .....	Bass.
Caranx trachurus .....	Scad.
Callionymus lyra.....	Miller's thumb.
Atherina presbyter .....	Smelt.

*Anacanthini :*

Rhombus maximus .....	Turbot.
Rhombus lævis .....	Brill.
Solea vulgaris .....	Sole.
Solea variegata .....	Thickback.
Pleuronectes microcephalus .....	Merry sole.
Pleuronectes platessa .....	Plaice.
Pleuronectes flesus .....	Flounder.
Pleuronectes limanda .....	Dab.
Arnoglossus megastoma .....	Megrim.
Arnoglossus laterna .....	Scald-back or scald-fish.
Gadus morrhua .....	Cod.
Gadus æglefinus .....	Haddock.
Gadus pollachius .....	Pollack.
Gadus merlangus.....	Whiting.
Gadus luscus .....	Pouting or whiting-pout.
Merluccius vulgaris .....	Hake.
Molva vulgaris.....	Ling.

*Physostomi.*

Conger vulgaris .....	Conger.
Clupea pilchardus .....	Pilchard.
Clupea harengus .....	Herring.
Belone vulgaris .....	Gar-fish.

The technical names given above are in all cases those used by Day in his *Fishes of Great Britain and Ireland, 1880—1884*.

The following are the names given by Yarrell for some of the species where vulgar nomenclature is the most uncertain.

*Names given by Yarrell, British Fishes, 1836.*

<u>Species.</u>	<u>Name preferred.</u>	<u>Synonyms given.</u>
<i>Pleuronectes microcephalus</i> ...	Lemon dab, or smooth dab ...	Smear-dab; sandfleuk, <i>Edinb.</i> ; town dab, <i>Hastings</i> ; Mary sole, <i>Devonshire</i> .
<i>Arnoglossus megastoma</i> .....	The whiff .....	Carter, <i>Cornwall</i> .
<i>Arnoglossus laterna</i> .....	The scaldfish .....	Megrim, <i>Cornwall</i> ; smooth sole.
<i>Solea lascaris</i> .....	Lemon sole... ..	French sole, <i>Sussex coast</i> .
<i>Solea variegata</i> .....	Variegated sole.	
<i>Atherina presbyter</i> .....	Atherine or sandsmelt.	

With these may be compared the vernacular names given by Couch.

*Names given by Couch in his Fishes of the British Islands, 1864.*

<u>Species.</u>	<u>Name preferred.</u>	<u>Synonyms given.</u>
<i>Pleuronectes microcephalus</i> ...	Smear dab .....	Lemon dab, lemon sole, queen, smooth dab.
<i>Arnoglossus megastoma</i> .....	Carter .....	Mary sole, queen's sole?, lantorn fish, whiff.
<i>Arnoglossus megastoma</i> .....	Sail fluke (described as a distinct species).	
<i>Arnoglossus laterna</i> .....	Megrim .....	Scald-fish.
<i>Solea lascaris</i> .....	Lemon sole.....	Sand-sole.
<i>Solea variegata</i> .....	Variegated sole .....	Thickback, bastard sole, red-backed sole.
<i>Solea minuta</i> .....	Solenette .....	Little sole.
<i>Atherina presbyter</i> .....	Atherine.....	Smelt, sand smelt, guid (meaning white) in <i>W. Cornwall</i> .
<i>Gadus luscus</i> .....	Bib .....	Whiting pout, blens, blinds.

As will be seen from the above, *Pleuronectes microcephalus* is a species whose vernacular name is highly variable. In Plymouth I have never heard it called by any other name than "merry sole;" this is obviously the same as "Mary sole," which Yarrell says is applied to it in Devonshire, and by which it is known on the West Coast of Ireland (Co. Kerry). In the neighbourhood of the Firth of Forth this fish is invariably called the "lemon sole," a name for it which is mentioned by Couch. In London also it is sold under this name. Plymouth fishmongers sell *Arnoglossus megastoma*

as the lemon sole, while the fishermen of that port always call it the "megrim."

Couch gives the name Mary sole to *Arnoglossus megastoma* and megrim to *A. laterna*. As he lived at Polperro it is possible that the names are used there as he gives them, for I am informed by Mr. Dunn, of Mevagissey, that the names are applied there in quite a different way from that in which they are used at Polperro. At Mevagissey, according to Mr. Dunn, the name megrim is quite unknown, and the two species of *Arnoglossus* are called, "carter" and "scaldfish," or either of them may be called the "lanthorn;" the *Pl. microcephalus* is called the "butter-fish," but lately a few call it the "merry sole," this name having apparently been recently introduced from Plymouth. The name lemon sole appears to be confined to *Solea lascaris*. It is noticeable that both Yarrel and Couch assert that *Arnoglossus laterna* is called the megrim in Cornwall, although it is quite certain that among Plymouth fishermen megrim always means *A. megastoma*. But Couch alone ascribes the name Mary sole to *A. megastoma*, and as both Yarrell and Plymouth custom agree in giving this name to *Pl. microcephalus* perhaps Couch made a mistake.

Two flat-fishes which are common on the Scottish coasts seem to be entirely absent from the coasts of Devon and Cornwall; at least I have not yet met with a specimen of either. These are *Pleuronectes cynoglossus* and *Hippoglossoides limandoides*. The former is called the "witch," the latter the "long rough dab," on the shores of the Firth of Forth, while the former is usually called the "pole flounder" by British naturalists.

All the fishes I have given in the list of names used by Plymouth fishermen have a value in the market as food with four exceptions, namely, *Capros aper*, *Callionymus lyra*, *Arnoglossus laterna*, and *Caranx trachurus*.

**The Netherlands Zoological Station.**—Professor A. A. W. Hubrecht has kindly furnished some particulars relative to the history and work of this institution. The Netherlands Zoological Association recognised in 1875 the necessity of having an establishment on the Dutch coast suitable for anatomical and microscopical investigation of marine Fauna and Flora. A Committee was appointed to take the steps necessary for realising this scheme, but reported early in the following year that a suitable locality was not to be had in those places on the Dutch coast where a zoological station might be built with a prospect of success, and that the funds at the disposal of the Association did not permit of a permanent building being erected on a suitable scale. Accordingly, it was determined, on the

recommendation of the committee, which consisted of Drs. Hoffmann, Hoek, and Hubrecht, to purchase a movable wooden building which might be transported every season to such a locality as might be deemed desirable. The necessary funds were raised by public subscription, and in July, 1876, the station was placed for the first time on the great dyke near the seaport of Helder, opposite to the island of Texel. The work was continued for eight weeks, and was greatly assisted by a small steamer lent for the purpose by the Minister of Marine. Since this date the station has been erected at different points of the Dutch coast, such as Welfzyl, Terschelling, Nieuwe Diep, Flushing, Bergen op Zoom, Tholen, and this year at Enkhuizen on the Zuyder Zee. The original object of the station was purely scientific, and it stood at its commencement in no official relation to the Netherlands Fishery Commission, although the latter body from the first gave it encouragement and supported its applications for Government aid. Before long, however, the services of the skilled naturalists who directed the station were requisitioned for practical purposes, and in 1881, '82, and '83 elaborate investigations on the life-history and development of the oyster were undertaken by the Zoological Station, and the results were published in a separate volume under the title *Recherches sur l'huitre et l'Ostreaculture*, Leiden, 1883-4.

In 1886 the Association was brought into closer relations with the Government, being entrusted with the disposal of a grant from the funds of the Fisheries Commission, which was spent in the investigation of the life-history and development of the anchovy (*Engraulis encrasicolus*). The results of this investigation were published in the report of the Fisheries Commission for 1886, and included Wenckebach's account of the anchovy.

Recently the Netherlands Government has appointed Dr. P. P. C. Hoek as scientific investigator of the Fisheries, his duties being to investigate such fishery problems as may be brought under his notice by the Fisheries Commissioners. Dr. Hoek was from the foundation of the Zoological Station one of its most active members, and secretary of the managing committee, and on his appointment the Netherlands Zoological Society, the founders and owners of the marine station, placed the transportable building with its inventory and apparatus at the service of the newly-constituted official, on the condition that its members should always have access to the working tables and should enjoy such facilities as the naturalist might be able to afford them. Now that a definite relation between the Fisheries Commission and the Marine Station has been established, it is hoped that a permanent building may be erected, probably at Nieuwe Diep, and that the scientific knowledge of the Dutch

Fisheries may with its help be greatly increased. In the meantime the scientific work of the Dutch Station has been, considering its limited accommodation, remarkable. Although inconvenient in some respects a movable station has the great advantage of enabling the naturalists working in it to extend their researches over a wider area, and to study more perfectly the distribution of marine animals along the coast. The reports of the work done at the station have appeared yearly in the Dutch language.



ERRATUM.

Page 115, line 12, for *Gadus aeglefinus* read *Gadus merlangus*.



# Journal of the Marine Biological Association.

## LIST OF Governors, Founders, and Members.

1ST JULY, 1889.

### I.—Governors.

The British Association for the Advancement of Science, 22, <i>Albemarle Street, W.</i> .....	£500
The University of Cambridge .....	£500
The Worshipful Company of Clothworkers, 41, <i>Mincing Lane, E.C.</i> .....	£500
The Worshipful Company of Fishmongers, <i>London Bridge</i> .....	£2000
The University of Oxford .....	£500
Bayly, Robert, <i>Torr Grove, Plymouth</i> .....	£1000
Bayly, John, <i>Seven Trees, Plymouth</i> .....	£600

### II.—Founders.

\* Member of Council. † Vice-President. ‡ President.

1884 The Corporation of the City of London .....	£210
1888 The Worshipful Company of Drapers, <i>Drapers' Hall, E.C.</i> .....	£210
1884 The Worshipful Company of Mercers, <i>Mercers' Hall, Cheapside</i> ...	£315
1884 The Worshipful Company of Goldsmiths, <i>Goldsmiths' Hall, E.C.</i> ...	£100
1889 The Worshipful Company of Grocers, <i>Poultry, E.C.</i> .....	£100
1884 The Royal Microscopical Society, <i>King's College, W.C.</i> .....	£100
1884 The Royal Society, <i>Burlington House, Piccadilly, W.</i> .....	£250
1884 The Zoological Society, 3, <i>Hanover Square, W.</i> .....	£100
1884 Bulteel, Thos., <i>Radford, Plymouth</i> .....	£100
1884 Burdett-Coutts, W. L. A. Bartlett, 1, <i>Stratton Street, Piccadilly, W.</i>	£100
1888 Bury, Henry, B.A., <i>Trinity College, Cambridge</i> .....	£100
*1884 Crisp, Frank, LL.B., B.A., V.P. and Treas. Linn. Soc., 6, <i>Old Jewry, E.C.</i> .....	£100
1884 Daubeny, Captain, <i>Lutton, South Brent, S. Devon</i> .....	
1885 Derby, The Rt. Hon. the Earl of, K.G., 33, <i>St. James's Square, S.W.</i> .....	£100
1884 Eddy, J. Ray, <i>The Grange, Carleton, Skipton, Yorkshire</i> .....	£100
1884 Gassiot, John P., <i>The Culvers, Carshalton, Surrey</i> .....	£100

*1884 Lankester, Prof. E. Ray, F.R.S., 42, <i>Half Moon Street, Piccadilly,</i> <i>W.</i> .....	£100
1884 Lister, S. Cunliffe, <i>Swinton Park, Masham, Yorkshire</i> .....	£100
†1884 Lubbock, Sir John, Bart., M.P., F.R.S., <i>High Elms, Bromley, Kent</i>	£100
1884 Moseley, Prof. H. N., F.R.S., <i>Parkstone, Dorset</i> .....	£100
*1884 Poulton, Edward B., M.A., F.R.S., <i>Wykeham House, Oxford</i> .....	£100
1889 Revelstoke, Lord, <i>Membland, Yealmpton, S. Devon</i> .....	£100
*1884 Romanes, G. J., LL.D., F.R.S., 18, <i>Cornwall Terrace, Regent's</i> <i>Park, N.W.</i> .....	£100
1884 Thomasson, John P., M.P., <i>Woodside, near Bolton</i> .....	£100
1889 Thompson, Sir Henry, F.R.S., 35, <i>Wimpole Street, W.</i> .....	£100
*1887 Weldon, W. F. R., <i>St. John's College, Cambridge</i> .....	£100

### III.—Members.

*ann.* signifies that the Member is liable to an Annual Subscription of One Guinea.

*C.* signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

1888 Acland, Sir Henry W., K.C.B., F.R.S., <i>Broad Street, Oxford</i> .....	<i>ann.</i>
1885 Adami, J. G., <i>Christ's College, Cambridge</i> .....	<i>ann.</i>
1884 Adkins, J. E., <i>Yealmpton, Plympton</i> .....	<i>ann.</i>
1886 Adlard, J. E., 22½, <i>Bartholomew Close, London, E.C.</i> .....	<i>ann.</i>
1889 Aldridge, Dr., <i>Plympton House, Plympton</i> .....	<i>ann.</i>
1884 Alger, W. H., <i>Widley Court, near Plymouth</i> .....	<i>C.</i>
†1884 Allman, Prof. G. J., F.R.S., <i>Ardmore, Parkstone, Dorset</i> .....	£20
†1884 Argyll, The Duke of, K.G., <i>Argyll Lodge, Kensington, W.</i> .....	<i>C.</i>
1885 Armstrong, Lord, C.B., F.R.S., <i>Crag Side, Rothbury</i> .....	<i>C.</i>
1884 Ashworth, J. W., M.R.C.S., 40, <i>Benyon Road, Kingsland, N.</i> .....	<i>ann.</i>
1884 Bailey, Charles, F.L.S., <i>Ashfield, College Road, Whalley Range, Man-</i> <i>chester</i> .....	<i>ann.</i>
1888 Balfour, Henry, <i>Trinity College, Oxford</i> .....	<i>ann.</i>
1884 Balfour, Prof. Bayley, <i>Royal Botanic Gardens, Edinburgh</i> .....	<i>C.</i>
1888 Balkwill and Co., 106, <i>Old Town Street, Plymouth</i> .....	<i>ann.</i>
1888 Balkwill, F. H., 3, <i>Princess Square, Plymouth</i> .....	<i>ann.</i>
1884 Bateson, Miss A., 8, <i>Harvey Road, Cambridge</i> .....	<i>ann.</i>
1884 Bateson, Mrs. Anna, 8, <i>Harvey Road, Cambridge</i> .....	<i>ann.</i>
1884 Bateson, Wm., <i>Morphological Laboratory, New Museums, Cambridge</i>	<i>ann.</i>
1884 Bayliss, W. Maddock, B.Sc., <i>St. Cuthbert's, Hampstead Heath, N.W.</i>	<i>ann.</i>
1884 Bayly, Miss, <i>Seven Trees, Plymouth</i> .....	£50
1884 Bayly, Miss Anna, <i>Seven Trees, Plymouth</i> .....	£50
1888 Bean, Chas. E., 5, <i>Buckland Terrace, Plymouth</i> .....	<i>ann.</i>
1884 Beard, John, B.Sc., <i>Fishery Board for Scotland, Edinburgh</i> .....	<i>ann.</i>
1884 Beaumont, W. J., 66, <i>Clyde Road, Didsbury, Manchester</i> .....	<i>ann.</i>
1885 Beck, Conrad, 68, <i>Cornhill, E.C.</i> .....	<i>C.</i>
1887 Beddard, F. E., <i>Zoological Society's Garden's, Regent's Park, N.W.</i> ...	<i>ann.</i>
1884 Beddington, Alfred H., 8, <i>Cornwall Terrace, Regent's Park, N.W.</i> ...	<i>C.</i>
*1884 Bell, Prof. F. Jeffrey, 5, <i>Radnor Place, Gloucester Square, W.</i> .....	<i>ann.</i>
1887 Berrington, A. D., <i>Board of Trade, Whitehall</i> .....	<i>ann.</i>
1885 Bignell, Geo. Carter, M.E.S., 7, <i>Clarence Place, Stonehouse</i> .....	<i>ann.</i>

†1885	Birkbeck, Sir Edward, Bart., M.P., 10, <i>Charles Street, Berkeley Square, W.</i> .....	ann.
1885	Blandford, J. Fielding, M.D., 71, <i>Grosvenor Street, W.</i> .....	ann.
1885	Blandford, W. F. H., <i>Trinity College, Cambridge</i> .....	ann.
1885	Blundstone, E. R., <i>Christ's College, Cambridge</i> .....	ann.
1884	Bompas, G. C., 4, <i>Gt. Winchester Street, E.C.</i> .....	ann.
1884	Bossey, Francis, M.D., <i>Mayfield, Redhill, Surrey</i> .....	ann.
1884	Bostock, E., <i>Stone, Staffordshire</i> .....	ann.
1884	Bourne, Gilbert C., <i>The Laboratory, Citadel Hill, Plymouth</i> .....	ann.
1884	Bowman, Sir W., Bart., LL.D., F.R.S., 5, <i>Clifford Street, Bond Street, W.</i> .....	£20
1884	Bradford, J. Rose, B.Sc., 30, <i>Blomfield Street, Upper Westbourne Terrace, W.</i> .....	ann.
1886	Brent, Francis, F.S.A., 6, <i>Tothill Avenue, Plymouth</i> .....	ann.
1885	Brett, John, A.R.A., 38, <i>Harley Street, W.</i> .....	ann.
1886	Brooksbank, Mrs. M., <i>Leigh Place, Godstone, Surrey</i> .....	C.
1884	Brown, Arthur W. W., 6, <i>Sussex Square, W.</i> .....	C.
1884	Buckton, G. B., <i>Weycombe, Haslemere</i> .....	ann.
1886	Bullar, Miss Anna K., <i>Basset Wood, Southampton</i> .....	ann.
1887	Burd, J. S. Cresswell, <i>Higher Compton, Plymouth</i> .....	ann.
1889	Burnard, Robert, 3, <i>Hillsborough, Plymouth</i> .....	ann.
1884	Burt, Major T. Seymour, F.R.S., M.R.A.S., <i>Pippbrook House, Dorking, Surrey</i> .....	C.
1884	Caine, H. T., 5, <i>Upper Wimpole Street, W.</i> .....	C.
1884	Caine, W. S., M.P., 132 and 133, <i>Palace Chambers, Bridge Street, S.W.</i> .....	£21
*1887	Caldwell, W. H., 12, <i>Harvey Road, Cambridge</i> .....	C.
1888	Carkeet, John, C.E., <i>Ladywell, Plymouth</i> .....	ann.
1885	Carpenter, Dr. P. Herbert, F.R.S., <i>Eton College, Windsor</i> .....	C.
1887	Carter, James, F.G.S., 30, <i>Petty Cury, Cambridge</i> .....	ann.
†1884	Chamberlain, Rt. Hon. J., M.P., 40, <i>Princes Gardens, S.W.</i> .....	£22
1884	Chapman, Edward, <i>Frewen Hall, Oxford</i> .....	ann.
1884	Christy, Thomas Howard, <i>Malvern House, Sydenham</i> .....	ann.
1887	Clarke, Rt. Hon. Sir E., M.P. ....	£25
1884	Clay, Dr. R. H., <i>Windsor Villas, Plymouth</i> .....	ann.
1885	Clerk, Major-Gen. H., F.R.S., 3, <i>Hobart Place, Eaton Square, S.W.</i> £21	
1886	Coates and Co., <i>Southside Street, Plymouth</i> .....	C.
1889	Cole, A. C., 64, <i>Portland Place, W.</i> .....	ann.
1885	Collier Bros., <i>Old Town Street, Plymouth</i> .....	C.
1885	Cooke, A. H., <i>King's College, Cambridge</i> .....	ann.
1884	Crofton, Edward, 45, <i>West Cromwell Road, Earl's Court, S.W.</i> .....	ann.
1889	Crossman, Major-General Sir William, K.C.M.G., M.P., <i>Cheswick, Northumberland</i> .....	ann.
1885	Cunningham, Geo., 2, <i>King's Parade, Cambridge</i> .....	ann.
1889	Cunningham, J. T., M.A., F.R.S.E., 1, <i>Sussex Place, Plymouth</i> .....	ann.
1884	Dallinger, Rev. W. H., M.A., F.R.S., <i>Wesley College, Sheffield</i> .....	ann.
1889	Darbishire, R. D., <i>Victoria Park, Manchester</i> .....	ann.
1885	Darwin, Francis, F.R.S., <i>Trinity College, Cambridge</i> .....	C.



1885 Darwin, W. E., <i>Basset, Southampton</i> .....	£20
1888 Daw, R. Harvey, <i>Marsh Mills, Plympton</i> .....	ann.
1889 Deacon, J. Barrington, 11, <i>Osborne Place, Plymouth</i> .....	ann.
1885 Deby, Julien, C.E., 31, <i>Belsize Avenue, N.W.</i> .....	ann.
1885 Deck, Arthur, F.C.S., <i>King's Parade, Cambridge</i> .....	ann.
1885 Dendy, Arthur, B.Sc., <i>Victoria University, Melbourne, Australia</i> .....	ann.
1884 Dewick, Rev. E. S., M.A., F.G.S., 26, <i>Oxford Square, Hyde Park, W. C.</i>	
1885 Dixey, F. A., M.A.Oxon., <i>Wadham College, Oxford</i> .....	£26 5s.
1884 Dobson, G. E., Surgeon-Major, F.R.S., <i>Adingole, Spring Grove, Isleworth</i> .....	ann.
1888 Dolley, Prof. Chas. S., M.D., <i>Biological Department, University of Pennsylvania, U.S.</i> .....	ann.
1889 Doughty, Major Chester, <i>4th Batt. Shropshire Light Infantry, Hereford</i> .....	ann.
1889 Ducie, the Earl of, F.R.S., <i>Tortworth Court, Falfield, R.S.O.</i> .....	£40 15s.
1884 Duff, W. Pirie, <i>Oakfield Lodge, Champion Park, Denmark Hill, S.E.</i>	ann.
1884 Duncan, J. Matthews, M.D., F.R.S., 71, <i>Brook Street, W.</i> .....	C.
1884 Dunning, J. W., 4, <i>Talbot Square, W.</i> .....	£26 5s.
1885 Durham, A. E., <i>Christ's College, Cambridge</i> .....	C.
*1884 Dyer, W. T. Thiselton, M.A., C.M.G., F.R.S., Director, <i>Royal Gardens, Kew</i> .....	C.
1887 Ebrington, Viscount, <i>Castle Hill, North Devon</i> .....	ann.
1884 Edmonds, R. G., <i>Mount Drake, Plymouth</i> .....	ann.
1889 Elliot, George Henry, Lieut.-Col. and Paymaster R.M.L.I., <i>Plymouth</i> .....	ann.
*1884 Evans, John, D.C.L., Treas. R. Soc., <i>Nash Mills, Hemel Hempstead</i>	£20
*1885 Ewart, Prof. J. Cossar, <i>University, Edinburgh</i> .....	£25
1884 Fayrer, Sir Joseph, M.D., K.C.S.I., F.R.S., 53, <i>Wimpole Street, W.</i>	ann.
1884 Fison, Frederick W., <i>Greenholme, Burley in Wharfedale, Leeds</i> .....	C.
*†1884 Flower, Prof., C.B., F.R.S., Director of the British Museum (Natural History), <i>Cromwell Road, S.W.</i> .....	C.
1885 Fowler, G. Herbert, B.A., Ph.D., 12, <i>South Square, Gray's Inn, W.C.</i>	ann.
1884 Fox, George H., <i>Dolvean, Falmouth</i> .....	ann.
1889 Freake, Sir Thomas S., <i>Warfleet, Dartmouth</i> .....	ann.
1886 Freeman, F. F., 8, <i>Leigham Terrace, Plymouth</i> .....	C.
1884 Fry, George, F.L.S., <i>The Warren, Chobham, Surrey</i> .....	£21
1884 Fryer, Charles E., <i>Board of Trade, S.W.</i> .....	ann.
1885 Gadow, Dr. Hans, <i>King's College, Cambridge</i> .....	ann.
1884 Galton, J. C., F.L.S., <i>New University Club, St. James's Street, W.</i> ...	ann.
1887 Gamgee, Dr. A., F.R.S., 17, <i>Great Cumberland Place, W.</i> .....	ann.
1885 Gaskell, W. H., F.R.S., <i>Trinity College, Cambridge</i> .....	C.
1885 Gaskell, E. H., <i>North Hill, Highgate, N.</i> .....	C.
1884 Gibson, Ernest, F.Z.S., 1, <i>Eglinton Crescent, Edinburgh</i> .....	ann.
1885 Glennie, W. R., <i>Berkeley Lodge, Wimbledon</i> .....	ann.
1884 Godwin-Austen, Lieut.-Col. H. H., F.R.S., <i>Nore, near Bramley, Guildford</i> .....	ann.
1884 Gonne, William, 32, <i>Sussex Gardens, W.</i> .....	£26 5s.
1885 Gordon, Rev. J. M., <i>St. John's Vicarage, Redhill, Surrey</i> .....	ann.

- 1885 Gotch, F., *Physiological Laboratory, Oxford* ..... ann.  
 1888 Goulding, F. H., *George Street, Plymouth*..... ann.  
 1888 Grant, Rear-Admiral, W. B., 7, *Elliott Terrace, The Hoe, Plymouth* ann.  
 1885 Green, J. R., *Trinity College, Cambridge* ..... ann.  
 1886 Gresswell, D. Astley, 5, *Oakley Square, Camden Town, N.W.* ..... ann.  
 1884 Grove, E., *Norlington, Preston, Brighton* ..... ann.  
 1884 Groves, J. W., 90, *Holland Road, W.*..... ann.  
 1884 Gull, Sir William W., Bart., F.R.S., 74, *Brook Street, W.* ..... ann.  
 \*1884 Günther, Albert, F.R.S., *Natural History Museum, Cromwell Road, S.W.*..... ann.  
 1884 Haddon, Prof. Alfred C., M.A., *Royal College of Science, Dublin*..... ann.  
 1884 Halliburton, W. D., M.D., B.Sc., Fellow of University College, London, *University College, Gower Street, W.C.* ..... ann.  
 1884 Hannah, Robert, 82, *Addison Road, Kensington, W.* ..... C.  
 1885 Harmer, S. F., *King's College, Cambridge* ..... C.  
 1885 Harker, Allen, F.L.S., *Royal Agricultural College, Cirencester*..... ann.  
 1889 Harvey, T. H., *Cattedown, Plymouth*..... ann.  
 1888 Haselwood, J. E., 3, *Lennox Place, Brighton* ..... C.  
 1884 Haslam, Miss E. Rosa, *Ravenswood, Bolton*..... £20  
 1888 Hawker, W. H., *Burleigh, Plymouth* ..... ann.  
 1884 Hayne, C. Seale, M.P., 3, *Eaton Square, S.W.* ..... ann.  
 1884 Head, J. Merrick, F.R.G.S., *London Road, Reigate* ..... ann.  
 1884 Healey, George W., *Brantfield, Bowness, Windermere* ..... ann.  
 1884 Heape, Walter, *Northwood, Prestwich, Manchester*..... C.  
 1887 Heath, William, 24, *George Street, Plymouth* ..... ann.  
 1884 Heathcote, Fredk. G., *Trinity College, Cambridge* ..... C.  
 1884 Herdman, Prof. W. A., *University College, Liverpool* ..... ann.  
 1884 Herschel, J., Col. R.E., F.R.S., *Observatory House, Slough, Berks*... C.  
 1884 Herschel, Sir W. J., Bart., *Lawn Upton, Littlemore* ..... ann.  
 1884 Heywood, James, F.R.S., 26, *Palace Gardens, W.* ..... C.  
 1884 Hickson, Sydney J., M.A., D.Sc., *Downing College, Cambridge* ..... ann.  
 1885 Hill, Alex., M.D., *Downing College, Cambridge* ..... ann.  
 1888 Hodge, H. Cotty, *Redland House, Vinstone, Plymouth* ..... ann.  
 \*1884 Holdsworth, E. W. H., F.L.S., F.Z.S., 40, *Pall Mall, S.W.* ..... ann.  
 1884 Hope, Robert Charles, F.S.A., F.R.S.L., *Albion Crescent, Scarborough* ann.  
 1884 Horniman, F. J., *Surrey Mount, Forest Hill* ..... ann.  
 1887 Howes, Prof. G. Bond, F.L.S., *Science and Art Department, South Kensington* ..... ann.  
 1884 Hudleston, W. H., *Oatlands Park, Weybridge* ..... ann.  
 1885 Hurst, C. Herbert, *Owens College, Manchester*..... C.  
 1885 Hurst, Walter, B.Sc., *Owens College, Manchester*..... ann.  
 †1884 Huxley, Prof. T. H., LL.D., F.R.S., 4, *Marlborough Place, Abbey Road, N.W.* ..... £21  
 1888 Inskip, Capt. G. H., R.N., 22, *Torrington Place, Plymouth* ..... ann.  
 1887 Iago-Trelawny, Major-Gen., F.R.G.S., *Coldrenick, Liskeard* ..... C.  
 1885 Jackson, W. Hatchett, M.A., F.L.S., *Pen Wartha, Weston-super-Mare* ..... ann.  
 1885 James, C. H., *Ingleside, Mutley, Plymouth* ..... ann.

- 1889 Jennings, Wm. Henry, 58, *Emma Place, Stonehouse*..... ann.  
 1884 Johnson, Miss Alice, *Llandaff House, Cambridge* ..... ann.
- 1888 Keen, Miss, 1, *St. James's Place, Plymouth* ..... ann.  
 1884 Kellock, W. B., F.L.S., F.R.C.S., *Stamford Hill, N.* ..... ann.  
 1884 Kent, A. F. S., 33, *New Street, Salisbury* ..... ann.
- 1885 Langley, J. N., F.R.S., *Trinity College, Cambridge*..... ann.  
 1888 Latter, O. H., *Keble College, Oxford* ..... ann.  
 1885 Lea, A. S., M.A., *Trinity College, Cambridge* ..... ann.  
 1884 Lewis, George, 88, *Portland Place, W.* ..... ann.  
 1888 Lloyd, Fred. H., 5, *Gertrude Terrace, Exmouth* ..... ann.  
 1884 Lloyd, Thomas, *Winchester* ..... ann.  
 1884 London, The Lord Bishop of, *The Palace, Fulham, S.W.* ..... ann.  
 1888 Lopes, Sir Massey, Bart., *Maristowe, Roborough, South Devon* ..... ann.  
 1884 Lovell, Miss Matilda S., *Calke Abbey, Derby* ..... ann.  
 1887 Lundgren, F. H., 29, *St. Bartholomew's Road, Camden Road, N.*..... ann.  
 1885 Macalister, Professor, F.R.S., *St. John's College, Cambridge* ..... ann.  
 1884 Mackrell, John, *High Trees, Clapham Common, S.W.* ..... C.  
 1886 MacMunn, Charles A., *Oak Leigh, Wolverhampton* ..... ann.  
 1885 Marr, J. E., M.A., *St. John's College, Cambridge*..... C.  
 1884 Marshall, Prof. A. Milnes, M.D., D.Sc., F.R.S., *The Owens College, Manchester* ..... £25  
 1884 Mason, Philip Brookes, *Burton-on-Trent* ..... ann.  
 1885 Matthews, J. Duncan, *Springhill, Aberdeen* ..... ann.  
 1884 McAndrew, James J., *Lukesland, Ivy Bridge, South Devon* ..... £26 1s.  
 1885 McCarthy, J., 15, *Finsbury Square, E.C.* ..... ann.  
 1884 McIntosh, Prof. W. C., F.R.S., 2, *Abbotsford Crescent, St. Andrews, N.B.* ..... C.  
 1887 Methuen, Rev. T. P., 7, *Somerset Place, Bath* ..... ann.  
 1884 Michael, Albert D., *Cadogan Mansions, Sloane Square, S.W.* ..... C.  
 1884 Milne-Home, Col., *Paxton House, Berwick-on-Tweed* ..... ann.  
 1885 Mitchell, P. Chalmers, B.A., *McLean Place, Dumfermline* ..... ann.  
 1885 Mocatta, F. H., 9, *Connaught Place, W.*..... C.  
 1886 Mond, Ludwig, 20, *Avenue Road, Regent's Park, N.W.* ..... C.  
 1884 Moore, Thomas John, C.M.Z.S.L., Curator Free Public Museum, *Liverpool*..... ann.  
 1884 Morgan, C. Lloyd, *University College, Bristol* ..... ann.  
 1885 Morris, John, 13, *Park Street, Grosvenor Square, W.*..... C.  
 1885 Morrison, Alfred, 16, *Carlton House Terrace* ..... £52 10s.
- 1884 Newton, Prof. Alfred, M.A., F.R.S., *Magdalene College, Cambridge*... £20  
 1888 Nicholson, Henry Martyn, 38, *Torrington Place, Plymouth* ..... ann.  
 1884 Noble, John, *Park Place, Henley-on-Thames* ..... ann.  
 †1884 Norman, Rev. A. M., M.A., D.C.L., *Burnmoor Rectory, Fence Houses* ann.
- 1885 Oliver, F. W., *Trinity College, Cambridge*..... ann.  
 1884 Ommaney, Admiral Sir Erasmus, C.B., F.R.S., 29, *Connaught Square, W.* ..... ann.  
 1884 Ormerod, G. W., M.A., F.C.S., *Woodway, Teignmouth* ..... ann.

- 1885 Paget, Sir James, Bart., F.R.S., 1, *Harewood Place, Hanover Square, W.* ..... C.
- 1884 Parker, J. J., 54, *Eaton Terrace, S.W.* ..... ann.
- 1884 Parker, Prof. W. Newton, *University College, Cardiff* ..... ann.
- 1884 Parsons, Chas. T., *Norfolk Road, Edgbaston, Birmingham* ..... ann.
- 1887 Pechey, Miss Edith, *Cumballa Hill, Bombay* ..... ann.
- 1888 Peek, Sir Henry W., Bart., F.Z.S., *Wimbledon House, Wimbledon*... C.
- 1885 Phillips, Chas. D. F., M.D., 10, *Henrietta Street, Cavendish Square, W.* ..... C.
- 1889 Phillips, George, 1, *Victoria Place, Stonehouse* ..... ann.
- 1884 Pittock, George M., M.B.Lond., 23, *Cecil Square, Margate* ..... ann.
- 1885 Pochin, H. D., *Bodnant Hall, Eglwysbach, Denbighshire* ..... C.
- 1884 Potter, Michael C., M.A., *Herbarium, New Museums, Cambridge* .. ann.
- 1884 Powell, Thos. Harcourt, *Drinkstone Park, Woolpit, Bury St. Edmunds* ..... C.
- 1886 Power, D'Arcy, M.A., F.R.C.S., 26, *Bloomsbury Square, W.C.* ..... ann.
- 1886 Power, Henry, F.R.C.S., 37A, *Great Cumberland Place, W.* ..... ann.
- 1888 Prance, C. R., M.D., 18, *Princess Square, Plymouth* ..... ann.
- 1885 Pritchard, Urban, 3, *George Street, Hanover Square, W.* ..... ann.
- 1884 Pye-Smith, P. H., M.D., 54, *Harley Street, W.* ..... C.
- 1884 Radford, Daniel, *Mount Tavy, Tavistock* ..... ann.
- 1884 Ralli, Mrs. Stephen, *Cleveland House, Clapham Park* ..... £30
- 1885 Ransom, W. B., *Trinity College, Cambridge* ..... C.
- 1887 Riley, W., *Newcastle House, Bridgend, Glamorganshire*..... ann.
- 1884 Rowe, J. Brooking, F.S.A., F.L.S., *Lockyer Street, Plymouth*..... ann.
- 1885 Ruscoe, John, *Albion Works, Henry Street, Hyde, near Manchester*... ann.
- 1885 Saunders, Rev. J. C., M.A., *Downing College, Cambridge*..... ann.
- 1884 Schäfer, Prof. E. A., F.R.S., *University College, Gower Street, W.C.*... ann.
- 1888 Scharff, Robert T., M.D., *Science and Art Museum, Dublin* ..... ann.
- \*1884 Selater, P. L., F.R.S., 3, *Hanover Square, W.* ..... ann.
- 1884 Selater, W. L., *Indian Museum, Calcutta*..... ann.
- 1885 Scott, D. H., M.A., Ph.D., *The Laurels, Bickley, Kent* ..... C.
- \*1884 Sedgwick, A., M.A., F.R.S., *Trinity College, Cambridge* ..... C.
- 1888 Serpell, E. W., 19, *Hill Park Crescent, Plymouth* ..... £50
- 1885 Sheldon, Miss Lilian, *Newnham College, Cambridge* ..... ann.
- 1884 Shipley, Arthur E., M.A., *Christ's College, Cambridge* ..... ann.
- 1886 Shore, T. W., M.D., *St. Bartholomew's Hospital* ..... ann.
- 1889 Simpson, Francis C., *Maypool, Churston Ferrers, R.S.O., S. Devon* ann.
- 1889 Slade, Lieut. E. J. Warre, R.N., 3, *Outram Terrace, Stoke, Devonport* ..... ann.
- 1884 Sladen, W. Percy, Sec. Linn. Soc., *Orsett House, Ewell, Surrey* ..... ann.
- 1884 Smith, Robert Mackay, *Edinburgh*..... C.
- 1884 Sowerby, William, *Royal Botanical Society, Regent's Park, N.W.* .. ann.
- 1884 Spence, J., 121, *Lewisham Road, Lewisham, S.E.* ..... ann.
- 1888 Spencer, Prof. W. Baldwin, M.A., *Victoria University, Melbourne*... ann.
- 1884 Spring-Rice, S. E., 113a, *Queen's Gate, W.* ..... C.
- 1884 Stalbridge, The Rt. Hon. Lord, 12, *Upper Brook Street, W.*..... ann.
- 1884 Staples, Alderman, 87, *Avenue Road, Regent's Park, N.W.* ..... ann.



- \*1884 Stewart, Prof. Chas., F.L.S., *Royal College of Surgeons, Lincoln's Inn* ..... ann.
- †1884 Sutherland, The Duke of, K.G., *Stafford House, St. James', S.W.* ... C.
- 1888 Swayne, W. Paul, M.R.C.S., *The Crescent, Plymouth* ..... ann.
- 1889 Taylor, Thomas George, 6, *St. Mary Street, Stonehouse* ..... ann.
- 1884 Thompson, Prof. D'Arcy W., *Dundee*..... ann.
- 1884 Thornycroft, John I., *Eyot Villa, Chiswick Mall*..... ann.
- 1888 Thurston, Edgar, *Government Central Museum, Egmore, Madras* ... ann.
- 1888 Tripe, Major-General, 3, *Osborne Villas, Stoke, Devonport* ..... ann.
- 1889 Tweedy, W. Gage, 8, *Athenæum Terrace, Plymouth* ..... ann.
- 1885 Tylor, E. B., D.C.L., F.R.S., *Museum House, Oxford*..... ann.
- 1884 Upcher, Henry R., *Sherringham, Cromer* ..... ann.
- 1888 Vallentin, Rupert, 18, *Kimberley Road, Falmouth* ..... ann.
- 1884 Venning, Mrs., 3, *Wingfield Villas, Stoke Devon*..... £50
- 1884 Vines, Professor Sydney H., M.A., D.Sc., F.R.S., *Botanical Gardens, Oxford*..... ann.
- 1884 Walker, Alfred O., *Nantglyn, Cohwyn Bay, N. Wales*..... ann.
- 1884 Walker, Rev. F. A., D.D., *Dun Mallard, Cricklewood* ..... ann.
- 1884 Walker, P. F., 36, *Princes Gardens, S.W.* ..... ann.
- †1884 Walsingham, Lord, F.R.S., *Merton Hall, Thetford*..... £20
- 1884 Welch, H. Kemp, 32, *Onslow Gardens* ..... ann.
- 1884 Wilson, Scott B., *Heather Bank, Weybridge Heath* ..... C.
- 1888 Wood, G. W., F.I.C., F.C.S., *Ballagawne, Riggindale Road, Streatham, S.W.* ..... ann.
- 1884 Woodall, John W., *St. Nicholas House, Scarborough* ..... ann.
- 1884 Woollcombe, W. G., M.A., F.R.A.S., F.L.S., *Cathedral Close, Exeter* ann.
- 1886 Woollcombe, Surgeon-Major R. W., 14, *Acre Place, Devonport* ..... ann.
- 1889 Yerbury, Major, *Royal Artillery, Devonport*..... ann.

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#### IV.—Associate Members.

- 1889 Alward, George, *Fish Dock Road, Great Grimsby*.  
 Caux, J. W. de, *Great Yarmouth*.  
 Dunn, Matthias, *Mevagissey*.  
 Olsen, O. T., *Fish Dock Road, Great Grimsby*.  
 Ridge, B. J., 3, *Gainsboro' Place, Mutley, Plymouth*.



## Report of Council, June 26th, 1889.

THE Council has met nine times during the past year, and the meetings have been well attended.

The members of the Council have been informed through the periodical reports of the Director (Mr. Bourne) and the Naturalist (Mr. Cunningham), of the condition of the Laboratory and the progress of the work at Plymouth, and the business transacted by them has had reference to the course of work to be pursued at the Laboratory and the provisions necessary for such work.

The Council are able to report a satisfactory year's work since the opening of the Laboratory at the end of June, 1888.

The various arrangements in the tank-room and laboratories have stood the test of a year's work, and prove to be well adapted for their purposes. Some slight defects have come to light and some unavoidable mishaps have occurred, but the former have been remediable and the number of the latter has been fewer than might have been expected. There has been some trouble from the bursting of the feed pipes and delivery pipes of the pumps, but these have been put right.

The Council are glad to report that the system of circulation adopted by them for the aquarium fulfils all their expectations. At first it was feared that the density of the water in Plymouth Sound, which is some degrees below that of the open sea, would interfere seriously with hatching operations. But in the last six months the density has been maintained without trouble at the normal point, and spring-water has to be added every week to make up for evaporation. The water in circulation is perfectly aerated, and marine animals thrive well in it. The tank-room has been thrown open to the public free of charge, every Wednesday afternoon, and the Director reports that it is always crowded on these occasions.

The staff of servants in the employ of the Association consists of an engineer and caretaker (C. Marshall, wages thirty shillings per week), whose wife receives £18 per annum for cleaning and dusting the building; a laboratory servant (J. Walker, fifteen shillings per week), whose duties are confined to attendance in the Laboratory; a gardener (W. Hortop, nine shillings per week, remainder of wages paid by the Director); a fisherman (W. Roach, thirty shillings per week), and a fisherman's boy (ten shillings per week).

The boats used by the Association consist of a hook and line half-decked fishing boat of five tons, hired at £1 per week, and an 18-foot open boat bought by the Association, and called the "Anton Dohrn," after the founder of the Naples station. When long expeditions have been made, a steam-tug has been hired for the occasion. The special fund for the purchase of a steamboat, started last year, has reached the sum of nearly £500, but this amount falls far short of that required for the purchase of a really seaworthy vessel.

Dredging, surface-netting, and rock-hunting have been carried on continuously throughout the year, under the superintendence of the Director and Naturalist. Many species have been added to the list, published last year, of the Fauna of the Sound, and some of these are new to Great Britain.

The area of Plymouth Sound was carefully mapped out into districts and explored by the Director in the summer of 1888. It is found that the Fauna within the breakwater is poorer than it was some years since, and the best dredging-grounds are found south of the Mewstone and eastward into Bigbury Bay, and on the soft ground around the Eddystone Lighthouse.

In connection with the dredging work a collection of standard specimens is being made, a work which will necessarily take some years before it is completed.

The Council has always been mindful of researches bearing directly on fishery questions, and besides collecting all available information on fishery matters, they have directed special researches upon food-fishes and Crustacea.

The Director of the Association (Mr. G. C. Bourne, M.A.), besides his work of superintendence and organisation, is employed on a thorough investigation of the pelagic life of the seas near Plymouth. Special results of his work will appear from time to time, but it must necessarily be long before he can assert any connection between seasons or temperature and the abundance of pelagic life on the one hand, and between the latter and the abundance of certain fish on the other.

The Naturalist (Mr. J. T. Cunningham, M.A.) has continued his researches on the development of Teleostean fishes. The preliminary results of his researches appeared in the first number of the new series of the Journal, and form a very valuable contribution to our knowledge of this subject. Mr. Cunningham, acting under instructions from the Council, is now preparing a monograph of the common sole, which will be published at the end of the year.

The Council have appointed for six months Mr. Wm. Bateson, M.A., Fellow of St. John's College, Cambridge, to conduct a series of experiments and observations on the physiology of the sense organs of

food-fishes, with the special view of discovering whether any form of bait can be devised to supplement in times of scarcity the natural baits in general use. Mr. Bateson began his researches early in April.

Mr. W. F. R. Weldon, M.A., Fellow of St. John's College, Cambridge, has spent seven months of the past year in continuing his researches on the Decapod Crustacea of the Plymouth district. An important memoir on larval Decapods by Mr. Weldon is now ready for publication. Mr. Weldon is also engaged in the preparation of a monograph of the spiny lobster or crawfish (*Palinurus vulgaris*), and is conducting experiments on the artificial cultivation of the common lobster. The expenses incident to Mr. Weldon's researches have been defrayed by a grant from the Government Grant Fund of the Royal Society entrusted by the Government Grant Committee to the President of the Association, the Hon. Secretary, Professor Moseley, and Mr. Adam Sedgwick.

Mr. Walter Garstang, B.A., Assistant to the Director, has been employed on faunistic researches, especially upon the Composite Ascidians and the Nudibranchiate Mollusca.

In addition to the above, several volunteer workers have taken advantage of the Laboratory at Plymouth for pursuing zoological studies. In the summer of 1888 the following gentlemen were working at Plymouth: Mr. W. B. Hardy, B.A.Camb. (Development of *Porifera*); Mr. C. A. MacMunn, M.A., M.D. (Colouring Matter of Invertebrata); Mr. F. E. Beddard, M.A., Prosector Zoological Society (Marine *Oligochæta*); Professor Burdon Sanderson, F.R.S.; and Mr. Francis Gotch, M.A. (Electric Organs of Skates and Rays).

In the spring of this year the following gentlemen were at work: Mr. S. F. Harmer, M.A.Camb. (Anatomy and Development of *Dinophilus metameroides*); Mr. P. C. Mitchell, B.A.Oxon. (Histology of *Tunicata*); Mr. W. B. Hardy, B.A.Camb. (Physiology of *Myriothela phrygia*); Surgeon P. W. Fraser, R.N. (General Zoology).

During the summer there will be more than twelve naturalists working in the Laboratory, and the Director has been instructed to have four additional bays fitted up on the south side of the Laboratory to meet their requirements.

In order to keep up a connection with practical fishermen, the Council has submitted bye-laws providing for the admission of associate members, which were passed at a special general meeting called for this purpose on May 8th, 1889.

Amongst the receipts of the past year the Council have to report the following donations and subscriptions:—A donation of £500 from Mr. R. Bayly for bait investigation; a donation of £105 from the Drapers' Company; £100 from Mr. H. Bury; £200 from the British

Association for the Advancement of Science, to complete their contribution of £500 as Governors of the Association; £100 from the Clothworkers' Company, to complete their contribution of £500 as Governors of the Association; £200 from the Fishmongers' Company; and £500 from H.M.'s Treasury, being their Annual Subscriptions for five years from 1888.

From annual subscriptions and compositions £201 was received, in addition to £45 for rent of tables, specimens, &c., £128 interest on investments, and £340 towards a launch.

The expenditure, as shown in the Treasurer's account presented herewith, amounted to £5363, which includes £3735, the balance of the contracts.

The Association has now in hand, in cash and invested, £2550.

The Library has received important additions during the past year, but many works are still required to make it complete. The Lords Commissioners of H.M. Treasury have been pleased as an exceptional measure to present a complete set of the "Challenger" publications to the Association, and the Council wish to record their gratitude for this valuable gift. The thanks of the Association are also specially due to Professor A. A. W. Hubrecht for many zoological works collected in Holland and forwarded by him; to Professor Franz Vejdovský for a gift of his works on oligochaete worms; to Mr. W. T. Thiselton Dyer for a present of the back numbers of the Quarterly Journal of Microscopical Science; to the executors of the late R. Holman Peck for books and scientific materials and apparatus; to Professor G. B. Howes for a complete set of Buffon's *Histoire Naturelle*; to Messrs. J. and A. Churchill for current numbers of the Quarterly Journal of Microscopical Science; to Sir Henry Acland for several valuable works on zoology; to Mr. Rupert Vallentin for a copy of Forbes' rare monograph of the British Naked-eyed Medusa; to Dr. Brady and the Rev. A. M. Norman for a copy of their recent monograph of the Marine and Freshwater Ostracoda; to Professor Marion for the *Annales du Musée d'histoire naturelle de Marseille*; to Professor Alexander Agassiz, the Naples Zoological Station, the University of Copenhagen, the Liverpool Marine Biological Society, and the Marine Fisheries Society of Japan, and also to many naturalists for sets of their scientific papers.

The Council desire to record the indebtedness of the Association to the Councils of the Royal Society and the Linnæan Society for kindly permitting the Association to hold the periodic meetings of the Council and Association in their rooms.

The Council regret to have to announce that Mr. Frank Crisp, who has since the foundation of the Association been its Honorary



Treasurer and most valued adviser, finds it necessary, on account of the large demands on his time, to withdraw from the office which he has held with so much advantage to the Association. Mr. Crisp will remain a member of the Council, and continue to give the Association the benefit of his wide experience, but having helped the Association through the heavy work of collecting funds and superintending the contracts and similar matters connected with the erection of the Plymouth Laboratory, he desires to pass on his office to other hands. Mr. Crisp has been a generous subscriber to the funds of the Association, but the legal and administrative work which he has freely given to its service has been of a value which the Council can only indicate by the expression of their warmest gratitude.

The Council propose Mr. E. L. Beckwith, late Prime Warden of the Fishmongers' Company for election as Honorary Treasurer in succession to Mr. Crisp.

The Council of the British Association for the Advancement of Science having acquired the power of electing a Life Governor, have appointed Prof. Flower, C.B., F.R.S., as their representative. Mr. Bazley White, of the Clothworkers' Company, owing to other numerous engagements, has been obliged to resign his post as Governor.

The following is a list of Officers and Vice-Presidents proposed by the Council for the year 1889—1890.

*President.*—Professor Huxley, LL.D., F.R.S.

*Vice-Presidents.*—The Duke of Argyll, K.G., F.R.S.; The Duke of Sutherland, K.G.; The Duke of Abercorn, C.B.; The Earl of St. Germans; The Earl of Morley; Lord Walsingham, F.R.S.; The Right Hon. A. J. Balfour, M.P.; The Right Hon. Joseph Chamberlain, M.P.; Prof. G. J. Allman, F.R.S.; Sir Edward Birkbeck, Bart., M.P.; Prof. Flower, C.B., F.R.S.; Sir John Lubbock, Bart., M.P., F.R.S.; Prof. Alfred Newton, F.R.S.; Rev. A. M. Norman, D.C.L.; Captain Wharton, R.N., F.R.S.

*Council (elected members).*—C. Spence Bate, Esq., F.R.S.; Prof. F. Jeffrey Bell, F.Z.S.; W. H. Caldwell, Esq., M.A.; Frank Crisp, Esq., LL.B., B.A.; W. T. Thiselton Dyer, Esq., C.M.G., F.R.S.; John Evans, Esq., D.C.L., F.R.S.; Prof. J. Cossar Ewart, M.D.; A. C. L. G. Günther, Esq., F.R.S.; E. W. H. Holdsworth, Esq., F.L.S., F.Z.S.; E. B. Poulton, Esq., M.A., F.R.S.; G. J. Romanes, Esq., LL.D., F.R.S.; P. L. Selater, Esq., F.R.S.; Adam Sedgwick, Esq., F.R.S.; Prof. Charles Stewart, F.L.S.; W. F. R. Weldon, Esq., M.A.

*Hon. Treasurer.*—E. L. Beckwith, Esq.

*Hon. Secretary.*—Professor E. Ray Lankester, LL.D., F.R.S.



Treasurer's Account of Receipts and Payments for the Year ending 31st May, 1889.

1888.		RECEIPTS.		PAYMENTS.	
June 1.	Balance brought forward:	£	s.	£	s.
	£500 Forth Bridge Railway, 4% Debentures	995	2 6		
	£800 London and North Western Railway 4% Debentures	989	11 7		
	£933 North Eastern Railway 4½% Debentures.	1253	3 2		
	Deposit	500	0 0		
	Cash in Bank	1469	11 2		
		£5207	8 5		
	Cash Balance on 1st June, 1888.			1969	11 2
	Founder			100	0 0
	Compositions			47	5 0
	Annual Subscriptions			154	7 0
	Donations:				
	General	610	1 0		
	Mr. Bayly's Bait Investigation	500	0 0		
	Lanch	340	4 0		
				1450	5 0
	H. M.'s Treasury			500	0 0
	Interest on Investments			128	16 9
	Rent of Tables, Specimens and Journals sold			45	13 10
	Securities sold:				
	£433 North Eastern Railway 4½% Debenture Stock	613	18 4		
	£800 London and North Western Railway 4% Debenture Stock	1050	14 0		
				1664	12 4
				£6060	11 1
				1738	6 2
				1014	3 0
				444	0 0
				250	0 0
				200	0 0
				55	17 9
				33	15 0
				203	14 0
				486	12 1
				250	0 0
				19	12 4
				533	7 11
				104	2 3
				16	11 8
				5	0 0
				2	5 0
				5	16 8
				697	7 3
				£6060	11 1
				697	7 3
				1131	15 0
				725	0 0
				2554	2 3

Summary of Assets.

Balance as above	697 7 3
£900 Forth Bridge Railway 4% Debenture Stock at 125¼%	1131 15 0
£500 North Eastern Railway 4½% " 145%	725 0 0
(N.B.—The above prices are those current on June 1st, 1889.)	2554 2 3

## The Director's Report.—No. 2.

THAT most of the memoirs published in the present number of the Journal are purely zoological or botanical may seem to belie the promise made in my first report, that the Journal was to contain scientific memoirs bearing directly or indirectly on economical questions. Some of the papers describing the local Fauna have, in fact, an indirect bearing on fishery questions, for it is only by a study of marine life as a whole and by the knowledge of the habits of a large number of marine animals that we can hope to deal in a satisfactory manner with problems relating to the fisheries. It must not be understood that the papers published in the Journal represent the whole even of the purely scientific work of the Association. Much research is in progress, the results of which will be published in other scientific serials or in the Transactions of the learned societies, and will receive bare mention in these pages ; other work is being done which will never be published at all because it is tentative, and it would be a waste of time to publish accounts of a series of fruitless experiments. The late Lord Beaconsfield, when he was laughed down on making his maiden speech in the House of Commons, finished by saying, " I have tried many things many times and I have found that I have generally succeeded in the end." The same saying will apply to scientific researches directed towards particular objects. Many experiments must be made ; they must be made many times and they will generally result in failure, but in the end some success will be gained. That the greater part of this number of the Journal is not devoted to fishery matters is due to the fact that the experimental record of the past six months is largely a record of failures, not by any means indicating a waste of time or a want of skill on the part of those who have made the experiments, but showing that the problems which have been undertaken are difficult, and that time, patience, and experience are required before they can be worked out. The report of the Council gives an account of the practical work which is being carried on under its direction, and a further reason for the non-appearance of much fishery work in these pages is that Mr. Cunningham's valuable work on the life-history of the common sole is to be published as a separate volume.

Mr. Bateson's work on the physiology of the sense organs of fishes

is in full progress, but it will be some time before he will be in a position to publish on the subject. A few chance observations on the habits of animals other than fishes which have come under Mr. Bateson's notice are given in this number, but his observations on food-fishes are withheld until the publication of his complete work.

A contribution from Mr. Earle, of Jamaica, is published as showing the primitive condition of the fisheries in one of our colonies, and in future numbers similar contributions from other colonies will be published.

In order that the nature of the work carried on by the staff of the Association may be understood, and the difficulties encountered in attempts to cultivate and study sea-fish may be appreciated, a short sketch is here given of the progress of the Laboratory since the beginning of this year.

In the first months of the present year, immediately after my last report was written, the Laboratory was deserted by everybody excepting the permanent staff of the Association, viz. Mr. Cunningham, Mr. Garstang, and myself. Mr. Weldon, who had stayed at Plymouth up to Christmas, was obliged to return to Cambridge to resume his duties as Lecturer on Zoology in the University, and there were no gentlemen who could spare the time to continue their observations through the winter months.

In the months of December and January herrings visit the south coast of England in large numbers and deposit their ova in bays and estuaries. At this time large numbers are taken by small boats working with two or three drift-nets in Plymouth Sound; accordingly the first practical investigation of the year was a renewed study of the habits and development of the herring. The ova of the herring, as is well known, differ from those of the majority of food-fishes in being heavier than sea-water; they adhere in masses to rocks and weeds at the bottom of the sea and can only be obtained by the dredge or, of course, directly from the ripe fish. Mr. Cunningham obtained a number of fertilized ova in the latter manner, and these were hatched in the tanks in the Laboratory. The larvæ lived and were apparently very healthy up to the time of the absorption of the yolk-sac, but after that they all perished, as it seems, from want of suitable nourishment. Mr. Cunningham tried to feed them in many different ways, but none of his experiments met with any success. In January, Mr. Cunningham and I made several expeditions to Bigbury Bay, Cawsand Bay, and the coast near Raeme Head, with the view of obtaining the spawn of the herring by means of the dredge. Although we dredged over a large area in which full and shotten herring were being caught every night we did not succeed in hitting on the spot where ova were deposited. At the same time we obtained numbers

of the free-swimming fry of the herring, some of them very recently hatched and with the yolk-sac not yet absorbed, in the surface net.

In March I was present at the explosion of some submarine mines in the mouth of the St. Germans river and obtained a number of young herrings which were killed by the explosion. Some of these were very small and apparently belonged to the January brood of the year, but the majority were larger and must have been hatched out in the early months of 1888.

During the early part of February the weather was very rough and we were for some time prevented from carrying on dredging outside the breakwater. On the 12th of the month, being favoured with a fine northerly breeze, we chartered a trawler and succeeded in making a large haul of plaice, flounders, and other fish. Nearly all the plaice and flounders were ripe, and Mr. Cunningham fertilized and brought back a large number of these species, which were hatched out in the aquarium, and the larvæ lived, as those of the herring had done, until they had absorbed the yolk-sac, after which the same difficulty was found in feeding them and they all perished. At the same time Mr. Cunningham obtained the ova of the sprat and the dragonet (*Callionymus lyra*) and was able to verify some of his previous observations on these species.

The difficulty of feeding the young fry constitutes a serious difficulty to the cultivation of sea-fish. Similar difficulties have been experienced by the American Commissioners of Fisheries, who have had recourse to turning out the larvæ into the sea at the time of the absorption of the yolk-sac. Captain Dannevig, of Arendal in Norway, has been more successful and has hatched out and kept for three years herring, cod, and other valuable fishes. He keeps his fry in a large basin or tidal tank into which the sea is admitted directly by means of sluice gates. In this tank Captain Dannevig is able to grow seaweeds and to mimic the natural conditions of the sea very nearly to perfection. For some reasons which we cannot yet satisfactorily explain we are unable to keep seaweeds in the sheltered tanks of our aquarium, and in consequence we cannot supply that profusion of minute life on which the existence of the young fry depends. Success in rearing fish is probably to be obtained only by the use of tidal ponds into which the newly hatched fry can be turned loose.

In January the surface-net contained little else than Copepods of different species, and when it was attempted to feed the fry of fish with the material collected in the surface-net we found that these Copepods, instead of affording food for the young fishes, were themselves the aggressors, and attacked and destroyed the larvæ. The more delicate pelagic organisms which are so abundant in the



summer months, did not make their appearance till the middle of February, when larvæ of Echinids, Asterids, Holothurians, Molluscs and Worms began to make their appearance in great numbers. At the same time many species of Copepoda were breeding, the females carrying ovisacs, and the surface was swarming with the Nauplii of pelagic Copepoda and Cirrhipedes. There can be no doubt that these larval forms afford abundant food for young fish. At a somewhat later date a gelatinous Alga made its appearance in the sea, and proved a great hindrance to the investigation of pelagic animals. With the appearance of the Algæ the surface larvæ began to diminish in numbers, and towards the end of April we obtained little else than Copepods and Algæ in the surface-net. Similar facts have been noticed by the Liverpool Marine Biology Committee off the west coast of Lancashire and Wales.

The temperature of the sea last February was higher than it was in March, 1888, being  $45^{\circ}$  Fahr. on the 12th February, against  $44\cdot6^{\circ}$  and  $43\cdot88^{\circ}$  on March 8th and 16th, 1888. It is possible that the somewhat higher temperature of the sea this year had some effect in pushing forward the development of many marine animals, and also in promoting the growth of the gelatinous algæ, for in a visit made to Plymouth in April, 1888, I do not remember to have heard of any trouble from the presence of the latter.

Up to April in this year the temperatures of the sea and the water in the aquarium had been taken intermittently, but since that date they have been kept regularly and entered in a book, and will be published in a tabular form after a sufficient time has elapsed for making comparisons of the seasonal variations. The water in circulation in the tanks is naturally at a somewhat different temperature to that in the sea, and the following facts may be of some interest. From April 2nd to April 11th the weather was fine and warm, and the water in the tanks varied from  $48^{\circ}$  to  $48\cdot5^{\circ}$  Fahr., the sea temperature at the same time varying from  $46^{\circ}$  to  $47^{\circ}$  Fahr. On the 12th April the temperature of the tanks fell to  $47\frac{1}{2}^{\circ}$ , and remained at this till the 22nd, when it regained its previous temperature and rose to  $49\cdot6^{\circ}$ , at which it remained till May 4th. During this time the sea thermometers were under repair, and we were unable to take observations. On May 7th the sea near the Shagrock was  $50^{\circ}$ , and the water in the tanks  $50\cdot9^{\circ}$ . By the 15th the temperature had risen to  $52\cdot3^{\circ}$  in the tanks and  $54^{\circ}$  in the sea, whilst on the 23rd it was  $53\cdot6^{\circ}$  in the tanks and  $56^{\circ}$  in the sea. The temperature of the sea rose to  $57^{\circ}$  on June 4th,  $58^{\circ}$  on June 8th, and  $59^{\circ}$  on June 22nd, the tank temperatures for the corresponding days being  $53\cdot9^{\circ}$ ,  $58\cdot6^{\circ}$ , and  $58\cdot8^{\circ}$ . By July 1st the sea temperature had risen to  $60^{\circ}$ , and that of the tanks to  $60\cdot8^{\circ}$ .



The highest sea temperature recorded by us this year was 62° on July 13th, the tanks on the same day being 60·6°. These observations are interesting chiefly from showing how closely the temperature of the water in the aquarium follows that of the sea. In mid-winter, the water in the tanks being sheltered, and to some extent warmed by the hot pipes in the building, stands at a rather higher temperature than the sea, but in the summer it is generally rather below it, though seldom more than a fraction of a degree.

To resume the account of the work carried on at the Laboratory. At the end of February the Laboratory fisherman, W. Roach, was sent to Mount's Bay in a trawler to procure the fertilized ova of the whiting (*Gadus æglefinus*) and pout (*Gadus luscus*). The weather turned out very cold and boisterous, and during his week's work Roach was not only unable to keep alive the ova that he collected but caught a chill and was laid up for some days afterwards, so that dredging operations were nearly at a standstill. On March 15th the Steam Tug "Deerhound" was hired for the day, and we dredged all around the Eddystone Lighthouse in twenty-five to forty fathoms of water. Several interesting specimens were taken on this occasion.

Towards the end of March, the Universities' Lent term being over, several gentlemen came down for a month's work at Plymouth. Mr. Harmer soon discovered a new species of the interesting genus *Dinophilus* in rock pools below the Laboratory, and the anatomy of this animal forms the subject of a memoir in the present number of the Journal. Mr. Harmer also examined the larvæ of many species of Polyzoa. Early in April the staff of the Laboratory was increased by the arrival of Mr. W. Bateson, whose appointment by the Council for the purpose of inquiring into the physiology of the sense organs of fishes has already been mentioned. The primary object of Mr. Bateson's researches is to discover whether fish are attracted to their food by sight alone, or smell alone, or both, if by smell alone what odours are attractive to them, and the reverse, whether different fishes react differently to the same stimulus, and the like, and it is expected that his observations will be of great practical benefit. It may not be generally known to those who do not live near the sea that hook-and-line fishermen often have the greatest difficulty in procuring bait. A long line or bulter of 2000 hooks requires a large quantity of bait, and this must be fresh, whether it consists of muscles, whelks, pilchards, herrings or squid, these being the baits most sought after by fishermen. But the supply of mussels and whelks has been drawn upon to such an extent that they are very difficult to procure in many places, and for the supply of pilchard and squid the line fisherman is entirely dependent on the drift and seine netters and the trawlers. If after a spell of

bad weather or scarcity of net-fish these have brought no pilchard and squid into the market, the hook-and-line men are unable to go out, though the sea may be full of hook-fish. This often is the case, and if by any means a bait could be devised which would make the hook-and-line fishermen independent of supplies from present sources they would be very greatly benefited.

On the 9th of April the Laboratory fisherman when dredging south of the Mewstone brought up an adult specimen of *Amphioxus lanceolatus*, and on the following day I went out with him and obtained another specimen. Since then a few more have been procured. As I mentioned in my last report I took four larval *Amphioxus* in the tow-net last autumn in nearly the same locality, and there can be no doubt that *Amphioxus* exists in considerable numbers in this spot, but it is very difficult to catch them. They are found in a bottom of muddy gravel at a depth of sixteen fathoms. Such a depth can only be explored by the dredge, and this does not dig deep enough into the sand to ensure the capture of more than a few chance specimens. The rapidity with which *Amphioxus* burrows is surprising; one of the specimens caught in April was kept for some time alive in the Laboratory, and it was astonishing to see the speed with which it thrust itself to the bottom of the shingle placed in the vessel which contained it.

Towards the end of April the commencement of the Universities' Summer Term took away most of the gentlemen who had come down to work in the Laboratory. During April and May the dredge brought up a large number of Nudibranch Mollusca, and these, together with other specimens procured at different times, have been studied by Mr. Garstang. No less than nineteen of these are new to the Plymouth district, among them the exceedingly rare species *Idalia aspersa* and *Lomanotus marmoratus*. Mr. Garstang's paper in this number gives an account of the Nudibranchs collected by the Association.

The pelagic Copepoda collected by the surface-net during the past year have occupied my attention, and I am able to add a species new to Great Britain, viz. *Oncaea Mediterranea*. I have also obtained a few specimens of the beautiful Annelid larva *Mitraria*, which, as far as I know, is also new to Great Britain.

In the last number of the Journal I described a *Tornaria* larva which was obtained in the neighbourhood last autumn. I am now able to include the adult *Balanoglossus* among the Plymouth Fauna. On July 31st a single specimen was obtained in the dredge about two hundred yards inside the east end of the breakwater. Mr. Bateson believes that it is a male specimen of *B. salmoneus*, but as it has lost its proboscis and is otherwise mutilated, it is difficult to

determine its species with accuracy. A fortnight before the discovery of this specimen I obtained later stages of the larva off the south coast of Ireland. *Balanoglossus* is a genus new to Great Britain, but from the occurrence of the larva in such widely separated localities, it would seem that it has a tolerably wide distribution on the southern coasts of England and Ireland.

Towards the end of June the Laboratory began to fill again, and at the time of writing all the available space is occupied. Amongst the gentlemen working on the Fauna are Canon A. M. Norman and Mr. A. O. Walker, and their researches on the smaller Crustacea have already added several new species to the district. Of these the Stomatopod *Anchialus agilis*, G. O. Sars, may be mentioned as new to Great Britain, and it is interesting to record that two species of Amphipods new to Great Britain, *Lysianax ceratinus* and *Tryphosa gæsi*, found by Mr. Walker in Liverpool Bay a month since have again been discovered by him in the Plymouth district.

Since the General Annual Meeting the Association has acquired a small steam launch, the "Firefly," thirty-eight feet long. This boat is by no means an ideal steamer for dredging purposes, being suitable only for local expeditions in calm weather, but as such she is of great service, for there are many days, and especially many nights, in summer when it is impossible to get about in sailing boats owing to frequent calms.

One of the latest experiments in boats was not fortunate. Mr. Weldon in 1888 failed to rear young lobsters in the tanks beyond a certain stage, and he determined to repeat his experiment this year under more natural conditions. Accordingly he purchased the hull of a disused trawler and converted it into a well-vessel, the central well being separated from the fore and aft portions of the hold by strong bulkheads and communicating with the sea by ports cut in the side of the vessel below the water-line and covered with horse-hair cloth. This vessel was moored in a suitable place in the Sound, and at the beginning of July some thousands of larval lobsters were placed in the well. For a fortnight everything went well and the young lobsters were thriving so well that the experiment bade fair to be a complete success. Most unfortunately the vessel sprung a leak on July 20th and before she could be towed ashore she sank in four fathoms of water and all the young lobsters escaped, annihilating the chance of bringing the experiment to a successful issue this year. It might have been better to have constructed a tidal pool similar to that of Captain Dannevig at Arendal, or to have built a new well-vessel rather than convert an old hull, but in either case the expense was prohibitory and the cheaper method proved a failure. This mishap is a good instance of the difficulty

of obtaining a definite result in practical investigations in any given year. At the time of the foundering of the welled vessel the breeding season of lobsters was nearly past, and before fresh apparatus could be arranged for hatching and rearing the larvæ the season was fully past and the experiment impossible.

The names of the gentlemen who have worked or are working at Plymouth since January 1st are given in a table below.

G. C. BOURNE.

*August 9th, 1889.*

Naturalists working in the Plymouth Laboratory from January to August, 1889 (in addition to the permanent staff):

<i>Name.</i>	<i>Date of arrival.</i>	<i>Date of departure.</i>
W. F. R. Weldon, M.A., St. John's College, Cambridge.	... March 20	... April 24
S. F. Harmer, M.A., B.Sc., King's College, Cambridge.	... March 22	... April 20
W. B. Hardy, B.A., Caius College, Cambridge.	... March 26	... April 9
P. C. Mitchell, B.A., Christ Church, Oxford.	... March 24	... April 24
W. Bateson, M.A., St. John's College, Cambridge.	... April 1	
Surgeon P. W. Fraser, R.N. ... ..	... May 3	... July 2
G. H. Fowler, B.A., Ph.D., Keble College, Oxford.	... June 19	
W. F. R. Weldon, M.A., St. John's College, Cambridge.	... June 19	
M. C. Potter, M.A., St. John's College, Cambridge.	... June 24	... July 6
S. F. Harmer, M.A., King's College, Cambridge.	... June 26	
T. T. Groom, B.A., Christ's College, Cambridge.	... July 15	
Rev. A. M. Norman, D.C.L.,	... July 23	
A. O. Walker, Esq. ... ..	... July 29	... Aug. 5
T. Johnson, B.Sc. ... ..	... July 29	
A. E. Shipley, M.A., Christ's College, Cambridge.	... Aug. 1	
H. Driesch, Ph.D., Jena, Germany.	... Aug. 3	
P. C. Mitchell, B.A., Christ Church, Oxford.	... Aug. 3	



## Notes on the Anatomy of *Dinophilus*.

By

**Sidney F. Harmer, M.A., B.Sc.,**

Fellow and Lecturer of King's College, Cambridge.

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With Plates IX and X.

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THE anatomy of *Dinophilus*, a genus established by Oscar Schmidt in 1848, has formed the subject of several memoirs, amongst which attention must be specially called to the recent papers of Korschelt (6), Repiachoff (12), and Weldon (13). A complete account of the synonymy of the genus was given by v. Graff\* in 1882, whilst Korschelt (7) has, within the last year or two, published a review of the facts known with regard to the anatomy of the various species of *Dinophilus*. Full references to the literature of the subject will be found in v. Graff's monograph (loc. cit.) as well as in the memoirs of Weldon (13) and Korschelt (6 and 7). In view of the recent appearance of the above-mentioned papers, it is unnecessary for me either to give a complete list of references or to attempt any historical account of our knowledge of the genus.

The animal which forms the subject of the present paper was found at Plymouth†, and has been described as a new species, under the name *Dinophilus tæniatus*, at a meeting of the Cambridge Philosophical Society.‡

*D. tæniatus* was found, in very great numbers, in rock-pools far above low-water mark, during the latter end of March and the first half of April. It was unfortunately necessary to interrupt the observations on April 18th, a day or two before which time it was noticed that the eggs which were being produced by the females were rapidly developing. On returning to Plymouth on June 26th no trace of the animal was discovered. Other observers, as Hallez (4) and Weldon (13) have recorded the fact that the species of *Dinophilus* which they have respectively described are only to be found during the spring.

\* v. Graff, L., Monographie der Turbellarien. I. Rhabdocelida. Leipzig, 1882, p. 1.

† The study of the anatomy of *Dinophilus* was greatly facilitated by the excellence of the arrangements of the Laboratory of the Marine Biological Association, to the Director of which, Mr. G. C. Bourne, I desire to express my best thanks for the courtesy with which I have been treated during my visits to Plymouth.

‡ Proc. Camb. Philosoph. Soc., vol. vi, 1889.



It will not be superfluous to call attention to the fact that the bright orange colour which is so conspicuous a feature of *D. tæniatus* (as of certain other species of *Dinophilus*) cannot easily be regarded as a protective colouration. The rock-pools inhabited by this species of *Dinophilus* contain numerous bright green Algæ, and there is not the slightest difficulty in detecting with the naked eye individuals of *D. tæniatus*, whether crawling on this green background or on the mud or rocks which occur at the bottom of the tide-pool.

With regard to the habits of the animal, it may be noted that, so far as I am aware, it never performs those gyrations round a centre formed by the attachment of the tail to a foreign body, which have been described as of frequent occurrence in *D. metameroïdes*, for instance (4). The animal crawls (no doubt by means of its cilia) with considerable rapidity, but it is able to swim freely in the water; the latter method of progression appears to be specially characteristic of young individuals.

**Specific Characters.**—*Dinophilus tæniatus* is characterised as follows: Head with two circlets of præoral cilia. Body composed of five segments and a tail. Segments sharply marked off from one another in young individuals, each encircled by two rings of cilia, incomplete ventrally, where they are interrupted by the uniform ciliation of the ventral surface. Anus placed dorsally to the base of the conical unsegmented tail, surrounded by a ring of cilia, incomplete ventrally. Skin containing large numbers of transparent glandular bodies. Sexes not dimorphic. Maximum length, in either sex, about 2 mm. Colour bright orange, usually brighter in the male than in the female. Testes in the male extending nearly the whole length of the body, on the ventral and lateral sides of the alimentary canal; spermatozoa very long and undulating. Vesicula seminalis formed by the modification of the fifth nephridium on each side, opening into a median copulatory organ, whose external aperture is ventral and slightly posterior to the anus. Ovaries in the female four-lobed. Nephridia ten in number (five pairs), the fifth pair modified as a vesicula seminalis in the male. Ventral nervous system segmented.

As characters recognisable in living specimens, and which are sufficient to distinguish this species from all others at present known may be mentioned the following:

(1) The existence of five body-segments (in addition to the tail), each encircled dorsally and laterally by *two* rings of cilia; the segmentation being sharply marked in immature individuals.

(2) The four-lobed condition of the ovaries in the female.

(3) The existence, in the male, of a median penis and of lateral

vesiculæ seminales (in which respect, however, *D. vorticoides* may possibly be found to agree with *D. tæniatus*).

The characters above given appear to be amply sufficient to justify the formation of a new species. The species which most resembles *D. tæniatus* is probably *D. gigas*, Weldon, which, however, differs from it in such important features as the number of the segments, the arrangement of the ciliated rings, the general character of the reproductive organs, and more particularly the absence of a copulatory organ in the male sex.

**External Features.**—The form of the body is shown in Pl. IX, fig. 1, which represents a rather young individual (the distinctness of the cilia having been somewhat exaggerated). In an old animal, distended with ripe generative products, the external segmentation is not nearly so conspicuous as in the specimen figured. The arrangement of the cilia is often difficult to make out in living specimens, but may be very easily observed after treatment with hot corrosive sublimate, and before the extraction of the orange pigment by means of alcohol. In specimens thus treated, the cilia appear as white bands running over an orange background; when seen from the dorsal surface, the two rings of each segment together give rise to the impression that the middle region of the segment is encircled by a broad band; this appearance has suggested the specific name *tæniatus*.

The ciliation of the head is best studied in a sublimate specimen, seen from the anterior pole (fig. 8). The general surface of the head is not ciliated, the cilia occurring, on the contrary, as two definite præoral rings, between which are situated the eyes, near the dorsal surface. The anterior ring is more or less triangular, the apex of the triangle being directed dorsally.

In looking at the animal from above, it is seen that the posterior cephalic ring passes dorsally across the equator of each of the eyes (fig. 1). This ring, unlike all the other ciliated rings of the animal, is composed of several circlets of cilia. Of these, the first consists of long cilia directed forwards, and the third or last of somewhat shorter, backwardly-directed cilia. Between the two circlets occurs an intermediate series of very minute cilia (figs. 1, 15). It follows from this description that in structure, as in position, the second cephalic ring resembles the præoral ciliated band of a Trochosphere larva. No ciliated pits were observed. The head bears long, stiff sense-hairs arranged in two groups, situated within the area circumscribed by the anterior ciliated ring (fig. 1). Similar sense-hairs occur on various parts of the body and tail.

The study of longitudinal sections, in which, however, the cilia were not very well preserved, appeared to show that the second præoral

ring becomes much broader in approaching the ventral surface, and that it becomes indistinguishable from an investment of cilia which clothes the ventral surface of the head and which passes continuously into the ciliated lining of the œsophagus (cf. fig. 3). The examination of the ciliation of the ventral surface of the head is always difficult in fresh specimens, but at the time when these were accessible to me, I believed that I could convince myself that the anterior circlet of the second præoral ring passed completely round the head, as shown in fig. 15. The most satisfactory way, it appears to me, of reconciling the apparent discrepancy between fig. 3 and fig. 15, is to assume that, whilst the anterior circlet of the second præoral ring does really pass continuously round the ventral surface of the head, the middle and posterior circlets become, ventrally, an extensive ciliated area which is continuous with the ciliated lining of the œsophagus.

The arrangement of the five pairs of ciliated rings which occur on the body and of the perianal ring is sufficiently explained by fig. 1. All these rings are interrupted by the cilia which cover, in a uniform sheet, the entire ventral surface of the body and of the tail.

**Alimentary Canal.**—The mouth occurs on the ventral surface, at the limit between the head and the first segment of the body. The aperture of the œsophagus is guarded by two lip-like structures, an outer and an inner. Of these, the former constitutes the outer wall of a triangular space (fig. 15) which includes in front the aperture into the œsophagus, and behind the end of the tongue-like structure formed by the muscular appendage of the œsophagus. The arrangement of this organ is well seen in the longitudinal section figured (fig. 3), where it will be noticed that the end of the muscular appendage (which is covered by a modified, probably hardened epidermis) projects into the space enclosed by the outer lip. A similar arrangement is figured by Repiachoff (No. 12, pl. iv, fig. 1) in *D. gyrociliatus*, whilst the disposition of the organ appears, from Weldon's description (13), to be somewhat different in *D. gigas*.

In front of the tongue-like structure is seen the aperture into the œsophagus (fig. 15). This aperture is subtriangular, and is bounded by the two richly ciliated inner lips.

The course of the alimentary canal is shown in fig. 3. The œsophagus ascends obliquely towards the dorsal surface, the lateral walls of its first part being thickened (*v.* fig. 10), and passing continuously into the inner lips. The posterior section of the œsophagus lies very near the dorsal skin, and is lined by cells which have a more glandular appearance, and which bear longer cilia than those which line the anterior two thirds of the œsophagus. The posterior division corresponds to the proventriculus ("Vormagen") described by Korschelt in *D. apatris*.

As in other species of *Dinophilus*, racemose salivary glands open into the anterior division of the œsophagus.

The stomach (which, during life, is of a rich orange colour) is ciliated throughout: it ends cæcally on the dorsal side of the commencement of the intestine, as in *D. gigas*.

The intestine, like the rest of the alimentary canal, is ciliated. It opens into the stomach by a narrow aperture situated on the ventral side of the latter.

As will be seen by reference to fig. 1, the œsophagus and its muscular appendage belong to the first segment of the body, the stomach occupying the second, third, and fourth segments, whilst the intestine is found in the fifth and posterior part of the fourth segment.

**Nervous System.**—Although Korschelt (6) and Repiachoff (12) succeeded in finding the brain of *D. gyrociliatus*, our knowledge of the nervous system of *Dinophilus* is in the main due to Weldon (13), who has not only described the brain, but has shown that this structure is connected with ventral cords, whose arrangement resembles that found in *Protodrilus* (v. Hatschek, No. 5).

The nervous system of *D. tæniatus* exhibits a feature which has not hitherto been described in any species of *Dinophilus*. The ventral cords are distinctly segmented, the number of ganglionic enlargements—five—corresponding with that of the segments of the body.

The ventral cords (figs. 3, 10 and 11) are situated outside the basement-membrane of the skin, and lie, widely separated from one another immediately, on the median side of the longitudinal muscles (as in *D. gigas*). The cords seem to be provided with an external investment of ganglion-cells along their whole length. The ganglionic swellings (fig. 3) appear to be shifted backwards, relatively to the segment to which they respectively belong, so that the middle of the segment on the dorsal side (as indicated by the ciliated rings) is in front of the corresponding ganglion.

In transverse section (fig. 10) it may be seen that each pair of ganglia is connected by a transverse commissure. I could not satisfy myself of the existence of ganglion-cells in connection with this commissure, although, as the whole ventral nervous system lies in the ectoderm, it is possible that some of the nuclei which are adjacent to the commissures may really belong to ganglion-cells, and not to the epithelial portion of the skin. No transverse commissures were discovered other than those which pass between the ganglia.

The brain is very large, and fills up nearly the whole of the præoral lobe (figs. 3, 9). It consists internally of fibres, and externally of numerous ganglion-cells arranged in groups. The structure of the brain is very complicated; its surface appears lobulated, owing to



the arrangement of the ganglion-cells. A similar arrangement is figured by Repiachoff (12, pl. ii, fig. 10).

The brain gives off a pair of strong œsophageal commissures (fig. 9), which pass round the sides of the mouth to become connected with the ventral cords, as has been described by Weldon in *D. gigas*. The brain itself is, for the most part, separated from the skin by the basement membrane of the latter. The œsophageal commissures at first lie inside the basement-membrane, but perforate the latter shortly before they become continuous with the ventral cords.

On the ventral side, in front and on the median side of the origin of the œsophageal commissures, the brain becomes continuous with the ectoderm at two points, one on each side of the middle line (cf. fig. 6). It is probable that the tactile organs of the head itself receive their nerve-supply from this region of the brain, which, however, sends off at the same point an œsophageal nerve (figs. 6, 9, and 10) which may be traced, on each side of the œsophagus, as far as the end of the latter; these nerves were not observed to occur in the proventriculus. The œsophageal nerve supplies the wall of the œsophagus itself, and gives off a branch which can be traced as far as the surface of the muscular appendage.

The eyes, which are of a bright red colour, lie on the dorsal surface of the brain, immediately below the basement-membrane of the skin (fig. 9). Each consists of a double pigmented sac, filled with a clear substance, which no doubt functions as a lens. In surface view (fig. 1) the cavity of the eye is not seen, but it is shown in the horizontal section, fig. 7. Remembering that the plane of the section, fig. 9, is at right angles to that of the section, fig. 7, the difference between the two eyes in the former is readily accounted for by the obliquity of the section.

The ventral part of the head is provided with a pair of small sacs, each of which has an extremely fine lumen opening to the exterior at one side of the anterior portion of the mouth (fig. 9). These bodies are presumably sense-organs, since they are supplied by the above-mentioned œsophageal nerves. Similar organs are described by Repiachoff (12, pl. iv, figs. 1, 3, *y*) in *D. gyrociliatus*, in which species it must be noticed that they occur in addition to lateral, cephalic, ciliated pits.

**Body-cavity.**—The body-cavity is represented partly by irregular spaces in the loose connective tissue, as described by Weldon in *D. gigas*, and by Repiachoff in *D. gyrociliatus*, partly by more definite spaces, which seem to be specially connected with the internal ends of the nephridia. In males which are sexually mature, by far the greater part of the space between the alimentary canal and the skin is taken up by the very largely developed generative organs (*v.*



fig. 13). The further relations of the body-cavity may be conveniently considered in connection with the excretory and reproductive systems.

**Nephridia.**—Like *D. gyrociliatus*, as figured by Ed. Meyer (11, and as described, on Meyer's authority, in Lang's Polycladen, p. 678), *D. tæniatus* possesses five pairs of nephridia, whose arrangement is in some respects different from that of the same organs in *D. gyrociliatus*. It may be at once noted that the occurrence, in two species so distinct as *D. gyrociliatus* and *D. tæniatus*, of five pairs of nephridia, raises the question whether the body may not possibly consist of five metameres throughout the genus *Dinophilus*, in spite of variations in the number of the ciliated rings. Thus, according to Korschelt (6), Repiachoff (12)\* and Meyer (11), *D. gyrociliatus* is characterised by the possession of seven post-oral ciliated rings (one of which is perianal), in spite of which fact there only five pairs of nephridia. It may, however, be noted that Korschelt figures (pl. xxii, fig. 43) a recently hatched (female) individual, in which the body consists of six segments, sharply marked off from one another, in addition to the tail.

In the female *D. tæniatus* the five pairs of nephridia are all alike, whilst in the male the fifth pair is modified as a part of the generative apparatus. The fifth nephridia of the female occur in the fifth segment of the body, on the ventral side of the intestine (behind the cæcal end of the stomach). The fourth nephridium has exactly the same position with regard to the stomach as the fourth nephridium of the male; it lies behind the posterior ovarian lobe. The third nephridium is situated between the two lobes of the ovary, whilst the second and first nephridia are in the same position as in the male sex.

The following, more detailed description refers entirely to the male, in which the nephridia can be more easily investigated than in the female. The general arrangement of the system may be understood from fig. 15, which illustrates the anatomy of a male *D. tæniatus* as seen from the ventral surface under a compressorium. The figure of course represents the combined results of a long series of observations, but it must be premised that the opacity of the animal was sufficient to prevent any complete elucidation of the structure of the nephridia.

The first four pairs of nephridia may be considered together. Each nephridium opens to the exterior on the ventral side of the body, and probably not far from the longitudinal nerve-cords. The observation of the exact point where the nephridium pierces the skin

\* Repiachoff is strongly of opinion that there is no specific difference between Korschelt's *D. apatris* and the earlier described *D. gyrociliatus*.

was extremely difficult, but it may be taken as probable that the external aperture, in each case, is at a level between the two rings of cilia possessed by the segment to which a given nephridium belongs. The inner end of the first nephridium is very slightly behind the principal (second) præoral ring of cilia; this nephridium opens to the exterior on the first body-segment, and may be regarded as the equivalent of the head-kidney of a Trochosphere larva. The second nephridium commences at the anterior end of the stomach, runs at first dorsal to the testis, then bending round to open to the exterior on the ventral surface of the second segment. The third nephridium lies at the level of the middle segment, and, like the second, has its excretory portion situated on the dorsal surface of the testis, its duct curving round to open ventrally on the third segment. The fourth nephridium lies, in the fourth segment, on the ventral surface of the stomach, its internal end occurring close to the aperture from the stomach into the intestine. Its duct, unlike the ducts of the second and third nephridia, runs entirely ventral to the testis.

The internal end of each of the above nephridia lies in a perfectly definite space, which contains an orange fluid and which is probably merely a specialised portion of the general body-cavity. It is almost certainly the case that the spaces which surround the internal ends of the nephridia are continuous with one another, as shown on the right side of fig. 15. In the case of the first three nephridia, the space in question lies on either side of the alimentary canal, and in living specimens was usually most readily distinguishable in the region of the third nephridium, as a distinct cavity, apparently without proper walls, between the stomach and the membrane of the testis. In transverse sections it could usually be seen that this part of the body-cavity extended to the ventral side of the stomach (*v.* fig. 13), whilst in the region of the fourth nephridia, the median portion of the cavity was, in most specimens, observed to pass down ventrally as far as the skin, thus dividing the testis, in this region, into two symmetrical, right and left lobes. In the median space thus formed are situated the internal ends of the fourth nephridia.

The remainder of the general body-cavity consists of a meshwork of spaces, filling up the intervals between the various organs and the skin. These spaces are, like those described by Weldon in *D. gigas*, devoid of an epithelial lining. Many of the cells which bound these lacunæ are large, branching connective-tissue cells, which contain an orange pigment. The pigmented cells are usually more numerous in the male than in the female, their pigment in the female being often markedly paler in colour than in the male, whilst (in the female) their tint tends to be yellow rather than orange. The difference in the colouration of the two sexes, above alluded to

in the description of the specific characters, is dependent on the condition of the connective-tissue cells.

Each nephridium (of the first four pairs) consists of three portions: (i) the ciliated appendage; (ii) the excretory portion; (iii) the duct. The entire nephridium is almost certainly composed of a small number of perforated cells, although no nuclei were discovered: it forms a moderately short tube, without convolutions, the curvature of the tube, as actually observed, doubtless depending to some extent on the position of the animal in the compressorium. Thus the differences between the nephridia of the two sides in fig. 15\* probably imply nothing more than that the direction of the compression was not the same in all the observations made.

The excretory portion of the nephridium is of a distinct greenish-yellow or orange colour, the walls of this portion of the tube containing numerous colourless vacuoles, and granules of various sizes. One or two of the granules are very frequently large and deep orange in colour. The excretory portion is pear-shaped, the narrow end shading off insensibly, by gradual loss of the vacuoles and granules, into the duct. The first nephridia seem to be usually provided with two swollen portions, whose walls contain excretory granules and vacuoles, instead of with one only, as in the case of the remaining excretory organs. The nephridium is often suspended in a cord of the above-mentioned pigmented connective-tissue cells.

The internal end of the nephridium is composed of a triangular, ciliated appendage, the apex of which is inserted into the excretory portion of the tube. This insertion, in the case of the second, third, and fourth nephridia, takes place at some little distance from the proximal end of the excretory portion. The appendage is ciliated, the cilia together giving the appearance of a pointed flame-like structure which projects obliquely into the excretory portion of the organ. In certain conditions of the nephridium the ciliated appendage has exactly the appearance of a flame-cell, although as the animal dies and the cilia become more sluggish in their movements, the flame-like appearance is lost. I am inclined to believe, as the result of a long series of observations, that the appendage is provided with a number of cilia, which, working together, produce the optical illusion of a vibratile flame. This is almost certainly true of the portion of the tube described above as the duct, this region being undoubtedly lined by cilia, which, under certain conditions, give rise to a very flame-like effect.

In spite of having devoted a large amount of time to the observation of the ciliated appendages, I am unable to say whether or not

\* The form of each nephridium representing the result of one or more actual observations, made at different times.

these structures open into the portion of the body-cavity which undoubtedly surrounds them. In some cases the appendage appeared distinctly bifid (fig. 15), whilst in others it had a fimbriated appearance, and seemed to be composed of a large number of minute, elongated, pear-shaped bodies, each attached by its narrow end to the point where the appendage as a whole passed into the excretory portion of the tube. These minute bodies vibrated individually (*i. e.* not in connection with their neighbours) in the body-cavity space in which they were situated. These observations do not appear to favour the view that the ciliated appendage contains a single vibratile flame, nor indeed to render it easy to suppose that the appendage opens into the body-cavity.

At the same time, it must be noted that the ciliated appendages of the first nephridia are somewhat larger than those of the other nephridia, and that several observations were made which seemed to show that the appendage did really open into the body-cavity. In one of these cases I believed that I could see the individual cilia of the appendage projecting into the body-cavity. It is not impossible that the anterior nephridia have attained a somewhat higher degree of differentiation than the remainder.

The proximal end of the excretory portion, into which the cilia of the appendage project, as above described, does not seem to be ciliated, whilst the lumen of this region of the nephridium appears to be often in the condition of a series of isolated vacuoles rather than of a single passage continuous with the cavity of the rest of the organ. Cilia make their appearance towards the end of the pigmented portion, and can be followed uninterruptedly, from that point, as far as the external aperture. The "duct" has extremely delicate, colourless walls, and, as just stated, is richly ciliated internally.

**Generative Organs.**—A. *Male.*—The testes consist at first (as is shown by the examination of young individuals) of minute, paired, linear cords of cells (fig. 11), lying on the ventral side of the stomach in the general connective-tissue of the body.\* It appeared probable that the testicular cells were simply differentiated connective-tissue cells. Owing to an injury to the tail end of the individual from which fig. 11 was drawn, it could not be ascertained whether or not a penis was already developed.

At a slightly later stage the cords of cells which constitute the young testes are found to have become slightly expanded in a lateral

\* It is not impossible that this and the next stage described may really be young conditions of the *female* generative organs, and that, for instance, the structure described as the penis may be the unpaired oviduct. I believe, however, that I am right in identifying the animals in question as young males.



direction, so as to form a pair of narrow, horizontally placed plates of cells, still separate from one another. The penis is already developed as a hollow mass of cells attached in its definitive position by a narrow stalk to the ventral ectoderm of the body. There is no connection between the testes and penis, nor could any vesiculæ seminales be identified with certainty in the sections on which the observation of this stage was made. As development proceeds, the lateral extension of the testes goes on increasing, and the two originally separate rudiments fuse from place to place across the middle line. The testis now consists of a solid plate, composed of a few layers of cells, extending along the ventral side of the stomach, and still showing obvious traces of its double origin. The testis next extends laterally round the stomach, still composed of a solid mass of cells. In the final condition, some of these sperm mother-cells are found in groups in various parts of the testis, whilst ripe and half-ripe spermatozoa are found moving about freely in the indefinite cavity which is by this time excavated in the interior of the organ. The testis is separated from the body-cavity by a distinct membrane.

Although, in the adult condition, the testis is constantly continuous across the middle line in its anterior and posterior regions, it is usually divided into two lateral halves, in the region of the aperture from the stomach into the intestine, by a median extension of the body-cavity, which, as already explained, contains the internal ends of the fourth nephridia. The testis, in its most fully-developed form, extends from the region of the muscular appendage of the œsophagus nearly as far as the anus, as shown in fig. 15.

Unripe spermatozoa are found, attached together in sperm-morulae, in the cavity of the testis. The fully developed spermatozoon (fig. 4) is an extremely long, actively moving, undulating fibre. It hence closely resembles in form the spermatozoon of *D. vorticoides* as described by van Beneden (1) and Mereschkowsky (10) excepting that Mereschkowsky describes and figures a swollen head in the spermatozoon of *D. vorticoides*. I believe that no such structure occurs in *D. tæniatus*, although at the time when fresh material was accessible to me I was not familiar with Mereschkowsky's paper.

Although ripe spermatozoa may be found in any part of the adult testis, they are always present at its posterior end, if they have anywhere reached their mature condition. As has been already explained, the testes are fused together across the middle line in the region of the fifth body-segment, and the ripe spermatozoa which accumulate in this part of the organ are taken into the interior of a pair of vesiculæ seminales (v. fig. 15). In their most fully developed condition these structures are much larger than in the figure



just alluded to (cf. fig. 3), and occupy a large proportion of the cavity of the fifth segment.

The connection between the testis and the vesiculæ seminales is by no means easy to discover in sections, but can be best made out by careful compression of the living animal. Under these conditions, it may be observed that the anterior end of the vesicula seminalis is quite closed, and that the communication with the testis is effected by the agency of a ciliated funnel, which passes forwards from the posterior end of the vesicula, and somewhat from its ventral surface, to open into the posterior median region of the testis (fig. 15). This region is reduced to a narrow space between the two vesiculæ seminales (and therefore ventral to the intestine) during the condition of full distension of these structures by spermatozoa.

The funnel and the adjoining part of the inner wall of the vesicula are ciliated, but I believe that cilia do not occur in all parts of the latter. The vesiculæ seminales never contain unripe spermatozoa, although mature, actively moving spermatozoa are to be found in the cavity of very young and small vesiculæ, even when no such spermatozoa could be seen in the testis itself. This implies that the spermatozoa tend to make their way to the posterior part of the testis as soon as they become ripe.

It is perhaps worth while to mention that the above account of the communication between the testis and the vesicula seminalis has been confirmed, in its general features, by the study of sections.

The fully developed vesiculæ seminales are regularly ovoid in form, with their principal axes parallel to the main axis of the body of the animal. The posterior pole of each vesicula passes into a very obvious duct, which opens laterally into the sheath of the copulatory organ.

The generative pore is a median structure, situated on the ventral side of the base of the tail, a little posterior to the level of the anus (figs. 3, 15). The pore opens into a vestibule, into which projects the extremity of the penis. This organ is embedded anteriorly in a solid glandular mass of cells, and consists of two parts. The first of these is composed of very distinct cells, of a glandular appearance, and staining very deeply with carmine or hæmatoxylin. These cells radiate in a single layer from the internal cavity of the organ. The second part of the penis projects into the generative vestibule, and consists of a series of narrow, spike-like rods (in which nuclei could be distinguished), which, lying side by side, form a truncated cone, open at its extremity, and continuous with the cavity of the penis.

A copulatory organ of the same general character as that above described is well known to occur in the dwarf males of *D. gyrociliatus* (Korschelt, Repiachoff, &c.), whilst from a figure (plate viii, fig. 7)

given by M'Intosh (9) of *D. vorticoides* it appears probable that the entire male generative apparatus of this latter species closely resembles that of *D. tæniatus*.

So far as I am aware, copulation has not hitherto been actually proved to take place in any species of *Dinophilus*.\* The proof that such a process takes place in *D. tæniatus* is very readily obtained by merely placing a considerable number of individuals of both sexes in a small quantity of sea-water, as in a watch-glass. Under these circumstances, it is noticed, even a very short time after the animals have been placed together, that here and there a male is attached, by means of its penis, to the body of a female. In these cases, the terminal, conical portion of the penis is protruded through the generative pore, and is passed into the skin of the female; spermatozoa are then seen to have passed from the vesiculæ seminales, through the skin of the female, and to be accumulating themselves into a mass immediately beneath the perforation made by the penis.

There seems to be no localisation of the spot at which spermatozoa can be introduced into the female. The penis can obviously be inserted into the skin at any point, as is shown by the fact that, in the cases actually observed, the point selected was sometimes in the region of the neck, in other cases far back in the body of the female, and in other cases near the middle of the body.

The act of copulation has no relation to the maturity of the ova of the female, nor is it prevented by the fact that the female has already received an ample supply of spermatozoa by a preceding operation. It was extremely difficult to discover any female, in which ovaries were recognisably developed, which did not contain large numbers of spermatozoa in its body-cavity. These were observed in almost any part of the body of the animal, their position being probably partly dependent on the manner in which fertilization had been previously effected. The spermatozoa show, however, a great tendency to accumulate into a large compact mass, situated in a space on the ventral side of the stomach (*v. fig. 14*, and description of the female generative organs). In some cases it was observed that the female was receiving spermatozoa simultaneously from two males, in others that while, for instance, fertilization was being effected near the posterior end of the body, a great mass of spermatozoa (obviously obtained on a previous occasion) was visible at the anterior end of the body. In many cases the females were enormously distended with spermatozoa, which could hardly have been all received at one time.

The common occurrence of great numbers of spermatozoa in the body of the supposed female might suggest that *D. tæniatus* was hermaphrodite. Such a supposition is rendered sufficiently improbable

\* Korschelt (6) has probably seen something of this process in *D. gyrociliatus*.

by the following considerations: (i) That no other species of *Dinophilus* is known to be hermaphrodite; (ii) that the process of fertilization was frequently observed in *D. tæniatus*; (iii) that the spermatozoa so constantly seen in the female of the same species were, without exception, ripe and actively moving, no trace of spermorulæ or unripe spermatozoa being discernible. Such stages in the development of the spermatozoa were never missed in any adult male individual.

It will be noticed that the above-described process of copulation in *D. tæniatus* exactly resembles the processes which have been described by Lang (8, p. 231) in certain *Polyclada* (*Anonymus*, &c.)

The morphology of the vesiculæ seminales is one of the most interesting features of *D. tæniatus*, since there is reason to believe that these structures are the modified fifth nephridia of the male. The reasons for this conclusion are two:

(i) Five pairs of ordinary nephridia occur in the female *D. tæniatus* (as in the female *D. gyrociliatus*), whilst the most careful examination, often repeated, of the males of the same animal failed to show any trace, in that sex, of the existence of a fifth pair of undifferentiated nephridia.

(ii) The consideration of young stages of the vesiculæ seminales.

Fig. 5 represents the earliest of these stages which was observed. The vesiculæ seminales were in their definitive position in the fifth body-segment, and their identification as vesiculæ was rendered sufficiently certain by the fact that they contained ripe spermatozoa. The vesiculæ were arranged in an obliquely transverse position, their outer portions ending blindly at a level between the two ciliated rings of the fifth segment, their inner ends opening into the cavity of the testis. A part of the vesicula immediately succeeding the internal aperture was lined with long cilia; the next part of the tube contained a small mass of spermatozoa. The penis was well developed, and obscure indications of a duct leading from the vesicula to the penis were observed; the existence of this duct was not, however, completely proved. The resemblance of the young vesicula seminalis to an ordinary nephridium was manifested, not only in its shape and position, but still more conspicuously by the fact that its walls contained an orange pigment, exactly resembling that so commonly found in the walls of the excretory tubes.

Stages intermediate between that represented in fig. 5 and the mature form of the vesicula seminalis were frequently observed. The final form is acquired by the gradual distension of the originally subcylindrical tube by spermatozoa, this distension being accompanied by an alteration in the direction of its axis, the result of which processes is that the end which, in the young vesicula, is

external, is situated, in the adult condition, in front, the whole organ having now acquired an antero-posterior direction. The funnel, during the above changes, will naturally come to be situated near the posterior end of the organ.

There seems, therefore, fair reason to assume that the young vesicula seminalis shown in fig. 5 is morphologically the fifth nephridium; it must be especially noted that the funnel of the vesicula is in a position corresponding with that of the ciliated appendage of an ordinary nephridium, and that the original external aperture of the modified nephridium was probably (in the phylogenetic history of the organ) at the opposite end of the tube, which ultimately becomes the blind anterior end of the vesicula. The relations of the outer end of the young vesicula to the ciliated rings of the fifth segment further support this conclusion. The connection of the vesicula seminalis with the penis would, in this case, have to be regarded as having been acquired secondarily. Should the above account of the vesiculæ seminales of *D. tæniatus* be confirmed, the structure and mode of origin of these organs might be held to have an important bearing on the question of the phylogeny of the differentiated Chætopod nephridium. The structure of the first four nephridia in the male *D. tæniatus*, or of all five nephridia in the female, is obviously comparable with that of the head-kidney of a Chætopod larva. In this connection the figures given by Ed. Meyer (11) of the larval excretory organs of *Nereis* (Taf. xxvii, figs. 2, 3) and of *Polymnia* (Taf. xxvii, fig. 11) may be especially alluded to. The possibility of the conversion of the internal end of a head-kidney-like nephridium into a ciliated funnel, and of the entire nephridium into a vesicula seminalis, is a fact (if it be a fact) of some morphological interest.

Whilst the excretory nephridia of the male *D. tæniatus* open into a space which has been described above as a part of the body-cavity, the vesiculæ seminales open into the cavity of the testis. In certain other Archiannelids (*Protodrilus*, *Polygordius*), the space which is partially lined by generative cells, is certainly part of the body-cavity. From the analogy of these forms, it may perhaps be concluded that, in *Dinophilus*, the hardly differentiated space which occurs in the interior of the ripe testis is also a part of the body-cavity. In this case we could assume that whilst the excretory nephridia open into the general body-cavity, the vesiculæ seminales of *D. tæniatus* have acquired an opening into a special generative division of the cavity. Attention may be called to the similarity between the young generative organs shown in fig. 11 and the mesoblastic bands of a Chætopod larva, and also to the similarity between the subsequent history of the testis of *D. tæniatus* and of the body-cavity of the developing Chætopod. Although I make



this suggestion with all reserve, it is perhaps possible\* that in the connective-tissue lacunæ of the body of *Dinophilus* we have the representative of the so-called "primary body-cavity," whilst in the fully-developed male (fig. 13), the "secondary body-cavity" is represented by the cavity of the testis, with which the funnels of the vesiculæ seminales are connected.

B. *Female*.—The generative organs in the female *D. tæniatus* differ considerably from those of other known species of the genus, in the fact that the ovaries are four-lobed. The general arrangement of the ovaries will be understood by referring to fig. 2, where it will be seen that the ovaries, like the testes, are paired bodies, but that each half is subdivided into two lobes. Each lobe consists partly of small primordial ova and (in a moderately mature condition) partly of larger eggs which have already acquired the orange colour which characterises the ripe eggs. The ovaries are covered by a cellular investment, which is readily seen in fresh specimens to be continuous from lobe to lobe on each side of the body. The ovaries, as in *D. gigas*, are found on the ventral side of the stomach. No ducts could be discovered in the living animal. Spermatozoa, received during the process of copulation, occurred in almost every individual in which the ovaries were at this stage or more highly developed. In specimens in which the ova had become still further developed, the eggs were no longer confined to the four ovaries. As many as fourteen large spherical eggs of a distinct orange colour may, in such cases, occur on the ventral side of the stomach or intestine, and the two ovarian lobes of each side are then usually pushed apart from one another by the occurrence of ripe eggs between them.

Fig. 14 represents a transverse section through the region between the anterior and posterior ovaries of a female with numerous and fully-developed ova. On the ventral side of the stomach is a large space, containing a great mass of ripe spermatozoa, which appears to have no proper wall on its dorsal side at least, being in this region merely roofed in by the stomach. Laterally its walls are formed by the cellular investment of the ovaries, this investment passing across the middle line of the body on the ventral side of the space. In a section which passed through one of the ovaries on each side, the ovarian lobes would simply take the place of the ripe eggs shown in fig. 14. The cellular investment of the ovaries already noticed in fig. 2 would be seen to surround each lobe completely, and to be further continuous across the middle line on the ventral side of the interovarian space, exactly as in fig. 14.

Fig. 12 represents a longitudinal section through the two ovaries

\* As has previously been suggested, for other animals, by the Hertwigs.



of the same side at a much earlier stage of development, at a period, indeed, when the entire ovary is composed of a mass of small, uniform, primordial ova. The relations of the investment of the ovaries are further explained by this figure, in which it is seen that the space between the anterior and posterior lobes is, as in the later stage, devoid of any epithelium on its dorsal side. Ventrally, the space is floored by a single layer of cells, separated from the skin by loose connective tissue; the space itself contains (as was occasionally observed in older stages) a few free cells of unknown function.

In the absence of any developmental evidence it is not easy to say what is the nature of the interovarian cavity. From the analogy of the male, as well as from a consideration of the general arrangement of the ovaries, it would appear that the ovaries are primitively paired bodies, and not merely lateral thickenings of a median cavity. The interovarian cavity would thus be a specialised portion of the general body-cavity, which conclusion would be supported by the absence of any proper wall, the space being bounded partly by the investment of the ovaries and partly by the wall of the stomach. The conclusion is further strengthened by distinct evidence obtained from sections, that the internal ends of the fourth nephridia project into the space.

In most females observed in section there was found to be a mass of spermatozoa at the sides of the stomach and dorsal to the ovaries, these masses of spermatozoa usually passing continuously into the large central mass which is nearly always present in the interovarian cavity. The spaces in which these lateral masses of spermatozoa lie appear to be parts of the general body-cavity, which is hence continuous with the interovarian cavity at those points where the spermatozoa enter the latter. This continuity does not necessarily prove that the ventral space is really part of the body-cavity, as, from the method in which the spermatozoa are introduced into the female, they must probably often have to make their way through various obstructions in order to reach the ventral space.

The layer of cells connecting the two ovaries (figs. 12 and 14) across the middle ventral line of the body may thus be provisionally interpreted as resulting from the median fusion of two originally separate organs, and this process probably takes place at an early stage of development, as in the case of the testes of the male.

The interovarian cavity extends along the middle line of the body throughout the whole of the region of the stomach, and therefore occurs, not only between the ovaries themselves, but also behind and in front of the ovaries, which are lateral thickenings of the walls of the cavity, projecting into it. In consequence of this pro-

jection, the posterior part of the cavity in fig. 12 is separated (in the particular section in question) from that part which occurs between the anterior and posterior lobes; the posterior part of the cavity is of course continuous with the anterior part. It will be noticed from fig. 12 that the posterior part of the interovarian cavity has an epithelial wall on its dorsal side as well as on its ventral side, and the same is true of the anterior end of the cavity (not involved by the section shown in fig. 12). The complete conversion of the interovarian cavity into a tube which runs backwards below the intestine takes place at the level of the posterior ovarian lobes, and appears to be due to the fusion across the middle line of the investments of the ovaries of opposite sides. The tube thus formed runs backwards, becoming much smaller as it approaches the end of the body. In one specimen examined, the tube was distinguishable almost as far back as the anus, although very minute in the hinder part of its course.

In fig. 14, the eggs which are cut by the section are still outside the interovarian cavity. Most of the large eggs in this individual possessed two nuclei, as shown in one of those figured. They were further provided with a somewhat shrivelled membrane, which is probably the vitelline membrane. In the fresh condition, the only case noticed in which the vitelline membrane was acquired before the eggs reached the exterior was in a dead female, most of the tissues of which were beginning to break up into fragments.

In other sections of the series from which fig. 14 is taken, eggs are found in the interovarian space. The posterior, tubular continuation of this space may probably be regarded as an oviduct, although the process of egg-laying was not directly observed. It does not appear to me probable that the eggs are liberated by the death of the female, as Weldon (13) supposes to be the case in *D. gigas*.

In *D. vorticoides* (van Beneden, No. 1) and in the species described by Korschelt (6) as *D. apatris* (probably identical with *D. gyrotilatus*), the eggs are known to pass to the exterior by means of a minute pore situated on the ventral side of the animal, at the base of the tail. This pore is said not to be recognisable except when the eggs are being laid; the eggs completely lose their shape in passing through the aperture, but regain their spherical form on arriving in the water.

In *Protodrilus*, an animal to which *Dinophilus* is probably allied, the eggs are said by Uljanin and Repiachoff (*v. Repiachoff*, No. 12, p. 29) to escape from the body in the same way as in the above-mentioned species of *Dinophilus*. According to the observations of Uljanin, quoted and confirmed by Repiachoff, the ripe eggs of *Protodrilus* move about freely in the meshes of the network of connective tissue

which fills the general body-cavity, passing from segment to segment through apertures which remain between the interlacing muscle-fibres constituting the dissepiments, and finally escape from the body on the ventral side of the last segment.

The above description shows that in *Protodrilus* the eggs fall into the general body-cavity, whilst the same is true of *D. gyrociliatus*, where the body-cavity opens to the exterior by means of a ventral pore situated near the base of the tail. The fact that in *D. tæniatus* the interovarian cavity has been above shown to be continued ventrally almost as far as the anus, taken in conjunction with the admitted difficulty of discovering the actual generative pore except when eggs are being laid, is distinctly in favour of the view that the eggs of *D. tæniatus* are laid in the same manner as that which has been already described in other species of *Dinophilus*. The analogy of *D. gyrociliatus*, in which the eggs undoubtedly fall into the general body-cavity, further suggests that the interovarian cavity, into which the ova fall in *D. tæniatus*, and which is continuous with a passage which leads towards the exterior, is similarly a part of the general body-cavity.

**On the Affinities of Dinophilus.**—It has been repeatedly pointed out, by Metschnikoff, Lang, Repiachoff, and Korschelt, that *Dinophilus* has affinities with the Annelids, and more particularly with the Archiannelids. Weldon (13) expresses himself even more definitely in favour of the Archiannelid relationships of this form, supporting his conclusions by referring to the muscular œsophageal organ, to the ciliated ventral surface, associated with lateral nerve-cords, and to the character of the excretory organs, as described by Meyer.

The similarities between *Dinophilus* and the admitted Archiannelids are so numerous and so striking that it can hardly be doubted that the above conclusion is amply justified by the facts. It may, however, be worth while to call attention to the special resemblances shown by *D. tæniatus* to admitted Archiannelids, and to one or two considerations which are suggested by the study of this animal.

1. *External ciliation.*—The existence of two rings of cilia on each segment, a feature which appears to be so characteristic of *D. tæniatus* is common to this species and to *Protodrilus Leuckartii* (Hatschek, No. 5). In the latter animal, each segment is provided with two rings, interrupted, as in *Dinophilus*, by the uniform cilia which cover the ventral surface (ventral groove in *Protodrilus*). Two præoral rings of cilia exist in *Protodrilus*, which, however, differs from *Dinophilus* in possessing an elongated "postoral region of the head" (containing the muscular appendage of the œsophagus, and hence probably identical with the first body-segment of *Dinophilus*) which bears five rings of cilia.

2. *Nervous system*.—In *Protodrilus*, as in *Dinophilus*, ventral nerve-cords run along the sides of the ciliated ventral region of the body. In both cases, these cords are connected with the brain by œsophageal commissures running round the sides of the mouth. Further, the œsophageal commissures in *Protodrilus* acquire a relation to the longitudinal muscles which is precisely similar to that which obtains, not only in the same region, but throughout the body, in *Dinophilus*. *Protodrilus* is well known to possess an almost continuous layer of longitudinal muscles, which are separated by small interspaces into two ventral and two dorsal groups. In the region of the head (*v.* Hatschek) the four groups of muscles become widely separated; by referring to Hatschek's fig. 14 (Taf. ii), representing a section passing through the region of the mouth, it will be seen that the ventral longitudinal muscles, in their relative size and in their relations to the œsophageal commissures, are exactly similar to the longitudinal muscles of *Dinophilus*. Still further forwards in *Protodrilus*, the dorsal muscles (which do not seem to be represented in *Dinophilus*) disappear altogether.

The ventral nervous system of *Protodrilus* is not known to be segmented, and Hatschek describes only one transverse commissure between the two cords, occurring at the junction of the "head" and body.

The researches of Foettinger (2) have shown that *Histriobdella* is to be regarded as an Archiannelid. Foettinger re-names this animal *Histriodrilus*, in order to mark its removal from the group of the Leeches to that of the Archiannelids.

In one respect, the nervous system of *Histriodrilus* shows a closer resemblance to that of *Dinophilus tæniatus* than is manifested by that of any other Archiannelid. The ventral nervous system has been shown by Foettinger to be definitely segmented, in correspondence with the external segmentation indicated by metameric constrictions of the skin. *Histriodrilus* possesses about eight ventral ganglia, which, however, differ from those of *Dinophilus* in being continuous across the middle ventral line. In the intersegmental regions alone, the ventral nervous system consists of separated ventro-lateral cords. Paired œsophageal nerves, similar to those of *Dinophilus*, are described and figured by Foettinger (pl. xxv, figs. 10, 11).

3. *Excretory and generative organs*.—The nephridia of *D. tæniatus* closely resemble those of *Protodrilus*, as described by Hatschek. According to this observer, each nephridium of *Protodrilus* commences with a small funnel, opening into the body-cavity, and bearing internally a single, very long cilium. The difficulty of the investigation of nephridia of this type makes it possible that the difference between the funnel in *Protodrilus* and the ciliated appendage in



*Dinophilus* is really less considerable that would appear from a comparison of Hatschek's figures with my own.

In many of its features, *Polygordius* differs from *Dinophilus* far more than does *Protodrilus*. This is sufficiently obvious by such characters of *Polygordius* as the fusion of the ventral nerve-cords, the absence of a muscular œsophageal appendage, the form of the nephridia, the greater development of the longitudinal muscles, &c. (cf. Fraipont, No. 3). All these facts justify us in concluding that *Polygordius* is less closely related to *Dinophilus* than is *Protodrilus*.

*Histriodrilus* (*Histriobdella*), on the contrary, is probably more closely related to *Dinophilus* than is *Protodrilus*. The similarity in the nervous systems of the two genera has been already alluded to, and the same general resemblances characterise the excretory and generative systems.

The arrangement of the excretory system in *Histriodrilus* is said to differ in the two sexes. The nephridia are somewhat S-shaped, intracellular tubes (unfortunately not figured by Foettinger in much detail); it is stated that five (or perhaps six) pairs are found in the male, and four pairs in the female; their relations to the segments are shown by means of woodcuts on p. 469 of Foettinger's Memoir. The second nephridium was observed on two occasions to end internally in a ciliated ampulla.

In the existence of structures connected with the generative apparatus, and which may possibly be regarded as modified nephridia, *Histriodrilus* again shows evidences of affinity to *Dinophilus*.

In the female *Histriodrilus* there are two ovaries, which are more or less fused posteriorly (as in *D. gigas*). These ovaries are situated, as in *Dinophilus*, on the ventral side of the alimentary canal. The ripe ova fall into the body-cavity, whence they are taken up by the ciliated funnels of a pair of tubes which open to the exterior laterally. These funnels (woodcut, p. 481 of Foettinger's paper) are large, and open into the body-cavity on the ventral side of the ovaries. The tubes into which the funnels lead possess a dilatation, containing spermatozoa which have been presumably derived from a male individual. The resemblance of these structures to the vesiculæ seminales of the male *D. tæniatus* (in which evidence has been brought forward above to show that the vesicula is a modified nephridium) suggests that they too are possibly modified nephridia.

The male generative organs of *Histriodrilus* appear to be very complicated, and their structure and functions were not thoroughly understood by Foettinger. The testes are placed on the ventral side of the alimentary canal, and are more or less paired in front, whilst they are fused posteriorly. At the posterior end of the generative segment are a pair of vesicles containing spermatozoa (Foettinger,

pl. xxix, fig. 3) and obviously comparable with the vesiculæ seminales of *Dinophilus*. As in the latter animal, the vesicles open by ducts into a median organ, supposed by Foettinger to be copulatory, and of very complicated structure. No communication between the vesicles and the body-cavity or testis is described. Anteriorly the generative segment has a pair of lateral eversible penes. The existence of three separate copulatory organs in *Histriodrilus* recalls the condition met with in some Polyclads (*Anonymus*, *Thysanozoon*), where more than a single penis is found.

The above facts, together with other well-known and striking resemblances between *Dinophilus* on the one hand and *Protodrilus*, *Polygordius*, or *Histriodrilus* on the other, make it in the highest degree probable that *Dinophilus* is a true Archiannelid, as has been insisted on by so many of the more recent writers on the subject. In the number of segments, in the segmentation of the ventral nervous system, and in the arrangement of the muscular system, of the nephridia, and of the generative organs, *Dinophilus* more nearly approaches *Histriodrilus* than any of the remaining Archiannelids. On the other hand, in the character of the muscular appendage of the œsophagus, in the wide separation of the ventral nerve-cords, and in the method adopted by the female for laying its eggs, *Dinophilus* most closely resembles *Protodrilus*. Although *Dinophilus* seems so clearly an Archiannelid, it is nevertheless possible to hold with Korschelt, Weldon, and others that it gives evidence of having been derived from Platyhelminth-like ancestors.

Weldon (13) has called special attention to the significance of the muscular œsophageal appendage as a representative of the pharynx of a Planarian. The median position of the generative pore, and the method of fertilization adopted by the male *Dinophilus tæniatus*, further support the view of the Platyhelminth origin of the Archiannelids. The median penis of *D. tæniatus* and *D. gyrociliatus* is strictly comparable with the same structure in a Planarian, although it is probably a highly significant fact (if this is really the case) that this organ has entered into relations with a pair of modified nephridia which receive the spermatozoa from the testes.

Korschelt (6) and others have drawn attention to the remarkable fact that, whilst the female of one species of *Dinophilus* differs comparatively little from that of any other species, there are very great differences between the males of the various species. In *D. gyrociliatus* (including *D. apatris*) (and possibly in *D. metameroïdes*, in which the male is not known), there is very striking sexual dimorphism, the female being many times larger than the male. In *D. vorticoides*, *D. gigas*, and *D. tæniatus*, on the contrary, the males do not differ appreciably in size from the females. Whilst in *D. gigas*

the male is said to have neither penis nor vesiculæ seminales, these structures are found in *D. tæniatus*, which is probably closely allied to *D. gigas*.

I have no observations which explain the disappearance of *D. tæniatus* during the summer. It is, however, important to notice that the eggs develop immediately after being laid. Small individuals were of common occurrence during the early part of April, although I did not succeed in finding the segmenting eggs till April 16th; the termination of my visit to Plymouth occurring a day or two after that date, I have no observations worth recording on the development. The eggs may be easily obtained by looking through mud drawn by means of a siphon from the bottom of a rock-pool which is inhabited by *D. tæniatus*. The general course of the development is apparently similar to that which has been described by Korschelt in *D. gyrociliatus* (*D. apatris*), the embryo, as in this species, acquiring most of its adult characters while still enclosed in its vitelline membrane. The absence of any metamorphosis in *Dinophilus* appears to me a noteworthy fact. It is perhaps a legitimate inference, from the facts known with regard to *Dinophilus*, that a Trochosphere stage is not to be expected in the ontogeny of this animal, since in the persistence of the præoral ring of cilia, and probably of the head-kidneys, and in the general characters of the alimentary canal, the adult *Dinophilus* may be considered to remain in a condition which is practically that of a Trochosphere.

*Postscript.*—I owe to the kindness of Dr. Norman the opportunity of referring to the description which has been given by G. N. R. Levinsen of *Dinophilus caudatus*, published in a paper which had previously been inaccessible to me (*Bidrag til Kundskab om Grönlands Turbellarienfauna*, Vidensk. Meddel. fra den naturh. Foren. i, Kjöbenhavn, 1879—1880).

*D. caudatus* is identified by Levinsen with the *Planaria caudata* of Fabricius (*Fauna Groenlandica*, 1780) and of O. F. Müller (*Zool. Danica*), and, in the words of Fabricius, "Habitat stupenda multitudine in confervis, et ulvis littoralibus, sæpe illas tegens."

It resembles the species above described as *D. tæniatus* in the division of the body into segments by deep constrictions of the skin, in the form of the testes, and in the existence of a penis and of vesiculæ seminales, but is stated to be so well known that detailed description is unnecessary; it is, moreover, unfortunate that Levinsen has published no figure of the species described by him.

It appears to me quite possible that "*D. tæniatus*" is identical with *D. caudatus*, but as the evidence on this point is quite inconclusive, I do not propose to withdraw, for the present at least, the

specific name, which has already been published in the Proceedings of the Cambridge Philosophical Society (vol. vi). According to Levinsen, *D. caudatus* is the species which has been described by other writers as *D. vorticoides*; its colour is stated to be red, whilst no mention is made of the existence of four-lobed ovaries or of segmental ciliated rings.

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## DESCRIPTION OF PLATES IX AND X.

Illustrating Mr. S. F. Harmer's paper, "Notes on the Anatomy of *Dinophilus*."

*N.B.*—All the figures refer to *Dinophilus tæniatus*.

FIG. 1.—Dorsal view of a young individual; the mouth, which is ventral, is represented as being visible through the semitransparent tissues of the head.

FIG. 2.—Ventral view of an adult female, somewhat compressed.

FIG. 3.—Longitudinal section of an adult male (combined from several sections). Most of the organs are shown as they appear in a median section; *i. e.* the brain, alimentary canal, testis, penis, and generative pore. The eye, ventral ganglia (the distinctness of which is slightly exaggerated), and vesicula seminalis, being laterally placed, would not





Fig. 1.

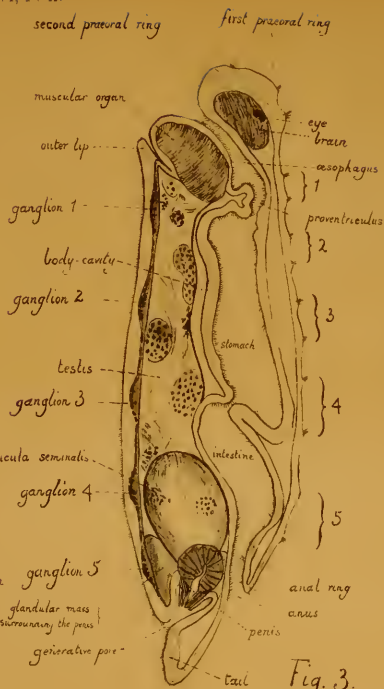


Fig. 2.



Fig. 3.



Fig. 4.

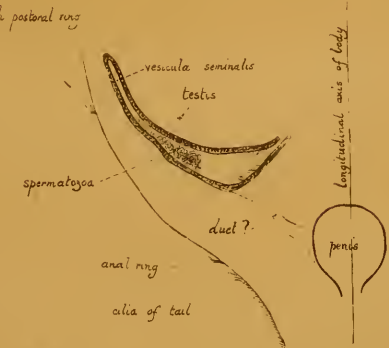


Fig. 5.

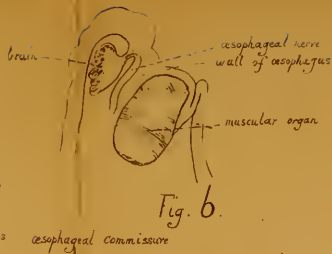


Fig. 6.

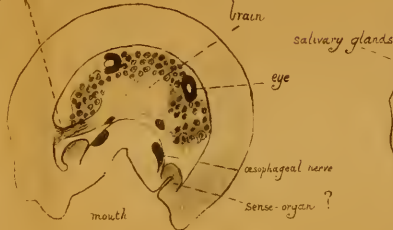


Fig. 7.

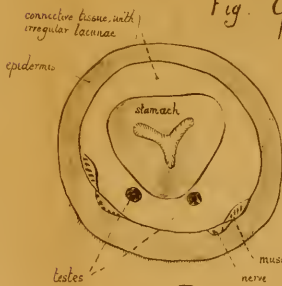


Fig. 8.

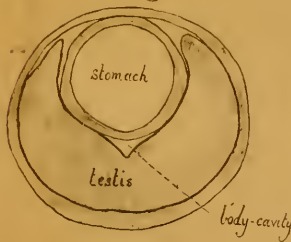


Fig. 9.

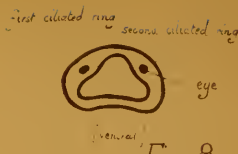


Fig. 10.

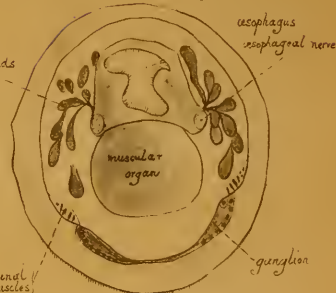


Fig. 11.

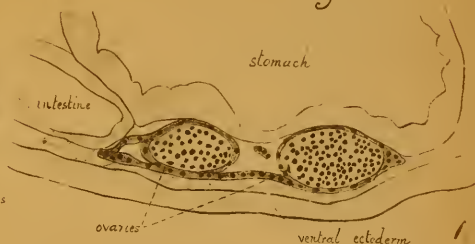


Fig. 12.

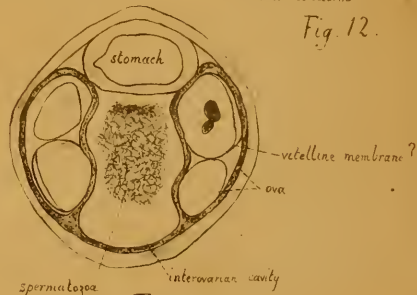


Fig. 13.



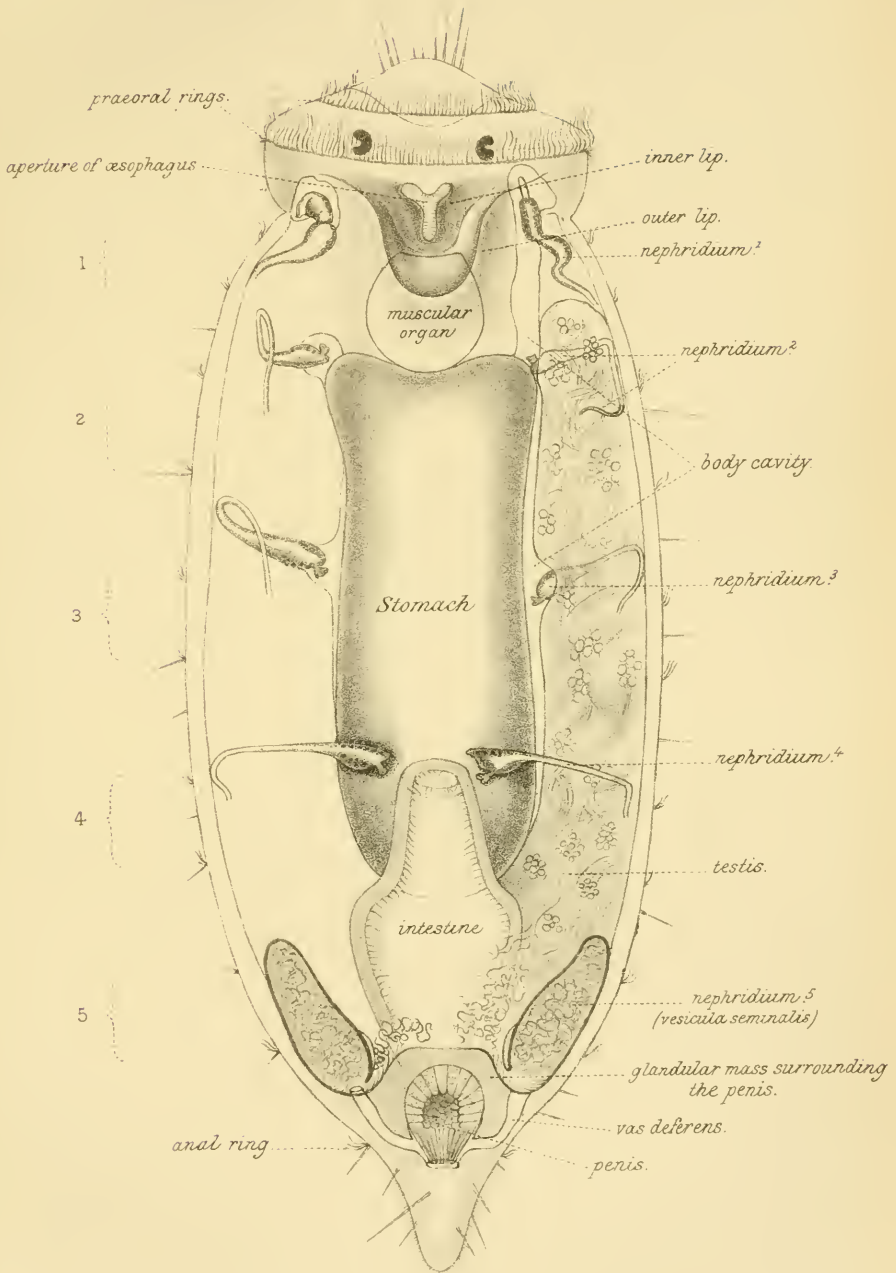


Fig. 15.





appear in a strictly median section. The two ciliated rings of each of the five segments of the body are indicated by one of the brackets to which the numbers 1, 2, 3, 4, 5 refer.

FIG. 4.—Spermatozoon.

FIG. 5.—Ventral view of part of the posterior end of a young male, as seen in a compressorium. The vesicula seminalis is still very young and nephridium-like, opening at its internal end into the cavity of the testis. The existence of the structure marked "duct?" was not established with certainty.

FIG. 6.—Longitudinal section of head, almost median, showing one of the œsophageal nerves.

FIG. 7.—Horizontal section of eye.

FIG. 8.—View, seen from the front, of the surface of the head of an individual killed with hot corrosive sublimate.

FIG. 9.—Transverse section through the head, passing through the origin of one of the œsophageal commissures.

FIG. 10.—Transverse section through the region of the first postoral pair of ganglia.

FIG. 11.—Transverse section through the middle region of the body of a young individual (probably a male).

FIG. 12.—Longitudinal vertical section, not median, passing through the two ovaries of one side of the body, of a young female.

FIG. 13.—Transverse section through the middle region of the body of an adult male.

FIG. 14.—Transverse section through the region of the interval between the anterior and posterior ovaries of an adult female.

FIG. 15.—Ventral view of an adult male, as seen under strong compression in a compressorium. The figure represents the results of a long series of observations. The vesiculæ seminales have been drawn at a rather young stage of development; at their period of maximum development they would appear very much swollen, and would extend forwards as far as the posterior end of the stomach. The double ciliated rings of the five segments are indicated, as in fig. 3, by the numbers 1, 2, 3, 4, 5. The testis is not shown on the left side of the figure.

## Report on the Pelagic Copepoda collected at Plymouth in 1888-89.

By

**Gilbert C. Bourne, M.A., F.L.S.,**

Fellow of New College, Oxford, and Resident Director of the Association.

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With Plates XI and XII.

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THE Copepoda not only form the greatest part of the pelagic life in temperate seas, but are also of the greatest importance in pelagic economy. Feeding on minute organisms and particles of animal and vegetable matter, they are themselves a prey to larger organisms. Some fishes such as the herring, pilchard, and mackerel feed almost exclusively on Copepoda at certain seasons of the year, and experienced fishermen are accustomed to look on the swarms of Copepods which make their appearance in the spring and early summer as the sure precursors of a shoal of fish. The important part played by these minute crustacea in the change of material in the sea has led me to pay particular attention to them amongst the other organisms found swimming free at the surface or at different depths in the open sea. The following is a preliminary account of the species which I have hitherto met with in the surface net collections made during the past year. The systematic work necessarily precedes the more laborious and thorough investigation of the life-history and bionomy of the group which I hope to be able to enter into at a later date, the present work, therefore, pretends to nothing more than an enumeration of the species captured, and an indication of their distribution. The species taken in the surface net amount to sixteen, of which the majority, as might be expected, belong to the Calanidæ. Of the sixteen, nine species belong to this family, two to the Cyclopidæ, three to the Harpactidæ, and two to the Corycæidæ. The majority are well known on British coasts, two species which I have found in abundance, viz. *Paracalanus parvus* and *Eutерpe gracilis*, are generally considered rare in this country, and *Pontella wollastoni* is a rare English form which I have found sparingly. One species, *Oncæa mediterranea*, has not hitherto been seen north of the Mediterranean. On the other hand, several well-known species of Calanidæ are altogether absent from my collections, viz. *Metridia armata*, *Isias clavipes*, and *Centropages humatus*. The labour of looking through and sorting the large amount of material

collected by us during the past year has been very great, but I am satisfied that I have not allowed a species to escape my notice, and the above-mentioned forms must have been absent, during the past year at all events, from the open sea in this neighbourhood.

Having had access to only a limited number of systematic works on the Copepoda I am obliged to confine myself in the descriptive part of this paper to references to the following works. Brady's Monograph of the British Copepoda, three vols. Brady, Report on the Copepoda collected by H.M.S. Challenger, 1883. Claus, Die freilebenden Copepoden, 1863. Ibid, Neue Beitrage zur Kenntniss der Copepoden, Arbeit aus dem. zool. Inst. Wien, 1880-81. Giesbrecht, Die freilebenden Copepoden der Kiele Foeherde. Vierter Bericht der Commission zur wiss. Untersuchung der deutschen Meere in Kiel, 1882. Canu, Les Copepodes libres Marins du Boulonnais, 1888. Thompson, Proceedings of the Liverpool Biological Society, vols. i and ii, 1887 and 1888.

*Family*—CALANIDÆ.

1. CETOCHILUS SEPTENTRIONALIS, *Goodsir*.

CETOCHILUS HELGOLANDICUS, *Claus*. Die freilebenden Copepoden, p. 171, Taf. xxvi.

CALANUS FINMARCHICUS, *Brady*. Monogr., i, p. 38.

— — — *Giesbrecht*. Copepod. Kieler Foeherde, p. 156.

— — — *I. C. Thompson*. Proc. Liv. Biol. Soc., ii, p. 63.

This genus was found at all seasons of the year in the surface net, though seldom in considerable numbers, apparently it is more abundant towards the end of the autumn, but in the majority of gatherings it is altogether absent.

In adopting the generic name *Cetochilus* in preference to that of *Calanus* I am following the example of Claus, whose arguments in favour of retaining Roussel de Vauzeme's name for the genus appear to me to have more weight than the argument based on the uncertain identity of Müller's *Cyclops longicornis* with Gunner's *Monoculus finmarchicus*. For the discussion of the subject, *vide* Claus Neue Beitrage zur Kent. der Copep., Arb. Zool. Inst. Wien, iii, 3, and Brady, Challenger Reports, loc. cit.

2. PARACALANUS PARVUS, *Claus*. Pl. XI, figs. 1—3.

CALANUS PARVUS, *Claus*. Freilebenden Copepoden, p. 173, Taf. xxvi and xxvii.

PARACALANUS PARVUS, *Claus*. Neue Beitr. zur Kent. der Copep., Arb. Zool. Inst. Wien, iii, 3.

— — — *Canu*. Copep. libres Marins du Boulonnais, Bull. Scient. de la France et de la Belg., iii sér., 1 ann., p. 81.

PARACALANUS PARVUS, *I. C. Thompson*. Copep. of Liverpool Bay, Proc. Liv. Biol. Soc., ii, p. 64.

This species appears to have been taken only once before in England, viz. by the Liverpool Marine Biology Committee in 1888. Canu found it in abundance at Wimereux. I cannot consider it as a rare species at Plymouth for I have found it in great abundance in several gatherings and less abundantly in many others. Apparently it is absent from these coasts in the winter, for I could not find a single specimen in gatherings made between September and March. I have not observed the disproportion in the numbers of males and females described by Canu. This species is easily recognised by the form of the first antennæ of the male, by the serration of the external edges of the outer branches of the swimming feet, and their simple spines in both sexes, and by the characteristic shape of the fifth feet in the male and female. The characteristic ensiform and plumose terminal setæ of the second maxillipedes of the male appear to have been overlooked by previous observers, *vide* Pl. XI, fig. 3.

### 3. CLAUSIA ELONGATA, *Boeck*.

- PSEUDOCALANUS ELONGATUS, *Brady*. Monogr., Brit. Copep., i, p. 45, pl. iii.  
 — — *Giesbrecht*. Freileb. Copep. der Kieler Foehrd, Nachtrag.  
 — — *I. C. Thompson*. Proc. Liv. Biol. Soc., ii, p. 63.  
 CLAUSIA ELONGATA, *Claus*. Neue Beitrage zur Kent. der Copep., Arb. Zool. Inst. Wien, iii, 3, p. 16, Taf. iii, figs. 11—15.  
 LUCULLUS ACUSPES, *Giesbrecht*. Freileb. Copep. der Kieler Foehrd, p. 160.

This is one of the commonest species in the Plymouth district. I have taken it in autumn, winter, and spring in immense numbers. The absence of the fifth pair of feet in the female, and the form of the fifth feet of the male are characteristic features of this species. Young males are frequently very abundant, and as Claus has pointed out (*loc. cit.*), they differ from the perfect males both in the form of the fifth feet and in other particulars, so that they might easily be mistaken for a distinct species. Giesbrecht in the body of his work, quoted above, refers *Clausia elongata* to a new genus and species, *Lucullus acuspes*, but withdraws this name in an appendix. It is difficult to understand how he can have overlooked the identity of his specimens with *Pseudocalanus elongatus*, Boeck; described by Brady, since the latter's figures of the fifth pair of feet of the male are readily recognisable, defective as his description may be in some particulars. I. C. Thompson in a report of Copepoda collected in Maltese seas, refers to *Lucullus acuspes*, Giesbrecht; and *Pseudo-*



*calanus elongatus*, Boeck, as distinct genera! ('Proc. Liv. Biol. Soc.,' ii, pp. 140, 142.)

4. DIAS LONGIREMIS, Lilljeborg, Pl. XI, figs. 4—6.

DIAS LONGIREMIS,	Brady.	Monogr. Brit. Copep., i, p. 51, pl. v.
—	—	Claus. Freileb. Copepod., p. 193, Taf. xxxiii, figs. 6—14.
—	—	Giesbrecht. Freileb. Copep. der Kieler Foehrd, p. 148.
—	—	I. C. Thompson. Some Copepoda new to Britain, &c., Proc. Liv. Biol. Soc., i, p. 37.

This species is one of the most common near Plymouth. I have taken it in great quantities at all seasons of the year. Giesbrecht remarks that the genus *Dias* is found very sparingly at Kiel during the early spring months, but that it increases in numbers from July to the autumn. At Plymouth the contrary appears to be the case. On February 20th, 21st, and 22nd, 1889, the Calanidæ taken in the tow-net consisted almost exclusively of this species, and it was abundant in gatherings made both before and after these dates.

A close examination of these specimens leaves me in some doubt as to the distinctness of Giesbrecht's three species, *D. longiremis*, Lilljeborg; *D. bifilosus*, and *D. discaudatus*. According to him the remarkable differences (auffallende Merkmale) between *D. longiremis* and *D. bifilosus* are the presence of spines on the last thoracic segment of the former, and their absence in the latter species; the shape of the furca, which is much longer in *D. longiremis* than in *D. bifilosus*, and the presence of frontal setæ in the latter species. *D. discaudatus* is distinguished principally by the swollen furcal segments of the female and the spermatophores of the male, but in addition to these characteristics there are differences in the fifth pair of feet in the male (*vide* Giesbrecht, loc. cit., Taf. viii, figs. 30, 31, and 32). In my specimens the spines characteristic of *Dias longiremis* are present, but are not so long as those figured by Giesbrecht; there are no frontal setæ and the feet of the fifth pair are precisely those figured by Giesbrecht for *D. longiremis*. The difference lies in the furcal segments, the proportions of which are those of *D. bifilosus*, Giesbrecht and not of *D. longiremis*. From his drawing of the fifth pair of feet of the male I have no doubt that Brady's figures are taken from *D. longiremis*, Lilljeborg, though he has overlooked the spines of the last thoracic and abdominal segments. Claus' figure of the fifth pair of feet of the male is undoubtedly taken from *D. discaudatus*, Giesbrecht (cf. Claus, Freileb. Copepod., Taf. xxxiii, fig. 14, and Giesbrecht, loc. cit., Taf. viii, fig. 32). At the same time Claus speaks of the frontal setæ characteristic of *D. bifilosus*. Giesbrecht considers that the varieties in the fifth pairs of feet of the

males taken by Claus in Heligoland and the Mediterranean point to their being in fact two distinct species, but the facts given above support the conclusion that the characters taken by Giesbrecht as specific are liable to great variation, and that his three species, *D. longiremis*, *D. bifilosus*, and *D. discaudatus* are, in fact, varieties of one species, viz. *Dias longiremis*, Lilljeborg.

#### 5. TEMORA LONGICORNIS, O. F. Müller.

- TEMORA FINMARCHICA, Claus. Freileb. Copepod., p. 195.  
 — LONGICORNIS, Brady. Monogr. Brit. Copep., i, p. 54.  
 — — Canu. Les Copep. libres marins du Boulonnais, Bull. Sci. de la France et Belg., iii sér., 1 ann., p. 89.  
 — — Giesbrecht. Freileb. Copep. der Kieler Foehrede, Nachtrag.  
 HALITEMORA LONGICORNIS, Giesbrecht. Ibid., p. 149.  
 — — I. C. Thompson. Proc. Liv. Biol. Soc., vol. i, p. 35.

This very common species was found sparingly during the winter months at Plymouth; its numbers increase greatly in April, and appear to reach a maximum in August and September. Thompson, in adopting the generic name *Halitemora*, overlooks Giesbrecht's appendix in which the latter gives way to the priority of Claus' name *Temora* (Claus, Sitz. der Kais. Akad. Wien, lxxiii, 1881.)

#### 6. CENTROPAGES TYPICUS, Kroyer.

- ICTHYOPHORBA DENTICORNIS, Claus. Freileb. Copepod., p. 199, Taf. xxxv, figs. 1, 3—9.  
 CENTROPAGES TYPICUS, Brady. Monogr. Brit. Copep., i, p. 65, pl. viii.  
 — — Canu. Les Copepodes libres, &c., Bull. Sci. de la France et de la Belg., iii sér., 1 ann., p. 96.

Taken in great abundance in summer, autumn, and spring, but it appears to be less abundant in the winter months.

#### 7. PARAPONTELLA BREVICORNIS, Lubbock.

- PARAPONTELLA BREVICORNIS, Brady. Monogr. Brit. Copep., i, p. 69, pl. ix, figs. 1—6.  
 — — I. C. Thompson. Copep. Liv. Bay, Proc. Liv. Biol. Soc., ii, p. 65.

I have only found this species on two occasions, and then in small numbers, viz. on August 31st, 1888, near the Eddystone Lighthouse, and on March 21st, 1889, in the Cattewater.

8. PONTELLA WOLLASTONI, *Lubbock*.

- PONTELLA HELGOLANDICA, *Claus*. Freileb. Copepod., p. 208, Taf. iii, figs. 5-7;  
 xxxvi, figs. 1-15; xxxvii, fig. 7.  
 — WOLLASTONI, *Brady*. Monogr. Brit. Copep., i, p. 73, pl. x a.  
 — — *Canu*. Copep. libr. mar. du Boulonnais, Bull. Sci. de la  
 France et de la Belg., iii sér., 1 ann., p. 100.  
 — — *J. C. Thompson*. Some Copep. new to Great Brit., Proc.  
 Liv. Biol. Soc., i, p. 37.

I have only found this species twice, on August 31st, 1888, and on October 23rd, 1888, near the Eddystone Lighthouse, in small numbers in each instance. According to Thompson it is not uncommon in Liverpool Bay, and it is one of the commonest species at Wimereux (*Canu*).

9. ANOMALOCERA PATERSONII, *Templeton*.

- IRENÆUS PATERSONII, *Claus*. Freileb. Copep., p. 206, Taf. ii, fig. 1; Taf. xxxvii,  
 figs. 1-6.  
 ANOMALOCERA PATERSONII, *Brady*. Monogr. Brit. Copep., i, p. 75, pl. xi, figs.  
 1-14; pl. x, figs. 13, 14.

This species was abundant at Plymouth in the autumn and late summer but was absent from winter gatherings. I found a few specimens in the contents of the surface net on May 19th, 1889. Sometimes it occurs in immense profusion in the Channel. Mr. Matthias Dunn has sent me a large number of Copepods, dipped with a bucket from Mevagissey Harbour. They consisted almost exclusively of *A. Patersonii*. In the specimens taken on May 19th I noticed that the upaired eye of the male was nearly half as large again as that of the female.

*Family—CYCLOPIDÆ.*1. OITHONA SPINIROSTRIS, *Claus*. Pl. XI, figs. 7 and 8.

- OITHONA HELGOLANDICA, *Claus*. Freileb. Copep., p. 105, Taf. xi, figs. 4-9.  
 — SPINIROSTRIS, *Claus*. Ibid., p. 105, Taf. xi, figs. 10-12.  
 — SPINIFRONS, *Brady*. Monogr. Brit. Copep., i, p. 91, pl. xiv, fig. 19;  
 pl. xxiv a.  
 — SPINIROSTRIS, *Giesbrecht*. Freileb. Copep. der Kieler Foehrd., p. 139.  
 — — *I. C. Thompson*. Proc. Liv. Biol. Soc., ii, pp. 1, 2.

This species is so rare as to be practically absent from Plymouth seas in the late summer and autumn, but it appears in great profusion in February, March, and April. Giesbrecht states that the same is the case at Kiel. According to the same author the different

European species of *Oithona* are to be considered as varieties of *O. spinirostris*, Claus. The figures of *Oithona* in Brady's Monograph are very unsatisfactory, but those of *O. Challengeri* in the Challenger Report are much better. The only accurate drawings of *Oithona* that I have seen are those of Giesbrecht, whose illustrations never leave anything to be desired. As his work is not always accessible to English naturalists, I give, in Plate XI, figs. 7 and 8, drawings of the mandibles and maxillæ of this species.

## 2. CYCLOPINA LITTORALIS, *Brady*.

- CYCLOPINA LITTORALIS, *Brady*. Monogr. Brit. Copep., i, p. 92, pl. xv, figs. 1—9.  
 — — *I. C. Thompson*. Copep. Liv. Bay, Proc. Liv. Biol. Soc.,  
 ii, p. 65.

A few specimens of this well-marked species were taken in the tow-net in the early days of April, 1889.

### Family—HARPACTIDÆ.

## 1. LONGIPEDIA CORONATA, *Claus*.

- LONGIPEDIA CORONATA, *Claus*. Freileb. Copep., p. 111, Taf. xiv, figs. 14—24.  
 — — *Brady*. Monogr. Brit. Copep., ii, p. 6, pls. xxxiv, xxxv.  
 — — *Giesbrecht*. Freileb. Copep. der Kieler Foehrde, p. 99.  
 — — *I. C. Thompson*. Cop. Liv. Bay, Proc. Liv. Biol. Soc.,  
 ii, p. 67.

A few specimens were taken in the surface net in March and April, 1889.

## 2. EUTERPE GRACILIS, *Claus*.

- EUTERPE GRACILIS, *Claus*. Freileb. Copep., p. 109, Taf. xiv, figs. 1—13.  
 — — *Brady*. Monogr. Brit. Copep., ii, p. 22, pl. xl, figs. 1—16.  
 — — *I. C. Thompson*. Copep. Liv. Bay, Proc. Liv. Biol. Soc., ii,  
 p. 67.

This species, rare in most localities, is very abundant near Plymouth in late winter and spring. I first found it on February 20th, 1889, when the tow-net taken near the Eddystone Lighthouse contained a profusion of females, nearly all carrying ovisacs. Since that date I have taken both males and females, sometimes sparingly, sometimes abundantly, in nearly every gathering up to May 20th.

## 3. THALESTRIS MYSIS, *Claus*.

- THALESTRIS MYSIS, *Claus*. Freileb. Copep., p. 130, Taf. xviii, figs. 12—16.  
 — — *Brady*. Monogr. Brit. Copep., ii, p. 121, pl. lviii, figs. 1—13.



Three or four specimens were taken in the surface net in the Cattewater on March 21st, 1889.

*Family*—CORYCÆIDÆ.

1. CORYCÆUS ANGLICUS, *Lubbock*.

CORYCÆUS GERMANUS, *Claus*. Freileb. Copep., p. 156, Taf. ix, figs. 1—4; Taf. xxiv, figs. 5, 6; Taf. xxviii, figs. 1—4.

— ANGLICUS, *Brady*. Monogr. Brit. Copep., iii, p. 34, pl. lxxxii, figs. 16—19; lxxxiii, figs. 11—15; lxxxiv, figs. 10—14.

This species appears to be somewhat rare and locally distributed on British coasts. I first found a few in the tow-net of February 20th, near the Eddystone Lighthouse, and from that date up to May I obtained numerous specimens, scarcely any gathering being without them. It is recorded in my note-book that of the specimens taken February 21st, 22nd, and 23rd, 1889, all the females had ovi-sacs attached.

2. ONCÆA MEDITERRANEA, *Claus*. Pl. XII, figs. 1—7.

ANTARIA MEDITERRANEA, *Claus*. Freileb. Copep., p. 158, Taf. xxx, figs. 1—7.

ONCÆA OBTUSA (?), *Brady*. Challenger Reports, Zoology, vol. viii, p. 120, pl. li.

— — *I. C. Thompson*. Copep. collected in Maltese Seas, Proc. Liv. Biol. Soc., ii, p. 148.

I have much pleasure in recording this species, which has not before been found north of the Mediterranean. It is very rare at Plymouth. I have only had two specimens, one taken on the 31st August, 1888, the other on April 15th, 1889; both are females.

I am satisfied that my specimens are identical with *Claus' Antaria mediterranea*, but am not quite sure of their identity with *Oncæa obtusa*, Dana. Comparing my specimens with *Claus' and Brady's* figures, the second joint of the second antenna agrees in my specimens with *Claus' drawing and description* (zweite Glied der Klammerantennen aufgetrieben, dreieckig, so gross als die dritte), but in *Brady's drawing* it has not the characteristic swollen three-cornered shape. The furca in *Brady's drawing* is as long as the three preceding abdominal segments; in *Claus' Antaria mediterranea* and in my specimens it is but little longer than the last abdominal segment. The spines on the first abdominal segment of the male are longer in *Claus' figures* than in *Brady's*. From want of specimens I am unable to give an opinion on the specific distinctness of these two forms, but I have preferred to use *Claus' specific name* for my specimens because of their full agreement with his drawings and description.

## PLATES XI AND XII.

Illustrating Mr. G. C. Bourne's paper on *The Pelagic Copepoda collected at Plymouth in 1888-89.*

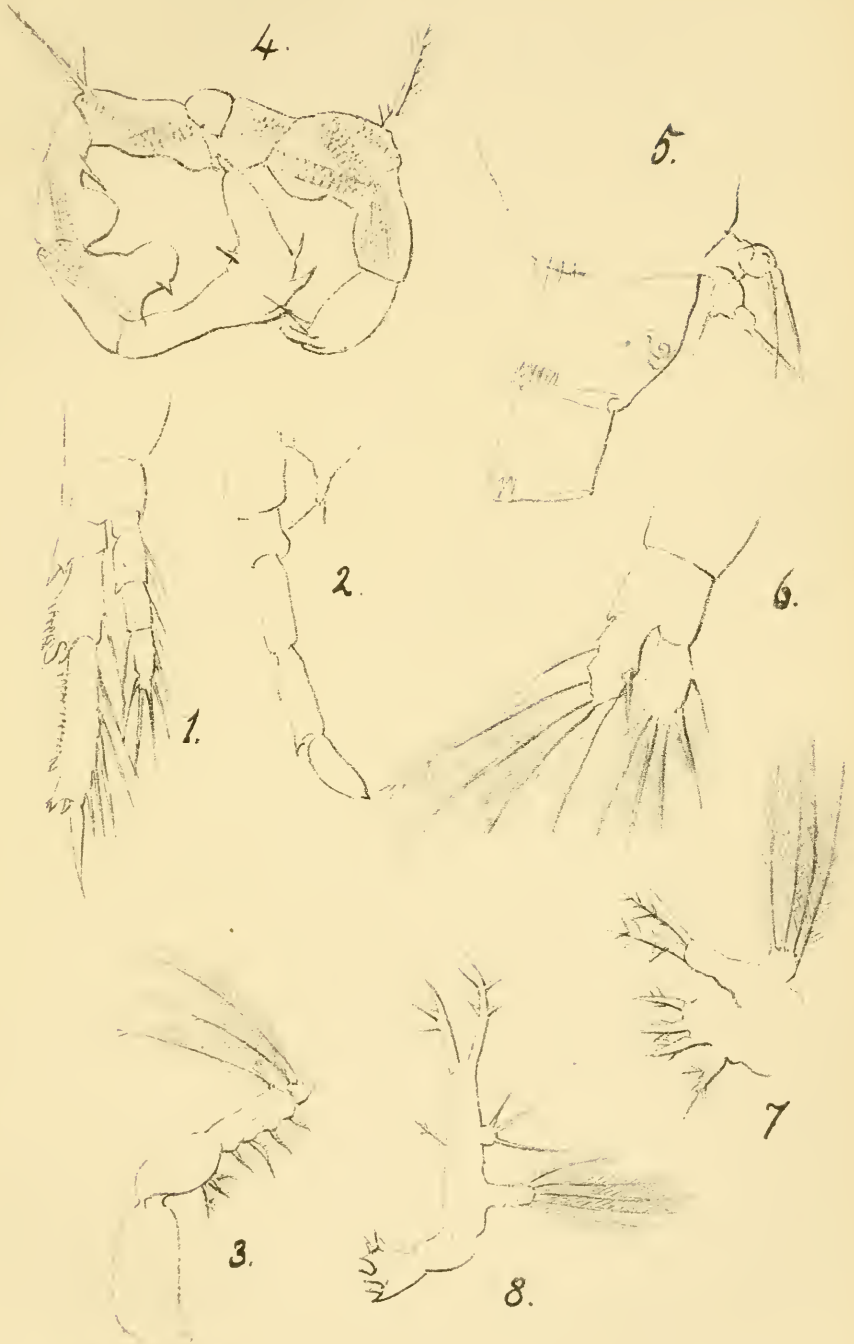
## PLATE XI.

- FIG. 1.—*Paracalanus parvus*. Third swimming foot.  
 FIG. 2.—Ibid. ♂. Fifth pair of feet.  
 FIG. 3.—Ibid. ♂. Second maxillipedes.  
 FIG. 4.—*Dias longiremis*. ♂. Fifth pair of feet.  
 FIG. 5.—Ibid. Last thoracic and first two abdominal segments of ♀ showing the spines.  
 FIG. 6.—Ibid. Furcal segments of ♂.  
 FIG. 7.—*Oithona spinirostris*. Maxilla.  
 FIG. 8.—Ibid. Mandible.

## PLATE XII.

*Oncœa Mediterranea*. ♀.

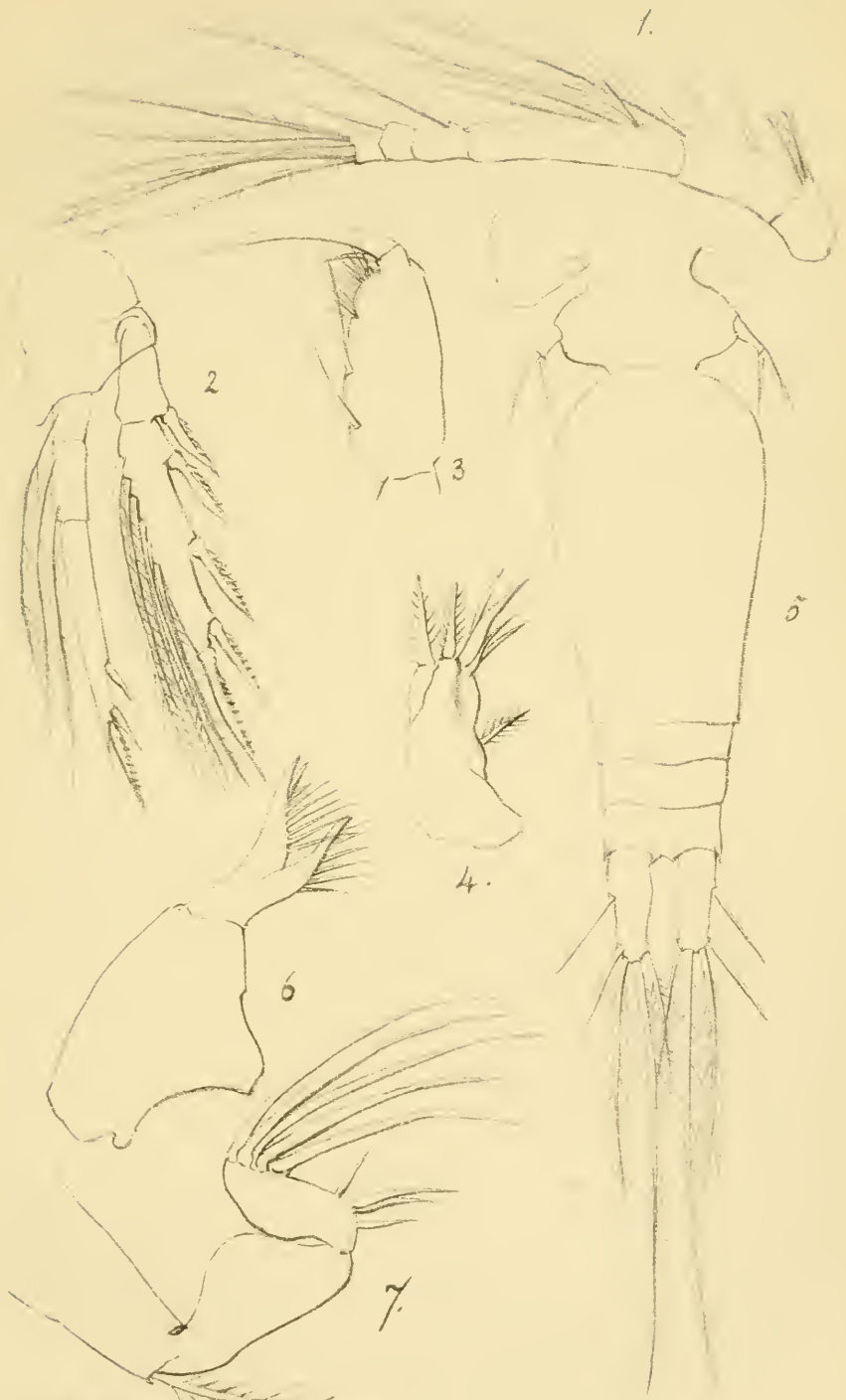
- FIG. 1.—First antenna.  
 FIG. 2.—One of the swimming feet.  
 FIG. 3.—Second maxillipede.  
 FIG. 4.—Maxilla.  
 FIG. 5.—Abdominal segments.  
 FIG. 6.—First maxillipede.  
 FIG. 7.—Second antenna.



G. C. Brown del.







G. C. Brown. del.



## Destruction of Immature Fish.

By

**Gilbert C. Bourne, M.A., F.L.S.,**

Fellow of New College, Oxford, and Resident Director of the Association.

AMONG the questions on sea fishing which are periodically and pertinaciously brought forward by some people, there is none which is more persistently paraded before the public than the wholesale destruction by trawling and other means of immature food-fishes. When questions of this kind are brought forward they are invariably accompanied with demands for legislative interference, and in this instance it is demanded by some that beam trawling should be prohibited within the three-mile limit; by others that it should be prohibited altogether at certain seasons; by others, again, that shrimp trawling should be forbidden; and a fourth party, with some show of reason, requires that certain specified areas should be closed against trawling for a number of years. It is unnecessary to say that if any of these prohibitive measures were adopted an important branch of the fishing industry would be seriously affected, and it is well, before any credence is given to the statements of those who agitate in this matter, that the whole subject should be put clearly before the public, that the extent and the deficiency of our knowledge should be made known, and that accurate observations should be placed alongside of and compared with the more random statements of the would-be legislators.

In point of fact, very few observations of scientific accuracy have been made. By far the most important contribution to the subject is the report of Prof. McIntosh, published in the Appendix to the Report of the Royal Commissioners on Trawling in 1885. In addition to this, observations are being made by the officers of the Fishery Board for Scotland, and some few have been made by the Marine Biological Association, of which it is proposed to give an account here.

Before proceeding further with the subject, it is well to clear up an ambiguity arising from the misuse of the word "immature." Strictly speaking, an immature fish is a young fish which has never developed ripe roe or milt. If it could be proved that great quan-

tities of such fish were destroyed it might be conceivable that great damage is being done to sea fisheries, for young fish of all kinds have a great many enemies to contend with, and it is quite possible that man, by employing more numerous and more powerful engines for their destruction, might so diminish the number of breeding fish as to cause the young brood to be unable to cope with the numerous destructive agencies which beset them on their road to maturity. However this may be, and the case admits of much argument on both sides, the first question is whether such immature fish are in fact destroyed in vast numbers. It is just for this reason that a precise meaning should be attached to the expression "immature fish." An arbitrary standard of size is no criterion of the immaturity of different species of fish; a turbot of ten inches length may be immature when a plaice or sole of the same length is filled with ripe ova, and there are some species of fish commonly used for food which seldom exceed ten inches in length, and in such cases many adult, that is to say, sexually mature specimens, fall below the arbitrary standard and are classed as "immature" or sometimes "undersized" fish. In making inquiries on this subject it is necessary that, by comparison of very many specimens, a minimum of size should be determined for the adults of each species of fish, so that it can be affirmed with tolerable certainty in each case that every fish below a certain size is really immature. Obvious as this may seem, it is necessary to insist upon it, for hitherto size and not sexual maturity has been the test of observers; and even Prof. McIntosh's report, admirable in all other respects, leaves one in complete doubt as to whether the fish classed by him as immature were really sexually immature or merely undersized fish. It must be remembered, however, that the Professor had a very limited time in which to carry out his investigations, and that it would require long observation and experience to obtain the necessary data for determining at what average size different species of fish may be expected to come to maturity.

The importance of precision in definition will readily be understood after examination of Prof. McIntosh's report. In ninety-three hauls of the trawl 81,854 fish were taken, of which 11,613—a large proportion numerically—were classed as immature fish. But of these no less than 2956 were long rough dabs (*Hippoglossoides limandoides*), 6314 were common dabs (*Pleuronectes limanda*), and 1072 were combined common and long rough dabs. These two species of flat-fish are often small, never exceeding thirteen inches in length, and generally they are much smaller. It is probable that a large proportion of those taken by Prof. McIntosh were really mature, but small or undersized fish. But in any case the number

of long rough and common dabs taken, whether mature or immature, is of no great importance. Neither species is valuable, and though eaten they are only sold at a very low price to the poorer classes of certain districts. Thus, of the whole number of 11,613 fish classed as immature, as many as 10,342 belonged to nearly worthless species.

Prof. McIntosh's observations were carried out on trawlers working in the ordinary course of business in the following localities: St. Andrews Bay, Aberdeen Bay, off Smith Bank, the Firth of Forth, off Scarborough.

Similarly Mr. Cunningham, the Naturalist of the Marine Biological Association, has made frequent observations on trawlers engaged in their business off Plymouth and westward to Mount's Bay. His experiences in all seasons and in all weathers coincide very closely with those of Prof. McIntosh. Very young flat-fishes are not captured in the large beam trawls working in depths of thirty to forty fathoms. Flat-fishes somewhat less than six inches in length are not uncommon, but they invariably belong to worthless or nearly worthless species, and of these no specimen under three inches long has been noticed.

The more valuable species of flat-fish taken by Plymouth trawlers are the sole (*Solea vulgaris*), turbot (*Rhombus maximus*), brill (*Rhombus lævis*), merrysole (*Pleuronectes microcephalus*), megrim (*Arnoglossus megastoma*), plaice (*Pleuronectes platessa*). Mr. Cunningham has never seen any of these species less than six inches in length brought up in the beam trawl. But there are several smaller species of little marketable value of which numbers of small specimens are commonly caught; these are flounders (*Pleuronectes flesus*), dabs (*Pleuronectes limanda*), thickbacks (*Solea variegata*), and scald-fish (*Arnoglossus laterna*). As the staff of the Marine Biological Association has been engaged on other problems, these fish have not been regularly counted and measured, but in the matter of flat-fish it is obvious that there is no difference between the north-east coast of England and Scotland and the channel near Plymouth. In both cases large numbers of undersized flat-fish are caught, and in both cases they are composed nearly exclusively of worthless species. The long rough dab (*Hippoglossoides limandoides*) is an exceedingly rare fish on the south-west coast of England, and its presence in the one and its absence in the other case forms the principal difference between Prof. McIntosh's results and those of the Marine Biological Association. In Prof. McIntosh's experiments 596 immature plaice were captured, and these principally in St. Andrews Bay, in depths varying between four and a half and twenty fathoms. It has been seen that very few small plaice are caught in the beam trawl at Plymouth, but quantities are caught by other means, as will appear later.



Of immature round fish Prof. McIntosh captured an altogether insignificant number, the largest number being gurnards. Mr. Cunningham reports that small specimens of various species (whiting, pollack, pouting, hake, ling, doreys, and sea breams) are not uncommon in the contents of the large trawls, but he does not remember to have seen a specimen less than six inches in length. But the numbers of these small marketable fishes are altogether insignificant when compared to the cuckoo or boar fish (*Capros aper*), of which small species (it is less than six inches in length when full grown) vast numbers are sometimes caught. It is important to observe that round and flat fishes under six inches in length are caught in the large-meshed trawl, as it has often been maintained that soles and other fish of that size escape through the meshes. The conclusion with regard to flat fishes is that the young forms are not generally found in deep water, and that the large trawls do not and cannot destroy immature flat-fish. As for round fish it is known that when young they frequent rocky bottoms where the trawl cannot work, and their rarity in the trawl proves that they are not destroyed by it.

In fact no case has been made out against beam trawling. First it was attacked on the grounds that it was destructive of spawn, and this was speedily disproved; lately it has been attacked on the ground that it is destructive of immature fish, and this was disproved by the Royal Commissioners of 1883, whose conclusions have been confirmed at Plymouth; the last possible grounds of attack were equally disposed of by the Royal Commissioners, and it would be well if agitators would now let beam trawling alone. The complaints made of the destruction of very young fish in bays and estuaries appear, however, to have more foundation in fact, though more knowledge is sadly required. It is well known that in summer in certain localities millions of very small fish are to be seen along the margin of the shore, and that they often perish in vast numbers through the drying up of tidal pools by the sun. They are also eaten by gulls and by other fishes. A certain proportion escape destruction, and, according to their species, seek different habitats during their adolescence. It is an open question whether man can possibly destroy such a quantity of very young fish as to make any difference to the number of those that come to maturity. Often as it has been insisted upon, the public does not appear to realise that every female fish that comes to maturity lays a prodigious number of eggs; that if millions of these perish before hatching, or before they come to maturity after they are hatched, there will still be as many or even more adults left as the parents from which they had their origin, and that in spite of the seemingly enormous waste, the number of the species is kept up. That this is the case is familiar to all students of natural history, but

it would seem to be hardly understood by the majority of well-informed people who are not naturalists.

The Royal Commissioners of 1863, 1878, and 1883 have all come to the conclusion that the destruction of very young fry by man is so very small relatively to its prodigious destruction by other agencies that it can make not the slightest difference to the total number of fish that survive. In point of fact, however, very little is known as to the numerical relation between fry killed by man and those destroyed by other agencies, and until accurate estimates are made in several localities, it is not possible to lay down a law on the subject.

Minute flat-fishes are not found on the rocky shores of Plymouth Sound, but there are several localities on the south coast where the conditions are favorable to the life of young fishes; such are Tor Bay, Whitsand Bay, and Mevagissey Harbour. The want of a suitable steamboat has prevented the staff of the Marine Biological Association from making the long and numerous expeditions to distant places necessary to the prosecution of this line of research, but with the help of Mr. Matthias Dunn they have gained a good deal of information about Mevagissey Harbour. Mr. Dunn sent some two dozen young flat-fish, about as large as a man's thumbnail, to the Laboratory in April, and since then Mr. Cunningham has visited Mevagissey and received several consignments of young fish. His experiences are given in his own words.

“On May 15th I paid a visit to Mevagissey to see Mr. Dunn and examine the young flat-fishes which he had informed me were to be seen in large numbers in the harbour at low tide. The old harbour of Mevagissey is almost completely empty of water at low spring tides and it was in this condition when I was there; the bottom consists of soft mud or harder muddy sand, and in the inequalities of the surface were left pools of water and running streamlets. In these were myriads of young flat-fishes, most of them completely metamorphosed and of a dark colour, but a few transparent and still having an eye on each side of the head. Among them I found a few soles. The little fish were in constant motion, rising to the surface of the water and then going again to bottom and lying on or in the sand. They could be caught without difficulty by the hand or with a cup or with a muslin net. I found all except the soles were of one species, namely, the flounder (*Pleuronectes flesus*); the individuals of this species varied from 10 mm. to 18 mm. in length (three eighths to three quarters of an inch). The young soles were scarce, I caught only three specimens the day I was there, but Mr. Dunn sent me up fifteen more the next day; these were all about 14 mm. in length (half an inch).

“On May 31st Mr. Dunn sent up about a hundred more *Pleuro-*

*nectes flesus*, and one small sole caught in the harbour at low tide as before. The sole was 18 mm. long, the flounders 15 to 19 mm. The difference represents the growth which had taken place in the fortnight elapsed. From the fact that after two or three days' search during these spring tides Mr. Dunn was only able to find a single young sole, it may be inferred that after reaching the size of 18 mm. the small soles move into somewhat deeper water, and are no longer to be found within the low-water mark of spring tides.

"I searched the shores of Sutton Pool and the mouth of the Plym estuary at Plymouth, and found no specimens of young flounders such as were so plentiful at Mevagissey; but some boys brought me two specimens of *Pleuronectes flesus* on May 31st, 10 mm. long, taken at low water on the muddy shore of Sutton Pool."

There are three points of particular interest in this Report, first the preponderance of the comparatively worthless flounder over the valuable sole; secondly, the indication given of the rate of growth of both sole and flounder; thirdly, the inference as to the change of habits of the young sole. Much more information is required on the last two heads. Undoubtedly the minute fish migrate from the beach to deeper water in search of food, but next to nothing is known of their history and movements at this time. It is known that small flat-fish, between three and six inches in length, are commonly caught by shrimp trawls working in one to three fathoms of water, and by seine nets hauled inshore. It has already been pointed out that when undersized flat-fish are captured by large beam trawls, they almost invariably belong to small and valueless species; and it is important to note that the same rule holds good, though in a lesser degree, for shrimp trawls,—at any rate it is so in Plymouth Sound.

The shrimp trawls used at Plymouth have an iron beam from nine to twelve feet long, and the mesh of the net is about half an inch square at the cod end. Whilst working at the life-history of the sole during the last twelve months, Mr. Cunningham engaged the shrimp trawlers of Plymouth to bring him all the small soles caught by them in the Sound. The number brought in was not large, never more than three or four in a day, and as a rule they were not brought in on more than one or two days in a week. Thus the take of undersized soles in Plymouth Sound is not large, and as the shrimpers at once throw overboard all the soles which are too small to be of market value, no destruction is done. On several occasions the fisherman of the Marine Biological Association has trawled in Cawsand Bay and elsewhere with the express purpose of getting very young soles. The results of his fishing are instructive, and the following cases may be regarded as typical. On August 15th, 1888, the trawl was shot several times in Cawsand Bay, where it was reported the shrimpers



were catching and destroying " vast numbers " of small soles. Only one small sole, three inches in length, was taken, but with it were numbers of young scaldfish (*Arnoglossus laterna*), which may easily be mistaken for young soles on cursory examination. On May 8th of this year in the same locality several hauls of the trawl brought up, besides worthless gobies and dragonets, two specimens of *Solea minuta*, two and a half and three inches long, two dabs (*Pleuronectes limanda*) two or three inches long, and one scaldfish two inches long. *Solea minuta* is a distinct and absolutely worthless species, which never exceeds five inches in length ; it is commonly mistaken for a young sole. On May 9th the fisherman caught two marketable soles (seven inches and thirteen and a half inches long) below Plymouth citadel, and numbers of small dabs two inches long and upwards. On May 10th, trawling in the Cattewater, he took six *Solea vulgaris*, six and three quarter to seven and three quarter inches in length, and twenty-two dabs, one and three quarters to six inches in length. In August, 1888, the fisherman was instructed several days in succession to bring up to the Laboratory undersized flat-fish brought in by the trawlers. They all proved to be scaldfish (*Arnoglossus laterna*). At the time it was being reported that an immense number of young soles were being destroyed.

It seems to be clearly established that plaice under six inches in length congregate in large numbers in particular places, often referred to as " nurseries." They are caught in numbers at all depths less than twenty fathoms. Such a nursery has recently been discovered and described in Nature by the Fishery Board for Scotland, and it is remarkable that nearly the whole of the 596 undersized plaice taken by Professor McIntosh during his experimental trawling were captured in St. Andrews Bay. The largest number taken by him in one haul was 122 in four and a half fathoms of water, but the next largest numbers, 65 and 64, were taken in twelve and twenty fathoms respectively. The only " nursery " practically known by the Marine Biological Association is the estuary of the Plym, called the Cattewater. The fishing in the upper part of this estuary, from Oreston to Laira Bridge and upwards, is the private property of the Earl of Morley.

Fishing with seine nets last autumn, the lessee of the fishing, Mr. Henry Clark, Q.C., in seven hauls captured some 200 plaice less than seven inches long, together with others of larger size. All the small fish were returned alive into the water, and this is always done in this private water, but below Oreston, where the fishing is public, the small plaice are destroyed wilfully or through negligence. On the 16th of May Mr. Cunningham saw large numbers of young plaice (*Pleuronectes platessa*), herring (*Clupea harengus*), and pollack (*Gadus*

*pollachius*) caught by the seine in the Cattewater. The plaice were about four and three quarter inches, the herring five and one eighth inches, long. They were about one year old, except the herring, which were probably hatched in the January previous, and all were taken away, none returned to the water. In the following week the fisherman of the Marine Biological Association was fishing with a seine in the same place, and, as before, a numerically large proportion of undersized plaice were captured, but were returned to the water. It is beyond question that large numbers of undersized fish are destroyed by seines every year in the Cattewater, and from information received it appears that this is the case in many other localities. But it would be necessary to make continuous and careful observations before it could be asserted that such fishing is injurious and ought to be prohibited.

It appears from what has been said above that the Marine Biological Association is not acquainted with any "nursery" of young soles. It is stated that such nurseries do exist on various parts of the English and French coasts. Investigation should be made, and if such nurseries can be proved to exist on the English coast it would doubtless be proper to prohibit fishing there, since soles require protection more than any other fish. It is strongly suspected that quantities of young soles are destroyed every year in certain creeks in the estuary of the Thames. Faversham Creek is an example, but scientific evidence is required before any steps are taken, as these "young soles" may prove to be thickbacks (*Solea variegata*) or other species.

Young turbot and brill (*Rhombus maximus* and *R. lævis*), three quarters to an inch in length, are found floating at the surface of the sea. Mr. Cunningham has examined several such in the early part of June, and Mr. Dunn, of Mevagissey, finds them floating at the surface every year. Mr. Cunningham considers that these fish are little more than a month old, and that their pelagic habit is due to the fact that they possess a large air bladder. It is unnecessary to say that their habit at this age protects them from trawling in any form.

A consideration of this report will lead to the inference that the destruction of immature fish has been greatly exaggerated by persons interested in some particular branch of fishing. Destruction doubtless does occur, but in the case of very small fry it is an open question whether it is injurious. The destruction of plaice must be determined before it can be asserted that it is injurious, and the destruction of very small soles is not proven. But it is evident that in spite of the work already done an immense quantity of accurate information is still needed, and this the Marine Biological Association hopes, in



the course of its work, to supply. During the past year they have been unable to gather more than scattered and often chance pieces of information, but as soon as they are equipped with the means necessary to so extended an investigation, no effort will be spared to obtain data of the highest possible accuracy.

## The Cœlom and Nephridia of *Palæmon serratus*.

By

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With Plates XIII—XV.

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THE accepted accounts of the excretory organs of the Decapod Crustacea are based chiefly upon the investigations of those numerous observers who have studied *Astacus fluviatilis*; the only recent memoir which attempts to deal with the arrangement of this system of organs in any other genus being the well-known work of Grobben.\*

Dr. Grobben gives a short description of the nephridium of *Palæmon Treillianus*, which may be summarised as follows:

The whole organ he believes to consist of a single tube, beset with numerous cæcal diverticula, and arranged for the most part in a compact coiled mass, which forms the glandular portion of the kidney. The outer end of this tube dilates into a large bladder, which leads by a short and delicate ureter to the exterior; while its inner extremity terminates in a curious enlargement, the "end-sac," the walls of which are richly supplied with blood-vessels.

This account of the structure of a Decapod green gland is very attractive, because of its complete agreement with the descriptions given by Claus, Grobben, Hoek, and others of the shell-gland of the Entomostraca, and it has naturally received much attention from morphologists. Lankester† has compared the "end-sac" of the Crustacea with the space into which the nephridium opens in an embryo *Limulus*, and has suggested that in each case the vesicle which receives the termination of the renal tubule is a reduced representative of the cœlom; and Sedgwick has demonstrated that the similarly circumscribed space into which each nephridium of *Peripatus* is the remnant of an embryonic cœlomic pouch.‡

\* Grobben, *Die Antennendrüse der Crustaceen*, Arb. Zool. Inst. Wien, Bd. iii, 1880. The references to the earlier works are so fully given in this paper that they will not be repeated here.

† Quart. Journ. Micr. Sci., vol. xxv, 1885, p. 516.

‡ Sedgwick, *A Monograph of the Development of the Genus Peripatus*, Studies from

The considerations here shortly summarised have led to the conclusion that the Arthropods must be regarded as a group of animals in which a cœlom, comparable with that of Chætopods, Molluscs, &c., has either permanently retained, or has secondarily acquired the condition of existence as a mere appendage of the nephridium, the functional body-cavity being a space of an entirely different nature.

Observations recently made in the Laboratory of the Marine Biological Association at Plymouth have led me to believe that the cœlom of Palæmon, at least, is much more highly developed than is generally supposed; and to take a view of the structure of the nephridium which differs considerably from that enunciated by Grobben.

The observations referred to were made upon the common English *P. serratus* (Fabr.), and were suggested by an attempt to repeat the experiments on excretion recently described by Kowalewsky,\* who has shown that the renal tubules of *P. Treillianus* send branches into the thorax,—branches which extend back as far as the pericardium (l. c., p. 37).

Kowalewsky's observations were made by injecting various colouring matters into the tissues of the prawn; and these colouring matters, being absorbed by the renal tissues, stained such tissues deeply, and so made them easy of observation.

If a small quantity of a 1 per cent. solution of indigo-carminé be injected into the tissues of a healthy *P. serratus*, the colouring matter passes quickly into the venous sinuses, and in this way the gills speedily acquire a blue colour. Kowalewsky has demonstrated the presence in the gills of *P. Treillianus* of certain cells which take up colouring matters, and which have an acid reaction; so that a neutral or alkaline solution of litmus, passing from the body into the branchiæ, becomes reddened on absorption by these cells. I have been unable to satisfy myself of the existence of these cells in *P. serratus*, in which the blue colouration observed after injections of indigo-carminé seems to be due simply to the presence of colouring matter in the blood passing through the vascular and transparent lamellæ of the branchial plumes.

Be this as it may, however, the colouring matter, after appearing in the gills, gradually leaves these organs and is more and more completely taken up by the cœlomic and nephridial cells. Some hours after an injection the prawn is seen to have lost all colour, except in the region of the kidneys and in the median dorsal portion

the Morphological Laboratory in the University of Cambridge, vol. iv, pt. i, and Quart. Journ. Mic. Sci., vol. xxvii, 1887, pp. 533, *et seq.*

\* Kowalewsky, A., *Ein Beitrag zur Kenntniss der Exkretionsorgane*, Biologische Centralblatt, Bd. ix, Nr. 2, March, 1889.

of the cephalothorax; these portions of the body being after an injection of suitable strength intensely blue. The colouring matter remains in these regions for some time, presumably until its final excretion through the nephridia

If a prawn, in which indigo-carmin has been absorbed in the manner just described, be dissected in strong alcohol, it will be seen that the blue area of the thorax communicates by a deeply stained band of tissue with each nephridium; and if the blue structures be carefully dissected out and removed from the body they will present the appearance which is shown in fig. 1. The cephalothorax is then seen to contain a large delicate sac (*cœ.*), whose walls consist of a flat pavement epithelium with a slight investment of connective tissue. This sac extends from the front of the head, immediately behind the rostrum, to the anterior extremity of the generative gland, to which it is closely attached (fig. 1, *ov.*). Dorsally the sac is covered only by the integument, from which, however, it is separated in the middle line by the ophthalmic artery (*a. o.*).

The walls of the cephalothoracic sac have the power of absorbing indigo-carmin in considerable quantities; and it is this property which causes the appearance of a dark blue patch in the cephalothorax after injection. The cavity of the sac is filled with a clear fluid, which is not blood, and which does not, at least for some time after the injection of indigo-carmin into the tissues, become coloured blue.

At its anterior extremity the cephalothoracic sac gives off a pair of tubular processes, one on each side, each of which dips downwards and passes between the œsophageal nerve-commissure and the great antennary muscles to open into the urinary bladder of its own side (figs. 1 and 8). A perfect communication is thus established between the nephridia and the cephalothoracic sac.

It is evident that, if the observations here recorded are correct, we have a sac in close contact at one extremity with the generative gland and in communication at the other with the nephridial tubes, and so with the exterior. This sac is further devoid of any communication with the system of blood-spaces. That is to say, we have a sac precisely similar in all its relations to the cœlomic sac of a Mollusc—especially to that of such a form as *Octopus*.\*

The connection of the cœlom with the generative gland is so close as to render it perfectly probable that the cavity of the gonad and of its ducts may at an earlier stage in ontogeny be continuous with that of the cœlomic sac.

The junction between cœlom and nephridia is effected, as has

\* Compare the account of the renal and cœlomic organs of this form given by Grobben, Arb. Zool. Inst. Wien, Bd. v, 1884.

already been seen, by means of a rather long, narrow tube, which is beset with small cæca, and which from about its middle point gives off a long branched tube, which ramifies about among the tissues of the base of the eye-stalks and of the first antennæ. Similar tubules are given off from the bladder, running from this organ into the second antenna. All these cæcal appendages of the cœlomic system are lined throughout by an epithelium, which is perfectly characteristic, and by which they are easily to be recognised in sections of the eye-stalks or antennæ.

In a paper read at the meeting of the British Association at Manchester, in 1887, an abstract of which was subsequently published in *Nature* (vol. xxxvii, No. 960, March 22nd, 1888, p. 498), Lankester has described certain spaces in the limbs of *Astacus* which appear to be lined by an epithelium and to be distinct from the blood-vascular system of spaces. It seems possible that these spaces, which Professor Lankester considers to be cœlomic in nature, are derived from processes of the nephridio-cœlomic apparatus of the same nature as those just described in *Palæmon*.

The external appearance of the nephridium itself has been accurately described by Grobben, except for the omission of the cœlomic canal which enters the bladder at the postero-internal angle, and which was entirely overlooked by this author, whose mistake in this point is probably due to his method of dissection, for he begins his account of the kidney with the words, "Präparirt man die (hintere) Antenne los," in which case one could certainly not expect a communication between the nephridium and any structure in the trunk to remain unbroken.

The nephridium communicates with the exterior by a short, delicate ureter, opening in the ordinary position at the base of the first antenna, and which opens by its proximal extremity into the antero-internal angle of the bladder.

The bladder itself is large, and its outer wall is invaginated by the glandular portion of the kidney and by the "end-sac;" these last-named structures being therefore partially invested by the epithelium of the bladder, in the manner described by Grobben in *P. Treillianus*. The layer of epithelium thus investing a part of the kidney is shown in fig. 8.

The epithelium of the bladder varies in character in various regions. That portion of the wall which forms the investment of the end-sac and of the glandular tubules consists of a layer of flattened cells, the nuclei of which stain deeply with hæmatoxylin, and appear nearly homogeneous, the protoplasm of the cells being granular, and also staining deeply (fig. 7). In the free portions,



fig. 3, the epithelium is less flattened, and the cells exhibit traces of striation, especially towards their peripheral extremities; the nuclei in this region also staining deeply, and presenting a more or less homogeneous appearance. In all parts of the bladder the nuclei frequently appear, in preserved specimens, to project more or less beyond the cell-protoplasm into the lumen of the organ.

Grobben is of opinion that the bladder of *P. Treillianus* receives only a single nephridial tubule, which by its convolutions builds up the whole glandular substance of the kidney. In *P. serratus* a continuous series of sections shows that several tubules open into the bladder. In the series from which the drawings figs. 2 *a*, *b*, *c* were made, one such tubule is seen to open into the bladder in the section *a*, while ten sections below this point, in fig. 2 *b*, no communication between the bladder and the renal tubules is visible. Going still farther back, however, the section fig. 2 *c* shows a second opening, receiving a tubule which itself receives a number of branches. These figures suffice to demonstrate the existence of two openings into the bladder, and in the series from which the drawings are taken, five such communications could be recognised.

The course of the tubules in the substance of the gland is exceedingly hard to follow. All the tubes except one seem for a short distance after their exit from the bladder to run parallel with the surface of the gland, and then to bend inwards and upwards toward the end-sac. During their course they give off numerous cæca branches in the manner described by Grobben. One tube runs from the bladder along the posterior edge of the gland, and passes for some distance beyond the others; it then turns upon itself and passes into the substance of the gland, giving rise to a projecting process, attached to the postero-external angle of the organ (see fig. 1.)

Immediately after leaving the bladder, the lumen of the tubules is large; they are lined by an epithelium exhibiting the characteristic striation, and provided with a delicate cuticle. The nuclei of the epithelial cells are coarsely granular in stained sections, the granules staining fairly deeply. As it passes inwards, the lumen of each tubule becomes smaller, and the nuclei become clearer, and less distinctly granular. The two kinds of epithelium are shown in figs. 4 and 5.

The tubules are packed tightly together in the body of the kidney, the small spaces between them being filled with branched connective-tissue cells.

On reaching the dorsal surface of the organ, the renal tubules open into the "end-sac," which has been already referred to.\* In fig.

\* A quite similar case, in which communication between the end-sac and the body of a

7 the entry of three such tubules,  $\alpha$ ,  $\beta$ , and  $\gamma$ , is represented. The end-sac itself is a kidney-shaped structure, receiving in its concavity a large blood-vessel. It contains in its interior a considerable cavity, into which project a number of radial septa. These septa, together with the external wall of the organ, are made up of a dense connective tissue, which is deeply stained by hæmatoxylin, and in which run numbers of blood-vessels (fig. 7, *b. v.*). These blood-spaces are not, however, so numerous as those figured by Grobben in the corresponding septa of *P. Treillianus*; and there is a further difference between the blood-spaces of Grobben's figure and those seen by myself, inasmuch as the latter are always bounded by a distinct epithelium. I do not wish, however, to throw doubt on the accuracy of Grobben's figure without having had an opportunity of investigating the species described by him.

The cavity of the end-sac is lined by a curious epithelium, composed of large, pale, finely granular cells, with rounded nuclei (see fig. 7, *Ge. ep.*). In none of my preparations have I been able to see an arrangement of the epithelium so regular as that figured by Grobben (*l. c.*, pl. i, fig. 8). In many of my sections, also, patches occur on which the epithelium is absent,—apparently from some cause independent of the methods of manipulation.

The cavity of the "end-sac," and to some extent also the lumen of the nephridial tubes, is filled with an irregular, finely granular clot. For the sake of clearness, this clot has only been inserted in the upper half of fig. 7.

The arrangement, of which a description has here been attempted, will be made clear by an inspection of the diagram fig. 6, in which it will be evident that the comparison so often made (by Claus, Grobben, and others) between the glomerulus of the Vertebrate kidney and the end-sac of the Crustacean green gland is abundantly justified, each glomerulus being the termination of a cæcal outgrowth from a bent nephridial tube, which communicates on the one hand with the body-cavity and on the other either directly or indirectly with the exterior.

In a future paper I hope to describe the modifications of this arrangement in other genera. I may here say that I have found in *Pandalus annulicornis* a cœlomic sac which is similar in its relations to the sac just described, but that in this genus the glandular part of the kidney is formed entirely by the glomerulus,—this structure being formed by a folded invagination of the wall of the nephridial tube, containing large numbers of blood-capillaries.

nephridium is established by more than one tube, occurs in the young coxal gland of *Limulus* (cf. Gulland, Quart. Journ. Micr. Sci., vol. xxv, pl. xxxvi, fig. 2).

DESCRIPTION OF PLATES XIII, XIV, AND XV,

Illustrating Mr. Weldon's paper on the "Cœlom and Nephridia of *Palæmon serratus*."

*Reference Letters.*

*a. op.* Ophthalmic artery. *B.* Bladder. *B. ep.* Bladder epithelium. *b. v.* Blood-vessel. *Cæ.* Cœlom. *e. s.* End-sac. *Gl.* End-sac. *Ov.* Ovary. *u.* Ureter.

FIG. 1.—The cœlom and right nephridium of *Palæmon serratus*, dissected out.

FIG. 2, *a, b, c.*—Eight diagrams of sections through the bladder, showing the existence of more than one communication with the nephridial tubules.

FIG. 3.—Epithelium of bladder.

FIG. 4.—Epithelium of a renal tubule near its entrance into the bladder.

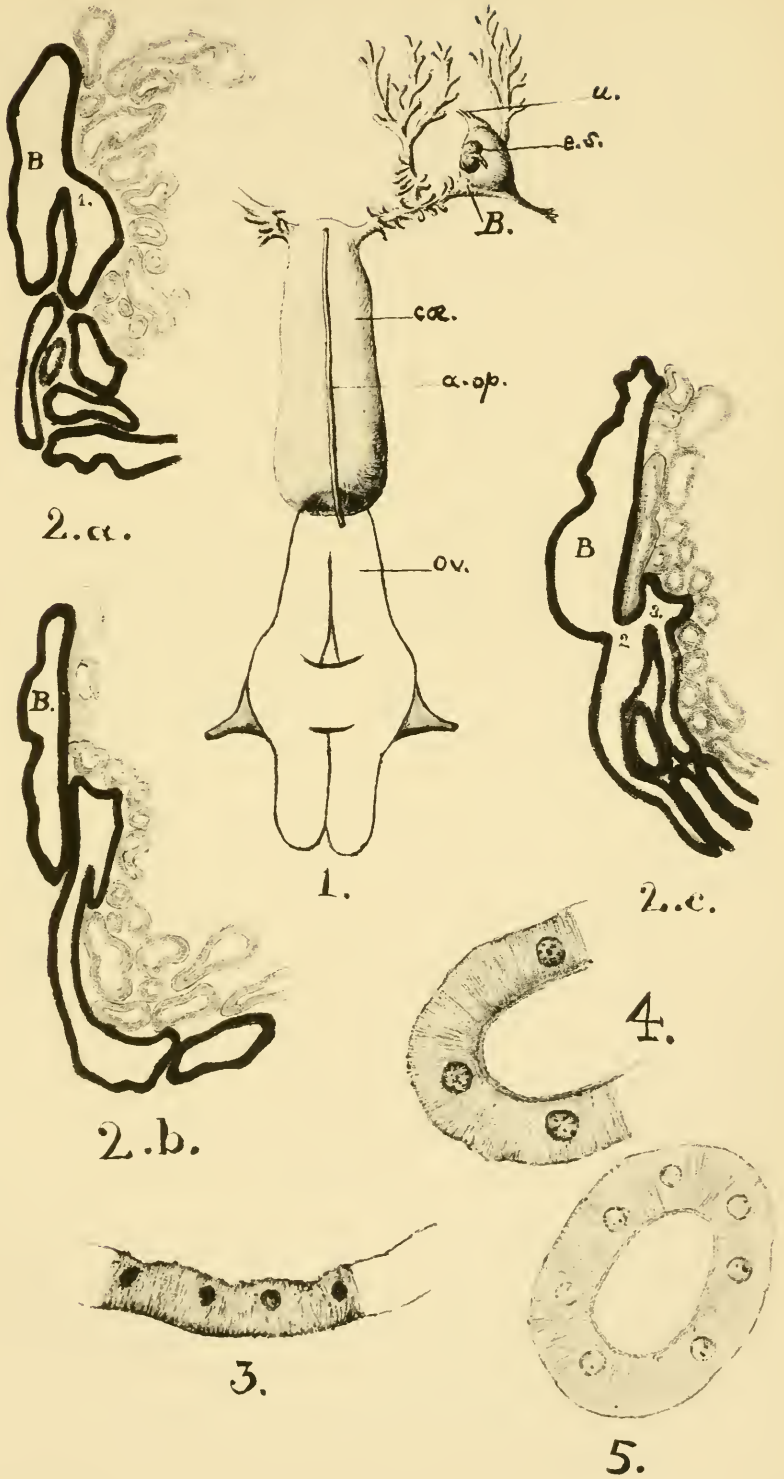
FIG. 5.—Epithelium of a renal tubule in the middle of its course.

FIG. 6.—Diagram of the arrangement of the bladder, tubules, and end-sac.

FIG. 7.—Section through the end-sac.

FIG. 8.—Section showing the communication between the bladder and the cœlom.

*Note.*—The shading in Figs. 2 and 8 is obviously diagrammatic; but the outlines are in both cases determined by means of a *Camera Lucida*.







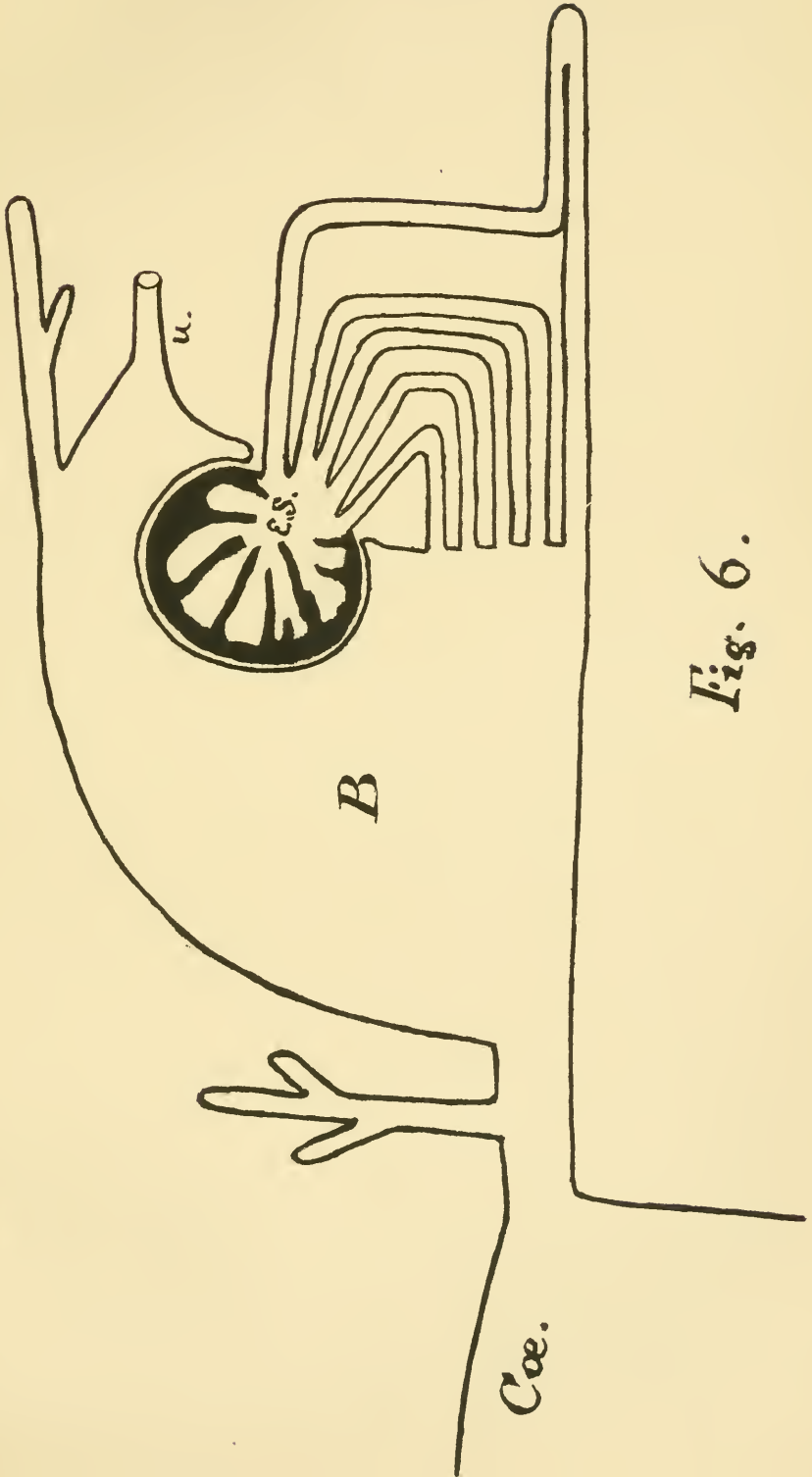


Fig. 6.





7.



8.

*A. F. R. G.*



## Note on the Function of the Spines of the Crustacean Zoëa.

By

**W. F. R. Weldon, M.A.,**

Fellow of St. John's College, Cambridge; Lecturer on Invertebrate Morphology in the University.

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With Plate XVI.

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ANYONE who has examined the so-called "protective" spines of the various Zoëa larvæ must have been struck by their great tendency to develop in one straight line, parallel to the long axis of the body. Among the *Macrura* this is the case in the Zoëa of *Peneus*, in the larva attributed by Claus to *Hippolyte*, and in the Galatheidæ. In the *Brachyura* the same result is attained in a slightly different way.

A comparison between the behaviour of those forms which are provided with long spines and those which are devoid of them, will show clearly that these structures have at least one function which has not, I believe, been hitherto recognised.

The accompanying drawing was taken from a Portunid larva, seen obliquely from above while in the act of swimming. The larva is seen to lie upon its back, and to swim in the direction of the arrow by rowing itself along with its maxillipeds, exactly in the manner of two men sculling a narrow racing boat. Steering is effected by means of the tail.

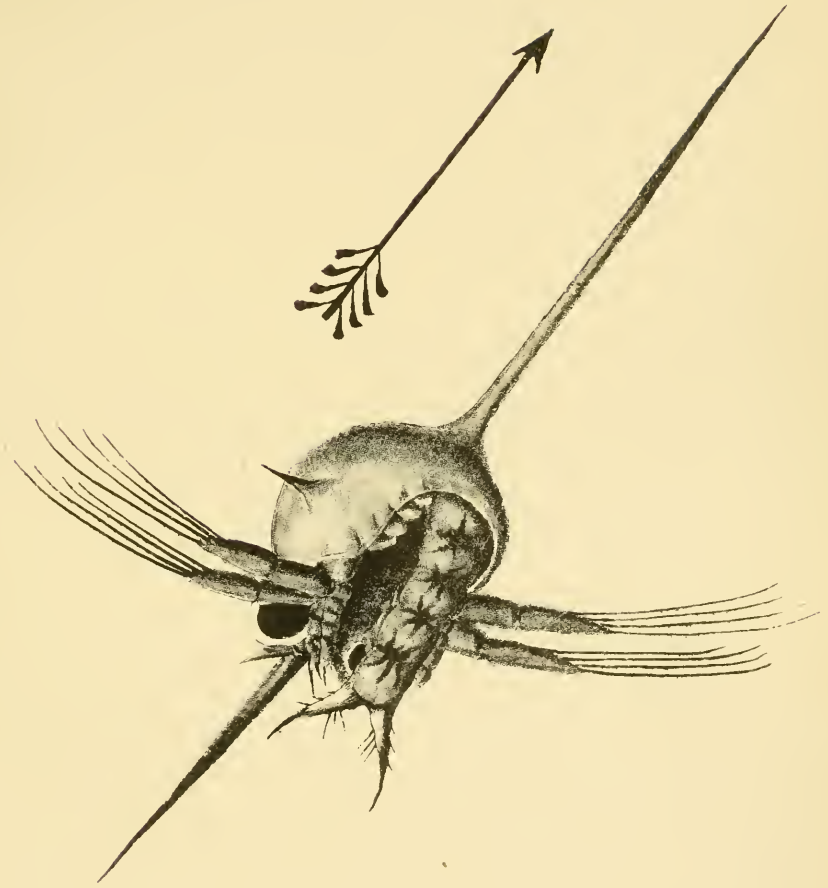
The great majority of the Brachyurous larvæ which I have observed swim in this manner, though some of them do not lie upon their backs.

If a number of Decapod larvæ be placed together in a large glass vessel, the effect of these spines upon their swimming capacities is very manifest. Such a larva as the Portunid of the figure will swim in an absolutely straight line towards the light, moving with great rapidity, and neither changing his direction nor losing his equilibrium during a journey of several feet. Those larvæ without spines, on the other hand, such as *Crangon* or *Palæmon*, will make their journey their journey towards the light in a very different manner. Their



progress will be in a succession of ill-directed spirals, and it will be accompanied by that peculiar rotation about the long axis of the body which is seen in larvæ whose locomotion is effected by means of ciliated girdles. And not only will all forward movement be thus indirect, but it will be impeded by frequent and apparently involuntary somersaults, after which each Zoëa will hang for a moment vertically in the water, as if to recover its sense of direction.

It is hard to avoid the supposition that this power of rapid and direct motion which accompanies the possession of long spines must be an advantage to its possessor ; but if this be the case, it is difficult to imagine the causes which have led to the abolition of such spines during the passage from the *Peneus* group to such forms as *Orangon*, *Palæmon*, &c., which are numerous and widely spread, while their larvæ are devoid of spines and incapable of executing the rapid and skilful movements in question.



*W. R. Ch.*



## On the Structure of the Thallus of *Delesseria sanguinea*. *Lamour.*

By

**M. C. Potter, M.A., F.L.S.**

With Plates XVII and XVIII.

THE *Delesserias*, a genus of red seaweeds, six species of which inhabit the shores of the British Isles, have the thallus differentiated into a well-marked foliar expansion and a cylindrical portion; these we may respectively term the leaf and the stalk. Descriptions of this thallus are given in all books on seaweeds, for instance, in Harvey's (*Phycologia Britannica*), or Hauck's (*Die Meeresalgen*), but as far as I am aware no detailed account has been given of these structures. Agardh\* and Wille† briefly describe their histology, but pay no special attention to them. The leaf is generally a fairly broad expansion (Pl. XVIII, fig. 1), with a definite midrib which gives off laterally a number of veins, these again giving off other veins and so on; the veins taper and become gradually finer till they end in being unicellular (fig. 2). This arrangement of veins exactly resembles the distribution of the fibro-vascular bundles in the leaf of an ordinary Dicotyledon and we shall see that they perform nearly the same functions in the two cases. By cutting transverse sections of the leaf we find that it is a plate of cells one cell thick (fig. 3, A, *a*) with here and there masses of cells, the veins. The cells of the leaf seen in surface view are polygonal with their protoplasm continuous‡ from cell to cell (fig. 4). While the leaf is small and is still growing the veins are developed by the cells of the leaf dividing into three (fig. 3, B); the cells on each side may divide similarly and thus the vein become broader (fig. 3, C); the cells also above and below (fig. 3, A, *b*) the central ones may cut off segments and thus the vein becomes thicker. In this way we can trace the development of a vein from its unicellular ending to its largest part where it joins the midrib or another large vein. The midrib is developed in exactly the same way. The central cells first formed (fig. 3, C) elongate considerably as the young leaf grows; the cells formed by the divisions of the outer ones do not become so long as the central cell; thus the cells in the centre of each vein are longer than those external to them. The cells of

\* *Florideernes Morphologi*, Kongl. Svenska Vetenskaps Akademiens Handlingar, 1879.

† *Bidrag til Algernes Physiologiske Anatomi*, Kgl. Svenska Vetensk. Akad., 1885.

‡ *On the Continuity of the Protoplasm in the Florideæ*, see Gardiner, in Proc. Camb. Phil. Soc., vol. v, p. 104, and Hick, in Journal of Botany, vol. xxii.

the vein, with the exception of the most external layer, are much longer than broad and have their protoplasm continuous with each other and with those cells which touch them (fig. 5).

As regards the stalk we find that the outer layer is made up of small squarish cells, while scattered irregularly in the centre are very large cells between which smaller cells are packed (fig. 6). Fig. 7 shows that the large cells are conducting cells, and that their protoplasm is continuous at their ends and also with the neighbouring cells at the sides.

We now come to consider the physiological importance of these structures, and at the outset we can clearly distinguish between an assimilating tissue, viz. the parts of the leaf where it is only one cell thick and the outermost cells covering the veins, and a conducting tissue, namely, the veins in the leaves and large cells in the stalk. The cell wall is thick, gelatinous, and pitted, and by means of these pits the protoplasm is continuous from cell to cell. The assimilated substances can easily be passed through a few cells to the veins; here they find an easy passage to various parts of the plant, some being stored up in the stalk which serves for a reservoir of reserve material as well as for an organ of attachment. Comparing the *Delesseria* leaf with that of a Dicotyledon, in both cases we have conducting tissue, but in the *Delesseria* there is only one conducting tissue required to take the assimilated substances to parts of the plant where they are wanted, and since the plant lives entirely submerged there is no need of a tissue to conduct water to the leaf; and we see too that in *Delesseria*, coupled with morphological differentiation into stalk and leaf, there is also physiological differentiation into assimilating and conducting tissue.

The above remarks apply especially to *D. sanguinea*, and judging from Harvey's pictures we conclude that in the main all the species are alike in possessing assimilating and conducting tissue.

#### DESCRIPTION OF PLATES XVII AND XVIII.

Illustrating Mr. M. C. Potter's paper "On the Structure of the Thallus of *Delesseria sanguinea*."

FIG. 1.—Part of thallus of *Delesseria sanguinea*.

FIG. 2.—Portion of leaf magnified. *a*. The midrib. *b*. Lateral veins given off from it. *c*. Fine veins.

FIG. 3.—Transverse section of leaf. A. Section showing the unicellular part (*a*) and a small vein (*b*). B and C. Section showing the development of a vein.

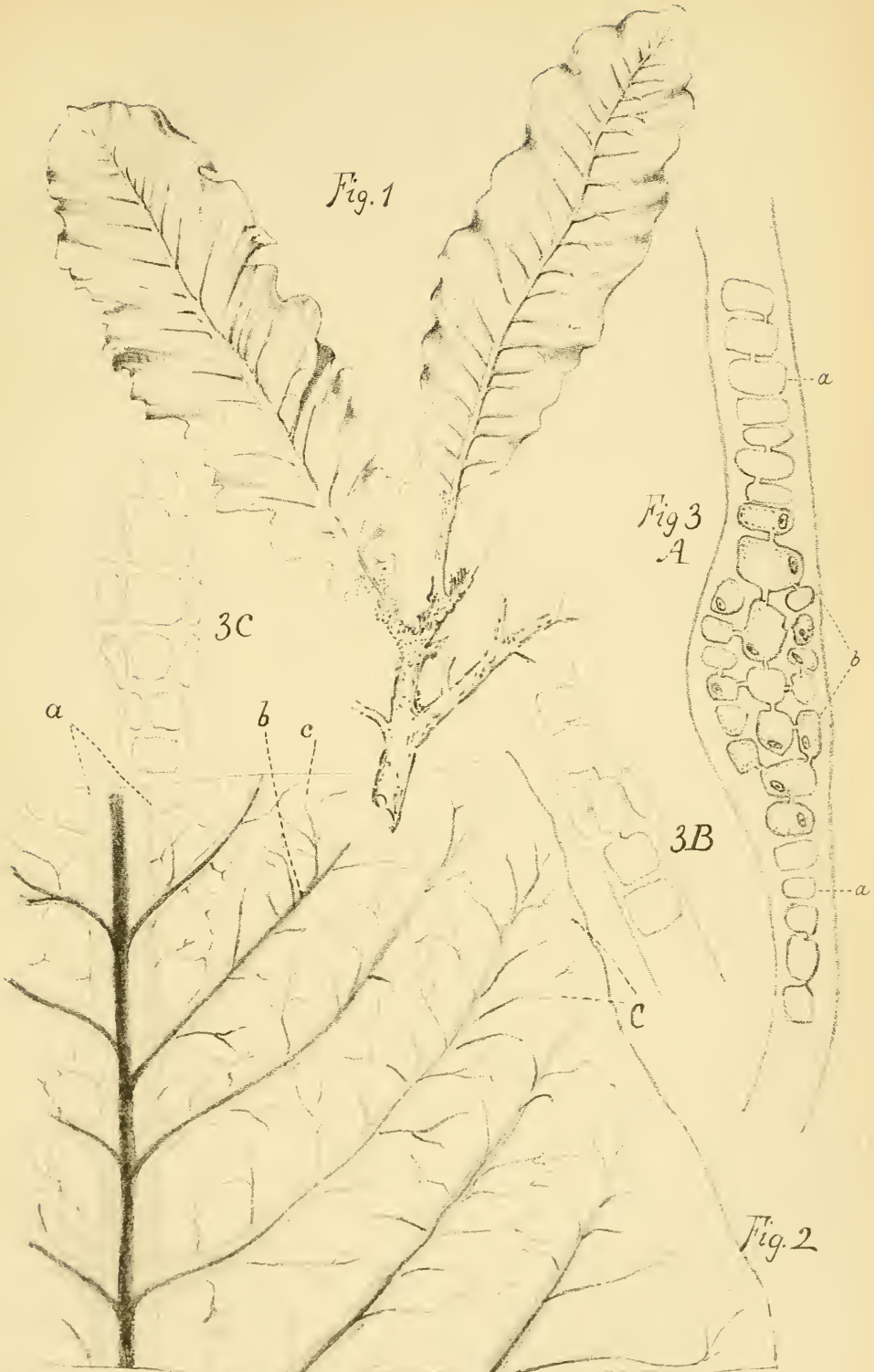
FIG. 4.—Portion of a leaf seen in surface view.

FIG. 5.—Cells from a fine vein.

FIG. 6.—Transverse section of portion of stalk, the shaded portions (*a*) indicating the pits where the cells are continuous at their ends.

FIG. 6.—Longitudinal section of stalk, showing a large conducting cell.





M.C. Peck del. G. Ent. reprod



Fig. 4



a



Fig. 6



Fig. 5

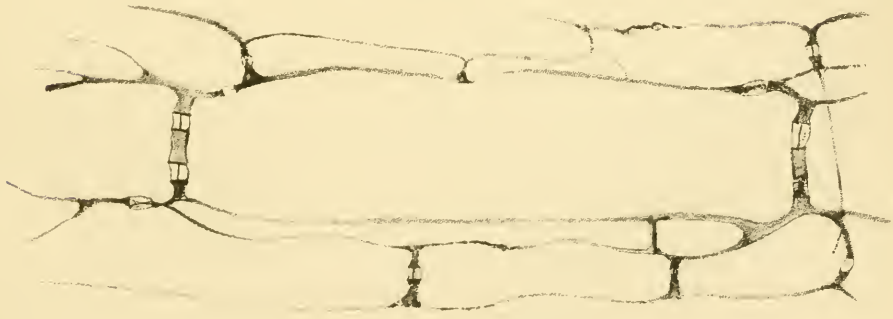


Fig. 7



## Report on the Nudibranchiate Mollusca of Plymouth Sound.

By

**Walter Garstang, B.A.,**

Jesus College, Oxford; Assistant to the Director M.B.A.

THE species included in the present report have all, with one exception, been taken since the opening of the Laboratory in June, 1888. Twenty-four genera and thirty-six species will be found recorded, and these afford a considerable addition to the previously known Nudibranchiate Fauna of the Sound.\* Many of the specimens have been obtained north of the breakwater by personally searching under the stones and examining the rock-pools between tide-marks, but the majority have been procured by means of the dredge, the best grounds for this being near the Duke Rock Buoy and around the Mewstone, a fine conical rock which marks the entrance to the Sound on the east.

That the Fauna of the Sound has deteriorated during the last fifteen or twenty years seems undoubted, the cause being the continued increase in the amount of outfall of waste and commercial products from the Three Towns.† Vayssière in his account of the Opisthobranchiate Mollusca of the Gulf of Marseilles reports similar impoverishment of the Fauna due to similar causes. At a part of the coast, he says (25, p. 7), where *Haminea cornea*, *Philine aperta*, *Aplysia punctata*, *Doris virescens*, *Polycera quadrilineata*, and numerous Eolids used to be found in abundance, "dans ces deux dernières années il nous a été impossible de rencontrer plusieurs de ces mollusques et ceux qui ont résisté deviennent rares."‡ From what I have heard of the zoological condition of other bays along the Devon and Cornish coasts, I have no doubt that, especially among the Nudibranchiata, there are many species to be found in the neighbourhood which have not been taken by us inside the Sound or in the adjacent waters.

Notwithstanding this, some very valuable captures have been made, notably two examples of *Idalia aspersa* and three specimens of *Lomanotus*. The latter especially have proved of great interest, and their characters afford a very valuable addition to our knowledge of the genus in British seas. One species of *Eolis* appears to be new. Moreover, I have throughout tried to make this report not merely a list of species, but as far as possible a contribution to

\* Cf. this Journal, No. II, First Series, p. 185.

† See the Director's Report, this Journal, New Series, No. I, p. 5.

‡ Cf. also some remarks by Thompson of Weymouth (24).



science. The *Zeit-geist* is in many quarters making for a re-examination of the very foundations of the theory of Natural Selection, and I trust that the observations here recorded on the subjects of variation, reproduction, rate of growth, colour, and habits of life may be of some service in furnishing facts as regards the life-conditions of this particular group of animals. I further trust that it may not be difficult for others to separate my own theoretical opinions or conclusions from the facts themselves.

During the past year a considerable advance in our knowledge of the value of colour in this group has been made. Darwin\* himself seems to have been very doubtful whether the bright tints of Nudibranchs, and especially of the *Eolididæ*, really served as a protection, except in a few cases; but evidence is accumulating rapidly to prove that in this group colour, whether conspicuous or dull, has a very important value for the individual and species. Giard (6) and Herdman (13) have simultaneously noticed that the colouring of the common *Archidoris tuberculata* affords a means of rendering it inconspicuous in the localities and positions in which it is usually found. This species feeds usually upon *Halichondria panicea*, a common spreading shore-sponge, and the colours of the two are very similar. I may point out that this mimetic resemblance is increased by the possession by the Mollusc of a layer of dermal spicules; an enemy, knowing by inherited instinct, or far more probably by actual experiment and consequent education, the unpalatableness of the sponge, would be doubly deceived as regards the Nudibranch, both by its resemblance to the sponge in appearance and colour, and also by its similar *feel*. The case of this *Archidoris* is, however, somewhat complicated; individuals are often found with patches of green or violet colour on the back, and these add to the general inconspicuousness by being the tints of overhanging or surrounding weeds. Indeed, these colours are often seen in the sponge itself. Herdman does not appear to have noticed the mimicry between the Nudibranch and sponge, but he has a very interesting case in which the colour of the former perfectly simulated that of the surrounding rock, Nullipores and *Spirorbis* tubes.

A case more closely approaching one of true mimicry I came across on the shore at Drake's Island in the early spring of this year. It was that of a small *Archidoris Johnstoni* fixed on the side of an upright rock between tide-marks, and so exactly resembling a small piece of *Halichondria panicea* (var. *papillaris*) that at first I was quite deceived by it. It was situated with the head above and the anus below, the gill-plumes being (as Alder and Hancock state to be usual in the species) half retracted and forming a perforated cone perfectly resembling one of the protruding oscula of the sponge.

\* Descent of Man, 2nd ed., pp. 261, 262, 264.

Several instances of pure "protective resemblance" to a fairly fixed surrounding may be found in Giard, and also one which seems to me to be a case of "mimicry" proper, namely, the resemblance of *Eolis papillosa* to a contracted *Sagartia parasitica*, the dorsal papillæ of the former corresponding to the tentacles of the latter. I have placed my remarks upon this most interesting case in my notice of the species (*infra*). Giard has made a mistake in regarding these cases of protective colouring as instances of a special mimicry existing between the Nudibranchs and the particular species which they affect for prey; but emphasis ought not to be laid upon this point, for (*e. g.*) *Eolis papillosa* not only preys upon *Sagartia parasitica*, but attacks anemones generally.

To what extent the colours of the smaller Eolids are explicable as instances of this mimicry of Actinians, I do not feel prepared to say at present. Wallace\* thinks it probable that in some cases at least they are "warning colours as a sign of inedibility."

My own opinion is that the bright colours of the papillæ of Eolids in the majority of cases are serviceable in two ways. Their main purpose is no doubt to warn enemies of the presence of disagreeable qualities (*e. g.* nematocysts). But from the bright colours being generally confined to the papillæ, which are well known to be detached from the body with the greatest ease, and to be reformed to their full size in two or three days, I think this arrangement must be serviceable in directing the experimental attacks of young and inexperienced enemies to the non-vital papillæ, and away from the vital, inconspicuously coloured parts of the body. The enormous mortality of Nudibranchs† shows what would be the value in the struggle for life of such a means of facilitating the education of enemies, while giving the individuals themselves an additional chance of escape. That butterflies often escape from the attacks of birds owing to the conspicuousness and prominence of their wings, is shown by the many captures of individuals with mutilated wings which have been recorded; but in the case of Eolids such attacks of enemies (fishes chiefly) at the same time give them the needful experience of the unpalatable nature of their intended prey.‡ I have, however, experiments in progress for the verification of these and other ideas as to the value of colour in Nudibranchs and other groups of marine animals.

The ways in which colour probably serves as a protection through-

\* Darwinism, London, 1889, p. 266.

† Cf. Darwin, Voyage of Beagle, 2nd edit., p. 245, note.

‡ Since the above was in type Mr. Poulton has drawn my attention to his account of the defensive value of "tussocks" in the larva of *Orgyia* (Trans. Ent. Soc., 1888, p. 589), which I had quite overlooked. The analogy is remarkably striking.

out the group are certainly very various, just as they are in *Lepidoptera*. One case especially is worthy of a moment's notice, viz. that of the tiny Dorid, *Ægirus punctilucens*. I have only met with one example of this form as yet, but in the conditions in which I met with it (see notice of species, *infra*) its general colour, form and size were highly protective in the way of rendering it inconspicuous. On a closer view, however, the sparkling blue-green spots which are so characteristic of the species became evident and conspicuous. The idea at once struck me that these spots must be serviceable in some way when the general protective colouring has failed to conceal the animal from its enemy, but of this, from lack of individuals for experiments, I can adduce no proof. Further, the habits of the Nudibranch itself are not at all satisfactorily known; D'Orbigny states it to live upon small species of *Ulva*, but though I can give no conclusive evidence I am almost sure that the habit which D'Orbigny observed is by no mean normal. Another case which appears to me to be similar is that of *Elysia viridis*, which is coloured bright-green and lives among green weeds. On its back, however, are a number of pearly spots in regular rows, very conspicuous upon a close view. I cannot help comparing them with the spots on the back of *Ægirus punctilucens*. In *Elysia* these spots appear to mark the positions of "pouch-like mucous follicles,"\* a fact which adds to the interest of the case. I hope shortly to give an account of their structure and function, and of the value to the species of the markings which indicate their presence.

I desire here to express my great indebtedness to my friend and former tutor, Mr. E. B. Poulton, M.A., F.R.S.,† for his constant kindness and encouragement; also to Mr. W. Hatchett Jackson, M.A., F.L.S., for the equal value of his friendship and advice; and to Mr. G. C. Bourne, M.A., F.L.S., the Director of the Laboratory, for the time and facilities which he has readily granted me. I must also thank Canon A. M. Norman, M.A., D.C.L., F.L.S., for the help of his experience on several points, and Professor Charles Stewart, M.A., F.L.S., for information about the Fauna of Plymouth Sound in previous years.

In the report I have refrained from discussing anatomical characters, since I have not been able to consult the original papers and monographs of Bergh (with one or two exceptions) and Trinchese. To the same cause I should wish to be attributed whatever imperfections may be found in my classification.

\* See Macalister, Introduction to Animal Morphology, part i, 1876, p. 280.

† I need hardly refer to the great suggestive value of Mr. Poulton's numerous papers on the colour, markings, and habits of lepidopterous larvæ and pupæ.

## NUDIBRANCHIATA

(= OPISTHOBRANCHIA NON-PALLIATA, Lankester).

### Sub-order 1.—PYGOBRANCHIA, Gray.

*Family*—DORIDIDÆ, Leach.

*Sub-family*—DORIDIDÆ CRYPTOBRANCHIATÆ, Bergh.

#### 1. ARCHIDORIS, Bergh.

##### 1. A. TUBERCULATA, Cuvier.

Common among the rocks between tide-marks. As many as thirty specimens were obtained on May 31st at Bovisand, north of the pier. Spawn this year most abundant in March and April, but on account of the mildness of the winter and warmth of the spring, marine animals generally have been breeding earlier than usual. On May 29th half-a-dozen specimens were obtained from the shore at Batten, of which one was only three quarters of an inch long, and several others were less than an inch and a half in length. The spawning is prolonged throughout the summer. On August 2nd a young individual was dredged in twenty fathoms off Rame Head, one inch in length. Several large specimens have been met with at various times; the finest, which was five inches in length, was obtained from the mouth of the Yealm on January 21st. It was seen in a fathom of water from the boat's side by W. Roach, our fisherman, and would have been in two feet of water at extreme ebb.

This species usually feeds upon *Halichondria panicea*, a very common littoral sponge, and\* Giard (6) has noticed the general resemblance it bears in form and colour to its prey. It would be more correct to say that it is protectively coloured in relation to its surroundings; see Herdman (13) for a very good case and for his remarks upon it. Professor Stewart tells me that he once obtained on the shore at Cremyll four or five individuals, apparently of this species and at least two inches long, from a mass of *Hymeniacidon sanguinea* upon which they were feeding, and that, remarkably enough, they were all bright red in colour. Possibly they were examples of Alder and Hancock's species *Archidoris flammea*, though more than twice the size of their specimens.

##### 2. A. JOHNSTONI, A. and H.

I have only seen one individual of this species, though Professor Stewart tells me that in former days it was very plentiful. I obtained

\* More than fifteen years ago Giard remarked upon the deceptive appearance of this species "au milieu des masses rougeâtres des Amarouques qui couvrent le fond" (Arch. Zool. Exp., i, 1872, pp. 553, 558.)



our specimen from a rock between tide-marks at the east end of Drake's Island in the spring of this year. As I have mentioned in the introduction, this individual had most perfectly the appearance of a young *Halichondria panicea*, the "blossom-like cup" (A. and H.) formed by the branchiæ simulating the osculum of the Sponge. It was about one inch in length when extended fully, but was very changeable in shape. In appearance it was of a very pale, creamy white colour.

The branchiæ in this individual were twelve in number, but Alder and Hancock state the normal number to be fifteen. I notice that Hancock's figures represent only twelve.\*

### 3. *A. COCCINEA*, *Forbes*.

Between tide-marks on the rocks below the Laboratory, May 14th, one specimen, three eighths of an inch long. One was also obtained in the autumn of last year. Mr. Heape found one on the shore at Ram's Cliff in November, 1886, and again in August, 1887, and also trawled one between the Duke Rock and Drake's Island in November, 1886.

### 4. *A. PLANATA*, *A. and H.*

One specimen, three eighths of an inch long, of a reddish flesh-colour, was obtained with the dredge from near the Duke Rock Buoy May 22nd, 1889. Mr. Heape also obtained one on ground between the Duke and New Grounds' Buoys in November, 1886, between the Duke Buoy and Drake's Island in the same month, and again in Barn Pool January 19th, 1888.

*Sub-family*.—DORIDIDÆ PHANEROBRANCHIATÆ, *Bergh*.

*Section A.* GONIODORINÆ (=GONIODORIDÆ, *Bergh*).

### 2. *ACANTHODORIS*, *Gray*.

### 5. *A. PILOSA*, *Müller*.

One fine specimen, an inch and a half long when not completely expanded, from the estuary of the Yealm, opposite the coastguard station, May 25th, 1889. It would come under Alder's third colour-variety (1), being very black in colour. We have obtained five or six other specimens also, but the record of their capture has been lost. They are quite colourless in spirit, and are not so large as the first-mentioned specimen.

\* I have since (Sept. 11th) obtained another specimen from Drake's Island, and in this the branchial plumes are fifteen in number.



3. LAMELLIDORIS, *Alder and Hancock.*6. L. BILAMELLATA, *Linneus.*

Thirty or forty specimens were obtained from the mouth of the Yealm, October 20th, 1888. Occurs also inside the Sound at Batten and Jennycliff. Seven or eight obtained with the dredge from off the Duke Rock, January 23rd this year.

7. L. SPARSA, *A. and H.*

Two specimens of this rare species were obtained with the dredge in fifteen fathoms water off Stoke Point, January 17th, 1889. Each was just a quarter of an inch in length, ovate in form, and nearly equally rounded at both ends. One was of a brownish-pink colour, deepening just behind the tentacles and within the branchial circle, the other was of the same general hue but very pale and slightly purplish in the middle of the back. A character which was marked in each of these specimens, but which Alder and Hancock have not mentioned in the account of their specimen, is that the spiculous tubercles on the back were each surrounded by a ring of blackish pigment, and generally contained a black spot in their centres. Hancock's drawing (Monograph, fig. 3) represents these markings, although there is no mention of them in the text. The tentacles were yellowish white with brown spots or patches; the tubercles on the margins of the tentacular cavities were white with a black spot in the centre of each; but the "obtuse point behind," mentioned and figured in Alder and Hancock's Monograph, was not well marked in either of these individuals. These specimens also did not show the "few distant reddish-brown freckles or spots" on the back which were strongly marked in their example. I believe the branchial plumes were ten in number, but they were very small, not expanded, and hard to make out. The two were kept alive for several days, but were very torpid and remained constantly on the bottom or sides of the dish, never being seen to float on the surface of the water.

8. L. ASPERA, *A. and H.*

A young individual of this species was dredged between the Mallard and Cobbler Buoys on July 25th of this year. The contents of the dredge were chiefly large quantities of Polyzoa (*Bowerbankia imbricata*, *Bugula flabellata* and *avicularia*), and it was apparently from among these that the Nudibranch emerged after being placed for some time in a dish. It was only one tenth of an inch in length,

but the dorsal tubercles were so characteristically flattened that there could be no mistake in the identification.

#### 4. GONIODORIS, *Forbes*.

##### 9. G. NODOSA, *Montagu*.

Common on rocks between tide-marks in the Sound. In October of last year it was obtained at the following localities—off Ram's Cliff, north of Batten breakwater, at the east end of Drake's Island, one mile west of the Mewstone, and in the estuary of the Yealm. This species, like many other Nudibranchs, comes to the shore in the spring to spawn. Very many large ones were found on the rocks below the Laboratory, near the ladies' bathing place, as early as February this year, and the spawn was abundant in March, April, and May. Young ones were being obtained frequently with the dredge in July.

##### 10. G. CASTANEA, *A. and H.*

One example, just an inch long, was obtained from the shore at Bovisand, north of the pier, on May 31st of this year. Near it was some spawn which corresponded *generally* with that described and figured in Alder and Hancock, but the coil was larger and curiously recurved so as to form a sort of figure 8. After finishing the third round in one direction, the animal had begun again on the opposite tack, depositing two coils. It was all in one piece, and probably was deposited by this individual.

#### 5. IDALIA, *Leuckart*.

##### 11. I. ASPERSA, *A. and H.*

We have obtained two specimens of this rare species. The first was dredged in the estuary of the Yealm on October 20th, 1888. It is rather more than three sixteenths of an inch long in alcohol and corresponds with Forbes's description of *I. inæqualis* in having the back "circumscribed, elevated, with steep sides," a character which may be exhibited by other individuals of this species *aspersa* (see Alder and Hancock). It is colourless in spirit, has no median tubercles or filaments on the back, and has the anterior gill-plume and the posterior pair of filaments bifurcated.

The second example was dredged off Penlee Point on June 29th of this year. It was just over half an inch in length and its colour

was a mottled rosy brown with yellow spots. This colour has largely persisted in alcohol. The two tentacular appendages on each side were as long as, or longer than, the tentacles proper, as Alder and Hancock have represented them, and they were constantly waving about while the animal was alive. The branchiæ were ten in number, but the anterior plume was deeply bifurcated as usual, thus forming eleven points. The posterior plume was not bifid. The lateral filaments were four on each side, the anterior ones very small, the posterior pair very broad at their bases and bifid.

These dorso-lateral rows of filaments are plainly homologous with the ridges found in the genera *Polycera*, *Goniodoris*, &c., and these also with the "epipodial folds" (Lankester, after Huxley) of *Archidoris*, so that a term to convey this idea would be of service. The "pallial ridges" of Alder and Hancock ought therefore to be termed "epipodial ridges." These structures are of considerable morphological importance and exist to a greater or less extent in every British species (at least) of the family *Dorididæ*, though often represented by very specialised vestiges (*e. g.* the branchial appendages of *Thecucera*); and I believe their homologues are to be seen in *Tritonia* and *Lomanotus*, becoming strangely modified in the *Eolididæ*. Additional ridges are sometimes developed, viz. a median, and a pair of sublateral (*cf.* *Goniodoris*, *Polycera*, *Idalia elegans* and *Leachii*).

In view of the variability of the branchiæ and epipodial filaments in this genus I think it must be regarded as certain that Forbes's two specimens of *Idalia inæqualis* are in reality varieties of *I. aspersa* (*cf.* Alder and Hancock's Monograph, Appendix, p. v). They were obtained together in thirty-five fathoms in St. Magnus' Bay, Zetland. The habit of associating in couples seems to be very common among Nudibranchs (*cf.* Giard, p. 502), and I have noticed it in species which are usually found in large groups (*e. g.* *Goniodoris nodosa*). If I should prove to be right in regarding the Zetland *Idalias* as varieties of *I. aspersa*, the Scarborough *Tritonias* (*lineata*, A. and H.) as varieties of *T. plebeia*, and the various British forms of *Lomanotus* as all of one species, then we should apparently have three instances of selective association between similar varieties in so low a group as the *Mollusca*.

#### 6. ANCUA, *Lovén*.

#### 12. A. CRISTATA, *Alder*.

In March of this year Mr. W. B. Hardy took a fine individual of this species from a tide pool below the ladies' bathing place. It was an inch in length when fully extended. I obtained another specimen between tide-marks near the same place in April.

*Section B.*—POLYGERINÆ (= POLYGERIDÆ, *Bergh*).7. *ÆGIRUS*, *Lovén*.13. *Æ. PUNCTILUCENS*, *D'Orbigny*.

On March 6th of this year we obtained one of these remarkable little creatures from near the Duke Buoy. Some of the contents of the dredge, consisting chiefly of Hydroids and Polyzoa, had been placed in a dish of sea-water, and after some time I found this Nudi-branch to have emerged and made its way to the side of the vessel.

The epipodial ridges are represented in this species by a row of tubercles on each side, somewhat more definitely marked than the rest.

The usual habitat of this species appears to be under stones at low-water mark (see Alder and Hancock, 1). Balfour obtained it in shallow water in the Firth of Forth (16), and M'Intosh (17) states it to be "not uncommon under stones in rock-pools between tide-marks" at St. Andrews.

For some remarks on the colouration see the Introduction (*supra*).

8. *TRIOPA*, *Johnston*.14. *T. CLAVIGER*, *Müller*.

One specimen of this species was obtained on March 29th with the dredge off the Mewstone. The lateral gill-plumes were considerably smaller than the median one. The orange pigment-spots on the back were confined to a median row.

9. *THECACERA*, *Fleming*.15. *T. PENNIGERA*, *Montagu*.

One example of this rare species was obtained on August 3rd of this year in twenty fathoms off Rame Head. Giard states it to be not uncommon on the coast near the laboratory at Wimereux, and that it is particularly an autumn species, feeding upon Bryozoans of the genus *Bugula*.

10. *POLYCERA*, *Cuvier*.16. *P. QUADRILINEATA*, *Müller*.

This species is not uncommon. It has been found in Jennycliff



Bay, in the Cattewater, on the north side of Drake's Island, and on the rocks near the ladies' bathing place, and has been obtained several times with the dredge off the Mewstone and in the estuary of the Yealm. Mr. Heape trawled it several times in Wembury Bay. It is subject to considerable variation, as Alder and Hancock state. In August, 1888, an individual was taken from the north side of Drake's Island which was irregularly spotted with black on a white ground. There were minute yellow tubercles on the body. The velar processes were two, with indication of a third, on the right side, and three on the left. The branchial prominences of the epipodial ridges were normal.

In May of this year a fine specimen from the Cattewater measured just over one inch in length.

On June 5th, from one and three quarter miles south of the Mewstone, was taken an individual of the variety mentioned in the Monograph as possessing no tubercles on the back. There were eight velar filaments, pigmented orange, and there was no pigment elsewhere. The gills and tentacles were normal; indeed, as yet I have seen no marked variation in the structure of these organs in this species, though such variation occurs, according to Alder and Hancock.

Another specimen of this variety was obtained on June 11th from three miles south of the Mewstone.

Young ones were obtained in tide-pools below the ladies' bathing place in July last year.

#### 17. *P. OCELLATA*, *A. and H.*

On March 6th was obtained one small specimen of this species from near the Duke Rock Buoy, with the dredge.

Late in June I found three individuals under a stone between tide-marks on the shore under Mount Edgcumbe Park near the "Bridge." On the same small flat stone was some spawn, one and a half times coiled.

### Sub-order 2.—*CERATONOTA*, Lankester.

*Family*—*TRITONIIDÆ*, Johnston.

#### 11. *TRITONIA*, Cuvier.

#### 18. *T. HOMBERGII*, Cuvier.

Not uncommon in deep water off the Eddystone, where it is



brought up in the trawl. A specimen was taken in April, 1888, forty miles north of the Longships lighthouse. Early in May of this year a mass of Molluscan spawn was brought to us by a trawler which I think must have been deposited by one of these fine Nudi-branches. It was in the form of an exceedingly long and narrow ribbon, greatly convoluted, and was of a salmon-pink colour as nearly as I can remember. I unfortunately did not appreciate its importance at the time and took no notes of it, but I am now almost sure that it must have been the spawn of this *Tritonia*. On August 25th, 1887, Cunningham dredged a young specimen an inch and a quarter long, in nineteen fathoms' water, one mile south of the Mewstone.

19. *T. PLEBEIA*, *Johnston*.

This species is taken somewhat frequently. In September of last year I found two specimens in a piece of rock bored by *Saxicava*, one of them being only half an inch in length. This stone had been brought up with the dredge from south of the Mewstone, and other captures show the species to be fairly common there. One obtained on May 21st showed somewhat peculiar characters. The colour was entirely salmon-pink, deeper on the back from the colour of the liver appearing through the integument. The oral veil was entire, semicircular, and not produced into tentacular prominences, but with a tendency to form four obtuse angles, two on each side. There were five pairs of branchiæ (the anterior pair much the largest) and no small intermediate ones. The edges of the tentacular sheaths were entire, but not so regular as in Hancock's figures in the Monograph. Around each of the branchiæ and around the tentacular sheaths was an area of white pigment, opaque. Length just over half an inch.

This species is also occasionally obtained inside the Sound. One specimen was taken from the Cattewater on November 20th, 1888, and on the next day another was obtained from east of the Mallard Buoy. These, however, had *probably* been thrown overboard with the rest of the "scruff" from trawlers on their way to Sutton Pool. They were probably at the time fixed to pieces of *Alcyonium digitatum* upon which they feed, and in relation to which, as Giard has pointed out, their colour and form are evidently serviceable as affording a protective resemblance to their surroundings. On the day of its capture the individual from the Cattewater spawned on a frond of *Fucus serratus* in a dish; the coil had six perfectly regular turns, attached at short intervals to the weed. The specimen from the Mallard had only four tentacular prominences on the oral veil;

it was very pale in colour and possessed intermediate branchiæ, differing in these respects from the other individual. The edges of the tentacular sheaths, I noticed, were capable of undulation, though they formed no fixed wavy outline. Several of the characteristics of this individual are thus seen to afford an approach to Alder's species *T. lineata*, of which he found two specimens at Scarborough. Indeed, I think the distinctness of this species is open to considerable doubt.

*Family.*—DENDRONOTIDÆ, *Alder and Hancock.*

12. DENDRONOTUS, *Alder and Hancock.*

20. *D. ARBORESCENS*, *Müller.*

Only one small specimen of this species has been obtained since June, 1888. It was brought up with the dredge from a depth of about twenty-five fathoms south of Penlee Point, in November. It was half an inch in length and had five pairs of branchial appendages, the tufts forming the two last pairs being arranged alternately, not opposite each other. The markings were of a brown-pink hue, with yellow tubercles and colouration here and there (cf. Alder and Hancock's variety, *pulchella*).

A larger specimen, just over seven eighths of an inch in length was dredged in twenty-three fathoms, about three miles south of the breakwater, on February 9th of last year (1888).

Though so rare here, Herdman (12 and 14) reports this species to be abundant at Hilbre Island during the winter months. It is abundant at Wimereux, and has a protective resemblance to the red-brown much-branched weeds of the genus *Callithamnion* (Giard, 6.)

13. LOMANOTUS, *Verany.*

21. *L. VARIANS*, *mihi.*

On June 11th of this year three Nudibranchs were included in the results of the day's dredging at about three miles south of the Mewstone which I found with pleasure to belong to this rare genus *Lomanotus* (*Eumenis*, A. and H.). It was not so easy, however, to assign them to any of the specific divisions which have been founded for the reception of the five hitherto known British examples, and after a careful examination I have come to the conclusion that I must either institute two new species for the specimens which we have dredged or unite the four previously described British species and the three specimens which we have dredged into a single species.

Reasons drawn from a study of the amount of variation which is exhibited among Nudibranchs generally have led me to take the latter course, although it is not without some diffidence that I do so.

The history of the genus in British waters is, so far as I know, as follows: Forty-five years ago Alder dredged a single example near Berry Head, Torbay, for which he created a new genus (*Eumenis*) and specifically named *Eumenis marmorata*. At the time he was not aware that Verany had already published the description of a genus which was identical (as Alder and Hancock subsequently stated in their Monograph) and which had been named *Lomanotus* by him. In Lamash Bay, Isle of Arran, another example was dredged by him, for which he created a new species, *Lomanotus flavidus*. In Weymouth Bay, also, Thompson (24) dredged two specimens, one in December, 1855, the other in December, 1856, which agreed apparently in all the points by which they differed from the two previous examples, and for which Thompson (adopting Alder's view) founded a new species which he named *portlandicus*. Lastly, Dr. Norman (19) dredging off Berry Head, Torbay (the spot whence Alder obtained his first example), in June, 1875, obtained another fine specimen for which he founded the species *Lomanotus Hancocki*.

Of the three specimens which we obtained on June 11th two were very closely alike both in size, structure, and colour, and the other was rather larger and much paler in colour and showed certain structural differences. I will describe this one first. In length it was just over five eighths of an inch. It was of a fawn colour, slightly reddish on parts of the back, with numerous small white spots, but without any dark spots or patches. The veil was produced into two tentacular prominences on the right, one on the left. The foot was as usual produced into a curved process at each corner anteriorly, and it was fairly broad as in *L. marmoratus* and *flavidus* (and probably in *L. portlandicus* and *L. Hancocki* also, since no peculiarity in this respect was noticed). The epipodial ridges formed on each side an almost upright waved expansion undulating into four lobes beset with small papillæ of irregular form, the median one in each lobe being somewhat longer than the rest. This condition is almost exactly the same as that described for *L. marmoratus*, but in our specimen the four *inward* undulations of the ridge were considerably more conspicuous than the outward from possessing larger papillæ, these papillæ increasing in size towards the centre of each of the (inwardly-directed) lobes. The waved ridges, indeed, might be said to be broken into four semicircular lobes, whose convexities are directed towards the median dorsal line of the animal. (Compare the definition of the species *marmoratus*, A. and H., in the

Monograph, Synopsis, p. 47, "branchiæ forming a *nearly* continuous waved line of papillæ on each side.") The dorsal tentacles had the same form as in *L. marmoratus* and were completely retractile within their sheaths. Each sheath was long, stout, and produced at the margin into five or six blunt prominences or tubercles. It is thus seen that this animal differs from Alder and Hancock's *marmoratus* almost exclusively in the form of the tentacular sheaths and in the colouring; and the doubt arises whether Alder's view of specific characters in this genus can be any longer regarded as correct, since upon it a new species ought to be created for the reception of the individual just described.

As was apparently the case with the Weymouth examples, our two other specimens agreed so closely that a single description will serve for both. Length half an inch. Colour much darker than in the preceding specimen, being of a rich, dark, velvety brown, spotted profusely with yellowish white. Veil with four blunt but prominent processes, thicker than in the preceding. Epipodial ridges on each side well marked, thick, fleshy, and foliaceous, undulating four times (four in, four out), the margins beset with bulbous papillæ of which the median ones of the inward undulations were longer than the rest. The outward undulations were as well marked as the inward. Tentacular sheaths spacious and fleshy, each with five projections on the margin. Foot exceedingly narrow and slender, to some extent at least from contraction. On the morning of June 12th each of these individuals had a couple of pieces of spawn upon its back behind the tentacles. Each piece was in the form of an incomplete coil, thickened at the commencement, and in shape much resembling a comma (◌), the tail being taken, however, rather closer round the head. The two pieces were placed with the "heads" close together and "tails" approaching each other, one of the commas being reversed (◌◌), and were guarded in this position by the first pair of inward undulations of the epipodial ridges which approached above so as to touch each other in the mid-dorsal line (cf. *L. portlandicus*). The chief peculiarities common to these two specimens were the dark brown colour, the thick fleshy character of the papillæ (which reminded me of the condition in *Ægirus punctilucens*), and the very slender foot. The fact that these two individuals should present such a close agreement in almost every point (in alcohol one has not quite so much brown pigment as the other) and that the differences between them and the other described British examples of the genus are comparatively considerable, would have been quite sufficient reason for the creation of a new species if I had not paid some amount of attention to the question of variation in the group generally.

In my notice of *Tritonia plebeia* (*supra*) I described one or two



instances of considerable peculiarities of structure in individuals of the species. I showed that the edges of the tentacular sheaths which are usually "entire-edged" may occasionally be somewhat undulate in outline; and one specimen exhibiting this character, in addition to a general paleness of colour and the possession of only four velar tentacles, was seen to bring us very close to Alder and Hancock's species *Tritonia lineata*, one of the distinguishing characters of which is the possession of "undulating margins" to the tentacular sheaths. Of this "species" only two specimens were (or have been, so far as I am aware) obtained, under stones at Scarborough. Now, the genera *Tritonia* and *Lomanotus* are nearly allied, and though they have diverged in certain points of internal structure yet they still retain a great similarity in the structure and form of the dorsum generally and of the epipodial ridges and tentacular sheaths in particular. The undulating ridges of *Lomanotus* are to be seen in *Tritonia Hombergii*, although the papillæ of the former have grown into the branchial plumes of the latter, the larger plumes being simply developments of the larger papillæ on the inward undulations in *Lomanotus*. Therefore having established variations from the usual type of entire-edged tentacular sheaths in a species of *Tritonia*, I would adduce this as an argument for the probability of variation in the corresponding structures in any given true species of *Lomanotus*.

Alder founded his species *marmoratus* because of the entire-edged sheaths and the irregular character of the epipodial papillæ (added to some peculiarities of colour) in his specimen. He judged his specimen *flavidus* to be specifically distinct because of its possession of tuberculated sheaths and better differentiated papillæ on the epipodial ridges. So also in describing Thomson's specimens from Weymouth, he concluded them to be types of a new species for which he suggested the name *fimbriata* because of the filamentary character of the processes on the edges of the tentacular sheaths and epipodial expansions. Dr. Norman also founded the species *Hancocki* partly because of the small size of the dorsal tentacles in his specimen from Torbay, but considerably because the edges of the sheaths were produced into "leaflet-like points" and the papillæ of the lateral expansions were of "flat triangular" form. Norman, however, adds a valuable observation. He says significantly, "The papillæ . . .

. . . are capable of contraction and dilatation, and are constantly changing their apparent dimensions while the animal is in motion." Very probably the "leaflet-like points" of the tentacular sheaths possessed the same contractility of tissue, for the edges of the sheaths and of the epipodial ridges generally possess the same characters.

It is most instructive also to compare the sizes of the different specimens of *Lomanotus* described. Norman's example was two and



a quarter inches long and Thomson's specimens were upwards of one and three quarters inches in length. Alder's *marmoratus* from Torbay was rather more than half an inch, as also was our largest specimen. Our two other specimens were just half an inch, and Alder's *flavidus* from Lamplash Bay was a quarter of an inch in length. Thus on the theory that they are all of one species we find that the oldest examples (as judged by size) have the greatest differentiation of the margins of the sheaths and of the epipodial ridges, that those nearest together in age are closely alike, and that the youngest individual (*flavidus*) has the simplest characters.

Altogether the conclusion seems inevitable that all the British specimens so far taken are members of the same species. The main difficulties to my mind are the apparent similarity of Thomson's two specimens (taken at different times in Weymouth Bay) and the close similarity of two of ours. But the difficulties are not sufficient to outweigh the evidence for the conclusion which I have just expressed; variation in Nudibranchs frequently takes place in definite directions (cf. *Cavolina Farrani*, No. 31, *infra*), and the Weymouth examples and our two similar individuals may well represent two fixed varieties of the species. It ought to be noted that these two individuals had apparently been copulating, on account of their depositing eggs at the same time. So far as the evidence goes, therefore, we have here a species of Nudibranch producing offspring of very variable external structure, the individuals apparently showing a tendency to unite rather with those of their own variety than with those unlike themselves.

I have to add that I regret to have been unable to consult Verany's account of his species *Genei*. In all probability it will be found that he has not limited its characters to so extreme a degree as Alder has done with regard to *L. marmoratus*, *flavidus*, and *portlandicus*, and in this case our specimens would probably be referred to *L. Genei*, Verany. In the meantime I have thought it well to adopt a new name, *Lomanotus varians*, for the single British species, since to employ any one of Alder's names would lead to confusion.

There is an observation which I omitted to add in its proper place above, viz. that the first described individual was seen by me occasionally to swim vigorously through the water in the dish in which I had placed it, by lashing its body from side to side, much as it is described by Lowe for a Nudibranch from Madeira of the genus *Peplidia* (*vide* Alder and Hancock's Monograph, p. 22). The two other individuals were torpid in their movements, and would not expand sufficiently for me to be able to make out the exact dimensions of the foot.

*Family*—MELIBEIDÆ, *Alder and Hancock*.14. *Doto*, *Oken*.22. *D. coronata*, *Gmelin*.

This species is common on *Plumularia*. Early in April a small specimen was dredged one mile south of the Mewstone, and another small one from the same locality on May 27th. In the latter the last branchia was very slender and simple in structure, not tuberculated; forwards from it there was a regular gradation to those with extensile tubercles. Cf. Herdman and Club, 14, p. 232.

In the collection of preserved specimens there is no undoubted example of *D. pinnatifida*. Mr. Heape has left a record of having found a variety of *D. coronata*, "or new species," in considerable numbers on Sertularians trawled in thirty-five fathoms, five miles south of the Eddystone.

23. *D. fragilis*, *Forbes*.

Commonly found here on *Antennularia ramosa*, sometimes on other Hydroids, *e. g.* *Halecium*. The habit, so noticeable in this group of Molluscs, of individuals of a species going about in couples, is very prevalent in the genus *Doto*. The two species mentioned above are usually obtained in pairs near the "roots" of Hydroid-stocks.

*Family*—PROCTONOTIDÆ, *Gray*.15. *Antiope*, *Alder and Hancock*.24. *A. cristata*, *Della Chiage*.

One specimen of this species was dredged west of the Mewstone on June 7th of this year. It was one and a quarter inches in length. In colour it was very pale, the usual yellowish colour being confined to the laminæ of the dorsal tentacles and the median crest between them. There were opaque white markings along the back in the form of a pair of discontinuous lines, one on each side, from the front of the head to the tentacles and from the tentacles to just behind the heart, where they joined to form a single median discontinuous line running to the tip of the tail.

*Family*—EOLIDIDÆ, *Gray*.16. *Eolis* (= *Eolidia* in the restricted sense of Gray).25. *E. papillosa*, *Linneus*.

This well-known species is by no means common here now, though

it is obtained occasionally between tide-marks and in shallow water. Prof. Stewart tells me that it used to be abundant at Cremyll.

Giard has pointed out the great resemblance which an individual of this species bears to a contracted *Sagartia troglodytes*. It is very probable that we have here a case approaching one of true mimicry, for Actinians are, as a rule, carefully avoided by shore-fish on account of their nematocysts, which, as I have several times tested, are very irritating to the lining membranes of the mouths of fishes. The fish are additionally deceived because of the possession by the Nudibranch of nematocysts at the tips of the papillæ. Some of the shore-fish which frequent rock-pools I have noticed to *touch* their intended prey, before eating it, with the fleshy margins of the mouth; and the usefulness of the possession of a certain number of irritating thread-cells is at once obvious. Further, the habit, which has been so often noticed in this and other Eolids, of erecting the papillæ when disturbed seems to me to be correlated with this function of the thread-cells, for by the bristling up of the papillæ the nematocysts at their tips are placed in the most advantageous position for the assault.

It is very interesting to note that in the two British species of *Hermœa*, which are inconspicuously coloured with respect to their surroundings, nematocysts appear to be absent. *Hermœa bifida* lives among red weeds of the genus *Griffithsia*; the body and papillæ generally are very transparent and of indefinite outline, *but the lateral hepatic canals of the body and the branches to the papillæ are highly developed and very conspicuous, having the form and colour of the branches of the weed.* The protective resemblance is here very perfect, though there still seems to be another resource for the animal when discovered, viz. the ejection, when touched, of a fetid, colourless fluid (see Alder and Hancock, 2).

*Hermœa dendritica* is coloured bright green, with dendritic markings, and lives upon the green weed *Codium tomentosum*.

For description of another possible species of this genus see No. 32.

#### 17. FACELINA, *Alder and Hancock.*

#### 26. F. CORONATA, *Forbes.*

Late in March of this year a specimen of this species, one and a quarter inches in length, was dredged off the Mewstone. On May 11th six magnificent specimens were dredged off the same ground, with a mass of *Syncoryne*. Some spawn was brought up as well, and a young individual was only three eighths of an inch long.

For the carnivorous habits of this beautiful Nudibranch see Alder and Hancock (2) and Gosse (7).

18. FLABELLINA, *Cuvier*.

27. F. PUNCTATA, *A. and H.*

On May 11th one specimen was dredged, just over an inch in length, from one mile south of the Mewstone. The rose colour of the head and back was much deeper in this than in Alder's individual from Torbay. The dorsal tentacles were coloured dark brown along the middle third of their length, especially at the sides on the lamellæ; the upper third of the tentacles was pale in colour.

19. CORYPHELLA, *Gray*.

28. C. RUFIBRANCHIALIS, *Johnston*.

Examples of this species were obtained by Mr. Heape in twenty to twenty-five fathoms off Whitsand Bay and ten miles south-east of Plymouth, in May, 1887. We dredged two splendid specimens along with a number of other Eolids on May 11th this year, one mile south of the Mewstone. Three more were dredged on June 11th in twenty fathoms, three miles south of the same rock.

29. C. LANDSBURGII, *A. and H.*

I took a small example of this rare and beautiful species from an *Antennularia*-stock dredged near the Duke Rock, in January last. It was only three sixteenths of an inch long. The colour was a beautiful, very transparent, pale violet, deepest on the lower part of the tentacles. The hepatic cæca of the dorsal papillæ were orange red in colour, with numbers of small, dark brown spots. The papillæ were arranged in four or five clusters, very ill-defined after the first set. They were very long in comparison with the size of the body, the largest being as long as the oral tentacles. They were not so stout as in Alder and Hancock's individual, and were capable of considerable flexion and extension. The opaque white ring near the tip of the papillæ was well marked. The dorsal tentacles were set well apart at the base.

This individual was kept alive for some weeks; the heart could easily be seen beating between the first and second clusters of papillæ.

Haddon (11) and Herdman (12) report the capture of individuals, probably of this species, of much larger size.



20. CAVOLINA, *Cuvier*.30. C. OLIVACEA, *A. and H.*

One specimen, dredged on May 11th, one mile south of the Mewstone. It was three eighths of an inch in length. The two pairs of lateral streaks of rose colour on the head were very well marked.

31. C. FARRANI, *A. and H.*

Two examples of this species were obtained at different times during October, 1888, from the Cattewater. The dorsal tentacles were short and rather thick. The oral tentacles were thicker and longer than the dorsal, entirely orange in colour, and constricted at the bases. One of them deposited some spawn, attached by the edge and coiled two and a half times.

On November 1st a number of Eolids were found on the blades of some *Laminaria saccharina* from the Cattewater (under Queen Anne's Battery), on which extensive stocks of *Obelia geniculata* were growing. I described and classified them at the time as follows:

"A. *Cavolina Farrani*.—White in colour, with orange-tipped branchiæ. Seven or eight.

"B. *Cavolina*, sp.—Length half an inch or more. Dorsal tentacles rather longer than the oral but more slender. Body transparent, whitish, marked on the back with large patches of orange red. Branchial papillæ inflated or elliptical; in six, seven, or eight rows, three papillæ on each side; of olive-green colour, orange at tips. Dorsal and oral tentacles coloured like the branchiæ. Large oval patch of yellow pigment behind the dorsal tentacles. Back of head olive brown, merging into orange red below (*i. e.* in front of the bases of) the dorsal tentacles.

"In the larger specimens the colours of the branchiæ and back were much intensified, the branchiæ being of a deep purplish black, and the back being mottled with deep orange red. The upper large branchiæ had whitish, not orange, tips. The oral tentacles were almost entirely orange in colour; the dorsal tentacles were long and cylindrical. Five or six specimens."

The examples of *Eolis Farrani* which Mr. Murray obtained on the coast of Elgin were mainly of a purplish or umber tint, and the colour of the tips of the branchial papillæ was "generally whitish, with only a slight tinge of orange" (see Alder and Hancock's Monograph, Appendix, pp. xi, xii). M'Intosh also has obtained "fine purple varieties" at St. Andrews, and his figure shows the presence of deep orange-red pigment (17, plate ii, fig. 13), therefore I think



there can be little doubt that our specimens were varieties of the same species, *Cavolina Farrani*. Compare also M'Intosh's *Eolis Andrea-polis* (18), probably a variety of *C. Farrani*, not a distinct species.

"*C. Cavolina*, sp.—Same generally as B, but the tips of the branchiæ are of an opaque white, instead of orange, and very conspicuous. The patches of colour on the back are crimson rather than orange, and the integument has the appearance of velvet. One specimen."

Probably also a variety of *C. Farrani*.

"*D. Cavolina*, sp.—Half an inch in length. Body slender. Branchiæ numerous. Entirely white in colour. Two specimens."

No doubt another variety of *C. Farrani*.

"*E. Cavolina*, sp.—Half an inch in length. Body slender. Entirely orange in colour. Tentacles equal in size. Branchiæ inflated, in six or seven rows of three papillæ on each side. Central gland much sacculated. Papillæ with specks of opaque orange; no specks on the tentacles. Radula as figured and described by Alder and Hancock for *Eolis Farrani*. One specimen."

Certainly a variety of the same species. Compare also M'Intosh's *Eolis Robertianæ* (18).

All these Eolids were feeding upon *Obelia geniculata*, and were obtained from the same blades of *Laminaria*. As they all agreed so far as structure is concerned (except as to slight variations in the length of the tentacles), there can be hardly any doubt that they are members of the same species *Cavolina Farrani*, A. and H.; and in trying to estimate the value of colour in the *Eolididæ* it is certainly very puzzling to find almost equal numbers of two very different colour-varieties (A and B) of a species living under exactly the same conditions. I am not quite sure yet of the reason for this dimorphism.

With the above-described examples of *Cavolina Farrani* taken from the *Laminaria* on November 1st there was another Eolid which for convenience' sake I will describe here, although its structure does not admit of its being placed in the same genus.

### 32. *Eolis*? sp.

Body half an inch in length. Foot produced at the corners anteriorly. Dorsal tentacles wrinkled with regular annuli, not laminated; set considerably apart at their bases. Branchial papillæ in fourteen or fifteen rows, four papillæ on each side; papillæ slender in form. Oral tentacles longer than the dorsal. Colour of body transparent white; glands of branchiæ yellowish. Opaque white spots at tips of branchiæ in the form not of complete rings but of semilunar or crescentic patches on their anterior faces. Very cha-

racteristic was a beautiful opalescent pale blue colouring on the back of the head between the oral and dorsal tentacles, on the inner faces of the oral tentacles, and on the anterior faces of the larger branchial papillæ. On the posterior faces of the branchiæ this colour became more pink than blue. It was also made out slightly along the back and markedly on the back of the foot or "tail." Here at the very extremity it merged into a patch of the ordinary opaque white spots. The individual lived very well in a dish for several days, but an accident very unfortunately prevented me from examining the radula.

I know of no species to which this remarkable little Eolid can be referred; if it should prove to be new I would suggest for the species the name *Eolis Huxleyi*, in honour of the President of our Association.

#### 21. GALVINA, *Alder and Hancock.*

#### 33. G. CINGULATA, *A. and H.*

We have obtained this species on two occasions. On June 11th one specimen was dredged in twenty fathoms three miles south of the Mewstone. It was not quite three eighths of an inch long and possessed nine rows of branchiæ. The lateral lines of olive-brown between the bases of the papillæ were broad and well marked. The tentacles were pale in colour, and there was no patch of pigment behind. The animal was very active and restless.

On August 7th another specimen was obtained from the estuary of the Yealm. When fully extended it was very slender and measured just over three eighths of an inch, but it possessed only five rows of papillæ. The olive-brown pigment was diffuse at the sides and did not form distinctly marked lateral lines. The ring of bright red colour on each of the tentacles shown in Hancock's figures was represented by a band of reddish brown in this individual. The papillæ often assumed a contracted and tuberculated state, such as is persistent in the genus *Doto*.

#### 22. TERGIPES, *Cuvier.*

#### 34. T. DESPECTA, *Johnston.*

Large numbers of these minute Eolids were found crawling about on the hydrosomes of extensive colonies of *Obelia geniculata* growing on *Laminaria saccharina* from off the Mewstone on March 28th of this year. The majority were transparent and quite colourless, having simply an opaque white mass at the tip of each papilla. The dorsal tentacles were constantly long and slender, while the oral tentacles in some individuals could barely be made out at all. The papillæ were slender and not very club-shaped; they were, as usual,

pointed at the tips. There was considerable variability in the arrangement of the papillæ, mainly due, however, to the animals being in different stages of growth. In the majority of individuals there was a pair in front, set opposite each other, and then two or three other papillæ behind them, arranged alternately, of which the first-formed one seems always to be on the left side. The heart was situated behind the first pair. In the largest individual, which was only one eighth of an inch in length, there were five *pairs* of papillæ, the second and fourth being the largest, with a single papilla on the left side behind the last pair. The heart was situated between the second and third pairs. The first pair was *double*, having two papillæ on each side, the outer ones being very small. In this large individual there was some faint brownish-yellow or slightly olivaceous pigment scattered over the body and on both pairs of tentacles. The "glands" of the papillæ were somewhat sacculate and of a faint yellowish-brown colour. The usual opaque white at the tips was yellowish at the extremity and faintly bluish in an ill-defined ring just below.

In one individual examined, which possessed remarkably long and slender dorsal tentacles, the left tentacle showed an abnormality in the form of a linear and slender outgrowth close to its base, directed backwards and outwards, and larger than either of the oral tentacles. M'Intosh figures a somewhat similar abnormality in the same tentacle of a *Doto coronata* (17, plate ii, fig. 14).

The spawn of this variety of *Tergipes despecta* was abundant on the stems of the Hydroid. The masses were not so reniform as they are represented by Alder and Hancock; they are more or less spherical in shape, slightly compressed from side to side and flat or very slightly concave along one edge (the *hilum*), from the centre of which proceeded a short gelatinous stalk for attachment. This stalk was constantly present, although I do not find it described for either *Tergipes despecta* or *exigua*. The spawn-masses varied in size, some containing only a quarter the number of ova found in the majority. The size of the spawn-masses was never so large as indicated in Alder and Hancock for *T. despecta*, and their shape was never so oblong and reniform as figured for *T. exigua*. The eggs were contained each in a separate capsule, and the larvæ possessed very long cilia on the edges of the velar lobes.

These little Eolids appeared to me to feed not upon the Hydroid itself but upon the minute Algæ which accumulate on its stems and branches.

Giard thinks the egg-masses of this genus to be of such form and colour, and to be so arranged upon the stems, as to imitate the gonosomes of the Hydroids upon which they are found.

## Sub-order 3.—HAPLOMORPHA, Lankester.

Family—ELYSIADÆ, Alder and Hancock.

## 23. ELYSIA, Risso.

## 35. E. VIRIDIS, Montagu.

This interesting species was dredged in the estuary of the Yealm in some numbers on October 20th, 1888, and was again obtained there early in August of this year. This animal lives among green weeds (*Codium tomentosum*, *Zostera marina*) and its general bright green colour is certainly protective. The value of the "lustrous specks" of blue or rose colour I have not been able to prove as yet. Whatever their meaning, they will probably be found to have the same value as the spots of sparkling blue on the back of *Ægirus punctilucens*. See some remarks in the Introduction.

Family—LIMAPONTIADÆ, Gray.

## 24. LIMAPONTIA, Johnston.

## 36. L. NIGRA, Johnston.

Found by Mr. Heape on the Reny Rocks, February 6th, 1888.

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## The Fish Pot of the Caribbean Sea.

By

**Edward M. Earle, Jamaica, W.I.**

THIS method of taking the fish alive is, I believe, peculiar to this sea and its neighbouring waters. Indigenous or non-indigenous matters but little in that which follows; it is sufficient to state that pot-fishing forms about the only mode of capture practised in these regions for supplying the people with fresh fish.

I say *about* the only mode of capture practised, but there are some exceptions. Of nets, here and there, a seine, a turtle, and a mullet will occasionally be found, but a drift, a trammel, and a trawl will be searched for in vain. Hand-lining is only occasionally practised, and whiffing only under exceptional circumstances, as the canoe travels from land to the pot, between the pots, and back to land; and during the king fish season a kind of bulter or trot may now and then be met with under the local name *palanca* or *palanque*—most probably derived from the Indian—but it is very rare, and these go to make up the auxiliaries.

While the fish are never taken from the pots in an offensive condition, they are more frequently than not in an unfit condition for food ere they reach the consumer, a state of things not very creditable to a country not more than one generation behind the rest of the world. But we look and hope for a change in these our fishy matters ere long.

It will perhaps be advisable if mention were made here that in writing of the fish pot of the Caribbean Sea I refer more particularly to those around the coast of this island and immediate waters; and although slight differences may exist in construction and working, in and around some of the other islands and the mainland, these differences are of so slight a nature as to call for no special mention.

It is to be regretted that in a country like this, consuming millions of pounds weight yearly of imported dry and wet cured fish, having a sea teeming with myriads of fine edible fish, the waters subject to no or very rarely to meteorological disturbances, where as a rule boats may fish and work for months together without interference from the elements, the people should remain content to depend upon outside energy and capital, and the feeble, very feeble, labours of a

handful of fishermen—so-called—working but four or five hours out of the twenty-four, and employing a system of capture—not altogether devoid of some merit—that existed three hundred years ago, for so important a factor of daily life and universal economy. And yet it is so not only here but all through the beautiful islands in our seas.

The fish pots of the Caribbean Sea are made of various shapes and sizes, an individual idea monopolising their construction. They are made principally of the bamboo (*Bambusa vulgaris*) and occasionally of the wild cane, but wherever the former plant is ubiquitous, and the growth of the latter partial—growing on the banks of streams and in the vicinity of water, but loving best the running water—nine tenths, or more, are made of bamboo. But those made from the calamus are much preferred, for besides, lasting nearly double the time they are exempt from the ravages of the sea maggot or worm, which plays sad havoc in the spring months with the bambusa.

Fish pots are made of various shapes as well as sizes, for some are square, some oblong, but generally they are shaped zig-zag like the frame of Coleman's agricultural harrow. They are usually made of three sizes, and the size is denoted by the number of entrances or funnels, such as one funnel (smallest size), two funnels, and three funnels (the largest).

In building a pot the maker first of all proceeds, with the aid of a matchette and strong sharp knife, to split the long canes into strips of from one half to three quarters of an inch wide, and then thins them down to one eighth or one twelfth of an inch thick, according to the size of the pot to be made. When a sufficient number of these long pliable laths are prepared the plaiting commences and is performed in a rapid manner on a level piece of ground, the plaits usually resting on one knee. The width of the pot is determined by the number of meshes forming the first row, and these being completed the work proceeds rapidly, the mesh being hexagonal and from three quarters to one inch from angle to angle. The plaiting invariably takes place on the spot where the bamboo grows, under the shelter of an adjacent clump, or a neighbouring mango or other tree. When the three or more sections of which the future pot is to be composed—the top, the bottom, and the sides—are completed, they are rolled into a somewhat large cylindrical parcel, and conveyed on the head to the beach of the fishing village, where they are spread out on the sand to straighten and lose the curve the temporary rolling has produced. When quite flat and the bend or curve gone the building of the pot commences. This is conducted in the following manner:—First of all the long side piece or pieces are

placed on edge so as to assume somewhat the shape the pot is intended to take. Upon this upstanding trellis the future top of the pot is placed, and its edges firmly laced to the upper edge of the side piece by the branches of a strong and durable withe locally known as the vine or bine pear (*Cereus triangularis*). When this lacing has been completed all round the incomplete structure is turned completely over, the top, or already laced section, now lying on the ground. The bottom piece is now placed in position, as was the first, or top, and similarly laced all round. The plaited funnels, or entrance mouths, already introduced into the pot's interior, are now placed in position between the top and bottom sections, and these are also lashed firmly by pieces of the same withe. When all the lacing and tying has been completed, a straight stick of from one and a quarter to one and a half inches in diameter and some six inches longer than the pot's depth, is placed in each corner of the pot, passing through the extreme corner meshes of both top and bottom sections, and these are firmly lashed in position.

The pot lying on the flat surface of the sand causes these upright pieces, or posts, to project or extend upwards, about four or five inches, through the upper or bottom section, and these form four legs or supports, biting the rock, grass, or sand upon which the pot is eventually set. To these four posts are first lashed and then nailed two long, round poles which cross each other in the centre of the pot, and they are firmly lashed along their entire length, giving to the structure stability and strength.

The bottom or under side of the pot now being complete, the structure is turned over, and two other poles are placed in similar positions over and along the top, lashed and nailed to the four corners upright.

The curved or bent heads or mouths of the funnels are now brought up against the top and firmly secured in position by lashing. When thus fastened these funnels have their inner ends raised against the top side of the pot, their mouths, which are pear-shaped, turning downwards. The next thing is the introduction of four stones, the size and weight depending upon dimensions of the pot, and these are lashed, one in each corner at the bottom, to act as sinkers and subsequently weights, when the pot is set and lying in position.

The finishing stroke now only remains, and this is done by attaching the cable to the two cross-poles at the point of intersection, which should be as nearly as possible over the centre of the pot. To this cable are attached withe stays which are run from the cross-poles, and these prevent the pot turning or swaying from side to side. The engine is now ready to be taken to sea and deposited as a submarine trap for fish, many of whom enter the funnels and

having passed through the pear-shaped mouths find themselves in a cul-de-sac and unable to get out.

The cables used for fish pots are usually of two kinds; either the large and strong pliable stems of curtain withes, or a two-ply rope made from the shredded leaves of the silver thatch (*Thrinax argentea*). Of the withes those generally used are the velvet (*Cissampelos pareira*) and the large milk (*Melastema parviflorum*), and, when they can be procured, the Iron and Old Tom withes. As may be supposed, it is not always possible to obtain these withes of the requisite size and strength for the larger pots, and when this is the case the cable is formed by twisting two or more together into a rough rope. These withes are of great value to the sea-fisherman, for with the silver thatch they form not only cables but cordage, and it is seldom that a yard of imported manufactured rope is seen in a fishing village or on the canoes. The withes and thatch above enumerated are not only strong but very durable, outlasting the pots, and under favorable circumstances, with care, a cable will serve two sets of pots. These withes are found and collected in the woods, suspended from large trees, or like tendrils encircling trunks and branches.

There is no more useful and valuable plant to the fisherman of these seas than the silver thatch, which on rocky soils and in droughty districts grows in great abundance. This small thatch plays an important part in the fisherman's economy as from its leaves he manufactures all his cordage and much of his cables.

The leaf is fan-shaped, the upper surface a bright glazed green, the under-leaf a silvery-grey and velvety, growing to a diameter of from two to three feet. The plant is usually found only a few feet in height, but will grow if undisturbed to a height of ten to twelve and fifteen feet. The leaves when required for twisting are shredded off the centre stalk which runs along its whole length, and these shreds are then twisted into a two-ply rope for cordage, a three-ply with thicker strands being used as cables. These ropes and cordage are exceedingly strong, their tensile strength being considerable, and the action of the salt water has very little effect upon their durability. The fishermen and fisherboys are adepts at twisting this thatch, and I have watched and known a boy of twelve or thirteen years get through his twenty-five fathoms in a day, not of continuous but spasmodic work, every now and again leaving off to spend ten or twenty minutes at a time in the waves as they roll up the sandy beach.

The pot now being ready for use is taken out to sea and lowered at some desirable spot, the locality and depth being selected to suit the idiosyncrasies of the owner. If snappers (*Messoprion uninotatus*, and *M. chrysurus*) are wanted the pot will be deposited in from ten



to twenty-five fathoms; if other and mixed fish then the depth will vary and run down to fifty and sixty fathoms according to the nature of the bottom and the principal fish sought. They are almost invariably set without bait of any kind, but in some localities some bait, such as dead sprats, viscera, and salted herrings (enclosed in fine netting), are attached to some part of the inner pot.

The cables to which the pots are attached are arranged as follows. Should the depth of water be thirty fathoms the cable is made to measure one fourth more, or forty fathoms. Two thirds of the depth, above the pot, a matured piece of bamboo, about six feet long, is securely fastened and floats suspended in mid-water, and this buoy keeps the lower portion of the cable continually taut. The upper end of the cable is attached to a similar piece of bamboo, and this is allowed to swing and play about, serving for a mark to identify and recover the pot when it is visited for the purpose of examination.

Under favorable conditions a pot will last for months, appearing bi-weekly or tri-weekly, as shall be required, at the surface, to have its contents transferred to the bottom of the dug-out; but—and it sometimes happens—a storm may carry away the upper and identifying bamboo and the pot is lost for ever, for the fisherman seldom tries to recover except in shallow water. An unusually strong current will perhaps carry the whole structure away, and in this case it is sometimes recovered. Should the pot not be visited for a week or more, its finny contents accumulating the while, some member of the shark family may utterly destroy its wicker sides to feast upon the enclosed captives, or a devil-fish will sever the bamboo buoys and leave the pot below unconnected and irrecoverable.

When set the fish pot is visited usually every other day, sometimes twice, occasionally only once a week. When this longer interval occurs some reason may be assigned for the delay. If the pots were visited daily they would yield a larger harvest, but then the Carib fisher believes in “letting to-morrow take care of itself,” and carries out his belief. A pot made of matured bamboo will withstand the action of the salt water and the worm, and remain serviceable for from six to eight months and in some cases a month longer; one made from the wild cane four to six months longer than the bamboo. The silver-thatch cable, like the withes, will invariably outlast the pot.

When a pot is *hauled*, as it is termed, it is brought to the surface by means of the cable, and when alongside the canoe it is turned on end, the fish shaken into one corner from which they are extracted by the hand, through a small gate or gap left purposely for that purpose. When all are transferred to the canoe the gate is closed, refastened, and the pot returned to its watery home. It is



rarely a pot is lifted without containing fish ; frequently great numbers, eight, ten and twelve dollars' value, are taken in the large deepset pots at a single haul.

In isolated cases where a fisherman can command the services of a large canoe, thirty feet or so in length, pots of extra large size are set in deep water down to 100, 120 and more fathoms, and when these are so set they more than repay for extra energy. These deep-sea pots require to be made of extra strength, and as it is only here and there a canoe can be found large enough to work them, they are very few and very far between.

The fishing canoe is a splendid boat, buoyant as a cork and as staunch as a lifeboat. They are made from the single trunk of the silk cotton tree, the *Bombax cieba* of botanists, shaped and dug out by adze and axe, and when properly shaped and thoroughly fitted, which they seldom are, no faster or safer boat exists.

## Tealia tuberculata (Cocks).—A Study in Synonymy.

By

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With Plate XIX.

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IN the Report of the Cornwall Polytechnic Society for 1851 Mr. W. P. Cocks described a species of sea-anemone under the name of *Actinia tuberculata*. He gave a small figure in illustration, but this was somewhat indefinite. His description is as follows:—"Body globular, light brown, densely covered with large greyish-white tubercles, the apex of each tubercle depressed; disc white; mouth large, lips thick, corrugated, and everted; tentacula numerous, large, obtuse, some bifurcated, others trifurcated. Diameter three and a half inches when contracted."

P. H. Gosse in his *British Sea Anemones and Corals*, 1860, quotes the above description, and adds that he had privately received further particulars from Mr. Cocks, namely, that the anemone was obtained thirteen miles south-west from Falmouth, attached to a valve of *Pecten maximus*, that it lived with Mr. Cocks for some months, that it was "bulky, rather loose in texture, when fully expanded covering the bottom of a large pan,—it had the appearance of a mammoth *Bellis*. It appeared to be extremely irritable, and upon the slightest provocation would throw off from its body a large quantity of thick glaire, which if allowed to remain produced a disagreeable smell. When contracted it had the appearance of a half-boiled sago pudding."

Gosse says he ventured to suggest that it might have been a large colourless deep-water specimen of *Tealia crassicornis*, but Mr. Cocks repudiated the identification while admitting the relationship; Gosse concludes that it *may* be distinct.

A species of anemone which is extremely common in deep water in the neighbourhood of Plymouth, off the south coast of Devon and Cornwall, and numbers of which have been brought to the Laboratory of the Association, is without doubt the species described by Cocks. Cocks' description is not as precise and detailed as the zoological definition of a species ought to be, but there are points in it which

apply so perfectly to the form I refer to that it is certain that my specimens belong to the same species as the specimen examined by Cocks. These points are (1) that the column is "densely covered with large greyish-white tubercles, the apex of each tubercle depressed;" (2) that the tentacles are "large, numerous, obtuse, some bifurcated, others trifurcated." This division of the tentacles does not occur in all specimens, and when it does occur is present only in two or three tentacles out of the whole number; it is confined to the extremity of the tentacle, which divides into two or three terminal portions, or bears a secondary tentacle growing from it almost at right angles. This branching of the tentacles is not therefore a constant character, and does not occur always on particular tentacles, but it is a kind of abnormal growth which has, so far as I know, only been observed to occur in this species. (3) Mr. Cocks' specimen was attached to a valve of *Pecten maximus*, and all the specimens I have received were attached to the surface (usually the inner) of single valves of large Lamellibranchs, most frequently valves of *Cyprina islandica* or *Pinna pectinata*.

*Description of the species.*—The size is large, ranging from 8 to 13 cm. in diameter of base and 2 to 5 cm. in height in the expanded condition. The tentacles are usually short and blunt with transverse stripes of colour. The disc is reddish or brownish in the centre round the mouth. The walls of the stomodæum are yellowish, wrinkled with longitudinal folds, and tumid. The directive or œsophageal grooves are very conspicuous, their surfaces are smooth and white, but at the upper end of each there is a slight projection of the oral disc which is distinguished by being more brightly coloured than the rest of the disc. The external part of the disc is of a light yellowish tint, but radiating striæ of red pass from the central coloured part to the bases of the tentacles, the base of each tentacle being enclosed by two such coloured striæ. The extent of the red-brown central area of the disc varies considerably,—sometimes it is absent altogether, sometimes it extends almost to the origin of the internal cycle of tentacles. This coloured area always disappears in specimens kept for some months in our aquarium, the whole disc becoming of a pale drab colour. The primary tentacles are distinguished by two milk-white bands, which lie within the red striæ enclosing the base of each, and which extend outwards from each primary tentacle to the most exterior cycle of tentacles, where they pass on to the adjacent sides of two tentacles belonging to this cycle. The tentacles are translucent with transverse rings of faint colour; the base is white; above this is a band of very faint red, then comes another band of white, then another band of red much more pronounced, and finally the tip is white. The tip of each ten-

tacle is perforated, and when a specimen is taken out of water and contracts forcibly, water is forced out of the terminal pores of the tentacles in streams with some force.

The column is of a yellowish-grey colour with scattered patches of red. It is closely beset with large bladder-like warts, which are arranged in vertical rows in close proximity to one another. The largest of these warts are on the margin of the column, while near the base they get smaller and gradually disappear. Each wart has from two to four white patches which are probably glandular. The warts have the power, probably due to these glandular patches, of attaching pebbles or sand to themselves, and to such objects they adhere with considerable tenacity, but this property is not often exercised in the natural condition, the surface of the column being almost always bare.

The base is usually expanded considerably beyond the column when there is room for it; when an animal on a somewhat small shell is left undisturbed in an aquarium the base soon extends on to neighbouring surfaces.

The tentacles are strongly retractile, that is, they can be contracted to a very small size towards their bases, and the margin of the column can be contracted so as completely to cover the tentacles and disc. When the animal is much irritated after the tentacles and disc have been retracted and covered by the column, the animal continues to contract and expel water from its interior until it becomes quite flat so that the walls of the column form a disc almost parallel to the base.

The principal peculiarities of the species consist in the number and arrangement of the tentacles. The primary tentacles, which as already mentioned are conspicuously distinguished from the rest by white bands enclosing their bases, are ten in number. These probably consist of two cycles of five, but there is nothing in the adult to indicate this. Having recognised these primary tentacles it is not difficult in the living animal to ascertain the arrangement of the other tentacles, in the space between any two of the primaries. It is found that in any specimen some of the intervals between two primaries possess a regular normal arrangement of other tentacles; this normal arrangement is seen in all the intervals on the right hand side in fig. 1. The normal arrangement consists in the successive subdivision of the space by tentacles, first into two halves, then into four parts, then into eight, then into sixteen. That is to say between the two primaries there is a tentacle of the second cycle with a pair of mesenteries corresponding to it; then on each side of this tentacle, *b*, there is a tentacle, *c*, of the third cycle, with a pair of mesenteries; then in the four spaces thus separated there



are four tentacles, *d*, of the fourth cycle each with a pair of mesenteries; and finally, there are eight tentacles, *e*, which have no mesenteries corresponding to them, but are between the pairs of mesenteries belonging to the other tentacles. Thus if this regular arrangement existed throughout the tentacular system the numbers would be 10, 10, 20, 40, 80, or 5, 5, 10, 20, 40, 80, in the successive cycles, and the total number would be 160. But in every specimen that I have examined the number and arrangement of the tentacles was abnormal in some of the spaces between the primaries. I have given diagrams showing the arrangement found in two specimens. In the specimen represented by fig. 1 the arrangement of the tentacles was normal in eight out of the ten spaces between the primaries. Two of the primaries opposite to each other can of course be distinguished as directives by their position opposite to the directive œsophageal grooves; and these two are further distinguished, as seen on dissection, by the fact that the muscles of their mesenteries are on the outer sides of the latter. In the diagram fig. 1, the two inter-primary spaces on the left of the upper directive tentacle have an abnormal number of tentacles. In each space there are two tentacles wanting; the deficiency is probably in the outer cycle (interseptal cycle). Thus the total number of tentacles in this specimen was 156 arranged thus: 10, 10, 20, 40, 76.

In the other specimen represented in fig. 2 the abnormality was much greater. Here only four of the spaces between the primaries possessed the normal number of tentacles. If we number the spaces from the upper directive tentacle round to the right, we find that in the first the arrangement is 1, 2, 3, 5; in the second 1, 2, 3, 7; the third is normal, 1, 2, 4, 8; in the fourth the arrangement is 1, 2, 3, 7; the fifth is normal; in the sixth the arrangement is 2, 3, 5, 9. Thus in this space there are four tentacles too many, the usual arrangement being altered from the beginning by the occurrence of two tentacles of the second cycle between the two primaries, instead of one. The seventh and eighth spaces are normal; in the ninth space the arrangement is 1, 2, 2, 4, a deficiency of six; in the tenth space the arrangement is 1, 2, 4, 6, a deficiency of two.

I have not examined the internal anatomy very minutely, but I have ascertained that in the existence of a very strong circular muscle, and in the large number of complete mesenteries this form agrees with *Tealia crassicornis*.

*Synonymy*.—It seems clear that this anemone is, on the one hand, not of the same species as *Tealia crassicornis*, and, on the other, that it is closely allied to that form. Gosse, as I have already mentioned, was inclined to consider Cocks' specimen as really belonging to *T. crassicornis*, and Andres, in his Monograph of the Actiniæ,



therefore places the names *Actinia tuberculata*, Cocks, and *Tealia tuberculata*, Gosse, among the synonyms of *T. crassicornis*. This he was scarcely justified in doing, as he had never examined a specimen.

But Professor Haddon\* has done something much more surprising. He places, with a note of interrogation, *Tealia tuberculata* (Cocks), Gosse, as a synonym of *Actinauge Richardi*, Marion. This species is one of the sub-family Chondractininae, of Sagartian Actiniæ; Sagartian Actiniæ, according to Haddon's definition, being those which possess acontia, while the Chondractininae are distinguished by emitting the acontia by the mouth only. All the Chondractininae have six primary mesenteries. It is thus sufficiently evident that *T. tuberculata* does not belong to the Chondractininae, and is not, therefore, identical with *Actinauge Richardi*. But it must also be pointed out that there are sufficient indications even in Cocks' original description and Gosse's remarks that Cocks' species was quite different from *Actinauge Richardi*. In the latter species, Haddon states that the pedal disc is usually bent round ventrally so as to form a cup-shaped concavity which is filled with sand. Cocks states that his specimen was attached to a valve of *Pecten maximus*. In *A. Richardi* Haddon states that the tentacles of the inner cycles have a well-marked swelling at their bases, and thinks that a mis-interpretation of this character was the cause of Cocks' description of some of the tentacles in his specimen as bifurcated or trifurcated. This certainly shows very little respect for Mr. Cocks' powers of observation, and it is to be hoped that Professor Haddon will receive better treatment at the hands of his successors. Mr. Cocks describes the tentacles of his specimens as obtuse, those of *Actinauge Richardi* taper towards the extremity. The diameter of the latter species is 3 cm., that of Cocks' specimen three and a half inches.

The classification of the Actiniæ is still very uncertain and unsatisfactory. Gosse's definition of the genus *Tealia*, which is practically adopted by Hertwig in his Challenger Report, applies to the species here under consideration in all respects but one,—the tubercles of the column in *T. tuberculata* are arranged in vertical rows, not irregularly scattered; but these rows are not so widely separated nor so distinctly marked as in *Bunodes*. Andres adopts Gosse's definition, with the addition of the clause: Tentacles in decimal cycles, not duodecimal. In this I agree with Andres. For the present, therefore, I think that we may define the genus *Tealia* as follows: Tentacles numerous, in decimal cycles, short, or of moderate length, very contractile; margin completely covering the disc in contraction; a fossa between the margin and the outer tentacles,

\* *Revision of the British Actiniæ*, see Trans. Roy. Dub. Soc., vol. iv, ser. ii.

column closely beset with numerous large, adhesive warts, which are largest on the margin; base extending beyond the column, no acontia or cinclides; size large, diameter exceeding the height; numerous complete mesenteries, circular muscle very thick and strong.

Of this genus there seem to be three species known: *T. crassicornis* (Müller), distinguished provisionally by the number of tentacles, 5, 5, 10, 20, 40; *T. tuberculata* (Cocks), distinguished by the ideal number of tentacles—5, 5, 10, 20, 40, 80, and by the irregularity of the tentacles in number and in shape; *T. bunodiformis* (Hertwig), described in the Challenger Report. *Tealia digitata* has been removed from the genus; it is a Chondractinia, one of the Sagartian genera.

There is one other described species which requires consideration in connection with the Genus *Tealia*, namely, *Bolocera eques*, Gosse. It is certain, I think, that *Bolocera eques* does not belong to the genus *Bolocera*; its characters, as described by Gosse (British Sea Anemones and Corals, 1860), are quite inconsistent with Gosse's own definition of *Bolocera*. The specific characters are, tentacles wholly retractile, white, encircled with a red ring; in these respects the tentacles agree with those of the genus *Tealia*. Gosse's figure gives only a few scattered warts, but his description says the column is "studded on the upper two thirds with numerous minute warts increasing in number to the margin; these are either prominent or level at the pleasure of the animal, and they have the power of attaching fragments of entraneous matter, which, however, seems rarely exercised." All this applies perfectly to *Tealia tuberculata* (Cocks); all the rest of Gosse's description applies equally to *Tealia tuberculata*, except the formula of the tentacles, which is given as 6, 6, 12, 24, 48, 48 = 144. If the tentacles are really thus arranged of course the form must be distinct from *T. tuberculata*, but considering the peculiar irregularity of the tentacles in the latter species and the unusual equality of the two outer cycles in Gosse's formula, it is possible that he made an error in the enumeration. I have little doubt myself that *Bolocera eques* is a synonym of *Tealia tuberculata*, and until someone has identified a specimen of *Bolocera eques* I shall hold this opinion. No one has yet identified *Bolocera eques*, except Gosse himself, who only saw two specimens, one from twenty-eight fathoms off the mouth of the Tees, the other from Banff.

*Tealia tuberculata* occurs most commonly in this neighbourhood, in about thirty fathoms, to the west of the Eddystone; it is especially common on the shelly ground off the Dodman Point. It is frequently taken in the Cattewater, but it owes its presence there to the fact that the trawlers often carry their "scruff" to the Cattewater and throw it overboard after they have anchored.

## NOTES AND MEMORANDA.

**Notes on the Senses and Habits of some Crustacea.**—In the course of investigations as to the perceptions of fishes, some interesting facts in the natural history of Crustacea have come under my notice. All the Crustacea in the tanks, except *Carcinus maenas* and *Portunus depurator* are more active by night than by day. Prawns, *Pandalus*, *Stenorhynchus* and *Inachus* generally remain stationary during the day, but will leave their places to hunt for food if any be put in; but *Ebalia*, *Portunus pusillus*, *Porcellana longicornis*, *Galathea andrewsii*, *Virbius varians* and shrimps are rarely visible until night falls, and hardly ever come out by day even to feed. *Eury-nome aspera*, though not hidden away like these, being naturally almost indistinguishable from the broken shells, &c., amongst which it lives, seems also never to feed by day. Excepting the shrimps, nearly each individual of the above-mentioned forms has its own place to which it retires when morning comes, and in which it remains during the whole day. One prawn has occupied the same hole for some weeks, and another, which had lived a fortnight in one corner, left it when some mussels were put in, and now sits on the mussels during the day. The distinction then between day and night is of importance to these animals. Such an animal as a shrimp is in fact certain to be caught by keen-sighted fishes if it uncovers itself by day. If shrimps are thrown by day among pollock, they are always eaten unless they reach the bottom of the tank, but there they are safe even if unburied, for the pollock seems unable to see them when on the bottom, and at once gives up the chase. This may or may not be due to their protective colouration. Pollock very rarely take anything off the bottom, and worms and even glistening things like pieces of mackerel are generally left by them if they are not eaten whilst sinking.\* Moreover, the bottom of the pollocks' tank is made of yellow gravel brought from the Chesil Beach, which in no wise resembles a shrimp.

Wrasses, however, which are especially fond of shrimps, can not only catch them as they sink in the water, but pursue them on the bottom. The sight of the wrasse is particularly keen, and I have often seen a large wrasse search the sand for shrimps, turning sideways and looking with either eye independently like a chamæleon. Its vision is so good that it can see a shrimp with certainty when the

\* This can only be true of small pollock, for large pollock are frequently taken with ground baits.

whole body is buried in grey sand, excepting the antennæ and antenna-plates. It should be borne in mind that if the sand be fine, a shrimp will bury itself absolutely; digging with its swimmerets, kicking the sand forwards with its chelæ, finally raking the sand over its back and gently levelling it with its antennæ, but if the least bit be exposed, the wrasses will find it, in spite of its protective colouration. Shrimps put into the wrasses' tank at night escaped for some days, hence they must retire to the sand before daylight is strong enough for the wrasse to see them. The knowledge of night and day is therefore of paramount importance to a shrimp, as it is not safe for it to hunt until darkness has come. Strangely enough, it seems that this knowledge is not obtained through the eyes, or at all events not entirely through them, for if the eyes be extirpated, the shrimps will bury themselves during the day, getting up in the twilight and careering about at night just like uninjured shrimps. On one occasion (7 p.m., August 4th) I noticed that the blind shrimps in a tub were lifting themselves out of the sand exactly at the same time as the normal shrimps in another vessel were doing so. If, however, food be thrown in by day, the blind shrimps will get up and hunt for it while the normal shrimps very rarely take any notice. Similarly, a blind prawn will remain in his place all day unless food be thrown in, but comes out and wanders at night. It is a singular fact that a prawn, though blind will often find his way back to his proper place, and stay in it.

Both prawns, shrimps, *Stenorhynchus*, &c., find their food almost exclusively by scent, and when blind find pieces of food quite as quickly as uninjured ones. If a piece of worm be put into a small glass sphere with a hole in it, and the sphere is then sunk in the tank, the prawns, &c., will come out of their holes and find it. They do not seem to have any very accurate knowledge of the direction of a scent, but on perceiving it they begin rushing vaguely about, feeling the ground all the way with their chelæ. On finding the glass, the first comer will feel inside, pull out the worm, and skip with it to some high place. I have noticed that those which come after generally find the glass in which the worm has been as easily as the worm itself, and they will continue feeling inside in a puzzled way for some time, showing that the scent remains after the worm is gone. (Conger, soles, and rockling, which all feed by smell and touch, will all do the same thing.)

Shrimps are much quicker at finding food than prawns. They hunt with their faces down on the ground like hounds questing, while the prawn hunts with his head held up as usual. If a piece of worm be just buried in sand, a shrimp will dig it out at once, whether blind or not. I have also seen a prawn, after much hesitation, plunge its



two arms resolutely into an anemone (*Anthea*) and pull out a worm which the anemone had closed over. In like manner a blind *Stenorhynchus* or *Inachus* will perceive a piece of worm when it has been in the water a few minutes, and will then set out and find it. I have seen them hunting about when worms have been put into another tank from which water was flowing into their own vessel. There can then be no doubt that these animals find their food by scent, and it becomes difficult to determine what sort of objects they can see. It is not even certain that they can see each other. If a prawn is eating a piece of worm and another prawn finds it and takes it away, the first prawn will again begin to quest wildly as at first, and does not make for the prawn with the worm, though it may be only a few inches off. Nevertheless, it is certain that prawns at all events can perceive more than mere difference between light and darkness, for they notice a hand or even a thin stick placed between them and the light, putting out their antennæ towards it. *Stenorhynchus* also will put up its anterior pair of walking legs when a fish swims close over its head. It would appear that the eyes of these creatures are particularly sensitive to shadows. If a worm is hung by a thread in the water about eight inches from the bottom, the prawns will first hunt on the bottom as usual, and will then begin swimming about in quest, but on coming a few inches below the worm they will rise to it directly.

Though it seems probable that the sense of smell is obtained through the antennules, in shrimps at all events it is not exclusively so derived, for a shrimp with no antennules will hunt if a piece of worm is put very near it. On the other hand, the antennæ, of a prawn at least, appear to have no such power, as prawns when eagerly seeking food may be seen to touch it with their antennæ and still be unable to find it.

As is well known, certain crabs, as *Stenorhynchus*, *Inachus*, *Pisa*, and *Maia*, have the habit of fastening pieces of weed, &c., on their backs and appendages until they are almost indistinguishable from the surrounding weeds if there are any. In the case of *Stenorhynchus* and *Inachus* I have often watched this process. The crab takes a piece of weed in his two chelæ, and neither snatching nor biting it, deliberately tears it across as a man tears paper with his hands. He then puts one end of it into his mouth, and, after chewing it up, presumably to soften it, takes it out in the chelæ and rubs it firmly on his head or legs until it is caught by the peculiar curved hairs which cover them. If the piece of weed is not caught by the hairs, the crab puts it back in his mouth and chews it up again. The whole proceeding is most human and purposeful. Many substances as hydroids, sponges, Polyzoa, and weeds of many kinds and colours are



thus used, but these various substances are nearly always symmetrically placed on corresponding parts of the body, and particularly long plume-like pieces are fixed on the head, sticking up from it. It may be supposed that these actions are of use for purposes of concealment, and hence it might be expected that they should be dependent on the power of vision, but not only are all these complicated processes gone through at night as well as by day, but a *Stenorhynchus* if cleaned and deprived of sight will *immediately* begin to clothe itself again with the same care and precision as before. It may be mentioned that there is certainly no disposition on the part of a *Stenorhynchus* dressed in any colour, say green, to take up a position amongst green weed or indeed amongst weed at all, and so on, while some individuals which have taken up their station among weeds do not dress themselves at all.

**Sense of Touch in the Rockling (*Motella*).**—Both the large three-bearded rockling and the small five-bearded form flourish in the tanks. They are nocturnal in their habits, and lie still all day. If a worm be thrown in by day, the small species will sometimes swim straight up and take it, having to some extent the power of seeing objects, but the large species never does this. Generally, both the animals take no notice of food thrown in until it has lain in the water some minutes, when they start off in search of it. The rockling searches by setting its filamentous pelvic fins at right angles to the body, and then swimming about feeling with them. If the fins touch a piece of fish or other soft body, the rockling turns its head round and snaps it up with great quickness. It will even turn round and examine uneatable substances, as glass, &c., which come in contact with its fins, and which presumably seem to it to require explanation. The rocklings have great powers of scent and will set off in search of meat hidden in a bottle sunk in the water. Moreover, a blind rockling will hunt for its food and find it as easily as an uninjured one.

The barbels of the rocklings bear sense organs having the structure of taste-bulbs, but the sensitive rays of the pelvic fins do not, having an epithelium made of tall, thin cells, somewhat like that upon the fingers of a gurnard.

**Sudden Colour Changes in Conger.**—During the months of May, June, and July I occasionally saw the conger living in the tanks more or less covered with bright, white spots. These spots come and go suddenly, and their size varies from that of small shot to that of a threepenny-piece. Sometimes the head, both sides of the pectoral and dorsal fins, and anterior end are thus covered, while sometimes

it is the posterior end or the middle of the body which is affected. I have seen these spots vanish suddenly, but sometimes they remain for several hours. It does not seem that these appearances are of the nature of secondary sexual characters, for they appear on conger of all sizes. These spots are, of course, caused by contraction of the chromatophores in the skin, but they do not appear to be connected with light, for they not only are occasional in their occurrence but once they appeared on a blind conger also. They do not appear to indicate any special emotion or diseased state, as frequently the animals thus affected are seen to feed like the rest.

**Contractility of the Iris in Fishes and Cephalopods.**—While in warm-blooded animals the size of the pupil is regulated by the accommodatory mechanism of the iris, this power appears to be wanting amongst Teleostean fishes in general. I have examined the eyes of conger, soles, mullet, wrasse, pollock, &c., and have never seen any alteration in the width of the pupil either by day or night or in twilight, neither do they contract when a strong light is flashed on them by night. On the other hand, all the Elasmobranchs living in the tanks are provided with a means of altering the size of the pupil. In the skate this takes the form of the well-known fern-shaped process from the upper edge of the iris which by day covers the whole pupil. This structure has often been described, but I have found no mention of the fact that it is gradually drawn up in twilight and completely so at night, leaving the pupil clear. If a bull's-eye lantern be turned on to one eye, this process very slowly descends again, and in about fifteen or twenty minutes it will reach down over half the pupil. Probably if the exposure to light were continued it would fall into the position which it occupies by day, but the skate always swam off after about twenty minutes. When the animal turned round, it could be seen that the process of the eye on the dark side had also descended to the same degree as on the light side.

In the dog-fish, nurse and angel-fish, the pupil is almost completely closed during the day by the iris, the edges of which nearly meet along a slit-shaped opening which extends more or less diagonally from the upper posterior edge to the lower anterior one. This slit gradually opens as twilight comes on and in the night the whole of the pupil is exposed. When the light of the lantern was turned into one eye of a dog-fish or nurse, the iris very slowly contracted until the edges met as by day. When the animal turned round the other pupil was seen to be still open widely as before.

The turbot\* is the only bony fish in which any great change in size of the pupil was seen. This fish has by day a downward pro-

\* I have since seen the same changes in the pupil of the brill.

cess of the iris, which covers the upper half of the pupil but which is drawn up at night. This process gradually returns to its position if an artificial light be shown. I have, however, also seen that the pupil of the gurnard (*Trigla cuculus*) which is almost diamond-shaped by day, enlarges somewhat and becomes circular at night.

It is difficult to correlate this power of contracting the iris among fishes with any special feature in the powers of vision or even with nocturnal habits. The skate and dog-fish in the tanks move very little by day and seem to find their food entirely by touch and smell, while the angels remain completely buried until night.

On the other hand, in such typically nocturnal fish as conger and soles there is no such mechanism of accommodation. It may be mentioned that the turbot sees very well by day and will rise to catch food falling in the water.

The eyes of the Elasmobranchs glow in the light of the lantern like a cat's eye, but the eyes of the other fishes in the tanks do not.

The iris of Cephalopods (*Eledone* and *Sepiola*) contracts for light like that of a warm-blooded animal, leaving a slit-like pupil. The size of the pupil in *Eledone* varies also with the emotions of the animal. I found that it contracted more for green light than for yellow and least of all for red. In the tanks the *Sepiolas* sit on the ground with their eyes closed by the lower lids throughout the day.

**Modes in which Fish are affected by Artificial Light.**—If the fish in the tanks are looked at by night with a lantern several somewhat interesting phenomena may be seen. Fish are differently affected according as they are day or night feeders. Soles and rockling stop swimming if a light is shown, and the former bury themselves almost at once. Bass, pollock, mullet, and bream generally get quickly away at first, but if they can be induced to look steadily at the light with both eyes they gradually sink to the bottom of the tank, and on touching the bottom commonly swim away. Sometimes the fish will lie close to the glass, turning one eye only to the light; in this case the animal never lies horizontally, but always with that side of the head depressed which is turned towards the light. In this connection I may mention that I have seen a whiting which had lost one eye by disease which always swam with the blind side higher than the normal one. In the case of mullet effects apparently of a mesmeric character sometimes occur, for a mullet which has sunk to the bottom as described will sometimes lie there quite still for a considerable time. At other times it will slowly rise in the water until it floats with its dorsal fin out of the water, as though paralysed. I once saw one which remained in this odd position for some minutes after the light had been turned off it. I

could not get the mullet to attend to the lamp if the room was generally lit up. The red gurnard and the bass will sometimes swim up to and lie by the light for a time, but they were never seen to take any other notice of it. Turbot, on the contrary, are occasionally greatly affected by the light of a lantern. When the light is first shown they generally take no notice of it, but after about a quarter of an hour I have three times seen a turbot swim up, and lie looking into the lamp steadily. It then seemed to be seized with an irresistible impulse like that of a moth to a candle, and throws itself open-mouthed at the lamp. On one occasion a turbot continued to dash itself with such violence at the lamp that it wore the skin of its chin through till it bled. When the light was moved to another part of the glass the turbot soon followed and began again.

**Sound heard by a Lamellibranch (*Anomia*).**—In the course of an attempt to find out what class of sounds are generally transmitted to animals living in water I found that *Anomia* if open can be made to shut its shell by smearing the finger on the glass of the tank so as to make a creaking sound. The animals shut themselves thus when the object on which they were fixed was hung in the water by a thread. It is therefore clear that the action perceived was not communicated merely by the jarring of the solid framework of the tank. The noise made by the finger had to be of a particular pitch, for neither mere rubbing on the glass nor the exceedingly high note made by squeezing the edge of a wet cork along the glass produced any effect. It is remarkable that the *Anomia* took no apparent notice of the sound made by creaking the antenna of a crayfish under water. Instances of real sounds being perceived by aquatic animals are so rare that this fact seemed worth recording.  
—W. BATESON.

**The Fisheries and Fishing Industries of the United States.**—The United States Fish Commission has recently published the third, fourth, and fifth sections of the treatise on the Fisheries and Fishing Industries of the United States which is being jointly produced by them and the United States Census Bureau. The three sections above mentioned comprise four quarto volumes, the first of which contains Sections III and IV, devoted to the Fishing Grounds of North America and the Fishermen of the United States respectively. The



section on the History and Methods of the Fisheries extends over two volumes of text and a volume containing two hundred and fifty-five plates illustrating the methods of catching and curing fish and other marine products. It is no disparagement of the excellent works published by private individuals in England to say that no such complete treatise upon the fisheries of a single country has ever yet been attempted or so successfully carried out. Mr. Holdsworth's excellent book upon deep-sea fishing is the most complete work of its kind published on the English Fisheries, but it could not be expected that an individual could include within the compass of a single octavo volume such a varied mass of information as is presented by the United States Commission. The editing of these volumes has been in the hands of Mr. Brown Goode, who has had the help of nineteen associates, many of them well known from their scientific and practical researches.

Members of the Marine Biological Association who would learn how much practical benefit can be conferred on a national fishing industry by such a body as the United States Fish Commission should obtain and read these volumes; they are not only instructive but interesting. It would be difficult to over-estimate the importance of the information given in Section III. Not only are all the areas frequented by United States fishermen described in the text, with an account of the fishes caught in each and the seasons at which they are to be found, but their exact localities are mapped out in a number of excellent charts which embrace the whole of the eastern coast of the North American Continent. No less valuable are the charts showing the annual variations of sea temperatures at various points on the same coast. The fact that the migrations of fish are largely dependent on the temperature of the sea has long been known in a general way, but hitherto no observations have been made of extent and accuracy sufficient to allow a judgment to be formed on the subject. The following paragraph, taken from Mr. Richard Rathbun's report, is instructive:—"During the winter months the water temperatures on the ocean plateau outside of the capes is higher than that of Chesapeake Bay or the Potomac River. The latter part of February or early in March the temperature of the bay waters rises above that of the ocean waters outside. Coincident with this the shad make their appearance in the Chesapeake and are taken in the pounds which are set in salt water along the shores of the bay. About the 1st of April the temperature of the water in the Potomac river rises above the temperature of the water in the bay. Coincident with this is the beginning of the shad fishing in the river."

The section on the fishermen is interesting reading. Some of the American fishermen appear to live as exclusive a life as the fisher-



men of Europe, and in Maine, for example, they are dependent on the middlemen, and get but small returns for their labour, 175 dollars, little more than £45 per annum. The fishermen of New England, of which the chief port is Gloucester, Massachusetts, are a very different class of men; they are well educated, do not form a class by themselves, and are withal admirable sailors and fishermen. They earn as much as £200 per annum, and a skipper who is part owner of a schooner has been known to make £3000 in a single year.

The section on history and methods may prove rather puzzling to English readers. There is no beam trawling in America, and the flat-fish which are held in so much esteem and command so high a price in this country, the sole, the turbot, and the brill, are unknown on the other side of the Atlantic. On the other hand, many names unfamiliar to us are to be found, such as tautog, menhaden, squeteague, skulpin. The different methods of catching fish are well explained in this section. It is noticeable that the Americans use larger ships than Englishmen, they set their lines in a different manner, they use nets such as the purse seine which are scarcely known and rarely, if ever, used in this country, and they do a great deal of their curing on board ship. Undoubtedly they are ahead of Europeans in their methods of fishing, as in many other things; the fishermen are certainly advanced in this, that they are not prejudiced in favour of old methods, but are one and all ready to try novelties in gear and boats, and to adopt them if successful, to listen to advice and to learn all that they can about marine life and the habits and characteristics of the fish they catch. They assist the Fisheries Commissioners in their researches, and in return receive many benefits from the Commission.

In comparing the work on Fisheries done by the United States Fish Commission with what has been attempted in other countries it must not be forgotten that they possess an income out of all proportion with that bestowed on other fishery departments or commissioners. But when they can produce such a work as this in addition to their scientific and practical researches, no one can assert that the income is not well spent.—G. C. B.

## C. Spence Bate, Esq., F.R.S.

THE Association has lost one of its ablest and most energetic members in Mr. C. Spence Bate, F.R.S., who died, after a painful illness, at his residence, The Rock, South Brent, Devon, on the 29th of July.

It is hardly necessary here to dwell on Mr. Spence Bate's scientific attainments; as a carcinologist he was distinguished throughout Europe, and his works on the British Amphipoda (in conjunction with Professor Westwood) and the Macrurous Crustacea of the Challenger expedition are testimony to his acute powers of observation and his patience in study.

From the date of its foundation Mr. Spence Bate took the keenest interest in the Marine Biological Association. He was elected a member of Council soon after its formation, and was among those who urged the advantages of Plymouth as a site for a Marine Laboratory. On Plymouth being chosen Mr. Spence Bate took an active part in the early arrangements necessary for acquiring the site and erecting the buildings; his influence was instrumental in securing for the Association that local support which has been so freely given by the authorities and inhabitants of Plymouth, and he personally took a large share in watching the progress of the building and arranging the details of its interior. Lately Mr. Spence Bate was a frequent visitor to the Laboratory, was ever ready to assist younger naturalists with his stores of knowledge on Crustacea, and was most helpful in lending from his own library scientific memoirs not in the possession of the Association.

# Journal of the Marine Biological Association.

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## The Director's Report.—No. 3.

THE present number of the Journal contains several memoirs of considerable practical importance. Mr. Bateson's paper on *The Sense-organs of Fishes* is the outcome of six months' work at Plymouth. It will be seen that he has dealt with the subject in the broadest possible manner; and whilst he is able to offer many practical suggestions as to the course to be pursued in further experiments with preserved and artificial baits, he has prepared the way for such experiments by his careful and interesting observations on the manner in which various fishes hunt for their prey. These observations give a far more accurate and well-founded account of the habits of food-fishes than anything that has been published before.

Through the kindness of Lord Revelstoke the Association will be able to institute a series of practical observations on the oyster in the river Yealm this year. In anticipation of these experiments Dr. G. Herbert Fowler and myself have studied literature of the subject, and have paid visits to some of the chief oyster beds in England for the purpose of obtaining information. Dr. Fowler has also visited the famous Dutch oyster establishments on the Schelde, and gives a very interesting account of what he learnt during his visit.

As I have found that Dr. Hoek's contributions to the natural history of the oyster are but little known in England, probably because they are published in a Dutch scientific periodical which has not a large circulation, even amongst scientific students, in England, I have written an abstract of the two papers published by him in 1883-84. In these abstracts I have confined myself to such matter as is of practical importance. Those who wish to enter more fully into the subject should consult his original papers, published in the Dutch and French languages, in the *Tijdschrift der Nederlandsche Dierkundige Vereeniging*.

Lord Montagu, of Beaulieu, who as Lord Henry Scott made a very complete exhibit of oyster culture at the International Fisheries

Exhibition of London, has allowed me to publish a letter describing the character and history of his oyster ponds in the Beaulieu river.

Mr. Cunningham has already attracted public attention to the possibility of an anchovy fishery in English waters. In a paper published in this number, he gives a further account of the observed frequency of the anchovy in our waters, and discusses at length the steps which might be taken for establishing a trade and fishery for English anchovies.

Mr. Johnson's paper on *The Flora of Plymouth Sound* although it might at first sight appear to be of little practical value, is of considerable importance. His observations on the growth of algæ in Plymouth Sound give a clear picture of the prejudicial effect of sewage and refuse matter on plant life. This disturbance of plant life necessarily leads to a disturbance of the numerous animal forms which are always found associated with plants, and which in turn afford food to other animals which are of importance to man. The impoverishment of a marine flora as a consequence of sewage contamination has not, as far as I know, been pointed out as clearly before, and it opens a wide field for research in districts, such as the mouth of the Thames, where the effects of sewage pollution are keenly felt, though the exact harm is imperfectly understood.

Finally, I must call attention to Dr. Fowler's abstract of the investigations made by the Dutch Fishery Officers, on the relation between the temperature of the sea and the annual catches of anchovies in Holland. The original paper, being written in the Dutch language, has met with very little attention. Nothing can show more clearly the importance of making extensive and continuous observations on the physical conditions of the sea, not in one place only, but all round our coasts, and of comparing those conditions with the observed movements or abundance of food-fishes.

Since the publication of the last Journal we have been passing through the winter months, and for obvious reasons there is little of importance to be said of the doings of the Laboratory during those months. The majority of the volunteer workers left Plymouth by the end of September, but Mr. Bateson returned in October for a month's stay, and Dr. Fowler stayed on till the end of November. Mr. T. H. Riches, B.A., arrived in October, and has been working nearly continuously ever since. Mr. Weldon is still residing at Plymouth to continue his investigations on the Crustacea, and Mr. Herbert Thompson, M.A., spent the month of February at the Laboratory in researches on Crustacean development.

During the whole of January we were prevented, by gales of exceptional severity, from doing any work at sea.

Special mention may be made of two circumstances. In November



the fisherman in the employ of the Association, W. Roach, gave up his place to return to his old work, and an experienced trawl fisherman, E. G. Heath, was engaged in his place. The loss of Roach's services is to be regretted, as he possessed a minute and peculiar knowledge of the rocks and shoals in the neighbourhood of Plymouth, and could dredge in many places where other fishermen would not venture to try.

The Association has incurred a considerable expense in altering the connection between the storage reservoirs and the feed pumps. This operation involved the cutting through in two places of a solid concrete wall four feet thick, and the purchase and erection of new supply pipes, valve boxes, and fittings. The result has been most satisfactory. The pumps run more smoothly, the circulation of the water is improved, and the sediment which accumulates at the bottom of the storage reservoirs is undisturbed.

It has been asserted recently that the Plymouth Laboratory is placed in an unsuitable position as regards water supply, and that the sea-water in circulation is drawn from a contaminated source, is turbid, and below the normal density of sea-water. I may take this opportunity of giving an emphatic denial to these statements.

It is true that on the ebb tide, and in neaps at all tides, the water of the Sound below the Laboratory is polluted by the material carried out of the Cattewater, and is often of insufficient density. But in spring flood tides a large volume of water flows direct to the shores beneath the Laboratory from the sea, and it is only on these occasions that water is pumped into the storage reservoirs. Usually the water when first pumped in has a density of 1.0255 or 1.0266, and after it has been a short time in circulation its density is raised by evaporation to 1.027, after which we have to add fresh spring-water to make up for evaporation. By keeping both storage reservoirs full we have always a reserve of 100,000 gallons of sea-water, from which the circulation is supplied. Since the alterations in the supply pipes we are able to circulate from both reservoirs at once, and as it takes sixteen hours to pass their united contents through the circulation, the water in them is very little disturbed, and there is ample time for the settlement of all solid matter which it may contain. The water now in circulation is, and has been for several months past, remarkably pure and bright, and its density is perfectly normal. I cannot say more than that it is satisfactory in every respect.

No doubt visitors may have observed that the water in the aquarium has occasionally been of indifferent quality during the first twelve months' working. This was partly due to the imperfections in the original supply pipes, partly to the fact that the tanks were



not properly seasoned. It is a matter of common experience that a sea-water aquarium cannot be got into good order for many months, and it was not to be expected that the Plymouth Laboratory should be exempt from the initial difficulties experienced by other institutions. It was further said that we were obliged to add salt to bring the water to the required density. This was done once, in August, 1888, immediately after the opening of the Laboratory. It has never been found necessary to do it since, and there is no reason to suppose that it will ever be necessary to do it again.

It is interesting to note that Dr. Dohrn, the experienced founder and director of the Naples Zoological Station, writing to Prof. Lankester about the choice of a site for the Laboratory of the Marine Biological Association, told him that the source from which the sea water was derived was not of so much importance as the size of the storage reservoirs, for no water that could be drawn from the sea would be as suitable for hatching and rearing delicate marine organisms as that which had been for some time in the reservoirs. Our experience proves the wisdom of Dr. Dohrn's advice.

G. C. BOURNE.

PLYMOUTH; *March 4th*, 1890.

## The Sense-organs and Perceptions of Fishes ; with Remarks on the Supply of Bait.

By

**W. Bateson, M.A.,**

Fellow of St. John's College, Cambridge, and Balfour Student in the University.

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With Plate XX.

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THE Council of the Marine Biological Association appointed me, in 1889,\* to make observations on the perceptions of fishes, and especially on those which constitute the modes by which they hunt for and recognise their food. It was suggested that this subject should be treated in as wide a manner as possible, and in accordance with this suggestion I have endeavoured to utilize any opportunities which presented themselves of getting an insight into the natural history of marine animals. In addition to this I have also made some experiments towards the practical solution of the bait question, both by making artificial baits, and by endeavouring to preserve materials which are already in use for bait.

The first part of this paper contains an account of those observations which seem to have a scientific interest ; and it is followed by some remarks on the present condition of the supply of bait, together with suggestions as to possible solutions of the difficulty.

Evidence bearing on the perceptions of aquatic animals is somewhat difficult to obtain, owing to the absence of any points of similarity between the conditions of their lives and those of terrestrial forms. To interpret their behaviour by comparison with our own is even more clearly an inadequate treatment than it is in the case of the other lower animals. From the nature of the case, moreover, satisfactory evidence as to their conduct in the wild state is scarcely to be had, so that it is necessary to depend largely upon observations made upon them while living in tanks. It must be understood, therefore, that the statements here made are, strictly speaking, descrip-

\* This appointment was made in connection with Mr. Robert Bayly's grant to the Association for an investigation of the means whereby deep-sea fishermen may be better supplied with bait.

tive only of their habits under these artificial conditions. Though the majority of the fishes observed by me, being inhabitants of water of moderate depth, may be assumed to be under approximately natural conditions, it is important to bear this reservation in mind in considering the case of conger and other fishes which live in deeper water, and are exposed in the sea to very different influences, especially as regards pressure and light. As an instance of the need for caution in estimating the powers of fishes by their behaviour in tanks, it may be mentioned that the whiting, though a diurnal feeder, and apparently unable to find its food otherwise than by sight, is nevertheless under exceptional circumstances caught in the sea with a bait on dark nights at a considerable depth.

It will perhaps be convenient to give a general account of the sense-organs of the animals before describing their habits and modes of perception.

#### THE STRUCTURE OF THE SENSE-ORGANS.

In examining the sense-organs of fishes I have been a good deal struck with a general fact concerning them, which, though sufficiently well known and obvious when stated, does not appear to be a matter of *a priori* necessity, and it may be well to call attention to it in this place. On comparing individual fishes of the same species but of different sizes, it is apparent that the size of the eyes varies with the size of the body. The same fact is true of the scales covering the body, which seem not to increase in number, but in size as the animal grows. In fact, so constant is the number of the scales that, as is well known, they have value as characters for the purposes of classification. In the case of the olfactory organs, increase in size takes place both by growth of the individual folds bearing the epithelium, and by the addition of new folds. Now the relation of such an organ as the eye to the organism may be compared to that of an instrument to a workman; and if this comparison is a true one, it is not a little remarkable that the sizes of the two should vary together. The question next arises, is a large eye, *cæteris paribus*, more efficient than a small one? It may easily be believed that a larger olfactory organ is more efficient, but such a case as that of the eye seems more difficult. If this question should be answered in the negative, it would be interesting to see if these facts are in harmony with the principle of economy of growth, in obedience to which it is believed that all superfluous parts tend to be eliminated from the body. If it is held by any to be manifest that a larger organ is obviously more efficient by reason of its greater

size, it may be asked to what limit it is proposed to carry this principle. Is it applicable to all organs and parts of organs? Are the cells, for instance, of the tissues of a large individual larger than the similar cells in a smaller one, or would they be more efficient if they were? It would in any case be most desirable to know in what animals this relation of size between the whole and the parts is found, and to what organs it extends. In particular, it would be of the highest interest to know whether the eggs of a large individual are larger or more numerous than those of a smaller individual of the same species, and so on. An insufficient experience of Crustacea, fishes, and plants leads one to think that in these cases the number of eggs or seeds increases without change of size, though in the absence of more data it is unprofitable to discuss the matter. But as the relation between the size of the body and that of its organs has a high importance in any attempt to obtain a view of the modes of occurrence of variations, these facts in the structure of fishes are emphasized here, in the hope that persons who have the opportunity of handling large numbers of animals may be led to record their observations of similar particulars.

#### EYES.

The general structure of the eyes of fishes is well known, but some points which have been observed in the course of this investigation may be worthy of notice. Particular attention was paid to the eyes of those fishes which are active at night, in order to see if there is any general common feature among them. The statement, for example, is made by Day (*British Fishes*, vol. i, p. xxviii) that "nocturnal fishes require larger eyes than diurnal ones." This may possibly be true, but it is by no means the fact that they are as a rule endowed with larger eyes, as is suggested in the passage quoted. The most typically nocturnal fishes are the conger and the eel. Of these the conger has a large eye, but not a remarkably large one when compared with that of the cod or the bream, which are diurnal, while the eel has a somewhat small eye. The eyes also of the sole, which is emphatically a nocturnal animal, are singularly small, while those of the angel-fish and torpedo are still smaller in proportion to the bulk. Among the rocklings, also night-feeders, the three-bearded rockling has an eye of average size, while that of the five-bearded rockling is decidedly small in proportion to its body. Under these circumstances any general statement is misleading.

Not even is there any uniformity with regard to the presence or

absence of a contractile iris amongst nocturnal or diurnal fishes. In this Journal (N. S., i, 2, p. 215) I have given some account of my experience in this matter, which it may be convenient to repeat here, with the addition of other facts since noticed.

In the great majority of fishes observed, the shape and size of the pupil do not alter materially for light. Of the exceptions in which such a mechanism is found, some are nocturnal, as the skate and rough dog-fish, while others are diurnal animals, as the turbot. All of the Elasmobranchs which came under my notice are provided with a contractile iris, but the mode of contraction and the form of the pupil differ greatly among them. The eye of the torpedo (*T. marmorata*) presents the simplest form of this mechanism. In it the pupil is circular by night, but by day the *lower* limb of the iris rises up so as to close the pupil almost completely, leaving a horizontal slit at the upper part of the eye (*v.* fig. 8). In the rough dog-fish, the angel-fish, and the nursehound the pupil is also closed by day, but in it the edges of the iris meet to form an oblique slit passing across from the upper posterior margin of the iris to the lower anterior one. The arrangement in the skate is altogether peculiar, and seems to have no relation to either of these types of mechanism. In it the pupil is covered in daylight by a process of the *upper* limb of the iris, which falls over it, forming the well-known fern-shaped structure (*v.* figs. 7*a* and 7*b*). This peculiar irideal fold seems to consist of a constant number (eleven) of processes. By night this fold is completely drawn up, leaving the pupil clear. As described in the place referred to, the pupils of the dogfish and skate contract at night when the light of a lantern is turned on the eye, but this contraction is not sudden, as it is in terrestrial animals and Cephalopods, but, on the contrary, takes a long time to be completed. In the skate the process of the iris did not completely descend when the eye had been exposed to light for about twenty minutes, but the pupil of the dog-fish was almost entirely closed in that time. Illumination of one eye only in the skate causes the irideal fold of both sides to descend simultaneously, but the pupil of the dog-fish remained open on the dark side when the folds of the iris had nearly met in the illuminated eye.

The eye of the sterlet (*Acipenser*), a night-feeder, also has a contractile iris, which is arranged as a circle which is incomplete at the upper edge (*v.* fig. 10).

Among diurnal fishes, the turbot and brill, together with the weever, all have a semicircular flap from the upper edge of the iris which partially covers the pupil by day, but is almost entirely retracted at night, slowly returning under the light of a lantern. In the Brighton Aquarium I saw a turbot in which this flap of the



iris was hardly developed at all. In speaking of the weever as a diurnal fish it is not intended to assert that it is not active at night. As is well known, it lives buried in the sand by day, but it has eyes which see well in daylight, for it will uncover itself and swim up to food just as a plaice does. As to its habits at night I have no evidence.

The pupil of the halibut is kidney-shaped, the concavity being upwards. The pupil of the plaice is of the same pattern, and without special irideal mechanism.

The pupil of the gurnard differs from all these in being slightly contracted by day so as to have a diamond shape, while it is circular by night.

All the fishes attainable were tested with a lantern by night, but in none was any alteration in the size of the pupil observed except in the cases mentioned. It is a somewhat remarkable fact that the reflex contractility of the iris, which is such a general character of land Vertebrata, should be so irregularly developed among fishes. In none of them does the usual sudden contraction for light occur, though it is nevertheless found in the Cephalopods (*v. loc. cit.*). Moreover, as the matter may have a bearing on the optical aspects of aquatic vision, attention is called to the fact that none of the animals mentioned which are provided with appliances for contracting the pupil have the circular aperture which is usual in many terrestrial animals and also in several of the other fishes which have no special mechanism of this kind.

The eyes of the three-bearded rockling (night-feeder) are extraordinarily convex, and protrude from the general level of the face so much that the lens can be seen through the cornea on looking down on the animal's head from the dorsal side. The same is true of the eyes of the boar-fish (*Capros aper*), which is a day-feeder; while those of the conger, also a night-feeder, are particularly flat.

The eyes of fishes are mostly not capable of much rotation, but those of the dory, wrasses, lump-sucker, and pipe-fishes can all be moved, and are used independently of each other (cf. p. 242). The eyes of the loach are also moveable, but to a less extent.

#### OLFACTORY ORGANS.

In all the fishes examined olfactory organs are present, but their development differs greatly in the different forms, the largest occurring in the eel, the conger, the *Raiidæ*, and the dog-fish, and the smallest in the top-knot (*Zeugopterus punctatus*). It might be expected that the olfactory organs of fishes which hunt by scent

would be consistently larger than in those which seek food by sight, but this is only partially true. For though the great development of these parts in the eel, conger, and Elasmobranchs is accompanied by an acute sense of smell, yet in the rocklings, the loach, and the sole, which also seek their food by scent, the olfactory organs cannot be said to be proportionally more developed than they are in forms which feed by sight, such as the plaice and the pollack.

**Nostrils.**—In all forms (? *Zeugopterus punctatus*) examined, two nostrils occur on each side in the manner characteristic of most fishes. Of these two nostrils the anterior is to some extent tubular in all the fishes (except the Elasmobranchs) which seek their food by scent (*v. p.* 235). This tube is most developed in the conger, in which it is simple and straight, projecting beyond the surface of the nose. In the eel this anterior portion of the nostril is formed of two flaps of skin. In the rocklings it takes the form of a very short tube, the dorsal edge of which is produced into a long barbel. The anterior nostril of the loaches resembles that of the rockling, but the tube stands up more vertically from the head, and the posterior edge of the aperture is not produced into a barbel, but is bent over it to form a kind of hood. This latter form of nostril is also found in nearly the same shape in *Lepadogaster*. In all these forms the posterior nostril is a simple opening without a valve.

These tubular nostrils are ciliated as well as the olfactory epithelium itself, and a current is thus caused which enters by the anterior and leaves by the posterior opening. In the majority of fishes rhythmical oscillations of the water in the olfactory pits also occur, but these are not present in any of the animals mentioned below as seeking food by scent, except *Lepadogaster*.

In the ordinary round fishes (*Gadidæ*, *Labridæ*, &c.) the two nostrils are placed close together. Through these openings currents are no doubt caused by the cilia on the olfactory organs themselves, but the principal movement of water in the olfactory chambers is an oscillatory movement which occurs rhythmically, keeping time with and being probably dependent on the respiratory movements of the fish. The former movements may nevertheless be suspended while the respiratory movements continue. It did not appear that in these fishes the water entered or left by either nostril in particular, but rather that it oscillated in and out through both of them at once.

In the flat-fishes the arrangement of this current is more complicated. The plaice may be described as having the structure which is found in most of them. This fish lies on its left side. The anterior nostrils are tubular, that of the right side being produced con-

siderably. The posterior nostril of the right side is valvular, and opens outwards. On inspiration water passes into the olfactory chamber through the anterior nostril, and on expiration the posterior nostril opens suddenly as the water passes out through it. The posterior nostril of the left side is not valvular, but simple. These remarks apply also to the dab and the flounder. In all these fishes the nostrils are so arranged that none of them are on the *lower* surface of the head, but rather on its dorsal side.

The sole has a different mechanism. It lies on its left side, and both the nostrils of the left side are on the under surface of the head—touching the ground, in fact, when the animal is at rest. On the left side the anterior nostril is large and open, and has a ciliated fold of skin which passes spirally down it; but the posterior one is very inconspicuous and valvular, being at some distance from the anterior opening. As the sole inspires, water passes in at the anterior opening, and on expiration it leaves by the posterior nostril, which opens and shuts with a jerk. The anterior nostril of the right side is tubular, and the posterior one is valved, acting like that of the left side.

In all these fishes, also, the flow of water through the olfactory organs may be suspended though the respiratory movements continue.

In the turbot, which lies on its right side, the left anterior nostril is guarded by a simple triangular flap of skin which projects forward from the posterior edge of the opening and covers it. This possibly forms a valve during life, though I have not had an opportunity of closely examining the currents through the olfactory chamber in a living specimen. The posterior edge of the anterior nostril on the left side is produced into a very large, leaf-like flap of skin, which in dead specimens usually covers the nostril. In one specimen (from Grimsby), however, this fold was reflexed, and lay against the side of the head in such a rigid manner that it could not have been used during life to cover the nostril.

The right posterior nostril of the turbot is widely open, and the left posterior nostril is also without any special valve, but the skin at its edges nearly meets across the opening. These structures do not materially differ in the brill (*R. levis*). In one brill (from Grimsby) the two nostrils of the right side were united, forming a common fossa in which the olfactory organ lay. In this specimen the leaf-like fold of skin, usually covering the anterior nostril, was divided into two parts, which were disposed on either side of this fossa. There was no indication that this variation was not congenital.

The left anterior nostril of *Arnoglossus laterna* is somewhat tubular, but the left nostrils of *Arnoglossus megastoma*, which also lies on its right side, were, in a preserved specimen, without valves or flaps of

skin of any kind. The right anterior nostril, however, has a very large loose flap of skin. The olfactory folds are but slightly developed, and are mere ridges on the floor of the olfactory chamber. Their number in the left organ of a large specimen was thirty (v. fig. 3).

The olfactory structures of Müller's stop-knot (*Zeugopterus punctatus*) are so abnormal and reduced that it will be best to reserve any statement about them until the homologies of the parts are more clear.

The **olfactory organs** themselves in fishes are composed of the well-known folds bearing the sensory and supporting cells of the epithelium. On this occasion I propose to give an account of the general structure of these organs, deferring the description of the histology until a full comparison can be made between the olfactory elements of the fishes which hunt by scent with the same parts in those which seem not to use their olfactory organs for this purpose.

The arrangement of the olfactory folds differs in the various fishes. Roughly speaking, they are built up on one of four types, or on some plan intermediate between them.

(1) In the skate and dog-fish the plates are arranged in a radiating manner on the inside of a hollow capsule, like the septa of an orange. In this case the free internal edges of the plates do not bear sensory cells, but are fibrous supporting tissues.

(2) The conger and eel have the plates of the organ arranged in two rows on each side of a central raphe, upon which the two rows are folded longitudinally so as to form the lining of the olfactory tube. The olfactory organ of the sole, though a much less considerable structure, is arranged on a similar plan; for on it the longitudinal raphe is depressed so as to form a groove from which the plates rise up on each side. The number of plates in an eel one and a half feet long was about thirty-eight pairs in each organ. As already mentioned, the number and size of these plates increase with the growth of the animal.

(3) The third type of olfactory organ, of which the second is a modification, is that most commonly found among fishes. In it the plates are fitted together in a radiating manner, forming a convex eminence in the olfactory chamber. The whole organ is either circular (as in *Cottus* and *Motella mustela*) or elliptical (as in the mackerel), according to the number and shape of the plates of which it is composed.

In all the Teleosteans hitherto mentioned most of the plates are placed at right angles to the long axis of the body, and each organ essentially consists of two rows of such plates united in the middle; for the circular collection of radiating plates of *Cottus*, &c., only differs in degree from the more common elliptical one.



Amongst the flat-fishes this elliptical series of plates arranged along a single axis is found in the genera *Rhombus* (turbot and brill) and *Arnoglossus* (merry sole and megrim). In a very large turbot the number of chief folds was thirty.

(4) In all the species of *Pleuronectes*\* examined, as well as in *Hippoglossus vulgaris* (the halibut), an entirely different arrangement is found. In these fishes (v. fig. 2) only one row of olfactory plates is present. The plates thus arranged in a single series lie in a direction parallel to the long axis of the body, and not transversely to it, as the majority of them do in other types. The arrangement in *Solea* has already been described.

In the pollack and rockling, and probably in all fishes, if the whole olfactory organ be destroyed with acid, the skin heals over the part, but the special epithelium and the nostrils are not reproduced; but in a conger in which the olfactory organ had been only partially destroyed, the plates of epithelium were found to be regenerating from the edges of the olfactory tissue which had remained undestroyed.

#### SENSE-ORGANS OF THE MOUTH AND SKIN.

The scales and skin generally of fishes are supplied with remarkable sense-organs, which resemble the taste-buds of higher forms. These organs have been fully described and figured by Merkel in his monograph, *Ueber die Endigungen der sensiblen Nerven in der Haut der Wirbelthiere* (Rostock, 1880). In the course of these investigations a good deal of the ground covered by Merkel's work has been gone over, and to it there is little to add. It will be profitable, however, to mention those facts which specially concern the purposes of the present inquiry, and to describe the characters of some of these organs in forms which have not been investigated by Merkel.

Such organs consist essentially of clusters of long cells arranged together to form a bulb-shaped body, of which the apex is not covered by cuticle, but projects on the surface of the skin. The base of the bulb may be in contact with the basement-membrane of the skin, or may be separated from it by several layers of cells of the lower layer of the skin (cf. figs. 13 and 14). Into this base a nerve enters. Such an organ may be large and visible to the naked eye, as in the pharyngeal walls of most fishes, or it may consist of only a few such cells and be extremely minute. These minute "taste-

\* Viz. *P. platessa* (the plaice), *P. flesus* (the flounder), *P. limanda* (the dab), *P. microcephalus* (the lemon sole of the east-coast fisheries).



buds" are found in clusters on the large papillæ which occur on the gill-bars of the dog-fish (as observed by Merkel), of *Cottus*, and many other forms. The whole sense-organ may be placed on the general surface of the skin, or it may be depressed into a pit or elevated on a papilla, according to its situation and the animal in question.

The cells forming these sense-organs consist of a very long, narrow cylindrical head, which is external, an internal enlargement in which the nucleus lies, and a tail passing into a fibre of varying length (*v. fig. 15*).

These sense-organs have a general resemblance to those of the lateral line, but the cells of which they are made do not appear to bear a hair on their peripheral buds, as those of the lateral line do.

I have examined them in the following forms, and have found them on the parts stated.

Bream (*Pagellus centrodontus*). On the palate.

Bullhead (*Cottus scorpius*). On the palate and on the papillæ of the gill-bars.

Gurnards (*Trigla*). On the palate and *not* on the fingers of the pectoral fin.

Pogge (*Agonus cataphractus*). On the villiform tentacles beneath the head.

Wrasses (*Labridæ*). On the palate as patches of minute sense-organs surrounded by ridges of skin.

Grey mullet (*Mugil*). On the palate and in great numbers upon the fleshy thickenings in the pharynx; also in rows upon the white rugæ which form the anterior borders of these thickenings.

Pollack (*Gadus pollachius*). On the lips and palate (a few).

Pouting (*G. luscus*). On the lips, palate, barbel, and pelvic fins in great numbers.

Whiting (*G. merlangus*). On the lips and palate.

Rocklings (*Motella*). On *all* the barbels, pelvic fins,\* and palate.

Blenny (*Blennius gattorugine*). No sense-organs were found on the tree-shaped processes, which stand up from the anterior nostril and from the orbit. As these are parts which might have been expected to bear such organs, mention should be made of their absence.

Plaice (*Pleuronectes platessa*). On the palate.

Dab (*Pleuronectes limanda*). No sense-organs were seen on the palate.

Sole (*Solea vulgaris*). Contrary to the natural presumption, the

\* In the last number of this Journal I stated that the pelvic fins of the rockling bore no organs of special sense. In specimens since prepared with gold chloride they are easy to see.

villi on the lower (left) side of the head do *not* bear sense-organs, though, as Mr. Cunningham informs me, such organs are found between the villi.

Conger (*Conger vulgaris*). On the outer and inner lips and palate.

Eel (*Anguilla vulgaris*). On the tongue and lips and on the skin of the tubular anterior nostril.

Dog-fish (*Scyllium canicula*). On the tongue and palate and in groups on the papillæ of the gill-bars.

Torpedo (*Torpedo marmorata*). No opportunity of dissecting this torpedo occurred, but these organs should be looked for on the papillæ bounding the spiracle of this species, in which place their occurrence would be interesting.

It is of course not suggested that these organs do not occur also on other parts of the animals named, as such structures are very generally distributed among fishes.

The nature of these structures is sufficiently shown by the figures. Upon the lips of the conger two types are found, of which the most usual is shown in fig. 13. The sense-organ is here seen to lie on the general surface of the skin, which is very thick. Below the sense-organ a narrow channel passes up through the whole thickness of the skin, and in this the nerve travels up to the sense-organ. The other type of sense-organ found in the same situation is precisely similar, except that it does not lie superficially but at the bottom of an open pit, depressed below the surface of the skin.

The nerve-supply of the sense-organs of the pharynx of the mullet (*Mugil*), &c., and of the barbels of the rocklings (*Motella*), &c., differs from these in that the skin is not channelled for the passage of the nerves to them. On the contrary, the fibres, after leaving the nerve-trunks, *pass bodily through the basement-membrane* and amongst the cells of the skin to break up on the sense-organs (*v. fig. 11*).

#### SENSES OF FISHES WHICH SEEK THEIR FOOD BY SCENT.

**Smell.**—The majority of fishes seek their food chiefly if not entirely by sight, but a certain number hunt for and recognise it by the sense of smell alone, while a few species are also aided in seeking by special organs of touch. The following is a complete list of the fishes which have been observed by me to show consciousness of food which was unseen by them; and, as will be hereafter shown, there is evidence that they habitually seek it without the help of their eyes.

<p><i>Protopterus annectens</i>. Rough dog-fish (<i>Scyllium canicula</i>).</p>	}	<p>Nursehound (<i>Scyllium catulus</i>). Skate (<i>Raia batis</i>). Conger (<i>Conger vulgaris</i>).</p>
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Eel ( <i>Anguilla vulgaris</i> ).	Loach ( <i>Nemacheilus barbatula</i> ).
Three-bearded rockling ( <i>Motella tricirrata</i> ).	? Sucker ( <i>Lepadogaster Gouani</i> ).
Five-bearded rockling ( <i>Motella mustela</i> ).	Sole ( <i>Solea vulgaris</i> ).
	Little sole ( <i>Solea minuta</i> ).
	Sterlet ( <i>Acipenser ruthenus</i> ).

To this list may almost certainly be added the remainder of the *Raiidæ*, together with the angel-fish (*Rhina squatina*) and torpedo. Unfortunately, however, the examples of these forms living in the tanks at Plymouth have never become thoroughly at home, and still (November, 1889) take food reluctantly. In fact, the skates have for many months subsisted entirely on shrimps, and very rarely take notice of other food; but owing to the kindness of Mr. Wells, the superintendent, I had an opportunity of seeing the habits of the skate under more favorable conditions at Brighton.

Of the fishes in this list the conger, rocklings, sole, and rough dog-fish were the most frequently and minutely watched.

There are many points of resemblance in the habits of the various animals mentioned above, and some general observations may be made with regard to them collectively before pointing out the special features of interest in the natural history of each. In the first place they are all more or less nocturnal animals, and (? sterlet and *Protopterus*) remain in hiding by day, many of them being furnished with special modes of concealment. For example, the conger and the rocklings live in holes in the rocks, the eel and *Protopterus* in mud, the sucker and the loach under stones, while the sole lies completely buried in the sand, the eyeballs alone being exposed. When left to themselves they generally lie motionless until dusk, when they begin to swim about with more or less activity. If, however, while they are lying thus hidden the juice of food-substances (such as squid or pilchard) is poured into the water, they come out and feel about for a considerable time, clearly perceiving the odour. The dog-fish, conger, and eels feel for food with their noses, *Protopterus* with its pectoral and pelvic fins, the rocklings with the barbels and pelvic fins, the loach with its barbels, and the sole with the villi on the left (lower) side of its head.

None of these fishes ever start in quest of food when it is first put into the tank, but wait for an interval, doubtless until the scent has been diffused through the water. Having perceived the scent of food, they swim vaguely about and appear to seek it by examining the whole area pervaded by the scent, having seemingly no sense of the direction whence it proceeds.

Though some of these animals have undoubtedly some visual perception of objects moving in the water, yet at no time was there the slightest indication of any recognition of food-substances by sight.

The process of search is equally indirect and tentative by day and by night, whether the food is exposed or hidden in an opaque vessel, whether a piece of actual food is in the water or the juice only, squeezed through a cloth, and, lastly, whether (as tested in the case of the conger and rockling) the fish be blind or not. On the other hand, if the olfactory epithelium is destroyed in the rockling or conger, the animal does not leave its hiding-place to hunt, though it seizes food placed near its face. Stones or other objects rubbed with food attract these fishes as much as food itself, and when very hungry they will snap at such uneatable substances, though they are rejected after being taken into the mouth. I saw no reason to suppose that any of these animals have the instinct of following a scent (as a prawn seems to do to some extent), though they always stop to examine bodies upon which food has lately rested. The scent of the food does not seem to remain long in the water, and apparently the scent of the surface of the food itself is dissipated or decomposed in a short time; for when, for instance, a piece of squid is not found after searching, it often happens that the fishes give up and retire, but will come out again in quest if the same piece of squid be taken out, cut in half to expose a new surface, and put back. None of the fishes were ever seen to hunt for more than about fifteen minutes unless the scent was renewed. It is difficult to estimate the distance to which a scent can be diffused in the water, but it is likely that, in water which is not rapidly moving, its virtues are destroyed before it has been carried far. There is, I think, no reason for supposing that scents are diffused through the water otherwise than by currents. This is most easily tested by experimenting with shrimps in a large shallow vessel. The shrimps remain buried until the scent reaches them. When the water was not in motion, if food was gently dropped in, the shrimps gave no sign for an indefinite time, but on stirring the water they began to seek. The longest tank at Plymouth is about twenty feet long, and an interval of from five to ten minutes elapses before conger at one end are aware of the presence of food put in at the other.

The perceptions, then, by which these animals recognise the presence of food are clearly obtained by means of the olfactory organs, and apparently exclusively through them. I was particularly surprised to find no indication of the possession of such a function by the sense-organs of the barbels and lips, or by those of the lateral line. As has been already described, the pelvic fins and barbels of the rocklings (*Motella*) and the lips, &c., of most fishes bear great numbers of sense-organs closely comparable in structure with the taste-buds of other vertebrates. No one who has seen the mode of



feeding of the rockling or pouting (*Gadus luscus*) can doubt that these organs are employed for the discrimination of food-substances ; but the fact already mentioned, that the rockling in which the olfactory organs had been extirpated did not take any notice of food that was not put close to it, points to the conclusion that they are of service only in actual contact with the food itself.

**Sight.**—In view of the fact that these fishes do not habitually recognise food by sight it would be especially interesting to determine what part in their economy is played by visual perceptions. Though nocturnal animals, they all have functional eyes, which in the conger, skates, and dog-fishes are as well developed as those of other fishes (*v. p.* 228). In the angel-fish, torpedo, and soles the eyes are, however, of small proportional size. Nevertheless, with the exception of the dog-fish and skates, in which the pupil is covered in daylight by the iris, there is nothing to suggest that there is any difference between the eyesight of these forms and that of other fishes. Positive evidence as to the class of objects which they distinguish is difficult to obtain owing to the general absence of facial or other expressions among fishes ; and it should always be remembered that the fact that animals take no notice of objects is no proof that they do not see them. For example, wrasses, mullet, and other fishes with excellent sight take no notice of a handkerchief suddenly flipped against the glass of the tank in which they are, which would scare away a terrestrial animal ; but it is perfectly certain that they see the handkerchief, for they will snap at a worm hanging by a thread or sticking to the outside of the glass. Similarly they take no notice of a *straight* wire held up and waved outside the tank, but if the wire be *bent* into a sinuous curve like the body of a swimming worm they (pollack) will often dash at the glass in the attempt to seize it. It would appear, however, that fish are by no means slow at gaining knowledge of this kind. A curious instance of this occurred in the case of the rockling (*Motella tricirrata*). When I first began to observe the mode of feeding of this fish I was inclined to believe that it did not *see* worms, &c., thrown in for food. As mentioned above, it does not come towards them until they have been for some time in the water, and then, moving its head and fins, it swims wildly about until it comes in contact with the food, even though it be hanging freely in the water directly in the line of sight. But one of these fishes which has been living for some months in a shallow tank has been constantly fed by persons leaning over the top ; and now when hungry not only comes up and splashes about on the surface of the water as soon as any one approaches, but will lift its head out of the water to snap at the fingers held above the surface, which it obviously sees and recognises. When last ob-



served, however, it still did not appear to have learnt to recognise a worm swimming in the water, but only the presence of the person feeding it. When it is remembered that this fish naturally hunts by scent, the acquirement of this new instinct seems somewhat remarkable, and suggests that it is not the vision which is defective, but the power of appreciation. Being a nocturnal animal, it must be supposed to have never *seen* food, or to have seen it so rarely that it made no impression on it. These considerations suggest the possibility that these fishes may in the course of time learn to distinguish food by sight as they are now habitually fed by day.

There can be no doubt that soles also perceive objects approaching them, for they will bury themselves if a stroke at them is made with a landing net; yet they have no recognition of a worm hanging by a thread immediately over their heads, and will not take it even if it touch them, but continue to feel for it aimlessly on the bottom of the tank, being aware of its presence by the sense of smell. Soles, eels, and rocklings, moreover, have a clear appreciation of light and darkness being always buried or hidden by day (unless food is thrown in), but swimming freely about the tank like other fish at night. When thus swimming at large they bury or hide themselves if a light be flashed on them. Conger and loaches have some appreciation of moving objects, and occasionally snap at them, but their perceptions are extremely vague, as may be shown by watching their attempts to take a piece of food trailed through the water with a line. Their movements altogether are suggestive of a blurred perception, and perhaps it may be that their eyes are capable of distinct vision under greater pressure or in less light or at a greater distance. That greater pressure might produce an effect is very possible, but on watching their movements at night with a dark lantern, or in a tank from which the light was screened, there was no perceptible difference in their aptitude in discovering food.

None of these fishes have much apparent difficulty in avoiding obstacles, but as *large* obstacles seem to be easily avoided by the same animals when deprived of sight, it may be doubted whether this perception of obstacles is not as much obtained by general sensation, especially of currents, as it is by sight.

As to the sight of the sterlet no experiments have as yet been made.

**Touch.**—In the rocklings, as mentioned in this journal (N. S., i, 2, p. 214), the pelvic fins are developed as special tactile organs, and are used in the mode there described. By these organs they are not only able to distinguish food-substances alone, for a rockling on brushing with its pelvic fins against a piece of glass or a stone smeared with vaseline, turns and examines it, clearly remarking the peculiar feel of such surfaces.

Filamentous fins similar to those of the rocklings are found in *Protopterus annectens*, in which both the pectoral and pelvic fins have this structure. Through the courtesy of Mr. Wells I was enabled to watch the mode of feeding of this fish in the Brighton Aquarium. The fins are used in a manner somewhat different from that of the rockling, which merely extends the fins at right angles to the body, and swims wildly about until they happen to touch the food. *Protopterus*, on the other hand, whips with them on the bottom of the tank until the food is struck. The tail also of this fish is, perhaps, used for seeking food, but this was not clearly established.

In connection with the sense of touch, the mode of feeding of the soles may be fitly described. The sole feeds in a manner peculiar to itself, and unlike that of any other fishes which have come under my notice. As already stated, it remains buried by day, and generally speaking, if the sand be fine its body is completely covered. When shrimps or pieces of other food are thrown in, after an interval the soles perceive it; they then give a writhing jump or succession of jumps from the bottom of the tank, and begin to search on the ground. When searching for food the upper (right) side of the sole is nearly always covered with a coating of sand so uniform that little or none of the skin can be seen. There can, I think, be little doubt that this sand sticks to the body owing to an outpouring of mucus on the surface of the skin, which probably occurs when the smell of food is perceived, and is comparable with the watering of the mouth in ourselves.\* This covering of sand is no doubt dusted over them by these energetic movements, but it only adheres when the sole is searching for food. At night, for example, when the soles are active, they carry no sand. The coating of sand must be pretty firmly attached, for if a sanded sole is made to swim rapidly the covering of sand remains.

In searching for food the sole creeps about on the bottom by means of the fringe of fin-rays with which its body is edged, and thus slowly moving, it raises its head upwards and sideways, and gently pats the ground at intervals, feeling the objects in its path with the peculiar villiform papillæ which cover the lower (left) side of its head and face. In this way it will examine the whole surface of the floor of the tank, stopping and going back to investigate pieces of stick, string, or other objects which it feels below its cheek. As already stated, the sole appears to be unable to find food that does not lie on the bottom, and will not succeed in finding food suspended

\* At the moment when a conger lying still first perceives the smell of food, he generally shakes himself, and takes a gulping inspiration, freeing a variable quantity of mucus from the skin and pharynx, which floats up through the water, owing to small bubbles of gas which are enclosed in it.

in the water unless it be lowered so that the sole is able to cover part of it with the lower side of its head, when it seizes it at once. These remarks apply to the common sole (*Solea vulgaris*), to *Solea minuta*, and probably to all the other species, but none of these have lived in the aquarium long enough for observation.

The fact that soles are hardly ever taken with a hook is no doubt due to this manner of feeding; for the bait is not allowed to lie on the bottom except in long line fishing, which is done with large hooks only and on rough ground. If long lines with small gear were laid on the soft ground where the soles live, it is by no means unlikely that they would be taken. In this case it would probably be found to be the most rational way of catching soles.

The sterlet and loaches on perceiving the smell of food hunt for it with their noses and barbels on the bottom. The barbels of the sterlet do not appear to be moveable as those of the pouting, &c., are, and the specimens watched at Brighton did not shovel with their noses, but protruded their remarkable jaws, and appeared to make random bites at the bottom when food was thrown in.

#### THE SENSES OF FISHES WHICH SEEK THEIR FOOD BY SIGHT.

The majority of fishes belong to this class. The following is a list of all the species which have been observed in the Aquarium either at Brighton or Plymouth to feed in this manner. Many others—as, for example, the *Salmonidæ* and *Scombridæ*—might have been added, but I have only given the names of those which have come under my own observation.

Bass ( <i>Labrax lupus</i> ).	Gattorugine ( <i>Blennius gattorugine</i> ).
Bream ( <i>Pagellus centrodontus</i> ).	Butter-fish ( <i>Centronotus gunnel-lus</i> ).
Bullhead ( <i>Cottus scorpius</i> ).	Grey mullet ( <i>Mugil chelo</i> ).
Red gurnard ( <i>Trigla cuculus</i> ).	Three-spined stickleback ( <i>Gasterosteus aculeatus</i> ).
Grey gurnard (Tub) ( <i>T. hirundo</i> ).	Fifteen-spined stickleback ( <i>G. spinachia</i> ).
Pogge ( <i>Agonus cataphractus</i> ).	Spotted wrasse ( <i>Labrus maculatus</i> ).
Weever ( <i>Trachinus vipera</i> ).	Rainbow wrasse ( <i>Coris julis</i> ).
Horse-mackerel ( <i>Caranx trachurus</i> ).	Pouting ( <i>Gadus luscus</i> ).
Herring ( <i>Clupea harengus</i> ).	Whiting ( <i>Gadus merlangus</i> ).
Dory ( <i>Zeus faber</i> ).	Pollack ( <i>Gadus pollachius</i> ).
Boar-fish ( <i>Capros aper</i> ).	Cod ( <i>Gadus morrhua</i> ).
Goby ( <i>Gobius minutus</i> ).	
Dragonet ( <i>Callionymus lyra</i> ).	
Lump-fish ( <i>Cyclopterus lumpus</i> ).	
Blenny ( <i>Blennius pholis</i> ).	

Turbot (*Rhombus maximus*).  
 Brill (*Rhombus levis*).  
 Müller's topknot (*Zeugopterus punctatus*).  
 Plaice (*Pleuronectes platessa*).  
 Dab (*P. limanda*).

Flounder (*P. flesus*).  
 Shorter pipe-fish (*Nerophis equoreus*).  
 Worm pipe-fish (*N. lumbriciformis*).

**Sight.**—The sense of sight in these fishes is developed in various degrees. In some, as in the bream (*Pagellus*), the eyes are practically fixed; while in others, as in the pipe-fishes (*Syngnathidæ*), dory (*Zeus faber*), and wrasses (*Labridæ*), the eyes are capable of considerable movement, and are used independently like those of the chameleon. None of the fishes observed appear to distinguish food (worms) at a greater horizontal distance than about four feet, and for most of them the vertical limit seemed to be about three feet; but the plaice at the bottom of the tank perceived worms when at the surface of the water, being about five feet above them. Though the distance of clear vision seems to be so small for objects in the water, many of these fish (plaice, mullet, bream) notice a man appearing on the other side of the room, distant about fifteen feet from the window of the tank. When hungry they swim up to the side of the tank and show great excitement if a person approaches. The same may be seen in the case of *Octopus* at Brighton, which, when the crowd collects in front of the tank, by its rapid and excited movements shows that it recognises the signs of approaching feeding-time.\* The range of sight of fishes on the whole appears to be short. The sight of the wrasses (*Labridæ*) in particular is plainly adapted for vision at very close quarters; for the habit of these fishes is to search for their food by minute examination of the bottom, weeds, &c., after the manner of insectivorous birds.

None of the fish seem to get any lasting appreciation of the nature of the plate-glass wall of the tank. The same fish will again and again knock its head against the glass in trying to seize objects

\* In this case there is some doubt as to whether the *Octopus* does not recognise feeding-time by the help of its internal sensations. I have as yet had no opportunity for accurate experiment; but Mr. Wells tells me that both the *Octopus* and conger begin to swim about at feeding-time, whether any one is at the top of the tank or not. The conger are fed on alternate days, and Mr. Wells assures me that they distinguish these days, and do not get excited on the off days. On two occasions only I have watched them myself. The first was not a feeding-day, and they were not swimming about; but they certainly were actively moving to and fro on the second visit, which was one of their feeding-days, as also were the eels, which is still more surprising in view of their exceedingly nocturnal habits. So far, therefore, as my observation went, it quite bore out the statement of the superintendent. The fishes at Plymouth have not hitherto been fed with regularity, as their meals have to be arranged with a view to other experiments, so that no conclusions on this point can be drawn from them.



moving on the other side. Any small oscillating substance may attract them, such as a button dangling to a thread ; and pollack (*G. pollachius*) often snap at even a curl of smoke from a pipe. After repeated attempts to take food on the other side of the glass they will desist ; but some of the oldest inhabitants (plaice, pollack, and bream), which have been living in the aquarium for about a year, will perseveringly try again the next time. Fishes brought newly to the aquarium injure themselves by trying to escape through the glass, and I have seen gurnard fretting themselves for hours against it when the water of the tank has been made turbid by pouring in sand, being evidently of opinion that it is a way into clearer waters. It may here be suggested that perhaps the result of the famous experiment of Möbius has been wrongly interpreted. The story runs that pike, having lived for some time in a tank separated by a glass plate from another in which small fish were living, desisted from trying to catch them, and on the glass plate being removed never attempted to do so. The suggestion is that the pike had come to believe these particular fish to be under special protection. While this may be so, it is nevertheless a fact that fish, like other animals, having grown accustomed to the presence of forms which they would naturally eat, do not molest them. On one occasion several pollack were put into the congers' tank at Plymouth, and in the morning two only remained, but these two continued undisturbed for a long period ; and other similar cases have been observed. The explanation should perhaps be referred to that paradoxical instinct which is widely developed among animals of many kinds, in obedience to which they occasionally do not eat or molest those with whom they are constantly associated. It is, of course, this unexplained instinct upon which the "happy family" of the travelling showman is constructed. Probably it is closely akin to many feelings and superstitions of which we are ourselves conscious, and which have received inadequate but rational explanations.

Many of the actions of fishes are of this paradoxical character. It is a common thing, when two fish swim up to the same worm, for the foremost to retire in a nervous way, leaving the worm for the other ; and this quite independently of the relative sizes of the individuals. A small cod whose gills were injured lived for some time in a tank with bream and bass. This fish rarely if ever ate anything, but always swam up for a moment to each piece of food as it was put in, and then left it. When the cod approached, the bass, though many times his size, used to fall back, and return to eat the food when the cod retired. This process would be repeated again and again, and happens so often in the case of bream and bass that it appeared almost the rule for a fish to refuse at food if another

fish came up behind it. Sticklebacks and blennies, on the other hand, snatch pieces from each others' mouths like hens; so also do eels and other fish which hunt by scent. Conger, in particular, fight lustily over their food; and though they may hesitate for some time to take a piece of food which is tainted, or a substance of otherwise doubtful scent, yet they bolt it at once if another conger or a crab begins to examine it or pull it away; afterwards, if need be, they reject it. These remarks illustrate the necessity for caution in making deductions as to the likes and dislikes of fishes from scanty observations.

It has been mentioned that various fishes differ in their powers of seeing things above or on a level with them, but far more remarkable is the difference in the degree to which they are able to see downwards. Of the fish mentioned above the following were never seen to eat food after it had fallen to the bottom of the tank:—bass, bream, dory, boar-fish, lump-sucker, and pollack. The pollack are particularly interesting to watch in this connection, appearing absolutely unable to find objects which have reached the ground. It may be that their vision is such as not to admit of the perception of things below them, or it may be that the whole surface of the bottom is to them indistinct and blurred, or possibly the protruding lower jaws of these fish prevent them from picking up objects lying on the ground, but certainly they never seem to attempt it; and if they fail to catch worms, shrimps, &c., as they are falling through the water they give up at once. It is to be regretted that the majority of the fishes living at Plymouth are littoral forms, and such as are accustomed to live and feed on the bottom; for it is likely that there are many other fishes which are similarly unable to find food which is below them. It may be mentioned that, in addition to those given above, it is rarely that mullet or *small* pouting find food on the bottom. Pouting of larger size, however, use their pelvic fins for this purpose, as hereafter described. In fact, it is probably exceptional for an ordinary freely swimming fish, which hunts by sight, to seek food which is not in suspension; for nearly all those that have the power of feeding on the bottom either possess organs of touch, as the gurnard and pouting, or moveable eyes, as the wrasses and pipe-fishes, or else have the eyes peculiarly placed, as the flat fishes and blennies.

The mode of feeding of the dory and pipe-fishes is sufficiently singular to call for special remark. These animals are both provided with transparent, vibratile membranous fins. In the dory these are caudal, anal, and pectoral, while in the pipe-fishes the pectoral and dorsal only are thus developed. By the oscillation of these the animal approaches its prey without making any general movements, and in fact stalks it. The flattened body of the dory is most in-

conspicuous when seen from in front, as is that of the pipe-fishes when seen end-on. The dory feeds on small fish, working up to them in this way very slowly and with precision, like a man working up to game in open country where there is no cover. On getting within range, which is some inches from the prey, the immense protrusible jaws are shot out, and the fish is drawn back with them into the mouth. When the dory sights his prey the whole aspect of the fish changes. The curious brown markings on the body, which are at times scarcely visible, blush up and become dark. Of these the most conspicuous is a wide dark band passing down the middle of the nose and continuing between the jaws; this dark stripe gives the fish a most singular appearance when seen from in front. In the case of the pipe-fish, which feeds largely on small shrimps, the face is drawn out into the well-known pipe-like process which is gradually pushed right up to the victim, who would be alarmed and escape at the approach of a more clumsily organised fish. During this proceeding the pipe-fish frequently comes forward on its ventral surface.

None of these sight-hunting fishes while living in the tanks appear able to see their food by night, or even in twilight; worms thrown in after dark fell through the water unnoticed. It did not appear that this was due to reluctance on the part of the fish to eat by night, for on some occasions pollack took worms by night when the light of a bull's eye was turned on them so that the fish could see them. In view of this fact it would be interesting to see if fishes would take an object made luminous with Balmain's luminous paint or otherwise. I made experiments with pieces of india-rubber and with twisted glass tubes filled with luminous paint and sealed up, but none of the fish took any notice of them. Perhaps, however, such fish as mackerel might be attracted by similar objects trailed along in the open sea by night; for so many of the animals which are preyed upon by fishes are phosphorescent, that it is likely that some at least are accustomed thus to recognise them.

In view of the brilliant colours which are so common among marine animals it would be highly interesting to get some idea of the colour sense of fishes, but so far my results have been chiefly negative. In the first place I endeavoured to find out if light of any particular colour were invisible to soles and other nocturnal fish which, as already stated, swim about in the dark, but hide themselves when a light is turned on them. My experience was that their behaviour did not appreciably differ whether the light was red, blue, or green; and in fact they (eels and soles) seemed to be conscious of and to avoid coloured light almost as much as plain light. On the other hand, the pupil of *Eledone* contracts much less for red light than for other colours; and the larvæ of the lobster, which swim *towards* a light,



leave red for yellow, and yellow for green, preferring blue-green to violet and to all the coloured glasses with which they were tested. As these animals seek the light it may be supposed that the blue-green seems to them the most intense. Whether, as happened in the case of Sir John Lubbock's experiments with ants, any of these animals perceive vividly the ultra-violet rays I cannot say, as I had not the necessary appliances.

As it has been suggested that the bright colours of animals may have a protective value, which suggestion has recently been extended by Garstang (*Journ. M. B. A., N. S.*, i, 2, p. 175) to marine animals, I endeavoured to ascertain in the case of mullet whether bright colours have any such deterrent power. The mullet in question were a shoal of small fry about one and a half inches long. They were accustomed to eat minced worms off a slate slab. Upon the slate slab I arranged a number of brightly coloured tiles, some having plain and others mottled surfaces, and the minced worm was laid on these. The tiles were dark red, white, pale blue, dark blue, and mottled greenish brown. On several occasions the food was first cleaned off the pale blue and the white tiles upon which it was most conspicuous, and next off the mottled ones. The food on the dark blue and dark red tiles generally remained the longest, but was eventually eaten. On the whole it seemed to me that the fish distinguished between the tiles, but there was nothing to suggest that they were afraid of any of them. Certainly the bright colour of the pale blue tile did not seem to trouble them. It would perhaps be worth while to make a similar experiment with some of the glass models of anemones, &c., which are now obtainable, in order to test whether the colours, *per se*, have any deterrent effect.

It has been stated above that pollack will snatch at a wire curved into the shape of a worm when it is held up outside the tank. The same wire when painted white, or bright yellow, or blue, proved equally attractive.

**Smell.**—It was stated above that the great majority of fishes hunt their food by sight, and there is a good deal of evidence that it is sought for by sight alone. None of the fishes mentioned on pp. 241-2 show symptoms of interest when the juice of food-substances is put into the water. They will attempt to take worms, shrimps, pieces of fish, &c., which are lowered into the water inside a glass tube, or which are simply sticking to the glass window of the tank. When hungry they are unable to find food in the dark, while by day they will seize uneatable substances which are quickly moving in the water. This evidence goes to show that the sense of smell plays little or no part in helping them to discover their food. On the other hand, both pollack and whiting, when their first hunger is satis-



fied, swim under the food so as to touch it with their noses and presumably smell it ; and this gesture is often performed by individuals in which the olfactory organs have been destroyed, probably by force of habit. Mullet examine food by sucking water from it, and bass, bream, &c., touch doubtful food with their lips before seizing it. Plaice, turbot, blennies, and wrasses do not seem to make any preliminary examination of the flavour before taking food into their mouths. The importance of the olfactory organs to such animals as these is therefore obscure.

The range of tastes and scents which fishes are capable of perceiving seems to be very small. Conger are equally willing to eat a piece of squid or pilchard if it is covered or smeared with spirit, trimethylamine, turpentine, iodoform, camphor spirit, cheese of various sorts, anchovy extract, or *Balanoglossus*,\* as if it had been unpolluted. On the other hand, they will refuse cooked or tainted food and food which has been soaked for a few moments in dilute acids. The same remarks apply generally to the other fishes. None of them paid the slightest heed to stones or other objects covered with any of the substances mentioned. I was particularly surprised that none of the fishes in the tanks took notice of *rogue*—the fermented roe of the cod, which has a most powerful odour, and is used with great success to attract sardines by the fishermen of Brittany—but of course none of my fish were *Clupeidæ*. It is supposed by the sardine fishermen that the odour is of great importance, and must be of the right quality. Hence it may be imagined that it does not merely attract the sardines by sight.

In this place mention should be made of the fact that some of the *Gadidæ*, which are, generally speaking, day feeders, are sometimes taken with a bait at night. At certain times of the year this is the recognised mode of catching hake (*Merluccius vulgaris*), while occasionally whiting are so taken. In both these cases the bait is sent down about *halfway* to the bottom, and not, as usually, to within a fathom of it. I was assured by fishermen that this mode of feeding is a most exceptional thing with whiting, and is supposed to be connected with the continued prevalence of calms, for under ordinary circumstances whiting-catching is not continued after dusk. In addition to these instances it sometimes happens that *large* pollack are taken on ground-lines by night. Whether in these cases the food is found by sight or by smell there is no evidence to show, for both the pollack and the whiting living in the tanks seem unable to find food in

\* As the disgusting smells emitted by various species of *Balanoglossus* may be thought to be protective, I tested various fishes with pieces of a single damaged specimen of *B. salmoneus* which was dredged in Plymouth Sound. It was refused by both mullet and wrasse after trial, but was eaten by a sole and by a plaice.

the dark. Taken in connexion with the fact that this habit of whiting is supposed to occur in fine weather, it is possible that the fish are guided by the phosphorescence either of the bait itself or of the animals carried past it by the tide. Mention should also be made of the fact that trout are often taken with a worm at night.

**Touch.**—Of the fishes which seek their food by sight some are provided with barbels, as the pouting and the cod, while a few have special tactile organs, as the gurnards, and again the pouting. When the pouting is hungry it takes its food promptly, without hesitation, but when it has had about enough it frequently erects the barbel so that it projects forward and touches the food with it, probably thus tasting it. In the Brighton Aquarium I saw that the pelvic fins of the pouting are used just as those of the rockling are, the fish swimming with them set at right angles to the body and touching the ground, but those at Plymouth were not seen to do this. The latter are much smaller specimens, which fact may possibly account for this difference in habit.

The fingers of the pectoral fin of the gurnards are certainly used in the search for food. Although the gurnards have good sight and will swim up to a bait, they are chiefly bottom-feeders, and move about with these fingers, half walking and half swimming as they seek their food. On touching a worm with the fingers they stop and scratch it about for some moments, as though raking it out of the sand, and then suddenly turn and snap it up. Though the fingers are thus employed, the gurnards often take food off the bottom without touching it with the fingers. I did not succeed in seeing the gurnards feed by night, but it is quite possible that they may do so.

I was surprised to find that the pogge (*Agonus cataphractus*) did not appear to use the filamentous villi of the lower side of the head for finding food. These villi are developed to a great degree, and bear sense-organs which suggest that they may be used for this purpose; but though repeatedly watched, it was never seen to seek food otherwise than by sight. Thinking that these structures might be of use to it in discovering food buried in the sand, I made some trials, but the fish never seemed to recognise the presence of the buried food.

**General Sensation.**—The power which fishes possess of avoiding obstacles even when deprived of sight is very remarkable. For example, a bream in which the cornea has been rendered opaque, after recovery from the shock does not run into the sides of the tank, but swims round in a circle avoiding them. If a large obstacle, such as a glass plate, is put in the way, the fish avoids that also. But it would seem that this is because such an object cannot be brought into position without causing a disturbance in the water which the

fish perceives. For if wire rabbit-netting or straight wires are gently lowered while the fish is at the other part of his circle, he does not avoid them on returning the first time. After colliding with such an object, though very gently, the fish seems to lose its balance, and does not swim upright for some seconds after, lying over generally towards the left side. If the wires are left in place the fish does not again run into them, but swims in a reduced circle. The sensibility of these fishes to movements in the water must be exceedingly delicate; for if a straight wire is put in the path of a blind fish it will be avoided if the finger only is kept on the top of the wire, though it does not avoid it if the wire is standing by itself. The same is true of pollack which had become blind from disease (apparently of the nature of cataract, to which fishes in captivity are very liable). It has been held by some observers that the sense-organs of the lateral line are of importance to the equilibration of the animal. Apart from the difficulties presented by the structure of these organs, which closely resemble taste-buds, it must be held that the case of the flat-fishes is practically conclusive against this view. For in the flat-fishes not only do the lateral lines retain the same position relative to the symmetry of the animal that they occupy in other fishes, but in those fishes (*e. g.* the dab, &c.) in which the course is peculiarly curved, this curve occurs equally on the upper and under surfaces. But as the flat-fishes swim in a plane at right angles to that of ordinary fishes the two lateral lines come to lie in the same vertical planes, and can therefore hardly be supposed to assist in equilibration. The fact that a fish in which the lateral nerve has been severed is unable to swim uprightly scarcely bears on this question, for almost any severe injury upsets the equilibrium of a fish.

**Shoaling.**—It was suggested to me by Professor Lankester that inquiry should be made as to the manner in which fishes keep together in shoals, and especially whether they follow each other by sight or otherwise. The only shoaling fish which was living in quantity in the tanks at Plymouth is the grey mullet. By day the whole shoal of about fifty little ones stays together more or less. Sometimes it divides into two or three shoals, but they run closely together if alarmed.\* At night they lie *on the surface* of the water, and seem not to swim about as a body, nor are their heads all pointing one way as they generally are by day. The shoal seems at no time to have any leader, but will sometimes follow the front fish until one

\* This instinct of packing together when afraid seems to be general among fishes which move in shoals. Mr. Dunn tells me that the proverbial phrase, "as close as hakes in a hoop," is derived from the fact that such fishes huddle together when surrounded by a net. Shoals of pilchard, herring, &c., also pack together when attacked by sea-birds.



of those that are behind makes a dart elsewhere, when the whole shoal turns round and follows. They certainly have no tendency to follow the largest fish in the shoal, or indeed any fish in particular. Similarity in size seems to be usual in these shoals. In one of the tanks there are two mullet which have been there for about a year, and are now about three inches long. They live apart on the ledge of the overflow, and never consort with the other mullet, which are about six inches in length. When, however, some of this year's fish (three-quarter inch) were put in, these two immediately swam out to them, and they all retired together into the overflow channel, where they afterwards remained habitually.

To the fifty small mullet in the long tank I introduced twenty more of rather smaller size, but of the same age, which had lived in another tank. The fifty at once ceased feeding, and huddled timidly away behind the stand-pipe, where they were joined by the new-comers. After a time the latter all left them in a body, thus showing that they recognised each other in some manner. They soon returned, however, and after staying together for a little a detachment of the new-comers again left, and so on; but on the following day the two shoals had amalgamated and fed together. Weakly fish never swim with the shoal, but keep apart—whether by choice or compulsion could not be determined.

Two specimens of horse-mackerel (*Caranx trachurus*), about two and a half inches long, put in in September, shoaled with the mullet, but the gobies never do so. In November on returning to Plymouth I found that one of the horse-mackerel was dead, and the other had left the mullet and moved about alone, but if alarmed it at once joined the mullet.

From the fact that the mullet do not move as a shoal at night, it may be so far inferred that they follow each other by sight alone, but it would be interesting to know whether other shoal-fishes travel at night. It may, in fact, be doubted whether such fish as pilchards habitually move about as a shoal at night. Of course drift-netting is carried on at night; but the nets are shot in places where the pilchards or herrings are known to be, and possibly the slight movements of the individuals and currents may take them into the net. That the shoals under some circumstances do not travel at night is seen by the use of the method of seeking pilchards known as "briming" for them. In this operation, which I have never seen, but which has been described to me by several fishermen, as the boat sails along, a man stands on the cuddy and stamps his foot at intervals. When the boat is among the pilchards, they are then seen by means of the "briming" or phosphorescence to dart away in all directions. Presumably, then, until disturbed by the noise



they were lying at the top of the water, as the mullet were observed to do in the aquarium.

**Hearing.**—Several attempts were made to determine the class of sounds which fishes can hear. During the month of November some blasting operations were carried out on the premises of the Association, and particular notice was taken of the behaviour of the fish. The pouting scattered for a moment in all directions when the report came, but were quiet directly afterwards. The soles, plaice and turbot buried themselves. The conger drew back a few inches, as is their habit also when a light is turned on them at night, and generally on being disturbed. None of the other fishes were seen to take any notice of the report.

As mentioned in this Journal (N. S., i, 2, p. 217), satisfactory evidence was obtained that the creaking sound made by smearing a wet finger on the glass window of the tank was heard by a Lamellibranch (*Anomia*). For some time I was of opinion that the same sound was heard by some fishes (pollack, &c.) which at once come to the spot and follow the finger. Mr. Wells, of the Brighton Aquarium, told me that his own observations led him also to believe this, especially in the case of bream, which come to the front in a body when this sound is made. Nevertheless, on further trials I saw no reason to suppose that the fish were not merely following the finger by sight, and I never saw them (pollack) attracted when the sound was made behind a screen of silk or weeds sunk in the water, and such a screen would scarcely interfere with the transmission of the sound. The movements of the bream at Brighton did not, however, resemble those of fishes trying to catch a particular piece of food, but were distinctly suggestive of general expectation. Seeing that the case of the *Anomia* proves that sensible vibrations are thus actually set up in the water, it may be that they hear them. The sound made by pebbles rattling inside an opaque glass tube does not attract or alarm pollack; neither are they affected by the sharp sound made by letting a hanging stone tap against an opaque glass plate standing vertically in the water. If they *see* the stones in either of these cases they follow them, but if the glass is opaque they do not. When the wall of the tank is struck with a heavy stick they behave as described in the case of blasting. As might be expected, none of the fishes were seen to take notice of sounds made in the air. Various loud noises were tried, but soles, for instance, when exposed did not bury themselves as they do when the side of the tank is struck. Probably, therefore, they did not hear the noises. The stories, for example, quoted in Day's British Fishes, p. xxxviii, of fishes coming to be fed when a bell was rung, can scarcely be taken to prove that the sound of the bell was heard by them, unless it be clearly proven that the person about

to feed them was hidden from their sight. The sound of the chopper which is also there mentioned in this connexion may have been communicated directly by the walls of the tank. There is no reasonable doubt that in the operation of "briming" for pilchards (*v. p.* 250), the sound made by the stamping of the foot is actually heard.

Though it may, therefore, be regarded as clear that fishes perceive the sound of sudden shocks and concussions when they are severe, it can scarcely be supposed that sounds of this nature play much part in their ordinary life, even if they occur at all. On the other hand, they do not seem to hear the sound of bodies moving in the water which they do not see. It may be remarked that the sounds emitted by fishes and *Crustacea* (dory, gurnard, crayfish, &c.) are of a stridulating or grumbling nature. In addition to these Mr. Wells called my attention to a peculiar snapping sound (audible in the room) which is made by large wrasses when feeding and biting with their strong jaws.

#### REMARKS ON THE SUPPLY OF BAIT.

The observations recorded above were made as a first step towards a practical solution of the difficulties which beset the bait question. It was felt that any attempt to find a cheap bait must be begun by getting a knowledge of the ways in which fishes find and recognise their food; and it was anticipated that when such knowledge should have been acquired, it would be possible to make use of it in a practical manner. Though the practical side of the subject was beyond the scope of this part of the investigation, it may be permissible to make a few remarks upon this aspect of the matter, and to indicate the lines of practical experiment to which these observations point.

The fishes which are chiefly sought by long-line fishermen on the south coast of England are conger, skates, and rays; while elsewhere the most important fishes which are taken with a hook are cod and halibut (*Hippoglossus vulgaris*). The chief substances used as bait are—for the east coast of England and North Atlantic, the herring; for the Scotch fisheries, the whelk (*Buccinum undatum*) and the mussel (*Mytilus edulis*); on the south coast of England the squid (*Loligo vulgaris*) and the pilchard are most in demand; while in the Channel Islands *Eledone* is used in great quantity. Everywhere the supply of bait is costly, and at times it fails, owing to calms or bad weather. It is therefore important that some substance should be obtained or manufactured which is attractive to fishes, but cheaper and more regularly accessible than the natural baits at present used.

In any attempt to prepare such a substance it is of the first importance to ascertain the mode by which fishes find and distinguish their food. As has been here set forth, satisfactory evidence was obtained that conger and the *Raidæ* seek their food by smell. While I was at Plymouth no opportunity occurred of watching the habits of the cod, for only one injured specimen was obtained. It was quite clear that this fish saw exceedingly well, but whether or not the barbel or olfactory organs may not be used also in seeking food on the bottom or at night I am unable to say, but from experience of other fishes it is *a priori* unlikely that they are of great value as organs of search. The halibut is of course not found on the south coast, and has not come under my observation in the live state; but the structure of the fish, which closely resembles the plaice, suggests that it feeds by sight. This suggestion is strongly supported by the statement of Pennant quoted in Day's British Fishes (ii, p. 7) that on two occasions halibut had been known to take a sounding-lead. The fishes, then, which are sought by the North Sea fishermen and others differ from those upon which the Plymouth men most depend, for the former feed by sight and the latter by scent. As might be expected, therefore, the same bait is of different value in the two cases. For while in the North Sea the herring is thought to be the best bait, Plymouth fishermen scarcely think it worth their while to go to sea with it. At Plymouth, for catching conger fresh squid is thought to be the best bait, and fresh pilchard is by some considered as good as regards attractiveness, but as it has not the toughness of squid it does not stay on the hook so long. My own experience with conger in the tanks leads me to think that squid is also more attractive as a scent than pilchard is. In the absence of pilchard and squid, mackerel is used when abundant, but usually this fish is too dear to be in use as bait, and it certainly does not attract conger as much as squid.

The facts already given point to the conclusion that for the purposes of the conger and skate fishery the bait question may be solved in one of three ways: either—

(1) By extracting the flavour of squid or pilchard, and compounding it with some tough substance which will not wash off the hook; or—

(2) By finely dividing squid or pilchard and mixing it with some cheap substance, so as to make a little of it go further; or—

(3) By preserving squid or pilchard when abundant in such a manner as not to destroy its flavour and scent: of course this last method would only help the fishermen to tide over periods of scarcity of bait.

I have made some experiments in each of these directions, and

perhaps a record of my experiences may be useful to those who intend to go on with the subject.

(1) This would no doubt give the most complete solution of the whole difficulty. I made some preliminary experiments with extraction by ether, and found that both from *Nereis* and from herrings after the ether had been distilled off, an oily fluid remained, which certainly attracted rocklings most powerfully, and caused them to snap at stones dipped in it. That obtained from herring also brought the conger out of their holes, but they did not show the eagerness that they do when seeking actual food.

Mr. Bourne has prepared a remarkable fluid by simple distillation of squid and water. This has a strong smell resembling that of cooked squid, and has stood for over a year without decomposition. It did not appear, however, that the fish noticed it at all.

By adding spirit very gradually day by day to mashed squid mixed with sea water which was kept warm, a good deal of the scent was extracted, and when the conger were very hungry a few c.c. of this extract poured into the tank sufficed to put them into a state of great excitement; they would seize rags which had been dipped in it, but I did not succeed in compounding it with any substance which they cared to eat. These results, though incomplete, are so far fairly encouraging.

(2) Many attempts were made to incorporate finely divided squid with gelatine. It seemed possible that if gelatine into which mashed squid had been stirred whilst warm and liquid, could be cast into sheets and dried, it might perhaps retain its flavour sufficiently to be eaten on being again softened with water. Consistency was given to these sheets of gelatine by stretching a sheet of butter-cloth in them when warm. When the conger were *very* hungry they would eat this substance with hesitation, and in the sea I caught an occasional fish (rockling and conger) with it, but it was by no means satisfactory, probably because each particle of squid was so coated with gelatine that its scent could not get out.

The next experiment was made by pouring melted gelatine into dishes smeared with mashed squid or mackerel, and then laying sheets of tissue-paper similarly smeared on the upper surface of the gelatine before it had set. When the gelatine was cold the paper was stripped off, and the gelatine remained covered on each side with a thin smearing of fish. The fish in the tanks ate this substance when fresh as readily as ordinary food, but it is unsuited to the purposes of fishing in deep water, as the coating of fish is washed off, and no doubt soon loses its scent. Probably the difficulty arising from the fact that the scent is soon destroyed on the surface of the



food would prevent its being used in a finely divided form, however compounded.

(3) In experimenting with squid on a small scale I found that it could easily be preserved for about a month by cutting it open, cleaning and drying it with a cloth, and then powdering it with boracic acid and flour. This squid was apparently unchanged, and was in excellent condition for bait. Unfortunately, now that so many of the trawlers go away to the Bristol Channel, but little squid is landed at Plymouth.

Salted squid and salted pilchards are used, but are very unsatisfactory.

On a small scale pilchards were preserved for three weeks in the same way with boracic acid and flour, and were satisfactory as bait for conger. I succeeded also in catching mackerel at the time when they were feeding near the bottom (August and September) with preserved pilchard and preserved squid.\* With the kind assistance of Mr. Matthias Dunn, of Mevagissey, I laid down several barrels of pilchards with boracic acid and flour as described, but for some unknown reason they did not answer. Though not decomposed, in a month's time they had become what is called by fish-curers "rusty," and their scent was that of cured fish rather than that of fresh. My experience with them on a small scale leads me to believe that with experience and precautions they might be kept with boracic acid in the dry state. Of course this preservation should be made with winter fish, which contain much less oil than summer fish. There is little hope that they could be preserved for bait in a *solution* of boracic acid, from the fact already mentioned that the scent of these things seems to be destroyed by contact with water.

In conclusion, I may repeat that the experiences here given suggest that the first step to a proper solution of the bait question for the south coast and Channel Island fisheries, where *fishes which hunt by scent* are caught, must be made by the extraction of the scent of squid or pilchards. Whether an artificial bait flavoured with such an extract would be useful in the fisheries of the North Sea, &c., cannot be predicted, but if made of some bright or white material (as dough or china clay) it might probably prove equally attractive to fish which hunt by sight. At the same time it must be borne in mind that any artificial bait must be extremely cheap if it is to be preferred (in the North Sea) to herrings, which are to be had for a great part of the year. It would, moreover, be interesting to see

\* When mackerel are fished for at anchor with a hand-line, these two baits are used *together*, a small piece of each being put on the hook. It is difficult to explain the reason of this curious practice, but either bait alone is said to be of little use, which my own experience fully confirms as far as it goes.

whether the conger, &c., of the North Sea would take pilchard or squid, which they have probably never met in their ordinary experience.

### DESCRIPTION OF PLATE XX.

Illustrating Mr. Bateson's paper on "The Sense-organs and Perceptions of Fishes; with Remarks on the Supply of Bait."

FIG. 1.—Head of a dab (*Pleuronectes limanda*), nat. size, showing the position of the olfactory organ as seen when the skin is removed.

FIG. 2.—Diagrammatic representation of the right olfactory organ of the dab.

FIG. 3.—Outline of the face of a megrim (*Arnoglossus megastoma*), showing the left olfactory organ as seen when the skin is removed (nat. size).

FIG. 4.—The olfactory plates of the left olfactory organ in a turbot (*Rhombus maximus*). The dotted circles show the position of the nostrils, and the arrows the course of the current.

FIG. 5.—Diagram of a single olfactory plate in the turbot, showing the mode of attachment to the rachis.

FIG. 6.—Diagram of the pupil of the rough dog-fish (*Scyllium canicula*). *a*, by day; *b*, by night.

FIG. 7.—Pupil of skate (*Raia batis*). *a*, by day; *b*, by night.

FIG. 8.—Eye of torpedo. *a*, by day; *b*, by night.

FIG. 9.—Pupil of angel-fish (*Rhina squatina*). *a*, by day; *b*, by night.

FIG. 10.—Pupil of sterlet (*Acipenser*). *a*, by day; *b*, by night.

FIG. 10A.—Pupil of turbot (*Rhombus maximus*). *a*, by day; *b*, by night.

FIG. 11.—Longitudinal section of skin of barbel of rockling (*Motella tricirrata*), preserved with gold chloride to show the nerve-fibres traversing the skin to supply the "taste-buds." Zeiss' obj. D, oc. 2.

FIG. 12.—Horizontal section of skin of barbel of rockling (*Motella tricirrata*), to show the immense numbers of "taste-buds" which it contains. Zeiss' obj. A, oc. 2.

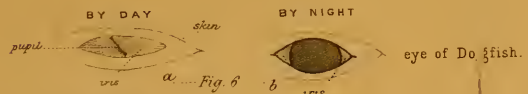
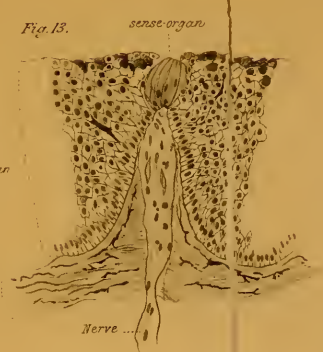
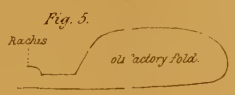
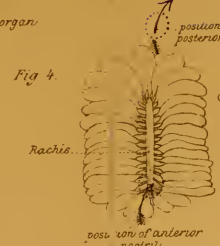
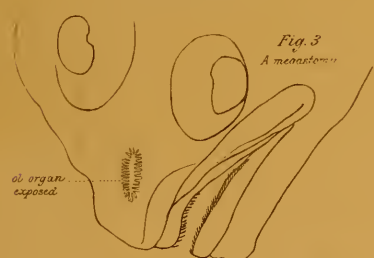
FIG. 13.—Vertical section of skin of lip of conger, showing a "taste-bud," and the nerve running to it in a channel through the skin. Zeiss' obj. D, oc. 2.

FIG. 14.—Vertical section of skin of pharynx of mullet (*Mugil*), showing a row of "taste-buds." Zeiss' obj. D, oc. 2.

FIG. 15.—Cells of one of the "taste-buds" of a mullet (*Mugil*) macerated in Hertwig's fluid. Zeiss' obj. F, oc. 2.

FIG. 16.—Cells of "taste-bud" of pollack (*Gadus pollachius*). Zeiss' obj. D, oc. 2.

FIG. 17.—"Taste-bud" in skin of the tongue of an eel (*Anguilla vulgaris*), preserved with gold chloride to show the nerve-fibres. Zeiss' obj. D, oc. 2.







## Notes on Oyster Culture.

By

**G. Herbert Fowler, B.A.Oxon., Ph.D.**

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With Plate XXI.

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### I. OYSTER FARMING IN HOLLAND.

WHILE on a visit to Holland last December, I took advantage of the opportunity to learn something of the extent and methods of oyster culture there practised. To Mr. C. J. Bottemanne, of Bergen-op-Zoom, the Inspector of Fisheries, and to Prof. A. A. W. Hubrecht, of Utrecht and his published papers, I desire to acknowledge my indebtedness.

Though the invention of the modern system of culture is to be credited to France, it is at present carried to its highest perfection on the Eastern Schelde, in the Dutch province of Zeeland. This, no doubt, is partly attributable to the fact that the geographical conditions are here almost ideally perfect for the purpose. Originally continuous with the Western Schelde, but now for many years cut off from it by the railway embankment (see map on Pl. XXI), the Eastern Schelde forms a quiet, almost land-locked, shallow bay, about twenty miles in length, which at low tide leaves acres of good hard ground exposed on both sides of its bed. There are two other exceptional advantages in this position: the one, that on the ebb tide the main bulk of the water lying in the extremity of the bay is never lost in the sea, so that the floating spat of the oyster, though carried down by the tide, is swept up again into the bay and over the collectors placed to catch it, without ever reaching open water; the other, that on the stone bases of the dykes, within 546 yards (500 metres) of which no one is allowed to dredge for fear that their foundations should be injured and the country be flooded, are at certain points enormous natural colonies of oysters, which provide every year a plentiful supply of spat for the artificial cultivation. The fact, also, that much of the land lies below high-water mark and is surrounded by dykes, makes it easy and cheap to construct store-ponds, &c., on shore, and to admit salt water through sluices. Beside, however, these natural advantages, there are further reasons for the success of the Dutch oyster culture: the patient

and careful industry of the people, the public spirit of the Government, and the fact that throughout the enterprise several members of a body of naturalists, the *Nederlandsche Dierkundige Vereeniging*, have constantly inaugurated fresh experiments and investigated causes of failure.

With all these advantages, it is hardly surprising that the industry has attained enormous proportions in a few years. In 1870, at the commencement of the enterprise, the rental of the (hitherto valueless) low-water flats, 7720 acres in area, leased by the Government to oyster farmers, was £1720; in 1885, when the leases were renewed, the rental amounted to £28,765. In 1888 (a bad year) there were despatched from five stations on the Flushing line *more than 2580 tons* of oysters, besides what was conveyed by water; 954 tons being destined for England by the Flushing route, and many more by way of Rotterdam. As to the amount of hands employed in the industry, it is not easy to give exact figures, since at some times of the year the whole population of the district, men women, and children alike, take a part; but about 480 boats, averaging three hands each, are regularly licensed for the oyster fisheries. A small fact, but one which indicates the importance of the interests concerned, is that it is intended in the course of this year to supply the police-boats, entrusted with the duty of watching the ground and preventing depredations, with electric search-lights for night service.

The statistics given above refer, be it noted, only to the artificial oyster culture; the natural beds (public beds) have, as in England, practically ceased to exist, owing to the rapacity of the dredgermen. Nominally dredging on these beds is permitted by the Dutch Government from March to September inclusive; but they are nearly valueless. It is only by sowing annually large numbers of clean oyster shells for cultch, and by absolutely prohibiting the free taking of oysters for years, that an overdredged bed can be restored to an effective condition. As during these years the bed would have to be policed, and occasionally dredged to clean away weeds and mud, it is probably only by action on the part of the Government that dredged-out banks in England could be again made valuable; action which, in despite of the bulky Reports of Commissioners, England has shown no inclination to take. In Holland, on the other hand, the Government, with a view to restoring the once celebrated but almost ruined Texel beds, some few years ago prohibited free dredging on a part of the beds and leased it out in parcels. A considerable amount is already paid for the lots, oysters have been imported from France and Zeeland, and the beds are already flourishing without any further interference from Government than the supply of police. To achieve

this in England by private enterprise, an order of the Board of Trade under Part iii of the Sea Fisheries Act would be necessary, and it is more than doubtful whether it could in such a case be obtained.

It is therefore from the artificial cultivation only, from the oyster farms, that these tons of oysters are produced. The farms vary naturally in size and complexity according to the amount of capital invested in the undertaking, and in the details of management, but they conform to a general type of the following character. Each consists of two sections; the one, an area of ground from 12 to 150 acres in extent in the bed of the Schelde, rented from the Government, covered at half tide and marked off by stakes from other similar properties; the other on dry land comprising the necessary buildings and the ponds (Fr. *claires*, *pares*; Dutch, *putten*). The river section of the farm is generally divided into one area on which are set the collectors for the spat, and another (often some distance off and in deeper water), where the "half-ware" or young oysters are placed to grow to a marketable size. The plan of the land-section of a typical farm is drawn in Pl. XXI (slightly altered from one at Bergen-op-Zoom); through the dyke communication is made by a sluice between the Schelde and a canal; from the latter the water passes by smaller sluices into the ponds I—III, which can also be put into direct communication with each other by other sluices. The natural rise and fall of the tide effect the changing of the water. A few buildings for packing and sorting houses, watch-house, carpenter's shop, &c., and a clear space of ground for stacking the tiles and "hospitals" during the winter are the chief other requirements. The method of procedure is thus arranged: the collectors, common roof tiles, coated first with hard, afterwards with soft lime, and thoroughly dried, are set about June in the bed of the Schelde at low water at right angles to the current, and sloped so as to make little eddies into which the swimming spat may be swept; they lie here, except for being occasionally swirled in water to wash off the mud, till September or October, by which time, if the season be good,\* numbers of tiny oysters will be found to have adhered to them. The tiles are carefully brought on shore and arranged in the pond marked II (Pl. XXI); they are generally set like the Greek capital II, two vertical covered by one horizontal, and stand in about three to four

\* A good season is conditioned chiefly by wind, state of the water, and most of all by temperature. With rough weather, foul water, and a cold summer, there will be no young oysters; but the statement so often to be met with in the evidence before committees that "there has been no spat here for many years" means, not that the oysters have failed to spat, but that the spat has been killed by unpropitious physical conditions, or has failed to find a suitable foothold. Plenty of spat is thrown off every year.

fect of water. Clean salt water is of course admitted constantly. Here they remain till about February; they are then taken up and the young oysters detached. This is not difficult owing to the layer of soft lime with which the tiles are coated. When detached they are placed in the "hospitals;" these are generally made of tarred wood (fig. 1, Pl. XXI), and are shallow trays about six inches deep standing on legs about six inches off the ground; they rest on the bottom of ponds II and III, singly or in two tiers, according to the depth of water (three to five feet) in the pond; in some cases they are allowed to float. Here the young oysters remain for about two months, increasing in bulk and strength, and recovering from any damage which they may have incurred in detachment from the tiles; at the end of this time they are sowed out on the private banks in the Schelde as "zaai-goed," it being found that, though the percentage of loss is here greater, growth is much more rapid and quality better than if they are kept in enclosed ponds. The grounds on which they are placed are occasionally cleaned by dredging without a net. The oysters are considered marketable in the third and fourth year; they are dredged up\* and brought to the sorting houses, and, according to size, are either replaced on the beds to grow larger, or are laid down in the store pond marked I. This latter is generally floored with tarred planks, an expensive material, but found to be better than either the natural ground, which becomes foul, or than brick, which is too "cold." On little piles driven into the bottom of this store pond run plank gangways, so that ready access may be had to any part and the oysters lying there be removed by a pole-dredge when required for the market; the water is kept at about four feet in depth.

In order to collect the maximum amount of available spat, or, in other words, to bring all the spat within reach of the collectors, experiments have for several years been conducted under the auspices of the Nederlandsche Dierkundige Vereeniging on the principle of enclosing breeding oysters with the collectors in ponds. At present the experiments cannot be said to have been entirely successful; spat is thrown off, and a small quantity certainly adheres to the tiles; but the difficulty of oxygenating the water and supplying food artificially in the one case, and, if water be pumped through the pond, of keeping the spat from passing through the filter in the other, have so far proved too great.†

\* In some cases steam dredges are used, working six dredges simultaneously.

† Similar experiments carried out in England have in one or two cases been more successful, though not as yet financially so. Prof. Ryder, in the United States, has devised an ingenious apparatus for the purpose, but no account of its working has as yet appeared (Rep. U. S. Fish Comm., 1885, p. 321).



Such is the outline of the method of procedure, evolved by many experiments and many failures, which the Dutch have found to be the best, at least for their own locality. Good as it is, however, there must occasionally come bad years when unfavourable weather ruins the crop; in 1888, for example, the severe winter wrought havoc among the old oysters, the cold summer killed the spat. Hence the enterprise of an oyster farm must be backed with a considerable capital, not only because there can be no appreciable return on the money invested for at least four years, and a bad season may defer it even longer, but also because out of this capital some must be held in reserve in order to replace the brood-oysters in case of disaster (elsewhere of course than in the Schelde, where the brood-oysters are on the dykes). On the other hand, however large the capital, it will be utterly thrown away unless expended with the most rigid economy; and in this fact we probably find the chief reason for the failure of so many oyster culture companies in England. It has often been shown that it is perfectly possible to raise oysters artificially in England, but it must be done at a less cost than the market price of the oyster if a dividend is to be expected. Each oyster raised by the Herne Bay Company was estimated by Mr. Blake (Rep. Sel. Comm. Oyster Fisheries, 1876) to have cost them £100. Most instructive in this connexion is the history of this unfortunate company. It was founded in 1864 with a capital of £100,000 and a right of "several oyster fishery" over nine square miles at Herne Bay, in the estuary of the Thames. Before a single oyster had been laid down no less than £43,700\* had been spent; its area was utterly disproportionate to the remaining capital, and it gradually dwindled away for want of vitality.† Against this, however, must be set the fact that in a few places in England oyster farming with collectors, &c., has been carried out for many years, if not with signal commercial success at least without disaster; but the problem of raising oysters cheaply on a great scale has not as yet been solved (except on paper) so far as England is concerned; and this, it may be noted, is not for want of suitable localities.

It is not my purpose to discuss here the means by which this solution may be attained, but I cannot conclude without a reference to one great obstacle to private enterprise in this direction, which has been pointed out again and again by those who have interested themselves in such subjects; namely, the absolute impossibility in the present state of legislation of ascertaining in many cases the ownership of any particular section of foreshore. As soon as a piece

\* Preliminary and Parliamentary expenses, £12,600!

† Its melancholy history may be read in the three Reports of the Inspector under the Board of Trade, Mr. Walpole, dated 1875, 1876, and 1882.

of otherwise worthless foreshore is judged to have capabilities for oyster or mussel culture, there crop up municipal charters, private charters, manorial rights, ducal rights, and what not, backed generally by wealth which can crush intruders with long and expensive lawsuits. Sir T. H. Farrer has expressed himself clearly on the matter:—"Where there were any rights below low watermark on the bed of the sea, there it was provided by a clause inserted in the Bill [of 1868] by the House of Lords that those Orders [of the Board of Trade which are described below, p. 264] should give no power whatever; and as there exist a number of rights—some very clear and some very shadowy—over the foreshore and bed of the sea, under all sorts of feudal grants and charters, and prescriptions, it is a question to say whether that restriction may not have had a very injurious effect both in preventing people from applying for Orders and in preventing the grant or due operation of such Orders." (Rep. Sel. Comm. Oyster Fisheries 1876, Farrer 7.) It is true that under Part iii of the Sea Fisheries Act, 1868, a right of several oyster fishery may be granted by the Board of Trade, but this only after filing of petitions, inquiry by a Government Inspector, examination of witnesses—itself a tedious and expensive process\* and a check to private enterprise. Nor is this vagueness of title a cause of trouble in oyster fisheries only, but in estuarine fisheries of all kinds. An Act requiring that by a certain date all titles to estuarine and foreshore rights should be satisfactorily proved and registered with the Board of Trade, and vesting foreshores not so claimed in the Crown, would commit no real injustice and would prevent much.

## II. NOTES ON RECENT LEGISLATION RELATIVE TO ENGLISH OYSTER FISHERIES.

WHEN desirous lately to ascertain the state of the law relative to oyster culture in England, and the working of that part of the Sea Fisheries Act, 1868, which permits the Board of Trade to grant "rights of several oyster fishery" to applicants under certain cir-

\* "A fee of thirty-five pounds has to be paid to the Board of Trade in respect of Fishery Orders under Part iii of the Sea Fisheries Act, 1868, and a deposit of the same amount has also to be made to cover the travelling and personal expenses of the Inspector when making the inquiry;" but this appears to be a small item in the total legal expenses. For this and for other information, most courteously rendered, I am indebted to the Fisheries Department of the Board of Trade. The author of a recent work on this subject (S. A. Moore, *A History of the Foreshore*. London. 1888. 8vo.) is extremely severe upon the Board of Trade for not adjudicating on these claims when brought under their notice; but examination of title can hardly be said to be among their already varied functions.

cumstances, I found some considerable difficulty in the task, and have therefore put together these few notes in the hope that they may prove serviceable to others interested, by indicating in what direction to search for information. It is to be remembered that they apply only to England and Wales, the fisheries of the two other countries being under the jurisdiction respectively of the Scotch Fishery Board and of the Inspectors of Irish Fisheries.

There is no need to refer in detail to the earlier legislation in the matter ; in many places along the coast both private individuals and co-operative bodies of dredgermen enjoy rights of several oyster fishery under charters of greater or less age. The Whitstable Company is at present the best known of such societies ; the constitution of another, under the jurisdiction of the City of Rochester, may be read at length in the preamble to an Act of 1728 (2 Geo. II, c. 19) which was framed in its defence. This society, which may be taken as typical, was a close corporation of fishermen and dredgermen, admission to which was gained only by a seven years' apprenticeship to a member ; it was governed by an "Admiralty Court," the "jury" of which was elected partly from the dredgermen, partly from the Corporation of Rochester. The jury decided upon the close time, upon the temporary closure of any parts of the beds, and upon the quantity or "stint" which any dredger might take in a day ; the bailiffs appointed by them had the right to board suspected boats, and to seize oysters or implements there found in contravention of their rules, and also to impose fines and penalties on those who disobeyed them. Similar Acts are 3 Vict., c. 59 (Faversham), and 22 and 23 Vict., c. 72 (Ipswich) ; and an Act of 1756 (30 Geo. II, c. 21) permitted the City of London to make general fishery regulations affecting the Thames and Medway. The earlier legislation will be treated in detail in a general work on the Oyster, for which material is at present being collected by Mr. Bourne and myself.

The present period of legislative activity, the result of constant complaints as to the scarcity of oysters, begins with the Herne Bay, &c., Fishery Act, 1864 (27 and 28 Vict., c. 280) ; this was followed by the Ham Oyster Fishery Act, 1865 (28 and 29 Vict., c. 147), and the Roach River Oyster Fishery Act, 1866 (29 and 30 Vict., c. 145) ; all these three created "rights of several oyster fishery" in favour of the companies concerned. Facilities for further enterprise in this direction were afforded by **The Oyster and Mussel Fisheries Act, 1866** (29 and 30 Vict., c. 85), which arranged for the granting of private rights of oyster and mussel fishery by means of Orders of the Board of Trade ; most of its provisions were re-enacted by Part iii of the Sea Fisheries Act, 1868 (*q. v.*), and the Act itself repealed ; no further notice of it is therefore at present necessary. **The Oyster Preserva-**



tion Act, 1867 (30 Vict., c. 18), concerned with the better protection of such private fisheries as might be constituted under the last Act, was also embodied in the Act of 1868 and was itself repealed.

The Sea Fisheries Act, 1868 (31 and 32 Vict., c. 45), forms, together with the Act of 1888, the main body of the legislation by which sea fisheries are at present regulated; Part iii of this Act is exclusively concerned with the oyster and mussel fisheries of England, and the following are its most important provisions:—"An Order for the Establishment or Improvement and for the Maintenance and Regulation of an Oyster and Mussel Fishery on the Shore and Bed of the Sea, or of an Estuary or Tidal River above or below or partly above and partly below Low-water Mark" may be made by the Board of Trade on the presentation of a memorial to the Board to that effect, after due notice given to all persons concerned as "Owners or reputed Owners, Lessees or reputed Lessees, or Occupiers (if any) of the portion of the Sea Shore to which the proposed Order relates"; and after an inquiry held by the Board's Inspector on the spot (evidence may be taken on oath) and the consideration of his report. Such an Order is to be confirmed by Act of Parliament before it can take effect (but *cf. infra*, 40 and 41 Vict., c. 42); and if a petition against it should be presented in the course of its passage through Parliament, it is to be referred to a Select Committee and there opposed as a private Bill. All the expenses of the Order are to be borne by the promoters. The Order grants, for a period not exceeding sixty years (*cf.* 48 and 49 Vict., c. 79) *either a Right of several Oyster and Mussel Fishery*, i. e. "the exclusive right of depositing, propagating, dredging, and fishing for, and taking Oysters and Mussels," and permission to the grantees to "make and maintain Oyster and Mussel Beds, or either of them, and at any Season collect Oysters and Mussels, and remove the same from Place to Place, and deposit the same as and where they think fit" within the limits of the Fishery; or *a Right of regulating an Oyster and Mussel Fishery* with power to carry out restrictions on the fishery and to exact tolls from persons fishing. The grounds over which the grant extends must be duly buoyed or marked out. The Order is determinable at any period by a Certificate of the Board to the effect that they are not satisfied that the ground is being properly cultivated, or that the regulations are not being properly enforced, and an inquiry may be held by the Board's Inspector to ascertain how far this is the case. A special clause states that no Order "shall take away or abridge any Right of several Fishery, or any Right on, to, or over any portion of the Sea Shore, which right is enjoyed by any person under any Local or Special Act of Parliament, or any Royal Charter, Letters Patent, Prescription, or imme-



morial Usage, without the consent of such Person” (*cf. supra*, p. 262, and note). A Report by the Board of Trade respecting their proceedings under this part of the Act is laid annually before both Houses of Parliament.\* There follow then clauses concerned with the protection of oyster beds, whether held under this Act or independently of it, vesting ownership of the oysters absolutely in the grantees or owners of the beds “for all purposes, civil, criminal, or other,” and providing penalties for such offences as dredging for ballast or depositing rubbish on the beds, supposing their limits to have been sufficiently well marked out. The first schedule to the Act contains the **Convention of 1867** between France and England relative to fisheries in the seas between the two countries; for various reasons this Convention has never come into operation, but Article xi, prohibiting the fishing for oysters between June 16th and August 31st outside the three-mile limit between lines running from the North Foreland to Dunkirk, and from Land’s End to Ushant, has been brought into effect by agreement between the Governments (Rep. Sel. Comm. Oyster Fisheries, 1876, ans. 5, Mr. T. H. Farrer).

Two Acts, 32 and 33 Vict., c. 31, and 38 Vict., c. 15, deal respectively with the Langston Fishery Order and with the Herne Bay Company, and are not of general interest.

An attempt was made in 1876 (39 Vict., Bill 65) to prevent the sale of any oysters from May to August inclusive, but the Bill fell through, and a less rigorous clause was substituted for it in **The Fisheries (Oyster, Crab, and Lobster) Act, 1877 (40 and 41 Vict., c. 42).**† This prohibited the sale or purchase of “deep-sea” oysters from June 15th to August 4th, and of other oysters from May 14th to August 4th, unless (1) taken in the waters of a foreign state; (2) cured in some way; (3) “intended for the purpose of oyster cultivation within the same district in which the oysters were taken, or were taken from any place for cultivation with the sanction of the Board of Trade.” Power was also given by this Act to the Board of Trade to restrict or prohibit during a period not longer than one year the taking of oysters from any particular bank or bed on the application of fishermen of the district, or of certain bodies specified. It was further enacted that an unopposed Order of the Board of Trade, under Part iii of the Sea Fisheries Act, 1868, might be confirmed by an Order in Council instead of an Act of Parliament. A Bill to repeal the restrictions laid by the last Act on the sale of “deep-sea” oysters (50 Vict., Bill 151) was dropped.

\* References to these Reports are appended below.

† This Act was the outcome of the interesting and valuable Report from the Select Committee on Oyster Fisheries, 1876.

The **Sea Fisheries Regulation Act, 1888** (51 and 52 Vict., c. 54), will, it is hoped, prove of great advantage to the fisheries of all kinds. It enacts that the Board of Trade may, on the application of a county or borough council (or, if they refuse to apply, on the direct application of twenty rate-payers), create a "sea fisheries district" and provide for the constitution of a "local fisheries committee" for the regulation of the sea fisheries carried on within the district. Due notice of the proposal is to be given beforehand, and an inquiry, if necessary, to be held on the spot. The "local fisheries committee" is to be a committee of the county council, or the borough council, or a joint committee of both, "with the addition in each case of such members representing the fishing interests of the district . . . as may be directed by the Order creating the district." The committee is empowered to make bye-laws regulating the methods and instruments used for fishing, for creating a district of oyster cultivation such as is contemplated by the heading (3) quoted above (p. 265) from the Act 40 and 41 Vict., c. 42, and for "prohibiting or regulating the deposit or discharge of any solid or liquid substance detrimental to sea fish or sea fishing" but not "affecting any power of a sanitary or other local authority to discharge sewage in pursuance of any power given by a general or local Act of Parliament, or by a Provisional Order confirmed by Parliament." The bye-laws are to be approved by the Board of Trade. The committees may also impose penalties for breach of their bye-laws, and appoint fishery officers with power to stop and search suspected vessels or vehicles within the limits of the district. A meeting for consultation with the Board of Trade, to which each committee may send at least one member, is to be held annually. Special regulations define the relations of the committee to boards of salmon conservators and harbour authorities; and they may not pass bye-laws prejudicially affecting any rights of several fishery, any bye-laws of salmon conservators, or any powers of sanitary authorities mentioned above.

The Reports by the Board of Trade of their proceedings under Part iii of the Sea Fisheries Act, 1868, will be found in the following places, among the Sessional Papers:

Session.	Volume.	MS. page.	Session.	Volume.	MS. page.
1868-9	... L	... 569	1879	... LXV	... 627
1870	... LVI	... 707	1880	... LXVII	... 875
1871	... LVI	... 783	1881	... LXXXIII	... 547
1872	... LIII	... 899	1882	... LXIV	... 685
1873	... LXI	... 475	1883	... LXIV	... 759
1874	... LXII	... 613	1884-5	... LXXI	... 977
1875	... LXXI	... 707	1886	... LX	... 689
1876	... LXVIII	... 589	1887	... LXXV	... 743
1877	... LXXVI	... 501	1888 and 1889	were not bound and paged when the above paper was sent to press.	
1878	... LXVIII	... 623			







Further information relative to these grants will be found in the Reports to the Board of Trade by their Inspectors

Session.	Volume.	MS. page.	Session.	Volume.	MS. page.
1870	... LVI	... 703	1878	... LXVIII	... 625
1877	... XXIV	... 465	1882	... LXIV	... 369

Also in the appendices to the Report of the Select Commission of 1876, and in Returns made to the House of Commons in 1872 (vol. liii, p. 891), 1880 (vol. lxvii, p. 877), 1882 (vol. lxiv, p. 179), and 1887 (vol. lxxv, p. 853). Twenty-six Orders in all have been made on behalf of oyster fisheries, of which nine have been revoked; of the existing seventeen, seven are Regulating Orders made to the corporations of six towns, the remainder grant rights of several oyster fishery to individuals and companies on various parts of the coast. The Reports of the Commission on Sea Fisheries of 1863 (pp. 82—105), and of the Select Committee on Oyster Fisheries of 1876, are the two which deal with England. The latter is full of valuable information on the subject.

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*Note.*—The dotted line on the map (Pl. XXI) running across the Ooster Schelde, from Schouwen to Nord Beveland, marks approximately the limit reached by the water of the upper part of the Schelde on the ebb tide (*cf.* p. 257).

## The Generative Organs of the Oyster.

Abstract of a paper by Dr. P. P. C. Hoek.\*

By

**Gilbert C. Bourne, M.A., F.L.S.,**

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With Plates XXII and XXIII.

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THE following description of the reproductive organs of the oyster cannot well be understood without some acquaintance with the general anatomy of the animal. With the help of Pl. XXII, fig. 1, the most important features of its anatomy may readily be understood. It must be remembered that the valves of the oyster's shell lie right and left of the animal; that the concave valve which lies undermost in the natural position of the animal is the left valve, and the flat upper valve is the right valve. The hinge marks the dorsal border of the animal, and the opposite border is the ventral border. That side which is on the observer's right in fig. 1 is the anterior surface, and that on the left hand is the posterior surface. As the animal is compressed from side to side the anterior and posterior surfaces are very narrow. The great adductor muscle, by which the valves of the shell are closed, is seen lying in the centre of the animal in fig. 1.

If the right mantle lobe is cut through along the anterior and ventral border of the adductor muscle, as in the figure, a finger-shaped process, called by Dr. Hoek the *oral process*, is seen to project from the trunk of the oyster, and to lie closely applied to the ventral border of the muscle. This oral process contains a loop of the intestine and, in addition, a portion of the reproductive organs and of the excretory organ. A large nerve-ganglion, the branchial ganglion, lies between the adductor muscle and the oral process. From this ganglion a number of nerves are given off, the most con-

\* Tijdschrift der Nederlandsche Dierkundige Vereeniging, Supplement Deel i, Aflevering i, p. 115. Leiden, 1883. See also Dr. Hoek's prize essay in the Literature of the International Fisheries Exhibition. London: Wm. Clowes and Son.

siderable of which passes forward for a short distance, curves over the oral process, and supplies the posterior part of the gills. It is shown in fig. 1. If this nerve is carefully examined in its course over the oral process, a slit may be distinguished, lying close and parallel to it, on the oral process. This slit—which may be seen on both the right and left sides of the oral process—is the *urogenital aperture*.

Fig. 2 is a diagram to exhibit the relations of the organs which open on each side of the body by the urogenital apertures. The so-called kidney or organ of Bojanus, first discovered and described by Dr. Hoek, is represented in shading. Its structure need not detain us; it is sufficient to say that it is a paired organ, and that it communicates on either side of the body with the pericardial cavity by a canal, marked *Rp.C.* in fig. 2. The generative organs are represented by thick black lines, but are shown smaller than they actually are to avoid encumbrance of the figure.

Like the organ of Bojanus, the reproductive organ is paired, but its branches interlace and anastomose to such an extent that the two members of the pair become confounded with one another, and the paired apertures are the only evidence of the double character of the organs.

Two portions may be distinguished on either side, the reproductive organs properly so called, and the genital duct. There are no accessory organs, such as yolk-glands.

The generative organs may most conveniently be studied in a year-old oyster. The genital duct opens into the anterior part of the slit-like urogenital aperture. At a short distance—half a millimetre, for example—from its opening the duct begins to give off a number of *culs-de-sac*, which are placed perpendicularly to the direction of the duct, and are nothing more than outgrowths of its wall which project into the surrounding connective tissue. The epithelium of the wall of the canal is continued along the walls of the outgrowths, but the cells are not provided with vibratile cilia and are not distinctly marked off from one another. It appears that at a subsequent period they multiply and become metamorphosed into generative products, ova or spermatozoa. If the genital duct is followed further forward to the pericardial cavity, a number of similar canals are seen to originate as outgrowths of the genital duct. These lateral canals penetrate into the connective tissue of the oral process or spread out parallel to the surface of the oyster. In the former case the genital products are developed on both sides of the canals, in the latter case only on that side opposite to the surface of the body. In the latter case the wall of the canal which runs parallel with, and at a little distance from the surface of the

body, is composed of an epithelium provided with vibratile cilia quite similar to that of the genital duct, of which it must be considered as a continuation.

In front of the pericardial cavity it becomes difficult to follow the genital duct. It divides into several branches, which spread on the surface of the body, and, like the outgrowths of the first part of the duct, run for a short distance parallel with the surface of the body. All these canals are oval in section, and their outer and inner walls differ in minute structure; the outer wall is lined with a ciliated epithelium, whilst the epithelial cells of the opposite wall are evidently already in the process of transformation into generative products.

The canals themselves are placed at considerable distances from one another. Their interior walls often show the commencement of a number of *culs-de-sac*, which enter the surrounding connective tissue. The *culs-de-sac* seem always to be longest near the genital aperture, and decrease in size and development the further they are from it.

In a ripe oyster several changes have taken place. The growth of the whole body is accompanied by a growth of the lateral branches of the genital duct, both in length and in size. The number of the branches is much increased, and they anastomose to form a network of branches and branchlets on the two sides of the body of the oyster, which is not the case, as far as can be ascertained, in a yearling oyster. Extending still further, the branches of the two sides of the body unite and anastomose. At this stage the generative organs nearly surround the trunk in front of the adductor muscle. They lie near the surface, but are separated from it by a thin layer of connective tissue, and are continued by the anastomoses of the network of either side, over the anterior and posterior surfaces, but are more conspicuously developed on the posterior than on the anterior surface.

The productiveness of the generative organs is dependent on the increase of their surface. This is attained not only by the multiplication of their branches, but also by the growth of the walls of each branch. That part of the wall of each canal which is opposite to the surface of the oyster increases greatly, and penetrates into the connective tissue. These outgrowths, at first small, grow longer afterwards, but remain comparatively small as long as the genital products are not ripe. Their extent continues to increase, both because they become individually larger and because the number of branches is considerably augmented, until in the breeding season the maximum development is found in oysters of four and five years old, in which the follicles and their ramifications form a layer several



millimetres in thickness, in which very little connective tissue can be distinguished.

The genital ducts are lined by a cubical ciliated epithelium, which is continued into the main branches given off from them, and it may be asserted that the cell-walls of all the ultimate ramifications of the organ are derived from an epithelium continuous with and derived from that lining the ducts.

The genital products are developed from the wall of the follicles, probably at the expense of the epithelial cells which line them. Both ova and spermatozoa are developed in the same follicle.

In the youngest stage observed the ovum of the oyster is a little cell, 20—24  $\mu$  in diameter, flattened on the side of the canal-wall, and rounded on its free surface. The protoplasm of the cell-body is feebly granular, the nucleus is large, spherical, and has a highly refringent single nucleolus of a moderate size. The youngest ovules pass by in sensible gradations into the more advanced, and these again into the mature ova. The granulations of the protoplasm become more and more numerous and more distinct, and little refractive granules accumulate in great numbers. The ripe ovarian ovum acquires, as soon as circumstances are favorable, a spherical form, and is rather more than 0.1 mm. in diameter. The manner in which the ova separate from the follicles has not been observed. After their separation there remains a lining of epithelial cells in the follicle, from which new generative products are formed.

It appears to be invariably the case, as will be shown afterwards, that the formation of ova is always followed by the formation of spermatozoa, but the process of spermatogenesis is much more complicated than that of oogenesis. The most favorable preparations for the study of spermatogenesis are procured from follicles which have been previously filled with ova. To procure this one must search in the manner common among ostreiculturists for an oyster with spat in its gills; when found it must not be opened at once, but must be marked and placed in an aquarium in a current of water. If it is examined a fortnight later the different follicles of the reproductive organ are found to be actively engaged in spermatogenesis. A follicle in this condition is found in Pl. XXIII, fig. 3. In the centre is a loose mass of ripe spermatozoa, and the tissue composing the walls is seen to be in the process of transformation into spermatozoa. The minute mother-cells of the spermatozoa have a diameter of scarcely 8  $\mu$ , they stain deeply with alum carmine, and have dark granular contents and a small nucleus. The spermatozoa are developed from them as follows. In each cell after the division of the nucleus the cell-body divides in two portions. Of these one is destined to give rise to numerous spermatozoa, the other seems to

serve only as a provisional connection between the developing spermatozoa and the wall of the follicle. The former cell grows rapidly, and the nucleus subdivides rapidly and repeatedly until a large cell is formed 25—30  $\mu$  in diameter, containing 40—50 nuclei. Each nucleus is about 4  $\mu$  in length. At this stage the whole structure looks somewhat like a club (Pl. XXIII, fig. 4), of which the swollen part is formed by the large multinucleated cell just described, and the handle is formed by the other derivative of the primitive cell. At this stage the multinuclear cell becomes separated from its peduncle. Its nuclei continue to subdivide and become darker and more opaque. Finally the mother-cell becomes entirely developed into spermatozoa derived from the sub-divided nucleus, but one cannot explain precisely the steps by which the smallest nuclei are transformed into spermatozoa.

#### THE PHYSIOLOGY OF GENERATION IN THE OYSTER.

Numerous researches have been made with the view of determining whether the oyster is a functional hermaphrodite, having the power of occasionally or generally fertilising its own ova, or whether it is physiologically unisexual whilst anatomically hermaphrodite. Davaine, de Lacaze Duthiers, and P. J. Van Beneden pronounced in favour of the former view, that the oyster is, potentially at least, a functional hermaphrodite, but subsequent investigators have inclined more and more towards the latter view. Dr. Hoek's researches lead him to the conclusion that, so far from being a functional hermaphrodite, the oyster is a unisexual animal at the moment when it performs the act of generation. He continues :

“It goes without saying, and should not be forgotten, that it is much more difficult to arrive at a certain result in this part of my researches than in the anatomical part. In the latter direct observation is possible, but in the former it is only possible within certain limits. One is obliged, indeed, to make observations from the very first, but one has afterwards to draw conclusions from them, and then everything depends on the greater or less importance which one attributes to each fact observed. A multitude of observations may give more solid grounds for one's conclusion, but cannot exclude the possibility of a fault in reasoning.

“The number of oysters examined was not very large. I call ‘examined’ those only which gave me satisfactory preparations and in which I could judge with mathematical certainty the condition of the generative organ at the moment of opening. Adult oysters (three years old or more) opened during the breeding season do not

always present the same appearance. Omitting all reference to diseased organs, the condition observed may always be classed under one of the five heads following.

"1. Abundance of ripe spermatozoa and scarcely any ovules. Early stages in spermatogenesis rare. Everything seems to concur in the production of as many spermatozoa as possible. The oyster fat.

"2. Spermatozoa ripe and in course of development. Ovules pretty numerous on the walls of the follicles, but not a single ovum ripe and in a condition to be fertilized. Oyster pretty fat.

"3. Spermatozoa in the course of development everywhere, and here and there a little mass of ripe spermatozoa. A single ovule still remaining on the wall of the follicles. Oyster thin.

"4. Abundance of ripe or nearly ripe ova (in condition to be fertilized) both on the walls of the follicles and free in their cavities. Among the ovules on the walls of the follicles some very small cells whose nature could not easily be distinguished. No spermatozoa. Oyster very fat.

"5. Abundance of ripe or nearly ripe ova. Ripe spermatozoa in the efferent ducts and in the primary lateral ducts leading into it. No younger stages of spermatozoa. Cellular elements among the ova on the walls of the follicles as in the previous case. Oyster very fat."

It should be added that the oysters in the second category show differences both in the number and condition of development of the ovules, but Dr. Hoek never saw ova in a condition for fertilization alongside of ripe spermatozoa, unless indeed Case No. 5 is a question.

As for No. 3, it must be added that the preparations of these oysters corresponded exactly with those made from oysters which were known with certainty to have had brood in their gills from one to four weeks before being opened.

Two facts may here be noticed which are of the greatest importance for the physiology of the organs of generation of the oyster. These are :

1. That the ova of the oyster at the moment of their escape from the genital aperture are already fertilized, and that they have already passed through the earlier stages of segmentation.

2. That on several occasions spermatozoa have been found surrounding the edges of the urogenital aperture as well as in the terminal portion of the genital duct, in the ureter, and even in the renal chamber.

When it is considered that autogamy, or the faculty of self-fertilization, is extremely rare in the animal kingdom, and that the nearest allies of the common oyster (*Ostrea virginica* according to Brooks and Ryder, *Ostrea angulata* according to Bouchon Brandely) are

unisexual, one can hardly escape the conclusion, in face of the facts above mentioned, that the oyster is at the moment of propagation a functionally unisexual animal. One could not otherwise explain the different conditions in which the generative organs are found during the breeding season. M. de Lacaze Duthiers, it is true, has found a few ova in oysters filled with semen, and a few spermatozoa in oysters filled with ova, but in the former case the spermatozoa could hardly be destined to fertilize such a very small number of ova, which are besides unripe; and in the latter case the number of spermatozoa found by him are altogether insufficient for the fertilization of the ripe ova contained in the animal. Further, it must be remembered that not only is it impossible that two oysters should copulate, but that it is equally impossible that the generative products of the two sexes should be brought together when floating freely in the sea; for how if this were the case could the development of the brood in the gills of the mother be explained? Nobody has attempted to deny that the brood contained in the gills of an oyster is derived from that oyster. It is impossible to believe that it could collect in its gills a number of ova from the surrounding water, when those ova, being denser than the water, do not float. At the moment of their exclusion the ova are fertilized, and as soon as "white spat" is observed in the gills of an oyster, its generative organs are found on examination to be empty and exhausted. Clearly the white spat in the gills has been produced by the same individual in which it is found. The spermatozoa by which those ova are fertilized might be produced by the mother oyster itself, or might be derived from another oyster. The former supposition is sufficiently refuted by the fact that the reproductive organs of a ripe oyster are either entirely filled with ova, or nearly entirely filled with spermatozoa. The fertilizing spermatozoa must therefore be derived from other oysters.

The only possible conclusion is that during the breeding season a number of oysters produce and emit such a large quantity of spermatozoa that the water passing over an oyster-bed is charged with them, and that a sufficient quantity are able to penetrate into the mantle cavities, and thence into the bodies of the ripe females, and thus fertilize their ova. The number of spermatozoa which are lost must of necessity be much greater than those which are utilised. In the only case in which the two genital products are found side by side and perfectly ripe in the reproductive organs the spermatozoa are all free, none are united into masses, and they are only found in the main genital duct and its principal branches, which is evidently in favour of the view that they have found their way there from without.



Another question remains, Do the reproductive organs of the oyster produce ova and spermatozoa in regular alternation? Robin, on theoretical grounds, and other authors as the result of observation, have asserted that oysters are androgynous hermaphrodites—that is to say, hermaphrodites which function first as fertilizing males, and afterwards as females requiring fertilization. Möbius (*Auster und Austernwirthschaft*, p. 20) simply states that ova and spermatozoa are not developed at one and the same time in the reproductive organs of the oyster, but successively; that spermatozoa may be formed soon after the ova are laid, and that probably, in the same season, half the oysters in any locality produce ova only, and the other half spermatozoa only. Dr. Hoek agrees entirely with the last-named author. An oyster which contains ripe spermatozoa in the breeding season almost always shows younger stages of spermatozoa in its reproductive organs, whilst, on the contrary, an oyster temporarily acting as a female, and full of ripe or nearly ripe ova, has all its ova in nearly the same condition; it follows, therefore, that it is able to produce spermatozoa for a long period, but that all the ova are laid at nearly the same time. This last point can also be demonstrated by the examination of an oyster which has very young spat in its branchiæ; in this case the reproductive organs are void of ova. In the case of oysters which come under the second category on p. 273, one may well suppose that they have acted and will act as males, but as females only in the following year; nevertheless there is no proof that this must necessarily be the case. But a very simple experiment, which has been several times mentioned, shows that oysters which have acted as females begin immediately to produce spermatozoa, and the latter may very probably serve in the same year for the fertilization of ova produced by other oysters.

**Age at which Oysters become Sexually Mature.**—Gerbe has examined a great number of young oysters (425, a year old). Of these 35 had spat in their branchiæ, 127 had their ovaries full of ova, and 189 had spermatozoa. It is doubtful, however, whether the oysters on the cultivated grounds of the East Schelde reproduce themselves when only one year old. Of a number of well-developed oysters which were opened at the end of the first year some appeared as though they would function as males in the following summer, others undoubtedly gave the appearance of being about to develop mature ova in the following year. It is impossible to decide whether these latter oysters must necessarily produce ripe spermatozoa first.

However, it is not at all impossible that the oysters of the East Schelde may be inferior in this respect to their relatives in a state of nature. If manipulation exercises an unfavorable influence on the number of breeding oysters, it is not at all unlikely that it should

also exercise an unfavorable influence on the age at which the animal begins to breed, so that a considerable number of natural oysters a year old might produce ripe ova and spermatozoa, whilst this might never be the case, or at least might be very exceptional, in cultivated oysters. The question can only be settled by further observation. Particularly it is necessary to compare cultivated and natural oysters. It is probable that it will be found that cultivated oysters differ greatly among themselves, since the brood, fixed in the summer, and usually detached in the spring months, is not always treated in the same manner. If the collectors with the young brood are placed in the sea for the winter, and if afterwards the young are left on the collectors, the oysters are flat and too much crowded; they have a low market value, but in the development of their generative organs they approach much nearer to natural oysters than do cultivated oysters.

The more a cultivator deviates from the course followed by nature the greater the danger of weakening the reproductive capacity of the oyster. It is certainly a considerable deviation to place the collectors in ponds during the winter. To detach the oysters from the collectors is another deviation; a third is the crowding of hundreds of oysters in small reservoirs; a fourth to keep young oysters for a whole year in parcs, &c. Although many of these deviations do not appear to be dangerous to the life of the nurselings, and are even necessary to the advantageous application of culture, one must not lose sight of the fact that they must necessarily exercise an unfavorable influence on the reproductive faculty.

It may be added that among cultivated oysters those of the fourth and fifth year are the most prolific. Oysters six years old still have well-developed reproductive organs, but in oysters of nine or ten years they are always poorly developed, and rarely contain generative products. The liver too, in these last is greatly enlarged, so that the layer of connective tissue between it and the body-wall which contains the follicles of the reproductive organs, is of very slight thickness. Ordinarily the follicles of these aged oysters contain no ova, but a few spermatozoa. The conclusions arrived at by Dr. Hoek in the course of his work are as follows:

#### A. *Anatomical.\**

1. The reproductive organ of the oyster consists of a genital gland and efferent ducts. There are no accessory organs.

\* Several of the anatomical conclusions arrived at by Dr. Hoek are omitted, as being beyond the purpose of the present abstract.

2. The genital gland is not a compact organ situated in a definite position. It is spread out superficially so as to cover nearly the whole of the trunk properly so called. At a short distance from the surface of the body, separated from the integument by a thin sheet of connective tissue, the genital gland spreads out as a system of canals which unite secondarily with one another, and their internal walls give rise to follicles placed vertically to the surface of the body and buried in the connective tissue.

3. The generative products are developed from the walls of the follicles. Spermatozoa and ova are developed alongside of one another in the same follicle. The two generative products are developed in all probability from the epithelial cells, which must be considered as the derivatives of the epithelial cells lining the walls of the genital ducts.

4. It is probable that a single epithelial cell is metamorphosed into a single ovum, whilst only a portion of a single epithelial cell becomes the mother-cell of spermatozoa. All the spermatozoa derived from a single mother-cell are united into a bunch of characteristic shape.

5. The ducts of the genital gland communicate directly or indirectly on the two sides of the body with a principal efferent duct, which opens to the exterior at the anterior end of an open groove, running along the muscle of the valves at a short distance from the great posterior branchial nerves.

### B. *Physiological.*

1. An oyster with spat in its branchiæ is the mother of that spat.

2. At the moment of extrusion the ova are not only fertilized, but have already passed through the earlier stages of segmentation.

3. The spermatozoa necessary to fertilization do not come from the mother oyster itself.

4. The water which passes over the oysters brings the spermatozoa which have been emitted by other oysters. Some of this enters the mantle cavity, penetrates to the genital aperture, traverses it, and spreads not only into the principal duct of the genital aperture, but also into its larger branches.

5. The oysters of the East Schelde may have spat in their gills when two years old. Ordinarily oysters in spat are older. Oysters of four or five years produce the most spat.

6. Similarly two-year oysters may produce spermatozoa, but the larger part is derived from older oysters. Neither earlier researches nor my own have established with certainty that year-old oysters from the East Schelde emit spermatozoa.

7. The number of oysters producing spermatozoa is, in the East Schelde, greater than those producing ova.

8. The ova of a ripe oyster are laid all at once, excepting a few which are ill developed. The production of spermatozoa probably for a longer period.

9. In every oyster examined the production and emission of ova was followed by a period in which only spermatozoa were formed.

10. A large portion of the brood which attaches itself every year on the banks of the East Schelde is not, in all probability, derived from the oysters in the establishments.

11. It would appear that cultivation exercises an unfavorable influence on the fertility of oysters.

12. In aged oysters the liver is much more developed than in young. This development is correlated with the retrograde condition of the reproductive organs.

A COMPARATIVE EXAMINATION OF CULTIVATED AND NATURAL OYSTERS,  
MADE TO DETERMINE THE NUMBER WHICH ANNUALLY TAKE PART IN  
REPRODUCTION.\*

After the publication of his first paper, Dr. Hoek received from Baron Groeninx van Zoelen and Baron G. H. Clifford, oyster culturists of the East Schelde, an offer of a sufficient number of oysters for the continuation and completion of his researches. This offer he willingly accepted, and received towards the end of June, 1883, 200 oysters from an establishment where only cultivated oysters had been laid down, and 200 others from a locality where no cultivated oysters had ever been laid down. The age of every oyster was noted, and also whether it had been growing on a tile, a shell, or a stone. Each individual was numbered, and a piece was taken and preserved in alcohol for further investigation. A thin section was eventually made from each piece, which was stained and treated for microscopical examination.

The oysters examined were opened between June 16th and 28th, and as the pieces removed were immediately placed in spirit, subsequent examination of them gave an exact idea of the condition of the sexual organs on the day on which they were opened. In several cases the examination of these pieces was not wholly satisfactory. Some of the oysters had spat in their beards; these might have been pronounced as functional females for the current year without any further examination: some others contained a great number of ripe

\* Dr. P. P. C. Hoek, Tijdschrift der Nederlandsche Dierkundige Vereeniging, Supplement Deel i, Afl. ii, 1883-4, p. 483.



or nearly ripe ova ; these they would have emitted in a few days. Others, again, contained spermatozoa either ripe or nearly ripe—one could see that they would participate in the season's breeding. On the contrary, the oysters which contained young cells producing ova and sperm mother-cells were in a condition in which it was very difficult to determine whether they would participate in the season's breeding, and what would be their function.

According as the male or female elements appeared to predominate they were classed as likely to become males or females. A certain number, though not many oysters remained in which the sexual organs were very feebly developed. It is impossible to say whether these oysters had already bred, or whether they were weak or diseased.

The results of the examination of 190 oysters from each locality are given in the following table :

Condition of reproductive organs.	Cultivated oysters.	Natural oysters.
A. Oysters with white spat . . . . .	11	19
B. „ with black spat . . . . .	17	12
C. „ with ripe or nearly ripe ova . . . . .	21	42
D. „ with ripe or nearly ripe spermatozoa . . . . .	75	94
E. „ which seemed likely to become females . . . . .	11	7
F. „ which seemed likely to become males . . . . .	17	6
G. „ with ill- or non-developed reproductive organs . . . . .	38	10
Total number of oysters examined . . . . .	190	190

Of 190 cultivated oysters, there were at least 49 functional females, and of the same number of natural oysters, 73, or 12½ per cent. more, were functional females. But the more numerous examples of cultivated oysters classed under E should probably be classed as females, and thus the difference is made less ; and since many of those classed under G had doubtless acted as females, the difference, which looks large at first, loses its importance. The same is the case with the males. The advantage remains with the natural oysters, but the advantage is so small that any conclusions founded on these data would be valueless.

One circumstance shown in the table is remarkable. The cultivated oysters are in advance of the natural oysters in their development at a certain season of the year. Ordinarily the consignments received comprised an equal number of the two kinds, so that they might be considered as having been opened at the same date. If we allow that, of those classed under G, one half had been functional females,

we should have to class the oysters which had already acted or were yet to act as females under the following categories :

Oysters with ripe or nearly ripe ova :	cultivated	21,	natural	42.
„ „ white spat . . . .	„	11,	„	19.
Oysters with black spat . . . .	„	17,	„	12.
„ which had produced young . . . .	„	19,	„	5.

The table shows sufficiently well that, in this particular instance, the cultivated are in advance of the natural oysters. This observation is confirmed by the assertion of oyster breeders, viz. that natural oysters spat after those under cultivation. In the establishments where the mass of spat to be collected is believed to be derived from natural oysters, the tiles are set out some time after they are set out in the cultivated beds.

As to the age necessary for reproduction, these researches give no certain information, since all the oysters received were nearly of the same age. The majority were three or four years old, some few two or five years. Even if the ages had varied more, the number of specimens examined would have been too small to give decisive results on this point.

To arrive at a definite conclusion it would be necessary to begin investigations in March, and to continue them till October. Each month, at nearly the same date, at least 100 specimens both of cultivated and natural oysters should be opened. The oysters should be two, three, and four years old. A section of each individual which would leave no doubt as to the actual condition of the reproductive organs should be made. With such materials one could arrive at numbers admitting of a comparison.

Suppose that the result still showed scarcely any difference in the number of females in the two kinds of oysters, it would be rash to conclude that the greater part of the free spat is not produced by natural oysters. Their spat might be hardier than that of cultivated oysters, and it might reasonably be admitted that the spat produced by a natural oyster is larger in amount than that produced by a cultivated oyster.

Fig. 1

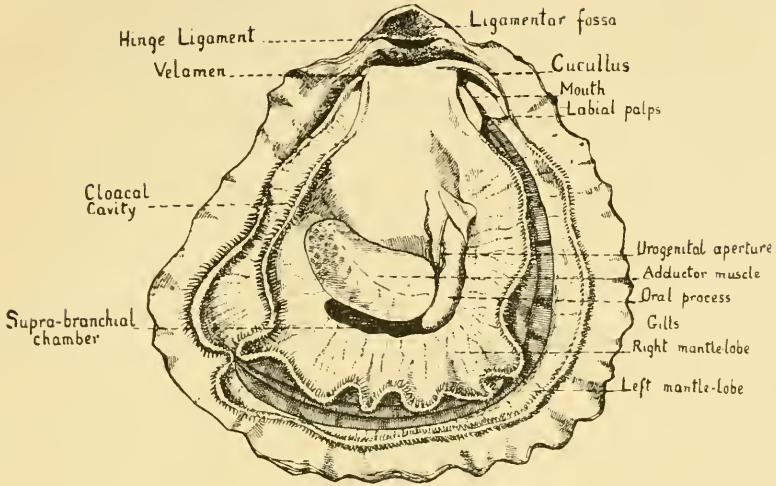
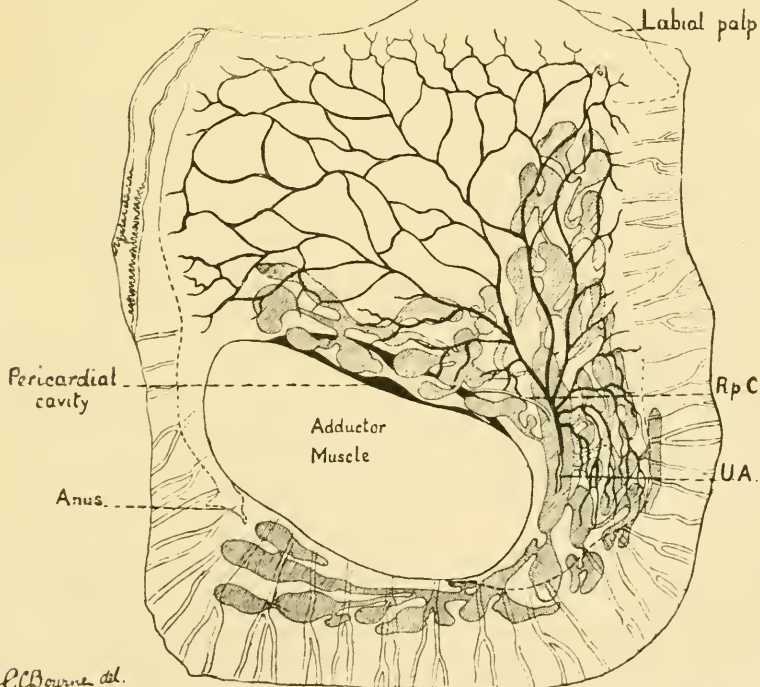


Fig. 2



Elbourne del.







Fig. 3



Fig. 6

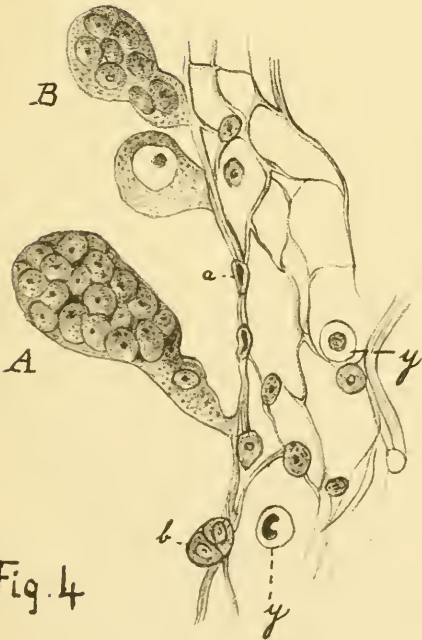


Fig. 4

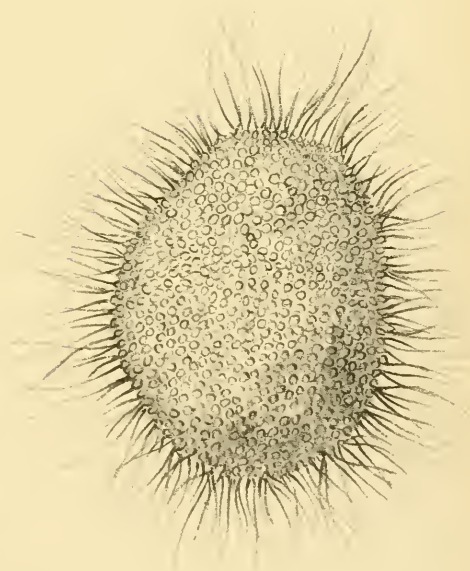


Fig. 5



## DESCRIPTION OF PLATES XXII, XXIII,

Illustrating the abstract of Dr. Hoek's paper on "The Generative Organs of the Oyster."

All the figures after Dr. P. P. C. Hoek.

FIG. 1.—View of a freshly opened oyster lying in the left valve after removal of the right valve. A portion of the mantle has been removed to show the oral process situated in the snprabranhial chamber.

FIG. 2.—Diagram of an oyster of which a part of the branchiæ and mantle have been removed to show the general arrangement of the generative organs and organ of Bojanus. The black lines represent the canals and ducts of the generative organ; the organ of Bojanus is shown in shading. To avoid enenmbrance of the figure the genital ducts and canals are made to appear much smaller than they are in reality. *U. A.* Urogenital aperture. *Rp. C.* Renopericardial canal.

FIG. 3.—Section of a follicle of the generative organ of an oyster which has laid ova. *s'*. Mother cells of spermatozoa in division with numerous nuclei. *s''*. Ripe spermatozoa ( $\times 190$ ).

FIG. 4.—A portion of the preceding figure more highly magnified ( $\times 900$ ). *a.* Epithelium. *b.* First stage of division of mother-cell. *B.* Numerous nuclei derived from the primitive nucleus. *A.* Stage previous to the separation of the swollen multinuclear mass from its pedicle. *y. y.* Blood-corpuseles.

FIG. 5.—Mass of ripe spermatozoa ( $\times 575$ ).

FIG. 6.—Ovules on the wall of a follicle. *e.* Epithelium of the follicle ( $\times 190$ ).

## Letter on Oyster Culture.

By

**By Lord Montagu of Beaulieu.\***

I HAVE tried breeding oysters in two enclosed ponds for over ten years. I began my experiments in 1878. These ponds are situated on the banks of the Beaulieu River, about three miles from the estuary. They were excavated from the mud-bank, and banked off from the river; the bottom was well chalked, and afterwards well coated with gravel. They are about half an acre each, and are divided by an embankment. There are three sluices communicating with the river from the ponds, and two between the two ponds. The situation of the ponds is very sheltered, being in the west bank of the river, with a wood on the west side, and the woods on the east side of the river also sheltering them. The water of the river at the spot is brackish to a certain extent, and decidedly so when there is much rain. At spring tides it is nearly as salt as the sea, but there is always a considerable mixture of fresh in the river. I have only once succeeded in obtaining any large fall of spat, and that was in the first year the ponds were made, 1878. That year there was a very early fall of spat, middle of June, and the tiles were fairly smothered with it. Since then there has been occasionally a little fall of spat, but nothing at all satisfactory.

I have used all kinds of collectors—tiles, brushwood, hurdles, shells. When spat is really *mature* it will adhere to *anything*. The tiles I have always coated with a mixture of lime and sand, so that it should not get too hard and adhere too strongly to the tiles, as if so it is impossible to remove the young oysters without breaking their shell, when they die. The labour of removing is great, and the expense also, and it is imperative to put these young oysters into boxes or ambulances, and to remove them to ponds on the sea fore-shore. The best, cheapest, and most effective collectors are small shells, and oyster culch, especially if they can be put on fine wire netting, a little above the bottom of the pond. I have tried to collect spat on artificial tile collectors in the river, but have not

\* Lord Montagu has kindly allowed me to publish this letter, which was written in answer to some questions of mine as to his experiences in oyster culture.—ED.



been successful in getting much, the amount being quite insignificant to the labour and expense of putting them down.

There are plenty of shells and natural stuff for oysters to settle on in the river if ever a fall of spat matures. That some do mature every year I have no doubt, but the quantity is very small.

I do not know that new natural spat in the river is stronger than that collected in the ponds. The shallowness of the water in the ponds causes the water to be warmer in summer, and this stimulates a greater growth in the young oysters in the ponds, but exposes them to greater risk from cold or snow water in the winter.

That oysters sicken and give a fall of spat every year I do not doubt, but it has always been a difficulty to ascertain if that spat is mature.\* There has been a fall of spat every year in the ponds more or less, but it has most years come to nothing. After floating about for a week it will disappear altogether. I should like to know the cause of this, and here is where some scientific research is greatly needed. The problem is, why does this spat disappear? I have not been able to account for it from any natural causes. I have had large bottles of spat and watched it through powerful magnifying glasses and under a microscope, and have never been able to see any other living organism preying upon it. The spat has been very lively and moving about, apparently full of life, and, as far as I could see, having no marked difference from spat which has matured and adhered properly to collectors. Why does it not do so?† I have tried every kind of oyster in the ponds, putting about 10,000 in each pond. French oysters from Arcachon, French oysters from Auray, Solent oysters, river oysters, Falmouth oysters. The former breed much the most prolifically; and my belief is that this is owing to their being matured in a warmer climate. If, therefore, there happens to be a fine week when they emit their spat, the chances of realising a good result are greater with them than other oysters. I have usually placed the oysters I intended to breed from in *shallow* ponds by the sea-shore; this has the effect of bringing them on, and causing them to mature their spat. I believe that climate and warm weather has more to do with success than anything else, and the maturity of the spat when it is emitted from the oyster depends greatly on this also.

It is also most essential that the surface for oysters to spat upon

\* The fall of spat has varied greatly in date: sometimes in June, often not till the end of July. I have hardly ever known a late spat come to maturity.

† I have generally put the mother oysters into the ponds about the end of May or beginning of June. The oysters I have selected have been generally about three years old. It is a question perhaps whether the spat from older oysters do not mature better. Those I have had from France have been between three and four years old.

should be clean, and not covered with slime, weed, &c. I have, therefore, latterly adopted the plan of waiting for a spat of oysters, and then throwing shells broadcast into the ponds. I believe this is a good plan. To show how capricious the oysters are, this last season I bred a few oysters in one pond, and there were none in the other close by, yet both were treated alike. I allow the tide to flow in and out through the sluices while the breeding is going on. Some hold this to be a bad plan, as it allows spat to escape. Some may perhaps, but the continual flow and reflow of fresh water into the ponds is most important. I believe it is true that spat rises to the surface in the day and falls to the bottom at night. I have tried this by experiments in large bottles, and there is no doubt that it did fall to the bottom in the dark, and rose to the surface with great activity on being brought out in the light.

There is no doubt that an oyster *must* have innumerable enemies. When it is an established fact that one oyster will emit a million little eggs or spat, it is clear that if it were not for wholesale destruction the stock of oysters would be always abundant, but it is not so. After maturing on a piece of stone, rock, tile, shell, or any other natural collectors in its youth the oysters are devoured wholesale by crabs, &c. ; but what destroys them almost at their birth? This is the most important question. The principal cause of our having no spat deposited in this river is the violence of the tide. Unless the oyster spat\* attaches itself to something during the lay tide and at neap tides the chances are it is all swept out of this river into the Solent ; it may deposit itself in places there, but I hold this to be the greatest obstacle to spat getting attached to anything in the river. The same reason, I think, applies to spat in the Solent, that part of the Solent between St. Helens and Osborne Bay being quite the best bed for oyster-dredging. It is between these two points that east and west going tides meet, and where there is no great current, and it is on this ground that the Solent oyster-dredgers work.

I believe that one of the reasons of a yearly fall of spat in the Essex rivers is much due to the same cause, and undoubtedly the *Whitstable*† beds are in an equally favorable position. The bay or inland sea of Arcachon is for the same reason most favorable for securing a fall of spat, the tide simply passing up and down the bay, and never running the spat into the sea. The Dutch beds at Bergen-op-Zoom are similarly situated. But I think there are other causes why our oyster beds at home are becoming yearly less

\* I believe that if an oyster spat is really fit, it will fix itself to some object in a very few hours of its being emitted from the parent oyster.

† Most of the *Whitstable* natives have for years past been supplied from Arcachon, and laid in the *Whitstable* grounds.

prolific. This, I believe, is over-dredging, and never having any reserved beds of oysters for breeding puposes. This, however, is a larger question into which I cannot now enter, and it is beyond your inquiry. I should add that there is a natural or native bed of oysters in the river here ; it is too small, and should be extended, and more ground opened for laying oysters. This is only a question of £ s. d., but if one has not the money one cannot spend it. I should say that the South of England Oyster Company's breeding ponds at Hayling Island, and Emsworth, in Langston Harbour, near Portsmouth, are well worth a visit, and, I believe, particularly well situated for oyster breeding. They have had varied success, but never can pay a dividend on their capital expended, which has been very large.

I can only say in conclusion that I shall be very glad to see you, and any one whom you may like to accompany you, at any time here ; and if my ponds can be of any use for making experiments, I shall be most happy to place them at the service of the Association on any terms that might be agreed upon. I am deeply interested in the whole matter, and should be very glad if the result of the investigations of the Association may solve some of the problems which have up to now defied private efforts.

Yours truly,  
MONTAGU.

## Flora of Plymouth Sound and Adjacent Waters. Preliminary Paper.

By

**T. Johnson, B.Sc.,**

Professor of Botany in the Royal College of Science, Dublin.

A GOVERNMENT grant by the Royal Society enabled me to spend the months of August and September of 1889, in the investigation of unknown or obscure points in the marine algæ, in the Laboratory of the Marine Biological Association, Plymouth. One of my chief objects was to obtain such material of the various members of the *Gigartinaceæ*, of *Spyridia*, *Stenogramme*, and other genera, as would permit me to make a detailed examination of the development of the fruit (cystocarp) from the earliest stage to maturity. Several of the genera required were very rare or of unknown locality, and in many cases only to be found by dredging. In searching for these, new weeds, or new localities for known weeds, were met with, and it seemed to me the notes I made would be of use to algologists. Cocks, Hore, Boswarva, Gatcombe, &c., and of late years Holmes,\* have combined in their work to give a very full account of the marine algæ to be met with without the use of the dredge. For twenty years Cocks, I am told, did not miss a single low tide at Plymouth (or, if not, Falmouth). Up to the present our knowledge of the weeds of Plymouth has been derived almost entirely from shore-hunting, some of the rarest weeds being described as washed ashore, so that it was a question as to whether such weeds were locally established or merely "drift" specimens. In 1867 Boswarva published his *Flora of Plymouth Sound* in the Transactions of the Plymouth Athenæum, his catalogue being compiled from the discoveries of himself, Cocks, &c. This list appears word for word in the Marine Biological Association Journal, No. 2, 1888. I am permitted by Mr. Holmes to say that through a misunderstanding he is stated to give the names of eight *additional* species. It is only fair to the early algologists to point out that *five* at least of

\* Through the courtesy of Mr. Holmes I have seen a list of species added by him to the Flora of Devonshire (Journal of Botany). I believe I am not overstating the case in saying that he has added one hundred species of algæ to the British Flora, some new to science.



these were known to occur in the Sound in Boswarva's time. I shall suppose readers of the following pages to be familiar with the above-mentioned catalogue, and to have a general knowledge of the Sound, from the Admiralty chart or otherwise. My chief objects when dredging were to see if the rare "washed ashore" weeds had any local habitat, if there was a well-marked connection between the east and west shores of the Sound by extra-tidal weeds, and to work out as fully as possible the extra-tidal flora. For the accomplishment of these objects it was necessary to work as near in to the shore as it was safe\* to take the steamer ("Firefly") or the sailing boat ("Mabel").

#### DISTURBING INFLUENCES IN THE FLORA.

Many disturbing influences have been at work since the date of Boswarva's catalogue, the weeds mentioned by him as occurring in particular localities being in many cases no longer to be met with, or only after very diligent search. Of these influences it will be well to notice a few.

**The Breakwater.**—This immense structure, completed in 1841, and extending for more than a mile across the Sound, must have had an impoverishing effect on the flora of the Sound internal to it. This is more especially seen in the eastern inlets. Rum Bay, Jennycliffe Bay, Batten Bay, protected by the Breakwater from the south-west gales, are also cut off, to a large degree, from communication in a south-west direction with the English Channel and the Atlantic Ocean, and, to this extent, deprived of the spores of weeds brought by south-west currents. Batten Bay has been still further denuded by the presence, since 1882, of Batten Pier, and, spite of the presence of several rare weeds, has changed from a locality rich in seaweeds to one of the poorest, the effects of town and harbour refuse on the seaweeds in these eastern bays being also very marked.

**Refuse.**—No doubt in the Sound, as elsewhere, the increase, with population, of refuse has had a deteriorating effect on the algæ, as *e. g.* in Batten Bay just cited. I was given to understand that during recent years the bed of the *Laira* has been raised five feet by the deposit of clay and general refuse from the china clay works on Dartmoor. This cannot but have an effect on the weeds of the *Laira* and the Cattewater. Batten Pier seems to tend to drive the water from the Cattewater, *Laira*, and Sutton Pool, westward, where, between the west end of Batten Pier and the ladies'

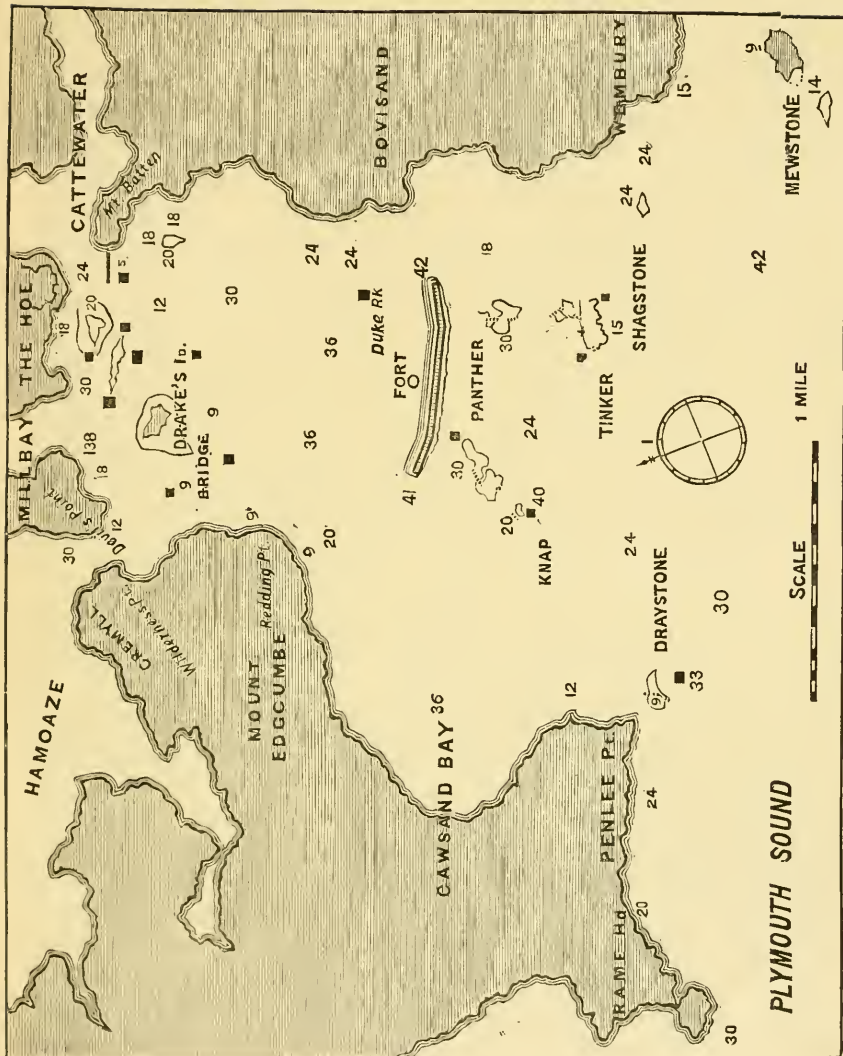
\* I have much pleasure in acknowledging the great help I received from the fisherman to the Laboratory, W. Roach, without whose astonishing knowledge of the submerged rocks, &c., it would have been impossible for me to do as I did.

open bathing-place below the Hoe, the weeds are not so clean as in many other localities.

*Firestone Bay*.—The shore of this bay is being completely altered. The west part of the beach has been converted into an artificial stony embankment, on which now the commonest of weeds grow. It seems useless to look for the rare forms at one time found on its shores—*Crouania attenuata*, *Spyridia filamentosa*, *Chrysymenia rosea*, *Striaria attenuata*. Blasting is in full operation in the eastern part of the bay, with a consequent disturbance of the flora.

I would record here my great indebtedness to Mr. G. C. Bourne, the Director of the Laboratory, for the liberal use I was allowed to make of the resources of the Association for the supply of material. I could not have wished for more use,\* having regard to the needs of the zoologists engaged in investigations in the Laboratory. I cannot hope to give an adequate idea of the innumerable opportunities for research. The brackish waters, with their accompanying mud-banks, furnish many plants needing investigation; Plymouth waters were long ago pointed out by Harvey as pre-eminently a habitat of the genus *Callithamnion*. There is quite enough material obtainable for the study of the unknown life-history of the plants *Dictyotaceæ*, *Ectocarpus*, *Tilopteris Mertensii*, *Pylaiella*, *Mesoglaea*, *Punctaria*, *Arthrocladia villosa*, *Sporochnus pedunculatus*, *Asperococcus*, *Bryopsis*, *Codium*, &c., and many *Floridææ* (until the great work on the *Floridææ* by F. Schmitz appears it is impossible to say what requires to be done in this group). One or two examples may be given. *Arthrocladia villosa*, described as occurring in Firestone Bay only, I found in at least seven other localities, and in several places in quantity. *Stenogramme interrupta* is a plant of which very little is known. There is doubt even as to the position of the tetraspores; male organs are unknown, and there is no description of the procarpia or fruit formation. I have got material in which I am able to come to definite conclusions on all these points.

\* The greater part of my work was done by the help of the dredge in the "Firefly," "Mabel," or "Anton Dohrn." Occasionally I used grappling-irons, working alone in a punt. In this case I either made the punt stationary to buoys, &c., and then hurled the grapples as far as possible, drawing them in slowly and with steady motion, or else I fastened the rope of the grapples to the boat, and rowing slowly dragged the grappling-irons for some distance. I used sometimes a small anchor with half a dozen curved, radiating teeth; or, better, grapples of a similar form, but made of soft iron, so that if caught on a rock a vigorous pull bent the iron and released the whole. A straight bar of iron, with a horizontal row of curved teeth on one side, was also very useful. In some localities where *Laminaria* is growing in plenty, e.g. some parts of Firestone Bay, grappling is better than dredging, for the dredge becomes choked in the first few yards with *Laminaria* and nothing can then enter.



Map of Plymouth Sound, illustrating the localities mentioned in Mr. Johnson's paper on the Flora of Plymouth Sound. The figures show the depths in feet.

## DREDGING RESULTS.

I was early anxious to ascertain whether the southern and sub-tropical weeds which reach their northern limit on the south coast of England (in many instances), and which are mentioned by Boswarva and others as found occasionally washed ashore on the east (Bovisand) and west (Mount Edgcumbe) sides of the Sound, had definite localities in the Sound ; and whether, if such localities occurred, they were such as to account for the occasional presence on the two shores of the same rare species. With these objects in view I dredged along the two shores and across the Sound, outside and within the Breakwater. Outside the Breakwater the huge rocks interfered with my plans ; inside, the cables connecting the main forts caused much trouble. Spite of these drawbacks the results were such as to show that the weeds referred to (e. g. *Stenogramme interrupta*, *Spyridia filamentosa*, *Scinaia furcellata*, *Dudresnaia coccinea*, *Halymenia ligulata*, *Spondylothamnion multifida*,\* *Antithamnion plumula*, *Sporochnus pedunculatus*, *Arthrocladia villosa*, *Taonia atomaria*) have a habitat in the Sound, and are, in nearly every case, found in some spots in quantities large enough to allow one to assign to them definite localities, from which (as I proved) further supplies could be drawn. The dredge, used along the eastern part of the Sound from Bovisand Pier to Batten Pier, yielded only poor results. With the exception of one or two patches in Jennycliffe Bay, Rum Bay, and Batten Bay, the sea bottom was muddy and comparatively free from weeds. I need not do more than refer to the effect I have supposed the Breakwater to have had on the eastern part of the Sound. No doubt the winds which in the stormy times before 1841 washed dead bodies into Rum Bay would, in calmer weather, bring enriching algal spores. One of the richest localities in the Sound is that included in the triangular area formed by joining Bovisand Pier, the Beacon on the east end of the Breakwater, and the Duke Rock Buoy. The region round the Duke Rock Buoy is especially good ; that south of the buoy may be taken as a habitat† for *Stenogramme interrupta*, *Dudresnaia coccinea*, *Scinaia furcellata*, *Halymenia ligulata*, *Antithamnion plumula*, *Spondylothamnion multifida*, and *Taonia atomaria*. I found *Stenogramme*

\* I use throughout these pages the specific names employed by Hauck in *Die Meeresalgen*, 1885 (Rabenhorst's Cryptogamen-Flora, ii).

† It should be remembered that my personal knowledge was gained in the months of August and September, and that my remarks refer of necessity to these two months. I do not attempt any comparison between the flora of Plymouth, Torquay, Falmouth, and such places.

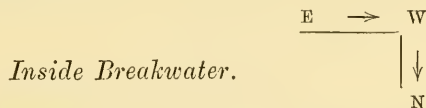


*interrupta* in plenty, tetrasporous, male and female plants, and hope to publish shortly the results of my examination of this interesting plant. *Dudresnaia coccinea* (tetrasporous and ♀ plants) was also in quantity, and in such a condition as to allow one to follow out all the stages in the strange formation of the cystocarps, first made known by Thuret and Bornet. A month earlier (middle of June to middle of July) would have yielded still better results.

The following are the more important forms met with in the triangular area :

<p>S. <i>interrupta</i>, and the others just named.</p> <p><i>Callithamnion seirospermum</i>, and other species.</p> <p><i>Antithamnion plumula</i>, <math>\alpha</math> geniculum, and <math>\beta</math> crispum, tetraspores, ♀, ♂, fruits.</p> <p><i>Naccaria Wiggghii</i>, ♀, fruit.</p> <p><i>Bonnemaisonia asparagoides</i>, ♀ fruit.</p> <p><i>Delesseria ruscifolia</i>, fruit.</p>	<p><i>Rhodophyllis bifida</i>, tetraspores, fruit.</p> <p><i>Nitophyllum Hilliæ</i>, tetraspores, fruit.</p> <p><i>Gracilaria confervoides</i>.</p> <p><i>Sporochnus pedunculatus</i>.</p> <p><i>Dictyota dichotoma</i>, ♂, ♀, tetraspores.</p> <p><i>Sphacelaria cirrhosa</i>.</p> <p><i>Striaria attenuata</i>.</p>
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Dredging between (1) the lighthouse on the west end of the Breakwater, and Picklecombe Fort on the mainland yielded *Halymeria ligulata* in abundance, with cystocarps, *Scinaia furcellata*, *Sporochnus pedunculatus*, *Bonnemaisonia asparagoides*, *Rhodophyllis bifida*, and *Dictyota dichotoma*, all fertile; and combined with dredging between (2) Queen Ground Buoy, Panther Buoy, and Breakwater lighthouse showed (spite of the nature of the sea bottom, which in some places is very rocky, in others sandy, neither condition being favorable to dredging) that, except for *Stenogramme interrupta* and *Taonia atomaria*, the weeds found at the west entrance to the Sound are very much the same as those found in the east entrance (round the Duke Rock Buoy). In all, representatives of at least forty genera (in some cases several species) were found. *Monospora pedicellata* and *M. clavata* with monospores, *Phyllophora rubens* with nemathecium, *Arthrocladia villosa* with zoosporanges, *Punctaria tenuissima* were met with here, and not in the east entrance.



Dredging inside the Breakwater across the Sound, east to west, was, as already said, interfered with by the forts' cables. The weeds found are not improved in quality by the use of this ground as the anchorage for the men-of-war, cinders, &c., being dredged in

abundance. *Stenogramme interrupta*, *Dudresnaia coccinea*, *Scinaia furcellata*, *Halymenia ligulata*, were not met with behind the Breakwater. Near the western buoy *Arthrocladia villosa* was obtained in quantity. In addition the following more important forms :

Antithamnion plumula, $\beta$ .	Hydrolapathum sanguineum.
Callithamnion thuyoideum ( $\delta$ , tetraspores), &c.	Rhodymenia palmata, R. palmata, R. ciliata.
Spondylothamnion multifida.	Phyllophora membranifolia, P. rubens (fruit).
Chantransia virgatula.	Dictyopteris polypodioides (a little).
Ceramium tenuissimum, fruit, tetraspores.	Striaria attenuata.
Nitophyllum punctatum, N. Hilliae, N. laceratum, N. Bonne-maisoni, $\delta$ .	Desmarestia aculeata, D. ligulata.
Delesseria alata, D. ruscifolia.	Dictyota dichotoma.

*Area enclosed by East Winter and other Buoys in Centre of Sound.*

Here (the mud "cakey" and a home for nemertians) the following are the more important forms observed :

Antithamnion plumula.	Rhodophyllis bifida.
Monospora pedicellata.	Delesseria ruscifolia, D. hypoglossum.
Chrysomenia rosea.	Phyllophora palmettoides.
Chylocladia clavellosa.	Punctaria latifolia.
Lomentaria corallina.	Desmarestia ligulata.
N. punctatum.	

The western part of the Sound, from Picklecombe Fort in the south to the bridge on the Mount Edgecumbe side in the north, is too dangerous for any nearer examination in the "Firefly" than that part marked out in the Admiralty chart as the regular passage to the Hamoaze. The bridge itself is covered with *Rhodymenia palmata* and *Laminaria digitata*, only a few other, and these common, forms being found. *L. digitata* is well exposed at low tide, thus illustrating a statement of Cocks, made twenty years ago, that this plant was gradually taking up a littoral position, and ceasing to be met with only as an extra-tidal weed.

*North of the Bridge.*

Dredging here showed a poor flora, the strong currents, no doubt, being to a very great degree accountable. It was of interest to find, though as scraps only, *S. interrupta*, *Chrysomenia rosea*, and *Dudresnaia coccinea*.

*Barn Pool.*

Owing to the very strong currents, dredging here is not possible, except for an hour before and after the turn of the tide. The results, so far as seaweeds are concerned, were negative,\* the dredge, in the parts nearer the shore, filling each time with large stones covered with ascidians.

*The Hamoaze.*

Owing to the extremely muddy nature of the bottom of the Hamoaze, dredging, except in one or two localities, is almost useless. The dredge quickly fills with mud, in which only a few weeds, not essentially different from the adjacent shore forms, are found imbedded, and not until much washed, fit for examination. The bottom of the Hamoaze, along the Royal Victualling Yards and along the building sheds, is not muddy—indeed, in the latter region it is very rocky in places, but yields weeds of the commoner kind only. Shore-hunting, either on foot, when one must be prepared to sink ankle-deep in mud, or better, in a punt, is the most successful mode of examination. Mr. Holmes has made many interesting “finds” at Torpoint. Owing to the regulations affecting the approach of steamers to the powder magazines, I was not able to take more than three or four dredgings off St. Peter’s Point. Shore-hunting on foot at the Point itself is full of interest, but very disagreeable. On the Saltash side of the Point the beach is stony for a short distance, and here it is useful to wade at low spring tide, and to pick up, in the muddy water, stones which will be found, in many cases, covered with delicate, filamentous, red weeds. Nearer Saltash it is necessary to take to the punt and to continue the shore examination in it, as the rocky beach ends abruptly, and wading is impossible. In the following list I give only the more important of the locally established weeds, making no mention of the many evidently Sound-drifted ones :

Delesseria hypoglossum, in all conditions, in abundance.  
 Griffithsia corallina, tetraspores,  
 ♂, ♀.  
 G. setacea.  
 G. devoniensis.  
 Antithamnion plumula, β, ♀,  
 &c.

Dasya ocellata.  
 Callithamnion seirospermum, C.  
 gracillimum, &c.  
 Chylocladia clavellosa, tetra-  
 spores, ♀.  
 Chondrus crispus.  
 Species of Ulva and Entero-  
 morpha, abundant.

\* This was the more disappointing, as I hoped to find the rare weed *Carpomitra Cabrerae*, which twenty years ago was found by Cocks established on Mount Edgcumbe mud-bank.

The preceding forms were, on the whole, better represented on the rocky beach.

*Beggar's Island (Rat Island).*

No algologist visiting Plymouth should omit to examine Beggar's Island and the region round St. Peter's Point, just described. Beggar's Island at low spring tide, on its west and south-west sides, presents a most interesting sight of weeds growing in brackish waters.\* The more interesting forms found were—

Antithamnion plumula, $\beta$ , very fine plants.	Polysiphonia, several species.
Griffithsia corallina.	Halymenia ligulata, several pieces, probably drifted.
Pleonosporium Borreri.	Ectocarpus siliculosus, E. tomentosus, &c.
Dasya ocellata, D. coccinea.	

*Firestone Bay.*

I have already mentioned how poverty-stricken the beach here is, the shore embankment, &c., being covered with the commoner species of *Fucus*, *Ascophyllum nodosum*, *Rhodymenia palmata*, *Gigartina mamillosa*, *Ectocarpus*, &c. I saw no signs of such rare forms as *Crouania attenuata*, *Arthrocladia villosa*, *Spyridia filamentosa*. In the extreme south-west of Firestone Bay, just off the beach, the dredge mouth became choked almost at once with *Laminaria digitata*. Deeper in, and in a north-easterly direction, the results are better, including—

Stenogramme interrupta, tetraspores, ♀.	Nitophyllum punctatum, 4-spores, ♂, ♀.
Spondylothamnion multifida, fruit.	Chantransia virgatula, on Zosteria.
Antithamnion cruciatum.	Gracilaria confervoides.
A. plumula, $\beta$ .	Ceramium diaphanum.
Chylocladia clavellosa, fruit.	Scytosiphon lomentarius.
Bonnemaisonia asparagoides.	Chorda filum.
Monospora pedicellata.	Punctaria (plantaginea?).
Delesseria hypoglossum, D. ruscifolia.	Desmarestia aculeata.
Rhodymenia laciniata, † fruit.	Cladostephus, Ectocarpus.

I dredged in this bay a *Crouania*-like plant which seemed to

\* Care must be taken in passing from the west to the less interesting central and eastern parts. Several times I sank knee-deep in mud.

† Miss A. L. Smith, of the Normal School of Science, is at present engaged on the examination of the development of the fruit of *R. laciniata*, and has already obtained many interesting results.



agree with Kützing's genus *Sporacanthus*. Through the kindness of the distinguished algologist, Dr. E. Bornet, I am able to say that it is a form of *Antithamnion cruciatum*, with pentamerous whorls of ultimate simple acicular branches, on which the scooped-out intercalary tetraspore-like bodies are *reserve-spores* according to the observations of Berthold.\* Dr. Bornet sent me a plant of *A. cruciatum*, dredged at Antibes, having both tetraspores and reserve-spores.

*Drake's Island.*

The shore of the greater part of this island is not rich in weeds. In the extreme south-west I found *Bryopsis plumosa* growing in half a dozen half-tide rock-pools—the best locality in Plymouth Sound for this weed. The south-west rock-pools are fairly rich, the weeds, for the most part, like those found on the north-east and east shores, the more important forms being—

*Gigartina mamillosa*, in great abundance.

*Lomentaria ovalis*, ♀, tetraspores.

*Chylocladia articulata*.

Dredging and grappling combined showed the region north and north-west of Drake's Island to be surprisingly rich in weeds, as the accompanying list will indicate :

*Stenogramme interrupta*, fruits, in abundance.

*Dudresnaia coccinea*.

*Sphærococcus coronopifolius*.

*Gracilaria confervoides*.

*Griffithsia corallina*.

*Antithamnion plumula*, β.

*Callithamnion*, several species.

*Bonnemaisonia asparagoides*.

*Ceramium tenuissimum*.

*Sarcophyllis edulis*.

*Phyllophora membranifolia* (P. palmettoides?).

*Rhodophyllis bifida*, fruit.

*Nitophyllum venulosum* (N. thysorhizans of Holmes).

*Gracilaria confervoides*.

*Chondrus crispus*.

*Porphyra*.

*Dictyota dichotoma*.

*Desmarestia*.

*N. laceratum*.

*Rhodymenia laciniata*.

*Chylocladia articulata*.

*C. clavellosa*.

*Gigartina mamillosa*.

*Gelidium corneum*.

*Dasya coccinea* (almost everywhere).

*Cutleria multifida*, ♀.

*Dictyopteris polypodioides*.

*Taonia atomaria*.

*Dictyota dichotoma*.

*Asperococcus compressus*.

*Scytosiphon lomentarius*.

*Cladostephus*, *Sphacelaria*, *Ectocarpus*, *Cladophora*, species.

Up to the present the different observers of fertilization in the *Cutleriaceæ* have failed to observe the nucleus in the ovum. I am

\* Berthold, U. d. Vertheilung d. Algen, i, S. v, Neapel.

about to publish the results of an examination of the ova of *Cutleria multifida* at the time of fertilization, my examination by means of the microtome leading me to say that the ovum is, as to be expected, nucleated. Hence, if I am correct, a re-examination of the process of fertilization in the *Cutleriaceæ*, in which account will be taken of the behaviour of the ♀ pronucleus, is necessary. I propose to use the microtome in the examination of the ova of other brown seaweeds, making use of much the same method as that which has been so successfully employed in the investigation of the maturation, &c., of the animal ovum.

I was quite unsuccessful dredging off the entrance to Mill Bay, the inner waters of which I did not examine. Dredging off the Laboratory, and in an easterly direction towards Batten, the specimens found were generally small and dirty, especially in Batten direction.

The chief forms found were—

*Halymenia ligulata* (a little).  
*Nitophyllum seirospermum*, N.  
 punctatum.  
*Rytiphlæa complanata*.  
*Callithamnion*, several species,  
 including *C. thuyoideum*.  
*Antithamnion cruciatum*, A.  
 plumula.  
*Bonnemaisonia asparagoides*.  
*Sarcophyllis edulis*.  
*Kallymenia Dubyi*.  
*Gigartina mamillosa*.  
*Gracilaria confervoides*.  
*Rhodophyllis bifida*.

*Rhodymenia laciniata*, R. ciliata,  
 R. palmata.  
*Delesseria alata*, D. hypoglossum,  
 D. ruscifolia.  
*Chylocladia clavellosa*, C. articulata.  
*Monospora pedicellata*.  
*Chantransia virgatula*.  
*Gelidium corneum*.  
*Ceramium diaphanum*.  
*Punctaria*, *Desmarestia*, *Chorda*  
 filum.  
*Laminaria saccharina*.

*Bryopsis plumosa* is found in several pools on the beach below the Laboratory, immediately east of the ladies' bathing-place. In one plant found here I saw zoospores, without, however, being able to bring about the dehiscence of the zoosporange.

#### *The Laira.*

Dredging in the Laira, as in the greater part of the Hamoaze, is, owing to the mud, out of the question. Under the Laira railway bridge, at the bases of the pillars, the genera *Ulva* and *Porphyra* are to be found in great plenty. The mud-banks above the railway bridge were, owing to the thick deposit of china clay works' refuse, too soft for extensive searchings on foot. I found it necessary to stay in the punt, and to pick up with the boat-hook as I moved

along any weeds required. The brackish waters of the Laira are not so rich as those off St. Peter's Point and Beggar's Island in the Hamoaze. I found—

Antithamnion plumula, $\alpha$ and $\beta$ .	Pleonosporium Borreri.
Delesseria hypoglossum.	Pylaiella littoralis.
Species of Callithamnion, Polysiphonia, and Ceramium.	Ectocarpus tomentosus.

I must have overlooked *Griffithsia*. Leaving the Laira, one may find, on the projecting end of Batten Pier amongst other plants, *Antithamnion plumula*,  $\beta$ , and *Callithamnion gracillimum*; and in Batten Bay, in the region of the Cobbler Buoy,—

Callithamnion thuyoideum.	Rhodophyllis bifida.
Antithamnion cruciatum.	Chylocladia clavellosa.
Monospora pedicellata.	Stilophora rhizodes, 1-loc. and 8-loc. sporangia.
Rhodymenia palmata, R. laciniata, R. palmetta.	Bryopsis plumosa.

I propose now to consider that part of the Sound which is on the English Channel side of the Breakwater, and to begin with—

#### Cawsand Bay.

This bay, especially in its south-west part, is pre-eminently the habitat for *Spyridia filamentosa* and the different species of *Ceramium*. The sandy rock-pools with stones in them, on the north side of the bay from Picklecombe Fort westwards, are especially good, and provide one of the best localities in Plymouth for the examination of littoral weeds, the following amongst others being found here:

Gracilaria confervoides, in abundance.	Chantransia virgatula.
Polyides rotundus.	Gymnogongrus plicatus.
Fastigiaria furcellata.	Porphyra.
Rhodomela subfusca.	Scytosiphon lomentarius.
Dasya arbuscula and D. coccinea.	Asperococcus.
Chylocladia, Ceramium, Polysiphonia, Callithamnion.	Pylaiella littoralis.
Rhodymenia, species.	Myriotrichia clavæformis, 1-loc. sporangia.
Gelidium corneum.	Sphacelaria, Cladostephus, Desmarestia aculeata.
Gigartina mamillosa.	Ectocarpus, Ulva, Enteromorpha, Cladophora.
Very little Delesseria or Nitophyllum.	Bryopsis plumosa.

Shore-hunting on the south side can scarcely be carried on at all except in a boat, and the flora is not rich in variety, Laurencia, Chylocladia, Polysiphonia, Ceramium, being the more important

genera represented. Dredging in Cawsand Bay yields a rich harvest of interesting forms, including in the north part of the bay—

*Stenogramme interrupta*.

*Spyridia filamentosa*, tetra-spores, ♀.

*Dudresnaia coccinea*, tetra-spores, ♀.

*Halymenia ligulata*.

*Naccaria Wiggghii*, fruit.

*Spondylothamnion multifida*.

*Sarcophyllis edulis*.

*Gracilaria confervoides*.

*Phyllophora*, *Fastigiaria*, *Rhodomela*, *Delesseria*.

*Ceramium*, *Dasya*, *Gelidium*, species.

*Rhodymenia jubata* and other species.

*Rhodophyllis bifida*.

*Gigartina mamillosa*.

*Callithamnion seirospermum* and other species.

*Antithamnion plumula*,  $\alpha$  and  $\beta$ , ♂, ♀.

*Chantransia virgatula*, ♂, ♀.

*Chylocladia parvula*.

*Arthrocladia villosa*.

*Sporochnus pedunculatus*.

*Sphacelaria cirrhosa*, and *penata* with propagula and sporangia.

*Asperococcus compressus*, with sporangia.

*Scytosiphon lomentarius*.

*Chorda filum*.

*Dictyopteris polypodioides*.

*Ulva*, *Enteromorpha*, *Cladophora*.

I found no better dredging locality for the different species of *Ceramium* than that between North Point and Pier Cove, in the 2—4 fathoms limit as indicated on the Admiralty chart. In this part and towards Penlee Point *Zostera* beds are plentiful, affording anchorage for different algæ. I was pleased, too, to find a definite locality for the rare (Plymouth) weed, *Spyridia filamentosa*. Most of the specimens found were tetraspore-bearing plants (a good sign so far as the propagation of the species is concerned); ♂ and ♀ plants were also found in sufficient quantities to permit one to work out in detail the sexual organs and fruit formation. The dredge should be used in the “ $1\frac{3}{4}$ — $2\frac{1}{4}$ ” fathoms belt, as near in to the rocks as possible, immediately south of Cawsand landing beach, and on the shore side of any moored boats. Cawsand Bay is not one of the easiest waters in which to dredge; on the south side the boat-anchors are very troublesome, and on the north side there is a very rocky shore with many submerged rocks close in. In addition to many of the species of *Ceramium* and *Spyridia filamentosa*, *Callithamnion seirospermum*, *C. gracillimum*, *Antithamnion cruciatum* with reserve-spores, *Phyllophora rubens*, and the more important (though by no means all) of the weeds found in the north part of the bay, *e. g.* *Halymenia ligulata*, *Dictyopteris polypodioides*, *Gracilaria confervoides*, *Pylaiella littoralis*, *Ectocarpus siliculosus*, were dredged in the southern part of the bay.



*Rame Head to Penlee Point.*

This part of the coast is fully exposed; the rock-pools are not good, numerous, or easily approached. In a cove south of Eastern Gear I found scarcely one filamentous weed, membranous weeds only. Dredging showed, on the whole, a similar general scarcity or absence of weeds. *Hydrolapathum sanguineum* is especially abundant here. In addition I found—

Bonnemaisonia asparagoides.  
Spondylothamnion multifida, in  
plenty.  
Antithamnion plumula,  $\alpha$  and  $\beta$ ,  
in plenty.  
Delesseria alata, *D. ruscifolia*.  
Sarcophyllis edulis.

Dictyopteris polypodioides and  
pennata.  
Sphacelaria cirrhosa.  
Cladostephus, Ectocarpus, and  
several others (6—8) common  
genera.

*Whitsand Bay.*

Owing to the very sandy nature of the bottom of this bay, and the scarcity of weeds, the dredge is of very little use, digging into and filling with sand in a few yards, with a resulting stoppage of the steamer if slowly moving. In the extreme east of the bay the ground is very rocky, and, owing to weather and want of time, my work here was confined to the shore weeds. Nowhere did I find more driftweed, and probably after a storm a rich harvest would be reaped in Polhawn Cove, below the Coastguard Station. The rock-pools are good, and well stocked with most of the weeds to be met with in the littoral zone of Plymouth waters, well repaying examination. The beach, 300 yards west of Polhawn Cove, is very barren for miles. Time after time the dredge when hauled in showed only one or two weeds, and had I relied for my conclusions on the contents of the dredge, I should have supposed that only very few weeds were present in Whitsand Bay, and that these were confined to half a dozen genera (excluding from this generalisation the unexamined eastern part of the bay). Fortunately I was allowed to overhaul the trawl of the "Penguin," after a run from west to east of the bay (nearly three miles).

On this trawl I found representatives of at least forty genera. I took off every weed on the trawl for detailed examination later. The weeds from this trawl, with a fifteen-foot beam, after a run of nearly three miles, occupied no more space than those taken in Cawsand Bay in the dredge after a run of 30—40 yards. The more interesting forms trawled were—

*Stenogramme interrupta*, 4-  
 spores, ♀.  
*Phyllophora rubens*.  
*Polyides rotundus*.  
*Spondylothamnion multifida*.  
*Antithamnion plumula*, β, A.  
*eruciatum*.  
*Bonnemaisonia asparagoides*.  
*Hydrolapathum sanguineum*.  
*Rhodomela subfusca*.

*Gracilaria confervoides*.  
*Cutleria multifida*.  
*Dictyopteris*, ♂, ♀, 4-spores.  
*Dictyota dichotoma*.  
*Sporocchnus pedunculatus*.  
*Arthrocladia villosa*.  
*Desmarestia ligulata*, D. acu-  
 leata.  
*Sphacelaria filicina*.  
*Fucus canaliculatus*.

It is naturally impossible to say at what particular point in the three miles course the different weeds were gathered by the trawl. Later in the same day the "Penguin" trawled inside the Sound from the Breakwater lighthouse to Batten Pier, and on the trawl many of the rarer weeds, previously described as growing in the Sound, were found, but in what particular locality they were taken up it is not possible to say. Such weeds were *Spyridia filamentosa* (the only time I found it in the inner part of the Sound), *Stenogramme interrupta* (in abundance), *Nitophyllum Bonnemaisoni* and *N. Hilliae*, *Scinaia furcellata*, *Sphærococcus coronopifolius*, *Griffithsia corallina*, *Arthrocladia villosa*, *Dictyopteris polypodioides*.

#### *Bovisand Bay.*

The local interpretation of "Bovisand Bay" is much wider than that sanctioned by the Admiralty chart. Locally, one understands the waters between Staddon Point in the north, Renny Point and the Shagstone in the south. The beach of Bovisand Bay proper ordinarily presents but few weeds; after a storm the weeds, it is said, lie ten to twelve feet thick, tons being carted away as manure. Between Andern Point and Renny Point, especially in the immediate neighbourhood of Renny Point, the rock-pools are well stocked with various weeds, including *Nemalion multifidum*, *Chylocladia articulata*, *Lomentaria kaliformis*, *Ceramium acanthonotum*, *C. ciliatum*, and species of *Chantransia*, *Griffithsia*, *Rhodomela*, *Laurencia*, *Delesseria*, *Gymnogongrus*, *Spondylothamnion*; *Ptilota elegans* (in great abundance), *Gelidium corneum* (several varieties, in plenty), *Mesogloea vermiformis*, *Dictyota*, *Ectocarpus*, *Cladophora*, *Bryopsis plumosa*.

Dredging in the waters between Staddon Point and Renny Point brings to light many interesting plants, which, taken in connection with those dredged round the Duke Rock Buoy, readily explain the occasional finding, as cast-up weeds, of *Stenogramme interrupta*, *Spyridia filamentosa*, &c. I dredged in Bovisand Bay at least 90 of the 350 species found in Devonshire waters, including—

*Stenogramme interrupta*.  
*Spyridia filamentosa*.  
*Dudresnaia coccinea*.  
*Scinaia furcellata*.  
*Microcladia glandulosa*.  
*Nitophyllum versicolor*, Hilliæ,  
*laceratum*, *punctatum*.  
*Phyllophora Brodiaei*, *palmet-*  
*toides*, *rubens*, *membranifolia*.  
*Rhodymenia laciniata*, *ciliata*,  
*palmata*.  
*Rhodophyllis bifida*.  
*Chylocladia articulata*, *parvula*,  
*clavellosa*.  
*Lomentaria kaliformis*, *ovalis*.  
*Delesseria alata*, *ruscifolia*,  
*sinuosa*, *hypoglossum*.  
*Hydrolapathum sanguineum*.  
*Gracilaria confervoides*.  
*Polyides rotundus*.  
*Fastigiaria furcellata*.

*Sarcophyllis edulis*.  
*Kallymenia microphylla* (K.  
*reniformis*).  
*Antithamnion plumula*,  $\alpha$  and  $\beta$ ,  
*A. cruciatum*.  
*Ceramium echniolum*, *ciliatum*,  
*diaphanum*, *decurrens*, *tenu-*  
*issimum*, *flabelligerum*, *ru-*  
*brum*.  
*Spondylothamnion*.  
*Bonnemaisonia*.  
*Callithamnion*, *Chantransia*.  
*Gigartina*, *Chondrus*.  
*Gymnogongrus plicatus*.  
*Griffithsia corallina*.  
*Corallina officinalis*, *C. squamata*.  
 Species of *Porphyra*, *Dictyo-*  
*pteris*, *Dictyota*, *Cutleria*,  
*Sphacelaria*, *Cladostephus*,  
*Ulva*, *Enteromorpha*.

I found Bovisand Bay the best locality for *Nitophyllum* and *Phyllophora*.

#### Wembury Bay.

Passing south-east from Renny Point one comes to a number of fine rock-pools, the ridge on which they occur running out from the mainland so as to join, within a few yards, the outlying rocks of the Mewstone. The passage left is so narrow and shallow that in the lowest spring tides one can, I am told, wade across. Many of the rock-pools are sandy, and have excellent *Zostera* beds. I do not know any more instructive locality in Plymouth waters for shore-hunting than Wembury Point.

*Cystoclonium purpurascens* and  
 $\beta$  *cirrrosa*,  
*Rhodymenia jubata* and  $\beta$   
*cirrrosa*,

*Codium tomentosum*,  
*Dictyota dichotoma*,  
*Mesogloea vermiformis*,

not to mention others, were all found in plenty.

On the rocks east of this reef the marine lichen *Lichina pygmaea* grows abundantly at half-tide. The rock-pools below Wembury Church are also full of interest, and amply repay examination. Here were growing in plenty *Gigartina pistillata* in fruit, *Monospora pedicellata*, *Corallina rubens* and  $\beta$  *corniculata*, *Gymnogongrus plicatus*, *Chordaria flagelliformis*, *Codium tomentosum*.

Wembury Bay itself abounds with submerged rocks, and a thorough knowledge of its topography, as Roach had, is necessary in dredging. There is no better locality for the *Phæophyceæ* and the *Corallinaceæ* than Wembury Bay. Chief weeds found :

Corallina officinalis, squamata, rubens, and $\beta$ corniculata.	Delesseria alata, D. sinuosa.
Gracilaria confervoides.	Dictyopteris polypodioides.
Rhodymenia jubata.	Dictyota dichotoma.
Fastigiaria furcellata.	Taonia atomaria.
Bonnemaisonia asparagoides.	Sporochnus pedunculatus.
Species of Callithamnion, Rhodomela, Polysiphonia, and Lomentaria.	Mesogloea, Sphacelaria, Cladostephus, Punctaria, Leathesia species.

*The Mewstone.*

The rock-pools of this interesting rock are well worth a visit; protected on the north side and close to the mainland, they are on the south side, for the most part, exposed to and in connection with an open sea. They are richest in the north, north-east, and south-west parts, and, as would be expected, the weeds found in the north and north-east pools are much the same as those found on the mainland opposite. I was pleased to find here a very fine plant of *Codium tomentosum* bearing zoosporanges, the whole plant a single multinucleate cell, weighing at least three pounds!

Polyides rotundus.	Gymnogongrus plicatus.
Sarcophyllis edulis (in plenty).	Several species of Callithamnion (including <i>C. polyspermum</i> ), Polysiphonia, Ceramium.
Dasya ocellata.	Cutleria multifida, ♀, and Laminaria bulbosa, drifted.
Nitophyllum Hilliæ, N. punctatum.	Dictyota, in plenty.
Rhodophyllis bifida.	Desmarestia, Sphacelaria, Cladostephus, Ectocarpus, Bryopsis, &c., were found here.
Antithamnion plumula.	
Gigartina mamillosa.	
Nemalion multifidum.	
Gelidium corneum, several varieties (four or five in one pool).	

On the south and south-west parts, in addition to most of the foregoing, the following amongst others were found :

Delesseria hypoglossum, D. ruscifolia.	Fastigiaria.
Cystoclonium purpurascens.	Laurencia.
Phyllophora rubens.	Chylocladia.
Spandylothamnion.	Rhodymenia.
	Bangia.



Porphyra.

Mesogloea (in plenty).

On a calm day one can see the bottom of the sea, even to the recognition of particular weeds, in many places in Wembury Bay, north and east of the Mewstone. Circumstances prevented me from carrying out an intention of using the dredge or grapples in these places. Dredging half a mile south of the Mewstone, in seven to nine fathoms, 200—400 yards east of the Black Buoy, revealed the rare (British) weed *Dictyopterus polypodioides* in great abundance, with tetraspores, ♀ and ♂ organs. I read a paper on this genus before the Linnæan Society in December last, in which paper the results of my examination of this Plymouth material were incorporated. I was able to show that the *Dictyotaceæ* are true *Phæophyceæ*, and that they fall into a series in which Reinke's *Tilopterideæ*, of which the Plymouth representative is *Tilopteris Mertensii*, are included. Other weeds dredged here were—

Rytiphlæa fruticulosa.

Scinaia furcellata.

Bonnemaisonia.

Schizymenia.

Rhodymenia jubata.

Corallina rubens.

Asperococcus.

Gracilaria confervoides.

Delesseria sinuosa.

Gelidium corneum.

Cutleria multifida.

Sporochnus pedunculatus.

Taonia, Dictyota, Cladostephus.

#### *Mouth of the Yealm River.*

Dredging in the Yealm in three to six fathoms, off the Coast-guard Station and close in, furnished a locality for *Gracilaria multipartita* (*G. polycarpa*), *Halymenia ligulata*, *Scinaia furcellata*, *Dudresnaia coccinea* (all in abundance). The following were also dredged:

Spyridia filamentosa,

Gracilaria confervoides,

and species of Monospora, Antithamnion, Spondylothamnion, Delesseria, Nitophyllum, Rhodophyllis, Gymnogongrus, Chylocladia, Ceramium, Ectocarpus, &c.

Asperococcus bullosus,

Sporochnus pedunculatus,

#### *The Breakwater.*

I was prevented from examining the Breakwater at all fully. On the inner side the boulders, &c., were seen, at low spring tide, covered with *Fucus*, *Ozothallia*, *Laminaria*, *Halidrys*, growing amongst which were *Gigartina mamillosa*, species of *Callithamnion*, including *C. seirospermum*, *Ceramium*, *Chylocladia*, *Plocamium*,

*Rhodomenia*, *Pylaiella littoralis*, *Scytosiphon lomentarius*, *Bryopsis plumosa*.

*Middle Fort* (behind Breakwater).

Examination of the inter-tidal and extra-tidal surface of this fort brought to light *Spondylothamnion multifida* (very fine plants), several species of *Callithamnion*, including *C. thuyoides*, *C. seirospermum*, *C. gracillimum*, *Antithamnion plumula*,  $\beta$ , species of *Nitophyllum*, *Gigartina*, *Rhodomenia*, *Delesseria*, *Chylocladia*, *Porphyra*, *Desmarestia*, *Ectocarpus*, *Ulva*, &c.

*The Buoys*.

Examination of the buoys, with which Plymouth waters abound, serves to give one some idea of the migrations of marine plants. It should be remembered that all the buoys are thoroughly cleaned and repainted twice a year (before and after winter—end of September, beginning of April). They might be used, coated with different substances, for experiments having as their object the discovery of the best weed-growing preventatives as applied to ships' bottoms. The weeds were generally healthy, in full fruit, and firmly attached. Those on the White Buoy, south-south-west of Drake's Island, were relatively poor and insecurely attached.

*Draystone Buoy* (off Penlee Point).

It was of interest to find plants of *Rhodomenia palmata*, for in this species no British fruit-bearing specimen has yet been found, only tetraspore-bearing forms.

Amongst others on the buoy were *Chantransia*, *Polysiphonia*, including *P. Brodiaei* (the tufted branches of which form nests for *Isopoda*), *Punctaria*, *Scytosiphon*, *Sphacelaria*, *Ectocarpus*, *Ulva*, *Enteromorpha*. The weeds growing on the buoys outside the Breakwater, marking the east and west channels for vessels, included those found on the Draystone Buoy, and, in addition, *Bangia fusco-purpurea*, *Ceramium rubrum*, *Callithamnion*, *Laminaria saccharina*, *Desmarestia ligulata*. The weeds on the Duke Rock Buoy were similar to those on the outer buoys, but less abundant.

*Desmarestia*.—With the exception of a brief notice in *Études Phycologiques* by Thuret and Bornet (p. 16) of unilocular sporangia in *Desmarestia viridis*, no description of reproductive organs in any species of *Desmarestia* has yet appeared. On a small plant of *Desmarestia ligulata* I was fortunate enough to find (after examining every plant of *Desmarestia* met with during my stay) unilocular,

usually monosporous sporangia in the position in which Harvey nearly fifty years ago suggested, and in the cortex too. I hope to publish shortly a detailed description.

*Bigbury Bay.*

The rocks south of Yealm River mouth towards Stoke Point, fully exposed to the south-west gales, were generally barren like those between Rame Head and Penlee Point. East of Revelstoke Point, and well protected by it, there are good, well-stocked rock-pools. A short visit to the pools west of Revelstoke Church led me to think the weeds generally comparable to those found on the Renny Rocks, Wembury Point, and the Mewstone. *Cystoclonium purpurascens*, *Sarcophyllis edulis*, *Monospora*, *Griffithsia equisetifolia*, *Ptilota elegans*, *Mesoglaea vermiformis*, and many others were seen. The dredge brought up *Phyllophora rubens* with nemathecia, *Spondylothamnion multifida*, *Antithamnion plumula*, *Bonnemaisonia asparagoides*, *Dictyopteris polypodioides*, *Sphacelaria filicina*, &c.

I propose in a subsequent number of the Journal to continue my observations on the flora, to give a more detailed list of the species met with, and to trace out the distribution, in the different localities, of individual species. I have, I trust, said enough to show that there is no lack of algæ needing investigation. It is impossible for me to give an adequate idea of the details of the flora. I shall be only too pleased to place my knowledge, gained under such great advantages, at the service of algologists.

## Report of a Trawling Cruise in H.M.S. "Research" off the South-west Coast of Ireland.

By

**Gilbert C. Bourne, M.A., F.L.S.,**

Fellow of New College, Oxford, and Director of the Association.

THE cruise, of which the zoological results are given in this report, was undertaken at the suggestion of Capt. Wharton, R.N., F.R.S., hydrographer to the Admiralty, who kindly advised me that H.M.S. "Research" was to make a fresh series of soundings off the entrance to the Channel, and put me in communication with the captain of the ship. To Capt. Aldrich I am indebted for unbounded hospitality and attention whilst I was on board, and I take this opportunity of expressing my most hearty thanks both to him and to the officers on board for the hospitality and kindness which they afforded me, and for the help which they gave me in the trawling operations. The "Research" is a paddle vessel of 520 tons register, built last year for the express purpose of surveying, and provided with a steam winch, deep-sea trawls and dredges, and 1000 fathoms of wire rope, with accumulators and accessory tackle. The available space on board was limited; there was no separate cabin at my disposal, so Capt. Aldrich most kindly made me his guest and gave me a berth in his own cabin, and I was given as much room as could possibly be allowed for storing my bottles and other apparatus.

Having joined the ship at Queenstown, we left the harbour on the evening of Tuesday, July 9th, and stood on a westerly course for Cape Clear. On the 10th, having cleared the Irish coast, the ship's head was turned south, and a line of soundings was made on the edge of the bank which was under survey. During this and the three succeeding days the ship was turned westward for a few hours each day, and the trawl was shot in deep water off the bank. At night we returned to the bank and anchored. On Sunday, July 14th, we remained at anchor at the south-west extremity of the bank, and on Monday we resumed a northerly course on about the meridian of  $10^{\circ} 7' W.$  longitude, retracing our course on the 18th to run another line of soundings a little eastward of our previous position. During each of these days the trawl was shot on the bank in from 70 to 80 fathoms. During the expedition I took a number of hauls



with the tow-net, both in daytime and at night. On the 19th we made for Queenstown, and arrived in port in the evening, after a very enjoyable cruise, during which we were favoured with remarkably fine weather.

A little more than a week previously the Rev. W. Spotswood Green had undertaken a similar cruise in the "Flying Fox," belonging to the Clyde Shipping Company, and had trawled in considerable depths in nearly the same locality as that in which we began our operations, but he kept further north than we did throughout his trip. Being before me both in his cruise and in the date of publishing his results, Mr. Green has rather taken the edge of novelty off my work; but although I must yield the pride of priority to some of his species, which were new, and were taken immediately after by myself, the interest of the trawling in the "Research" is not in reality diminished by this circumstance. In fact, my cruise may be considered as complementary to that of the "Flying Fox," and continued the line of trawling much further south, giving a fuller and more comprehensive view of the bottom fauna of this part of the sea.

Some of the most interesting results of my cruise were the capture of a second specimen of *Solea Greenii*, Günther, a new species, of which a single specimen only was taken in the "Flying Fox;" the capture of *Macrurus lævis* and *Rhombus boscii*, both new to British fauna before Mr. Green's expedition, and of *Haloporphyrus eques*, which was not taken by him. I also took several specimens of the rare Asterid, *Nymphaster subspinosus*, a single specimen of *Eupagurus carneus*, Pocock, which was first taken by Mr. Green, three fine specimens of *Epizoanthus paguriphilus*, Verrill, and a new species of the genus *Leptothyra*.

The general results of the trawling at the different stations are given below, and the list of the species collected is given in a separate table. I undertook to work out the whole collection myself, which has delayed the publication of my report; but eventually I have had to go to several friends for assistance in some of the groups, and I have received much assistance from Canon A. M. Norman. Professor Jeffrey Bell has kindly given me a separate report on the Echinoderms.

Station 1. July 10th, 1889. Position, 50° 50' 15" N., 11° 12' 30" W.—The trawl was shot at 4 p.m. in 200 fathoms, and was down an hour and a half. The bottom consisted of fine sand, containing many Foraminifera. A large haul of fish, including many "megrimms" (*Rhombus boscii*), two species of *Macrurus* (*M. lævis* and *M. colorhynchus*); *Haloporphyrus eques*, a *Phycis*, many *Scorpana dactyloptera*, and a single large specimen of *Raia batis*; quantities of *Spatangus purpureus* and Holothurians (*H. tremula*), a

single specimen of *Asterias rubens*, and a few *Actinauge Richardi*, with other specimens, among which was a hitherto undescribed species of *Leptothyra*.

Station 2. July 11th. Position,  $50^{\circ} 29' 26''$  N.,  $11^{\circ} 4'$  W.—The trawl was shot at 11 a.m. in 400 fathoms, and was hauled up at 1.12 p.m., taking an hour and twenty-eight minutes in coming to the surface. It contained only one fish, *Haloporphyrus eques*, a great quantity of *Spatangus purpureus*, four specimens of *Nymphaster subspinosus*, multitudes of *Echinus norvegicus* sticking in the swabs; several crustacea, including *Eupagurus carneus*, *Lipsognathus Thomsoni*, *Scyramathia Carpenteri*, *Bathynectes longispinosa*, and *Ebalia nua*; three specimens of *Epizoanthus paguriphilus*, and other forms, among which were two or three specimens of *Actinauge Richardi*.

Station 3. July 12th. Position,  $49^{\circ} 50' 2''$  N.,  $11^{\circ}$  W.—The trawl was shot at noon in 200 fathoms, but capsized and came up empty. A few specimens of *Dorocidaris papillata* and some fragments of *Brisinga* were sticking in the swabs.

Station 4. July 13th. Position,  $49^{\circ} 5' 40''$  N.,  $11^{\circ} 14'$  W.—The trawl was shot in 217 fathoms, and brought up a single large specimen of *Lophius piscatorius*, half a dozen *Rhombus boscii*, a single *Macrurus laevis*, one *Solea Greenii*, and two small Gadoids. There were, as before numerous specimens of *Spatangus purpureus* and *Holothuria tremula*, and a few *Dorocidaris papillata*. The specimen of *Solea Greenii*, a female, is considerably larger than that taken by the "Flying Fox," and was perfectly ripe, the ova running out on deck when it was brought on board. When alive its upper surface was of a uniform chestnut-brown colour.

Station 5. July 15th. Position,  $48^{\circ} 59' 42''$  N.,  $10^{\circ} 7' 27''$  W.—The trawl was shot twice in ninety fathoms. The first time it capsized and came up empty; the second time it was full, and contained among other things four *Rhombus boscii*, two small rays, of doubtful position, large numbers of *Pecten opercularis*, several specimens of *Asterias glacialis* and *A. rubens*, *Ophiothrix Lütkeni*, numerous Polyzoa, chiefly *Cellaria* and *Cellepora*; several Hydroids, including some fine specimens of *Eudendrium rameum*; several colonies of *Alecyonium glomeratum*, half a dozen specimens of *Polythoa incrustata*, and a *Polythoa* which I have not been able to identify satisfactorily.

Station 6. July 16th. Position,  $49^{\circ} 23' 54''$  N.,  $10^{\circ} 8' 34''$  W.—The trawl was shot in seventy fathoms on the spot marked in the chart as the "Great Sole Bank." The trawl came up empty, though to judge from the runners it had been working evenly enough. The swabs contained some Ascidians and a *Hermione*. The trawl was shot a second time a few miles further on ( $49^{\circ} 26' 36''$  N.,  $10^{\circ} 10'$  W.), and again was unfortunate, as it capsized and came

up empty. A few Pycnogonids and many Hydroids and Polyzoa were sticking in the swabs.

Station 7. July 17th. Position,  $50^{\circ} 24' 45''$  N.,  $10^{\circ} 7' 30''$  W.—The trawl was shot at noon in seventy fathoms, and hauled two hours afterwards. When it came on board a large hole was found to be torn in the cod end, through which much of the contents must have escaped. The catch included among other things a single specimen of *Luidia* (probably *ciliaris*), several specimens of *Echinus acutus*, and a single specimen of *Porania pulvillus*. Among other Hydroids was a considerable quantity of *Tubularia coronata*.

Station 8. July 18th. Position,  $50^{\circ} 22' 21''$  N.,  $10^{\circ} 7' 30''$  W.—The trawl was down for two hours on a gravelly bottom. Depth about seventy fathoms. The contents did not differ much from those of the previous day. A single specimen of *Holothuria tremula* was taken, and the presence of numerous *Ophioglypha albida* and *Adamsia palliata* was the only noticeable feature. A large Actinian, apparently an *Actinoloba*, was also caught, but it was so much damaged as to be beyond recognition.

The following is a list of all the specimens taken in the trawl and identified. It must be understood that not every specimen was brought home for identification. As I was asked not to bring too much baggage on board, I limited my supply of bottles and spirit, and each day after examining the contents of the trawl, I preserved only such specimens as I could not recognise. Naturally enough, I had afterwards to regret not having preserved many specimens which I identified on board and returned to the sea; but, on the other hand, I am satisfied that my actual collections, together with my notes of species observed on board, give a very nearly accurate account of the fauna as exhibited in our trawling.

#### VERTEBRATA.—PISCES.

##### RAIA BATA, *Linn.*

A single large specimen at Station 1, 200 fath. I am not aware that this species has been recorded from so great a depth before. Dr. Günther (Challenger Reports, Deep Sea Fishes, p. 11) says that it has been observed on the Norwegian coast down to 150 fath.

##### RAIA, sp. incert.

Several specimens of a small ray were obtained at Stations 5 and 6. Being unable to identify them with any described species, I forwarded a specimen to Dr. Günther, who kindly examined it and wrote as follows:—"I cannot identify it with any of the known

British species ; it comes nearest to *Raia circularis* and *R. miraletus* (from the Mediterranean), but shows differences in the scutellation form of the body, and ornamental colouring. But it would be hazardous to offer a more definite opinion, as we know very little about the amount of variation and of the changes with growth and locality in rays."

All the specimens taken were apparently young.

TELEOSTEI.—*Acanthopterygii*.

SCORPÆNA DACTYLOPTERA, *De la Roche*.

Several specimens in 200 and 217 fath. This species was also taken by Mr. Green, before whose expedition it was unknown to British fauna.

LOPHIUS PISCATORIUS, *Linn.*

A single large specimen at Station 4, 200 fath. The angler, according to Brown Goode, is known to descend to considerable depths.

CALLIONYMUS LYRA, *Linn.*

Many specimens, Stations 7 and 8, 70 fath.

*Anacanthini*.

GADUS ARGENTEUS, *Guich.*

Two specimens at Station 4, 217 fath. This species was first found in the Mediterranean, and has only once been taken since, by the "Porcupine" in 1869, very close to the station at which I obtained it. (See Günther, Ann. Mag. Nat. Hist., xiii, 1874, p. 138.)

PHYCIS ALDRICHII, n. sp.

Two specimens of this genus were obtained at Station 1, from a depth of 200 fath. After careful examination (they are unfortunately a good deal damaged) I cannot identify them with any described species, and therefore propose to name it, provisionally, *Phycis Aldrichii*, in honour of my host, Capt. Aldrich. This form is very closely allied to *P. americanus*, Schn. (with which it may prove to be identical), differing from it chiefly in the first dorsal, the anterior rays of which are not elongated in *P. Aldrichii*.

The following is the description of the species :



D. 10/52. A. 50.

Length of the head somewhat less than one quarter the total length of the body, excluding the caudal fin. Eye equal in length to the snout. Length of eye rather more than one third the length of the head. Interorbital space less than the height of the eye. Barbel about three quarters the length of the eye. The first dorsal has its origin behind the insertion of the pectoral fin. The third ray of the first dorsal is the longest, but is not as long as the head. Length of the pectoral less than that of the head. Ventrals extend as far back as the third or fourth ray of the anal fin. Vertical and caudal fins edged with black.

The specimens described are 20 cm. long.

*HALOPORPHYRUS EQUUS*, *Günth.*

One specimen was obtained at Station 2, 400 fath. New to Great Britain. Numerous specimens were obtained in the Farøe Channel by the "Knight Errant" in 1880 and 1882.

*MACRURUS CÆLORHYNCHUS*, *Risso.*

Three specimens from Station 1, 200 fath. This species and the following were unknown to British fauna before Mr. Green's expedition.

*MACRURUS LÆVIS*, *Lowe.*

Several specimens from Stations 1 and 4.

*RHOMBUS BOSCHII*, *Risso.*

Many specimens from Stations 1, 4, and 7. I at first mistook this species for the "megrim," *Rhombus megastoma*, but the enormous size of the eyes shows it to be *R. boschii*. At Station 1 we trawled nearly a hundred, and ate nearly all of them under the impression that they were megrims. They are very good eating. This, again, is a species found by Mr. Green, and previously new to British fauna.

*ARNOGLOSSUS LATERNA*, *Günth.*

Many small specimens from Stations 5 and 7, 70 fath.

*PLEURONECTES CYNOGLOSSUS*, *Linn.*

Stations 1 (200 fath.) and 8 (70 fath.).

Dr. Günther, in the "Challenger" report on deep sea fishes,

notes the remarkable fact that this littoral species is sometimes found at considerable depths. The greatest depth recorded is 732 fath.

*SOLEA GREENII*, *Günth.*

Station 4, 217 fath. I obtained a single specimen of this interesting new species, discovered a week before my cruise by Mr. Green, who also only obtained a single specimen. Mine is a female, larger than the other, being 18.8 cm. in length, and was perfectly ripe when caught, the roe running out on the slightest pressure. When fresh the colour of the upper side was a uniform chestnut brown.

TUNICATA.

*ASCIDIA VIRGINEA*, *O. F. Müller.*

Two specimens adhering to *Serpula* tubes.

*ASCIDIA FUSIFORMIS*, *Herdman.*

Five specimens, adhering to Annelid tubes and Polyzoa, varying in size from three quarters of an inch to an inch and a quarter. The larger individuals contained numerous ova in the peribranchial cavity. These with the preceding species were dredged in 70 fath.

*DIPLOSOMA*, sp. ?

One small colony, attached to a Hydroid stem.

MOLLUSCA.—GASTEROPODA.

*LEPTOTHYRA BOURNEI*, *Norman.*

*Vide addendum by Canon Norman, p. 323.*

*SOLARIUM MEDITERRANEUM*, *Monterosato.*

*Vide addendum by Canon Norman, p. 322.*

*NATICA NITIDA.*

Station 7, 70 fath.

*CALYPTRÆA SINENSIS*, *Linn.*

Station 7. Several specimens.

*APORRHAI PES-PELECANI*, *Linn.*

Shell containing *Phascolion strombi* from Station 8.

APORRHAIIS PES-CARBONIS, *Brogn.*

Station 1, 200 fath.

MORIO (CASSIDARIA) TYRRHENA, *Chem.*

Two fine specimens of this rare Gasteropod were taken at Station 2, 400 fath.

FUSUS GRACILIS, *Da Cost.*

Several specimens from Station 2.

SCAPHANDER LIGNARIUS, *Linn.*

Several specimens from 70 fath.

#### NUDIBRANCHIATA.

ARCHIDORIS TUBERCULATA, *Cuvier.*

Two small specimens from Station 8. Mr. Garstang has examined these and finds that they do not differ appreciably from specimens trawled in shallower water near Plymouth.

#### CEPHALOPODA.

OCTOPUS VULGARIS, *Lamk.*

Two small specimens.

ELEDONE CIRRHOSA, *Lamk.*

One young specimen.

#### LAMELLIBRANCHIATA.

PECTUNCULUS GLYCYMERIS, *Linn.*

Several specimens from 70 fath.

ASTARTE SULCATA, *Da Cost.*

A specimen from Station 2, 400 fath.

VENUS CASINA, *Linn.*

Station 1, 200 fath.

PINNA RUDIS, *Linn.*

Several specimens from 70 fath.

PECTEN OPERCULARIS, *Linn.*

Common in 70 fath.

PECTEN SEPTEMRADIATUS, *Müll.*

A single specimen from Station 2, 400 fath.

PECTEN TIGRINUS, *Müll.*

From Station 8, 70 fath.

## CRUSTACEA. DECAPODA.

ATELECYCLUS HETERODON, *Leach.*

From 400 and 70 fath.

PORTUNUS TUBERCULATUS, *Roux.*

A single specimen. Station 7, 70 fath.

BATHYNECTES LONGISPINA, *Stimp.*

A single specimen of this rare species was taken in 400 fath.

XANTHO TUBERCULATUS, *Bell.*

Station 2, 400 fath.

ANAMATHIA CARPENTERI, *Norman.*

1873. ANAMATHIA CARPENTERI, *Norman.* In Wyville Thomson's Depths of the Sea, p. 175, fig. 35.

1883. SCYRAMATHIA CARPENTERI, *A. Milne Edwards.* Recueil de figures de Crustacés nouveaux ou peu connus, pl. ii.

1885. — — *G. O. Sars.* Norwegian N. Atlantic Expl. Expedit., 1876-8, Crustacea, p. 6, pl. i, figs. 1-7.

1886. ANAMATHIA CARPENTERI, *S. J. Smith.* Rep. Decapoda, "Albatross" Dredgings, p. 21.

Seven specimens from 400 fath.

Canon Norman sends me the following note:—"Mr. Pocock, in his recent paper on the trawlings of the 'Flying Fox,' says that he is not aware that this species had gained a right to be included in the



British Fauna; yet the type specimens, one of which was originally described in *The Depths of the Sea*, were distinctly recorded as having been dredged on the *Holtenia* ground off the Butt of Lewis."

INACHUS DORSETTENSIS, *Penn.*

LISPOGNATHUS THOMSONI, *Norman.*

1873. DORHYNCHUS THOMSONI, *Norman.* In Wyville Thomson's *Depths of the Sea*, p. 174, fig. 34.  
 1881. LISPOGNATHUS THOMSONI, *A. Milne Edwards.* Comptes Rendus, pp. 878 and 932.  
 1883. — — *A. Milne Edwards.* Recueil de figures de Crustacés nouveaux ou peu connus, pl. iii.  
 1883. — FURCATUS, *Smith.* Proc. Nat. Museum U.S., vol. vi, p. 18.  
 1886. — THOMSONI, *Smith.* Report Decapoda, "Albatross" Dredging, 1884, p. 18.

A single specimen from 400 fath. This species was also obtained in the "Flying Fox" expedition. Canon Norman sends me the following note:—"This species, like *Anamathia Carpenteri*, was figured in *The Depths of the Sea* as one of the inhabitants of the warm area off the Butt of Lewis, yet Mr. Pocock says that he was not aware that it had been recorded as a British species. Moreover, both species were again recorded from the same district in my report of the Crustacea of the 'Knight Errant' Expedition."\*

STENORHYNCHUS TENUIROSTRIS, *M. Edw.*

EBALIA NUX, *Norman, MS.*

1880. EBALIA NUX, *Norman.* Notes on the French Exploration of "Le Travailleur" in the Bay of Biscay, Am. Mag. Nat. Hist. and Rep. Brit. Assoc., p. 387.  
 1883. — — (*Norman*), *Marion.* Annales du Musée d'Hist. Nat. de Marseille, vol. i, mém. 2, p. 36.  
 1883. — — (*Norman*), *A. Milne Edwards.* Recueil de figures de Crustacés nouveaux ou peu connus, pl. v.  
 1889. — — *Pocock.* Am. Mag. Nat. Hist., ser. 6, vol. iv, p. 426.

A single specimen was taken in 400 fath. The single specimen of the "Flying Fox" was taken in 315 fath. Canon Norman sends me the following notes on this species:—"Mr. Pocock seems to have been unaware that *Ebalia nux* had been admirably figured by Prof. A. Milne Edwards. The following is the distribution of the species as far as is known to me."

"'Porcupine,' 1869, Stations 1, 3, 6, 11, all off the west and south-west of Ireland, in 90 to 1630 fath.; also Station 46, lat. 59° 23' N.,

\* Proc. Royal Soc. Edinb., 1882.

long.  $7^{\circ} 4' W.$ , that is to the north-west of the Butt of Lewis, on the margin of the *Holtenia* ground, in 374 fath.

"'Porcupine,' 1870, Station 8, lat.  $48^{\circ} 13' N.$ , long.  $9^{\circ} 11' W.$ , 257 fath.; Station 10, off Cape Finisterre, 91 fath., Vigo Bay;\* Station 13, off Cape Mondego, coast of Portugal, 220 fath.; Station 26, off south coast of Portugal, 364 fath.; and in the Mediterranean, off Cape de Gatt, 60 to 160 fath., and on the Adventure bank, 92 fath.

"'Travailleur' Expedition, 1880. In this expedition *Ebalia nux* was taken many times in the Bay of Biscay off the Spanish coast. My notes taken on board give me July 17th, 666 metres; July 23rd, 1107 to 1353 metres.

"'Travailleur,' 1881. In this year's expedition Prof. Milne Edwards reports it as again taken in the Bay of Biscay, and also in the northern part of the Mediterranean, 300 metres.

"'Flying Fox' and 'Research' trawlings off the south-west coast of Ireland. Profs. A. Milne Edwards and Marion courteously recognise my MS. name *Ebalia nux*, but if that is rejected it will stand as *Ebalia nux*, A. Milne Edwards."

#### PARAPAGURUS PILOSIMANUS, *Smith*.

1880. EUPAGURUS JACOBI, *A. Milne Edwards*. Études préliminaires sur les Crustacés, Blake Exped. in Bull. Mus. Comp. Zool., viii, p. 42.

Three specimens in old shells covered by *Epizanothus paguriphilus*, 400 fath. Dr. Norman informs me that the first evidence he had of the existence of this species in the Eastern Atlantic was that of a single arm dredged by the "Triton" Expedition in 1882, Station 13, lat.  $59^{\circ} 51' N.$ , long.  $8^{\circ} 18' W.$ , in 570 fath.; and this fragment he was enabled positively to identify by direct comparison with American examples. Its occurrence is now first recorded. He also calls my attention to the fact that the species was in the same year recorded by Prof. Milne Edwards (under the name *Eupagurus Jacobi*, M. Edw.) as having been dredged off the Spanish coast by the "Travailleur." Thus this recently described deep-sea Pagurid is already known to have a most extensive range—Guadaloupe, St. Lucia, Martinique, N.E. America; in the British area north-west of the Butt of Lewis and off the south of Ireland, also extending southwards to the coast of Spain.

#### EUPAGURUS METICULOSUS, *Roux*.

Several specimens in shells covered by *Polythoa incrustata* in 70 fath.

\* So labelled, but probably one of the dredgings off Vigo Bay.

EUPAGURUS PUBESCENS, *Kröyer*.

EUPAGURUS CARNEUS, *Pocock*. *Ann. Mag. Nat. Hist.*, 6th series, vol. iv, p. 428.

This species was first taken by Mr. Green in the "Flying Fox." My single specimen, a female, was trawled in 400 fath. It inhabited a large shell of *Fusus gracilis*.

GALATHEA NEXA, *Emb.*

GALATHEA DISPERSA, *Bate*.

MUNIDA BAMFFICA, *Pennant*.

Stations 7 and 8, 70 fath.

PONTOPHILUS SPINOSUS, *Leach*.

A single specimen from Station 2, 400 fath.

#### ISOPODA.

ÆGA TRIDENS, *Leach*.

Single specimen, 200 fath.

#### AMPHIPODA.\*

AMPHITHOPSIS LATIPES, *M. Sars*.

METOPA BRUZELII, *Goes*.

ERICHTHONIUS DIFFORMIS, *M. Edw.*

MELITA OBTUSATA.

STENOTHOË MARINA, *Sp. B.*

#### COPEPODA.

ARTOTROGUS BOECKII, *Brady*.

A single specimen, 75 fath.

#### PANTOPODA.

PYCNOGONUM LITTORALE, *Ström.*

Several specimens from 200 and 70 fath.

#### POLYCHETA.

HERMIONE HYSTRIX, *Sav.*

Three specimens from 400 fath.

\* Mr. A. O. Walker has kindly looked through and identified my small collection of Amphipoda.

LAGISCA RARISPINA, *Sars.*

70 fath.

AMPHITRITE CIRRATA, *Müll.*

70 fath.

HYALINÆCIA TUBICOLA, *O. F. Müll.*

70 fath.

DITRUPA ARIETINA, *Müller.*

NEMERTEA.

AMPHIPORUS LACTEUS ?

Station 7.

GEPHYREA.

PHASCOLION STROMBI, *Théel.*

POLYZOA.

SCRUPOCELLARIA SCRUPOSA, *Linn.*

CELLARIA SINUOSA, *Hassall.*

CELLARIA JOHNSTONI, *Busk.*

CELLEPORA RAMULOSA, *Linn.*

CELLEPORA DICHOTOMA, *Hincks.*

All the Polyzoa were taken in moderate depths (70 fath.).

ANTHOZOA.

ACTINAUGE RICHARDI, *Marion.*

From Stations 1 and 2, 200 and 400 fath.

CHITONACTIS CORONATA, *Gosse.*

Station 1, 200 fath.

ADAMSIA PALLIATA, *Forbes.*

Many specimens from Station 8, 70 fath.

EPIZOANTHUS PAGURIPHILUS, *Verrill.*

Three specimens of this species, which is here recorded for the first time, I believe, from English seas, were obtained at Station 2, 400 fath. They were associated with *Parapagurus pilosimanus*. Mr. Pocock, in the Report on the Crustacea of Mr. Green's expedi-



tion, says that the *P. pilosimanus* obtained were associated with an *Epizoanthus*, but no further mention is made of the latter, which may have been *E. paguriphilus*.

POLYTHOA INCRUSTATA, *Sars*.

Several specimens from Station 5, 70 fath. Associated with *Eupagurus meticulosus*.

POLYTHOA, sp. incert.

The difficulty of identifying the species of this genus from spirit specimens is so great that I have given up the attempt in this instance. The specimen obtained was from 90 fath. at Station 5.

HYDROZOA.

PERIGONIMUS ARENACEUS?

Growing on a *Fucus* shell in 200 fath.

EUDENDRIUM RAMEUM, *Pall*.

TUBULARIA INDIVISA, *Linn*.

TUBULARIA CORONATA, *Abild*.

DIPHASIA PINASTER, *Ellis and Sol*.

SERTULARELLA GAYI, *Lam*.

AGLAOPHENIA MYRIOPHYLLUM, *Linn*.

ANTENNULARIA ANTENNINA, *Flem*.

With the exception of *Perigonimus*, all the Hydroids were trawled from moderate depths.

In addition to the trawling I made frequent use of the tow-net, but was somewhat hampered by the necessities of the cruise. At night we were anchored, and the tides were seldom strong enough to keep my net extended; during the day we were working rapidly along the lines of observation, when tow-netting was impossible, or we were trawling, when it was difficult. I did most of my work during the trawling, but whenever the paddles were moved—and they had to be moved pretty often to keep the ship's head up—I ran the risk of losing my net.

I was anxious to make a comparison between the surface fauna outside Plymouth and that at the entrance to the Channel, in order to settle the question whether there is a current setting in towards the Channel, and carrying the numerous southern and Atlantic forms which are from time to time taken on the south-west coast in an easterly direction. Such a current, if it existed, would be a part of

Reynell's current, but in fact it does not exist except as a surface current, due to prevalent westerly winds. This was shown both by the daily observations of Captain Aldrich with current logs, and by the contents of the tow-net. The current log showed that the tides cause a rotatory current moving in the same direction as the hands of a watch, and there is a tendency for the rotating stream to move very slowly eastward. The observations were still in progress when I left the ship, and will be published in another place by Captain Aldrich.

The surface fauna was quite different from anything that I have seen in the Channel. Going from Plymouth to Cork, we passed through shoals of *Aurelia*, but on our stations in the eleventh meridian W. not a single *Aurelia* was to be seen. On July 12th we passed through a shoal, miles in extent, of *Pelagia perla*, Haeckel, a form which I have never seen near Plymouth, and which is only at rare intervals cast ashore at Mount's Bay. Each day the net was full of *Salpa democratica-mucronata*, Forskäl, a form which I have never met with during two summers at Plymouth; and *Doliolum Ehrenbergii*, Krohn, of which only a few isolated individuals are to be found near Plymouth. Of the Copepoda certain ubiquitous species were plentiful enough (*Cetochilus septentrionalis*, *Clausia elongata*, *Dias longiremis*, *Centropages typicus*, *Oithona spinirostris*, and *Corycæus anglicus*), but more oceanic conditions were indicated by the relatively greater abundance of the first named. I obtained also a large number of *Ectinosoma atlanticum*, Brady and Robertson, a form which I have never seen in the neighbourhood of Plymouth. In addition to these I took two specimens of *Onceæa*, which I am satisfied belong to *Onceæa obtusa*, Dana, as figured by Brady in the "Challenger" Reports, and not to *O. mediterranea*, Claus, which I found near Plymouth in 1889.

The common oceanic Phyllopods *Podon* and *Evadne* occurred in great numbers, as also did *Hyperia galba*, Mont.; and there were a few Zoëa and Megalopa stages of Decapods, but these were far less numerous than in seas nearer land. *Tomopteris* was fairly common, but *Sagitta* was far less abundant than in the seas near Plymouth. On one occasion I obtained several very large *Bipinnaria* larvæ and several later stages in Asterid development. Together with these were Holothurian larvæ (probably of *H. tremula*), the tailed larvæ of *Doliolum*, and a single specimen of *Tornaria Krohni*, a species which I had previously taken near Plymouth.

Of the Anthomedusæ the species common near the English shores, such as *Obelia*, *Lizzia*, and *Thaumantias*, were entirely absent, but on two occasions I captured large numbers of a very fragile and peculiar Medusa, of which I have been unable to determine the

relations. It seems to be entirely destitute of either a manubrium or radial canals. A few specimens of *Arachnactis albida*, a form not uncommon at Plymouth, were taken in each catch.

Of Siphonophora I only obtained two species. One, a Monophysid which is sometimes found at Plymouth, seems to be *Muggiæa (Diphyes) Kochii*, Will.; the other is an Anthophysid. The latter broke into fragments in the process of preservation, and I cannot determine its species with accuracy. The palpons bear distinct conical eye-spots, which would point to its being a near ally of, if not identical with the *Athorybia ocellata* of Haeckel. I have never seen a member of the Anthophysidæ in the neighbourhood of Plymouth.

The absence of pelagic Radiolaria at Plymouth has often engaged my attention. In the "Research" I found the following well-known species in tolerable abundance:—*Thalassicolla nucleata*, Huxley; *Collosphæra Huxleyi*, J. Müller; *Sphærozoum punctatum*, J. Müller; *Acanthometron elasticum*, Haeckel. In addition to these were several species of *Ceratium*.

It is apparent from the foregoing that the surface fauna at the entrance to the Channel has a distinct facies, and is different from that nearer the shores of England. A more extended investigation of the surface fauna from the Channel to the Atlantic would probably yield some very interesting results. It may be found that many oceanic species are carried up in mid-Channel, as they are certainly cast ashore in some seasons near Brighton. I have noticed at Plymouth that there is generally a considerable difference between the shore tide and the Channel tide, the latter of which runs three hours later than the former. The Channel tide is almost invariably richer both in amount and variety of pelagic life. There is every reason to believe that the movements of mackerel and pilchards are largely influenced by the distribution of the pelagic fauna, and in proportion as we obtain a more extended knowledge of the latter we may expect to learn more of the still mysterious migrations of these fishes. During the cruise we saw on two or three occasions shoals of fish at a little distance from the ship; probably they were mackerel which were feeding on the abundant surface fauna. The sea, also, was full of the ova and larvæ of Teleostei. Most of the larvæ were Gadoids, but of what species it is impossible to say. Without a much more extended knowledge of facts it is impossible to assert anything about the relations of fishes and surface fauna, but it seems at least reasonable to suppose that the winter pilchards which strike on the south coast of Cornwall, fat and in excellent condition, have come from the rich feeding-ground afforded by the set of the Gulf Stream into the Bay of Biscay.

*Addendum by the REV. CANON NORMAN, D.C.L., F.L.S.*

SOLARIUM MEDITERRANEUM, *Monterosato*.

1873. SOLARIUM MEDITERRANEUM, *Monterosato*. Notizie intorno ai Solarii del Mediterraneo, p. 6, figs. 8, 9.

A single living specimen dredged in 400 fath.,  $50^{\circ} 29' 26''$  N.,  $11^{\circ} 4'$  W.

In his "Porcupine" paper Jeffreys considers *Monterosato's* species to be a variety of *S. pseudo-perspectivum*, Brocchi (*S. discus*, Philippi). It may be so, but I prefer to retain *Monterosato's* name here because it indicates that the first specimen taken in the British seas is referable to that particular form. It is distinguished from *S. pseudo-perspectivum* as follows: The comparative height is somewhat greater, the umbilicus more contracted, the periphery more acutely keeled, and the mouth consequently more pointedly produced in the position of that keel. The upper surface is much smoother, presenting little trace of sculpture beyond a faint spiral line (the corrugated ribs of *pseudo-perspectivum* being absent); this under surface, on the other hand, is more sculptured, the exterior half of the whorl bearing about ten fine riblets, of which the outer two show some signs of corrugation. Height 7 mm., width 12 mm.

This is a second species of this genus added to our fauna. Two living specimens of *Solarium siculum*, Cantraine, were dredged by the "Porcupine," 1869, lat.  $51^{\circ} 1'$  N., long.  $11^{\circ} 21'$  W., in 458 fath.

The Mediterranean specimens with which I have compared the Irish specimen of *S. mediterraneum* are accurately represented by Philippi's figure of *S. discus*; but Brocchi's figure of *S. pseudo-perspectivum* represents a shell of which the upper surface is smooth or nearly so, and in this respect like *S. mediterraneum*, but it wants the riblets of the under surface characteristic of the latter form.

*Family* TURBINIDÆ.

*Genus* LEPTOTHYRA, P. P. Carpenter, MS. (Dall, 1871) = *Collonia*, Philippi (non *Collonia*, Gray, 1852) = *Homalopoma*, P. P. Carpenter, 1864 = *Leptonyx*, P. P. Carpenter, 1864 (non *Leptonyx*, Swain, 1821).

Dall, in his Report on the "Blake" Mollusca (Bull. Soc. Comp. Zool., xviii, p. 352), by a slip of memory says in a note, "The name *Homalopoma* was under consideration by Dr. Carpenter as a substitute for *Leptonyx*, but was never published by him." The fact is that *Homalopoma* was the first term used by him (*Supp. Report*



*Mollusca West Coast of North America*, in Brit. Assoc. Rep., 1863, p. 537); but at a subsequent page (652), when he characterises the genus, he substitutes the name *Leptonyx*, adding "genus = *Homalopoma*, p. 537, nom. preoc." I cannot find that this name has been used, but as no description was given under the name *Homalopoma* it may perhaps be best to retain the name which has been adopted by Dall.

LEPTOTHYRA BOURNEI, n. sp.

Shell shortly conical, whorls six, girt (except at the base) with numerous thread-like riblets, one of which is a little more prominent than the rest, and forms a keel; on the body-whorl there are six riblets below and three above the more prominent riblet; on the penultimate whorl there are four below and four above; no transverse—that is, vertical sculpture; apex rather blunt. Base convex, without any trace of umbilicus or umbilical chink. Shell very solid. Pillar lip slightly longitudinally channelled, the channel interrupted in the middle by a transverse depressed nodule. Colour white; interior of shell and umbilical region highly polished and nacreous with fine prismatic colouring. Operculum calcareous; external surface minutely granulated, rather sunken centrally, exhibiting no trace of spiral arrangement; internal surface chitinous, with central nucleus and multispiral (11—12) whorls, the outermost whorl rapidly enlarging. Lingual membranes have the lateral uncini extremely numerous, hamate; central teeth hamate, ten in number.\* Length 18 mm., breadth 20 mm.

A single living specimen was dredged in 200 fath., 50° 50' 15" N., 11° 12' 30" W.

This is a fine shell, and the largest species known of the genus; its operculum closely agrees in character with that of the type (*L. sanguinea*, Linn.).

From *L. induta*, Watson (Report "Challenger" Gasteropoda, p. 128, pl. vi, fig. 1), it differs in the more shortly conical form, and in the total absence of the longitudinal "infra-sutural puckerings" and beaded riblets of the upper whorls; while, on the other hand, the spiral sculpture of the present form is much more developed. It comes much nearer to the shell described by Dall (*l. c.*, p. 352, pl. xxxviii, fig. 6) as *Leptothyra induta*, var. *albida*, but in that case the riblets are fewer in number but much more pronounced; and it may, I think, be questioned whether Dall's variety is really referable to Watson's species.

\* The mounting is not very good, but I am unable to discover the usual central tooth. In that position there seems to be a gap, on either side of which are five teeth.

Notes on the Echinoderms collected by Mr. Bourne in  
Deep Water off the South-west of Ireland in H.M.S.  
"Research."

By

**F. Jeffrey Bell, M.A., Sec. R.M.S.**

MR. BOURNE has been good enough to submit to me most of the interesting specimens of Echinoderms which he obtained during his short stay on board H.M.S. "Research." Coming so soon after the important collection made by the Rev. W. S. Green in neighbouring waters and at greater depths, it will, I think, suffice for me to treat this collection as an appendix to that, and to refer for a general discussion of such points as appeared worth noting to my report in the *Annals and Magazine of Natural History* for December last.

The great interest of Mr. Bourne's collection lies in the remarkable way in which the depths of some of our more common shallow-water species is increased, in some cases indeed to a remarkable extent; see the cases of *Stichaster roseus*, *Asterias rubens*, *A. glacialis*, and *Spatangus purpureus*.

The species which were observed on board ship, but which were not preserved, are indicated by an asterisk.

A list of Mr. Bourne's stations is given on p. 306.

ASTEROIDEA.

PONTASTER TENUISPINIS, *D. and K.*

Taken at several stations from 90 to 400 fath.

\*PSILASTER ANDROMEDA, *M. Tr.*

Station 2.

\*LUIDIA CILIARIS, *Phil.*

Stations 5 and 7.

PORANIA PULVILLUS, *O. F. M.*

Station 7.

\*PALMIPES PLACENTA, *Penn.*

Stations 7 and 8. The range given by Mr. Sladen for this species is 2—100 fath. ; but, as he also remarks that the " Porcupine " specimens are without exact locality or conditions, it is well to have a definite statement for British specimens.

STICHASTER ROSEUS, *O. F. M.*

Station 1. The depth—200 fath.—is an advance by 150 on any yet recorded.

\*ASTERIAS RUBENS, *Linn.*

Stations 1, 5, and 8. Mr. Bourne calls my attention to the depth of 200 fath. ; Mr. Green did the same for his depth of 100 fath. This considerable increase in the range of these two species is significant.

\*ASTERIAS GLACIALIS, *O. F. M.*

Station 5. The range of this species is increased from 66 to 90 fath.

BRISINGA CORONATA, *Sars.*

Fragments only.

#### OPHIUROIDEA.

OPHIOCTEN SERICEUM, *Forbes.*

Station 2.

OPHIOPHOLIS ACULEATA, *Linn.*

Station 7. Young specimens.

OPHIOTHRIX PENTAPHYLLUM, *Penn.*

Stations 1 and 5. Mr. Bourne, I notice, has labelled these specimens *O. Luetkeni*. Before long I hope to be able to marshal the evidence regarding the variability of *O. pentaphyllum* which is in my possession in such a way as to justify the doubts which Sir Wyville Thomson always had as to the distinctness of *O. Luetkeni*.

OPHIOBYRSA HYSTRICIS, *Lym.*

It seems very probable that the remarkable Ophiurid to which I refer in the introduction to my report on Mr. Green's collection belongs to this species, but a close and extended investigation is required. Mr. Bourne's specimen is from Station 2.

## ECHINOIDEA.

## CIDARIS PAPILLATA.

Stations 2, 3, and 4.

ECHINUS ACUTUS, *Lamk.*

Station 8.

\*ECHINUS ESCULENTUS, *Linn.*

Station 6.

ECHINUS NORVEGICUS, *D. and K.*

Station 2. This species was not collected by Mr. Green, and I am very glad to be able to put it with those collected by him.

SPATANGUS PURPUREUS, *O. F. M.*

Stations 1, 2, 4, 5, 8; very abundant 1, 2, 4. I should, after what I have been able to see of the variations of this species and of *S. raschi*, been particularly pleased had all the Spatangis from more than 100 fath. been preserved. In suggesting the possibility of intercrossing between the two species I felt I was going beyond my record for the time, inasmuch as I had not then evidence that *S. purpureus* lived at depths as great or greater than 100 fath.

## HOLOTHURIOIDEA.

HOLOTHURIA TREMULA, *Gunner.*

Stations 1, 2, 4, 8.

## NOTE.

Besides the Echinoderms above described I obtained three Asterids which appeared to me to be very similar to *Nymphaster protentus*, Sladen, described by Sladen in the "Challenger" Report of the Asteroidea. But as I thought that I could distinguish some differences in my specimens, I sent them to Mr. Sladen for examination



before I had thought of sending the whole collection of Echinoderms to Prof. Bell. Hence they do not appear in the above report.

Mr. Sladen writes to me as follows:—"The two star-fishes you sent are very fine examples of *Nymphaster protentus*, which I described in the Report 'Challenger' Asteroidea. They are larger than the type. One differs in having occasionally a small pedicellaria on the marginal plates like those on the abactinal plates. Their presence in your specimens is probably due to age. The second specimen differs in having a small spiniform granule, the largest about 1 mm. in length, on the infero-marginal plates on the inner two thirds of the ray, and a similar but smaller granule on a few of the innermost supero-marginal plates, not more than five or six being present in each interbrachial arc. This is to the eye a striking difference, but I do not consider it to be essentially of any great importance. I therefore shrink from ranking the example as a distinct variety of *Nymphaster protentus* on the basis of a single specimen, for the character in question is one subject to much variation in other forms, and may be sexual." Since I received this letter Canon Norman has called my attention to the fact that *Nymphaster protentus*, Sladen, is, in its younger condition, indistinguishable from *Pentagonaster subspinosus* of the "Blake" Expedition described by Perrier in 1884 (*Mém. sur les Étoiles de mer recueillies dans la mer des Antilles et le Golfe du Mexique*, Nouv. Archiv. du Muséum d'Hist. Nat., ser. 2, tom. vi, p. 234, plate vi, fig. 1). Perrier's specific name must therefore be adopted, and the range of the species is thus considerably extended. By the "Blake" Expedition it was dredged in 163—209 fathoms, off Havana, Barbadoes, and Cariacon; by the "Challenger" at Station 3, south-west of the Canary Islands, lat. 25° 45' N., long. 20° 14' W., 1525 fath.; by the "Flying Fox" off the south-west of Ireland in 315 fath., and by the "Research." For a description of the "Flying Fox" specimens, described as *Nymphaster protentus*, see Prof. Bell's paper, *Ann. Mag. Nat. Hist.*, ser. 6, vol. iv, p. 434.

G. C. B.

## Anchovies in the English Channel.

By

J. T. Cunningham, M.A., F.R.S.E.

### I. NATURAL HISTORY OF THE ANCHOVY.

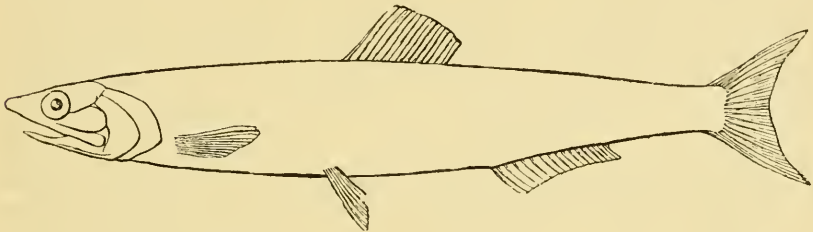
THE anchovy belongs to the same family of fishes as the herring, pilchard, and sprat, the family Clupeidæ. But whereas the herring, pilchard, and sprat have so many structural features in common that they are placed in a single genus, namely *Clupea*, the anchovy is in many respects so peculiar that it is placed in the distinct genus *Engraulis*. There are many species of *Engraulis* in various parts of the world, but only one on the coasts of Europe, and that one, commonly known as the anchovy, is called by zoologists *Engraulis encrasicolus*. The origin of these names dates back to a very early period. Both are used by ancient classical Greek authors. The derivation of ἔγγραυλις is not known; ἔγκρασίχολος is derived from χόλος, bile, and ἔγκρασις, infusion, and was given to the fish on account of its bitter flavour; the name means infused with bile, the taste of the fish suggesting to the ancients that its flesh was infused with bile. It is stated in Yarrell's British Fishes, and in Day's more recent work on the same subject, that the anchovy was in old times said to have its gall in its head. This statement is evidently derived from erroneous interpretations by mediæval zoologists of the name *encrasicolus*. In the French translation of Rondelet's work *Des Poissons*, published at Lyons in 1558, livre vii, chap. iii, it is stated that anchovies "sont nommés Encrasicoli à cause qu'ils ont le fiel en la teste." This shows that Rondelet derived the word from ἔν and κράς, the head; the dative singular of κράς is κράτι, and the dative plural κράσι: the root is κρατ, and the word if thus derived would have been ἔγκρατίχολος. The derivation I have previously given from ἔγκράσις is that given in Liddell and Scott's Greek Lexicon, and is doubtless correct.

The derivation of the modern word anchovy, which under various forms occurs in a number of modern European languages, has not been satisfactorily traced. In the most recent philological English

dictionary two derivations are given, but neither seems in the least degree probable. According to Diez the Italian *acciuga* is derived from a Latin word *apya*, which is altered from *aphya*, and this represents the Greek *ἄψυη*. This last word was applied to small fishes, which may have included the anchovy. The "ga" of the Italian word Diez considers as a suffix. In many Italian dialects the name is *anjova* or *anjoa*. Another theory is that the Spanish *anchova* is derived from the Basque name *anchoa*, which is identified with *antzuia*, meaning dry; so that anchovy means the dried fish. But there is no evidence that anchovies were used in the dried state. It seems more probable that the modern names are all derived from an unknown Latin name.

The identification of the fish called *encrasicholus* by ancient Greek authors with the anchovy is, according to Rondelet, proved by the fact that the modern Greeks in his time still called it *encrasicholus*.

Mediæval naturalists continued to call the species *encrasicholus*. Linnæus placed it in his system as *Clupea encrasicholus*, and Cuvier afterwards removed it to the position it now holds in a separate genus under the name *Engraulis encrasicholus*.



The anchovy is at once distinguished from any species of *Clupea*, from a herring, pilchard, or sprat, by the large and peculiar mouth. The depth of the gape in the anchovy is very large in proportion to the size of the fish. In the species of *Clupea* the angle of the mouth is below the middle of the eye; in the anchovy the angle of the mouth is a long way behind the eye, farther behind the eye than the eye is from the end of the snout. In the species of *Clupea* the apex of the upper jaw is at the end of the snout, so that the mouth is terminal; in the anchovy the mouth is on the lower side of the head as in a shark, and the snout projects forwards beyond the jaws. In the species of *Clupea* when the mouth is opened the lower end of the maxillary bone is drawn forwards, so that the sides of the gape are closed; in the anchovy the maxillary bone does not move in this way, and when the mouth is opened the sides of the long gape are open. The fins of the anchovy are very similar to those of the species of *Clupea*; there is a single dorsal fin as in all

*Clupeidæ*, and a single somewhat long anal fin. The dorsal fin is at the centre of the back ; the pelvic fins are inserted in front of the dorsal fin, as in the sprat ; the pectoral fins are close behind the gill openings. The gill openings are very large, their upper angles extending almost to the dorsal edge of the head. There is nothing very remarkable about the scales ; they are rather larger than those of the herring, and, as in most Clupeoids, are very deciduous : there are no keeled scales along the ventral edge. The skin is much more delicate than that of any species of *Clupea*, and the flesh also in the fresh state is very tender, though when salted it has considerable firmness. The fish never exceeds 8 inches in length ; Risso gives the maximum at Nice as 2 decimetres, or  $7\frac{7}{8}$  inches, and Mr. Dunn says he has obtained it 8 inches long off the coast of Cornwall. But 5 to 6 inches is the more usual length. Those I have obtained from the south coast of England are from 5 to  $5\frac{1}{4}$  inches long.

The range of distribution of the anchovy extends from the Mediterranean to the south coast of Norway and the entrance of the Baltic. It is common on both sides of the Italian peninsula, and at all the Italian fishing centres there is a regular anchovy fishery in the summer months. One of the largest fisheries is at the island of Gorgona, off Leghorn. The fish is also abundant on the Mediterranean coast of France, where the fishery is regularly pursued in its season at every fishing port, the product of a season's fishing at different centres varying from a few hundred kilogrammes (1 kilo. = 2 lbs.) up to over 300,000 kilos. Anchovies also occur on the Mediterranean and Atlantic coasts of Spain and Portugal, but I have no annual statistics showing the extent of the fishery in these countries. There are anchovy fisheries also along the Atlantic coast of France, on the coast of the Bay of Biscay. In the French official statistics we find that at Bayonne in 1884 the total catch of anchovies was 30,000 kilos. ; and at Quimper, at the northern end of the Bay of Biscay, the catch in the same year was 683,000 kilos. On the Channel coast of France anchovies are not mentioned in the French official statistics among the products of the fisheries, and I have found no mention of any anchovy fishing on the coast of Belgium. But on the Dutch coast there is a regular anchovy fishery in the estuary of the Schelde and in the Zuyder Zee. The annual catch in the Zuyder Zee according to the Dutch official statistics varies from 2000 to 100,000 *ankers*, an anker containing 50 kilos.

On the coasts of the British Islands no anchovy fishery has ever been carried on, but the species has long been known to occur on these coasts, especially on the south coast of England. It was first recorded in England by Ray, who obtained specimens from the estuary of the Dee. Donovan, in his *British Fishes*, published in 1804,



gives a figure of the anchovy, and states that he possessed a specimen caught a few years previously on the coast of Hampshire. According to Day, Mr. Peach obtained it from the herring nets off Wick ; and there is one in the Newcastle Museum found in 1834 among sprats in the Durham market. It is frequently taken in the stow-nets in the river opposite Lynn, in Norfolk. It has also been recorded from the coast of Essex and the mouth of the Thames. Mr. Dunn, as quoted by Day, says that it is quite a common fish in the autumn from Polperro to Falmouth. The same observer informed Day, and he has also stated the same to myself, that in November, 1871, he witnessed the capture of at least 150,000 in a pilchard seine at Mevagissey ; these were sold for almost nothing as manure. In Wales it has been recorded off Glamorganshire, and as abundant in some seasons at Swansea. It has also been taken on the Irish coast. Couch, in his *Fishes of the British Islands*, vol. iv, published in 1864, gives a figure and a chapter on the anchovy. I cannot do better than quote what he says on the subject:—"In the westmost portion of the British Channel these fish are often taken in drift-nets employed in the fishery for herrings and pilchards ; but this is only when they are sufficiently large to become entangled in the meshes as these chance to be doubled together ; and there is sufficient evidence to show that if nets of finer twine, with meshes of proper size, were employed, sufficient might be taken on the coast of Cornwall to supply the full amount of what is consumed in our own country, the whole of which, as sent to us from the Mediterranean, has been so much as, with a tax on the importation of twopence in the pound, to bring into the Exchequer year by year the sum of £1764. As regards the time when these fish are near us, I have met with an example in March from the stomach of a mackerel ; in summer they are found at St. Ives, in the ground seines employed in catching launce."

The mode of reproduction and development of the anchovy was first ascertained by a Dutch zoologist, K. F. Wenckebach, in 1886. The investigation was carried out at the Zoological Station of the *Nederlandsche Dierkundige Vereeniging* (Dutch Zoological Association) established in the summer of that year at Nieuwediep, which is on the west side of the entrance of the Zuyder Zee. Prof. C. K. Hoffmann had previously ascertained that the anchovies in the Zuyder Zee were sexually ripe in the months of June and July, that the eggs taken from the ripe ovaries were of oval form, about 1 mm. long and perfectly transparent ; but he had not succeeded either in finding fertilized eggs undergoing development in the natural conditions, nor in artificially fertilizing them. Wenckebach inferred from the transparency of the eggs that they were probably pelagic, and developed while suspended in the surface waters of the sea. He therefore tried

to obtain the developing eggs in the beginning of July, 1886, from the surface of the sea by means of a fine surface tow-net, and at once succeeded. He found that the floating eggs of the anchovy were to be found in July all over the Zuyder Zee. The eggs hatched at the end of the third day after fertilization, but unfortunately Wenckebach does not mention the temperature of the sea from which the eggs were taken nor the temperature of the water in which they were kept under observation. The egg is distinguished by the following characters: the form is, as already mentioned, oval or sausage-shaped, and about 1 mm. in length; this is alone sufficient to distinguish it, for no other pelagic fish egg is known which has an elongated oval form. The whole of the yolk is divided up into a number of polygonal segments, in which respect the anchovy's egg resembles that of the pilchard,\* and there are no oil-globules. The blastoderm is situated at one end of the egg, and the larva when hatched is without pigment and extremely transparent, like that of the herring and pilchard.

The Italian zoologist, Dr. Fed. Raffaele, found the ova of the anchovy abundant in the Gulf of Naples from May to September. According to Wenckebach the ova are not to be found in the Zuyder Zee after July 19th, so that we may infer that the period of reproduction lasts longer at Naples than in Holland—in the former extending through the months of June, July, and August, in the latter only through June and the first half of July. Raffaele says that hatching took place after two or three days, but he also neglects to give the temperature of the sea in which the eggs develop.

We have now to consider the conditions of life of the anchovy.

Like other Clupeoids it is a truly pelagic fish, a fish which lives and feeds entirely in the open waters, having no direct relation to the bottom or the shores of the sea. It feeds on other pelagic creatures, probably chiefly on Copepods and other pelagic Crustacea. It swims in shoals, and the shoals are constantly moving about. The important point is to obtain some evidence as to the extent and periods of the movement of the shoals. The theory of the great annual migration of the herrings has been generally abandoned, but we still occasionally find the view expressed that the anchovies which are found every year in the Schelde and the Zuyder Zee travel thither from the Atlantic Ocean through the English Channel and the North Sea. For instance, Professor Ewart, in a letter published in the *Times* on January 21st of the present year, calling attention to the fact that anchovies were caught in considerable numbers in the Moray Firth in December last, says, "Perhaps further inquiries may show that the migration northwards of the

\* See my paper on *Teleostean Ova* in this Journal, New Ser., No. 1, 1889.

anchovies is in some way related to the mildness of the winter. It is most desirable to ascertain whether the anchovies have reached the Moray Firth with the warm Atlantic water that during western winds rushes through the Pentland Firth, or by travelling along the east coast through the cold Arctic water that wells up from the bottom in the vicinity of the Dogger Bank." I am inclined to think that further inquiries will show that the anchovies in the Moray Firth come neither the one way nor the other, but that these fish are permanent residents in the North Sea.

The migration theory receives some apparent support from the fact that the anchovy fishery in Holland takes place in the summer months, namely May and June, while the anchovies have only been taken on the south coast of England in the winter, from November to January. But, on the other hand, as we have seen above, anchovies breed in summer from May to September at Naples, and doubtless at other places of the Mediterranean coast of Europe. It is exceedingly improbable that the anchovy should breed only at the extreme north and the extreme south of its range, and not at any intermediate point. Are we to believe that all the anchovies which live in the Mediterranean breed near the north coast of that sea, and never migrate beyond the Straits of Gibraltar, and that all the anchovies which live in the Atlantic Ocean travel to Holland to shed their eggs? Or are we to suppose that all the anchovies after breeding migrate to the ocean, and when the spawning period returns half of them travel to Holland to breed, and the other half enter the Mediterranean and shed their eggs there? Risso, in his *Ichthyologie de Nice* (1810), states that some anchovies reside constantly at the mouth of the Var, while others come in to the neighbourhood of Nice regularly as migrants.

It is probable that the anchovy will be found to breed in summer on all the coasts where it occurs. This has not yet been ascertained—in fact, I have not yet succeeded in finding whether the fishery for anchovies on the west coast of France takes place in summer or in winter. Ripe anchovies have, however, been obtained on the west coast of England. Mr. Jackson, of Southport, on June 9th, 1878, took some dozens in a shrimp trawl off that place, which were distended with ripe ovaries. I have not been able yet to obtain any information concerning the natural history of anchovies, or the anchovy fisheries on the coasts of Spain and Portugal.

Some extremely interesting researches have been carried out by the Dutch zoologist Prof. C. K. Hoffmann,\* on the rate of growth of

\* *Contributions to our Knowledge of the Life-history and Reproduction of the Anchovy.* Published as Appendix II to the *Verlag van den Staat der Nederlandsche Zeevisscherijen over 1885.* 'S Gravenhage, 1886.



the anchovy in the Zuyder Zee, and the relation of the temperature of the water to the abundance of the fish and the success of the fishery in different summers. Prof. Hoffmann shows from a comparison of the variations of summer temperature, and of the product of the anchovy fishery from 1857 to 1885, variations which he exhibits graphically by curves in carefully constructed diagrams, that a high temperature in one summer is followed by a large catch of anchovies in the *following* summer. He finds that the anchovy grows very rapidly, and that the reason of the fact just stated is, that in a warm summer more young anchovies are produced than in a cold one, and these returning to the Zuyder Zee in the following year, when they are already adult, afford the fishermen a heavy spoil. The young anchovies are hatched in June, and by October, according to Hoffmann, have reached the length of  $4\frac{3}{4}$  inches.

## II. THE PROSPECTS OF AN ANCHOVY FISHERY IN ENGLAND.

In November, 1889, paragraphs in various newspapers stated that the fishermen of Dover and Deal had been catching large numbers of anchovies in their nets, and had thrown them overboard through ignorance of their nature and value. Professor Lankester instructed me to go to Dover and make inquiries into this matter, as it seemed to him advisable to ascertain whether anchovies could be regularly obtained in English waters, and if so, to endeavour to establish a trade in them which would benefit both the fishermen and the community generally. Accordingly I went to Dover, and found that the fish believed to be anchovies had been caught by the sprat-fishermen. The nets used at that place for the capture of sprats are drift nets containing sixty-four meshes to the yard, that is, meshes about half an inch square. These nets are worked by open boats rigged with mainsail, foresail, and mizen, the mast being moveable. The nets are usually shot about a mile from the shore near the Admiralty Pier, towards the end of the flood tide, and they drift eastwards. Sprats are only caught in autumn and winter, chiefly in November and December. I was told that some boats had obtained at one shot 4000 sprats and 1000 anchovies. One man said he had seen anchovies among the sprats every winter, but never in such abundance as last season. I was unable to get any specimens of the anchovies on this occasion at Dover, for the sprat-fishing was temporarily suspended; some men had tried for them during the previous week, but had caught none. The reason of this, according to the fishermen, was that the weather was too quiet and the water too clear, so that their nets were visible on account of the phosphorescence on them in the water. They said that the best weather for



their fishing was a moderate south-west breeze, because then the water was "thick." However, from the description given by both the fishermen and a dealer whom I consulted, there could be no doubt that the fish called anchovies were really of that species.

I sent a letter to the *Times* describing the results of my visit to Dover, and giving a summary of what is stated in books on fish and fisheries concerning the distribution of anchovies, the condition of the anchovy fishery in various countries, and the occurrence of the fish in English waters. At the conclusion of my letter I asked for information concerning the capture of anchovies at any other parts of the English coast. This letter was published on December 12th, and the *Times* commented on it in a leading article, calling attention to the importance of the attempt to start a regular anchovy-fishery in England.

Among the letters I received in response to my public appeal for information the most important was one from Mr. Whitehead, of Torquay, who informed me that large quantities of anchovies had for some weeks before the date of his letter, December 13th, been taken among the sprats in Torbay. He could not say what proportion the anchovies bore to the sprats, but he noticed in one lot that about one fifth consisted of the former; he did not send me any specimens. On January 3rd, 1890, I received some actual specimens in spirit from Mr. Whitehead, together with another letter, in which he said that they were still being taken in the proportion of one fifth anchovies to four fifths sprats. These specimens placed beyond doubt the identity of the fish described by Mr. Whitehead as anchovies. They were genuine anchovies, and it was thus proved that during last November, December, and January a large quantity of anchovies were landed at Torquay. I shall discuss subsequently the question of what was done with these anchovies.

As Mr. Dunn, of Mevagissey, Cornwall, had previously noted the capture of anchovies at that place, I wrote to him on December 13th asking if any had been taken there this season, and if he could send me specimens. In reply he very kindly sent me eight specimens in spirit, and a letter saying that anchovies were plentiful off that part of the coast in the autumn of every year, that this season they had been present during the three previous months, but that very few were usually caught, only a few being occasionally meshed in the pilchard-nets; the greatest catch amounted to only about a dozen specimens, because the mesh of the pilchard-nets was too large, and the anchovies were only taken in parts of the nets which got entangled. It is evident that the capture of a few specimens in a pilchard-net indicates that the anchovies are present in the sea in large numbers.

In consequence of Mr. Dunn's information I inquired on December 17th of the pilchard-fishers at Plymouth if they ever caught anchovies, and they answered that they frequently caught a few specimens, but always threw them away. They promised in future to bring me all they caught. About the same time I borrowed a sprat drift-net and arranged to have it shot by our own men from our own boat, both inside and outside the Sound, thinking that a sprat-net, having a smaller mesh, might catch more anchovies than the pilchard-net.

As the result of my application to the Plymouth pilchard-fishers a number of anchovies taken in pilchard-nets in the neighbourhood of the Eddystone were brought to me in December, 1889, and January, 1890. These were brought in lots of from one to six specimens at a time. But I caught no anchovies in my sprat-net, from which it may be inferred that anchovies occur off Plymouth at some distance from land, about the Eddystone, but not in the inshore waters either inside the Sound or immediately outside it. The nearest places from which I got specimens were the south side of the Mewstone and a mile or so south of Penlee Point.

It was thus evident that although anchovies might possibly in the future be caught by suitable nets in marketable quantities off Plymouth and Mevagissey, that at the time they were actually landed in marketable quantities only at Torquay. I wrote to Mr. Whitehead at the beginning of January asking him to get me 5000 anchovies and send them to me at Plymouth, where I arranged with an Italian fish-curer to have them cured. But, unfortunately, fishing operations were entirely suspended during nearly the whole of the month of January by continuous stormy weather. On January 29th, when moderate weather at last set in, I went to Torquay to procure if possible a considerable quantity of anchovies. I found there that sprats were not taken with drift-nets as at Dover and Deal, but in large seines worked by means of several boats, one of them, into which the net is drawn, being a large barge-like boat moored in shallow water. The purse of a seine of this kind consists of very small meshes, so that it is impossible that any anchovies escape through the net; the net is as well adapted for catching anchovies as for catching sprats, and the two kinds of fish are caught in the net together. I saw one of these seines worked, and about a dozen bushels of sprats were taken in it, but among them were very few anchovies; I picked out about a dozen, but the total number was too small to make it worth while to sort the two kinds completely. I was told by the fishermen that in the past season as many as thirty bushels of anchovies had been caught at one haul of the seine.

On January 15th I had a letter from a gentleman at Sidmouth

asking me to send him some specimens of anchovies in order that he might ascertain whether the fish called by the local fishermen "Caplin," and caught together with sprats, were of that species. I sent him specimens, and he found that the so-called Caplin were anchovies.

On January 21st Professor Cossar Ewart, in a letter in the *Times*, stated that at the end of the previous December anchovies were abundant in the Moray Firth off Troup Head, on the east coast of Scotland, and had been caught in considerable numbers in the herring nets of the Buckie fishermen.

It is evident from these facts that anchovies were during last winter present in large numbers off the south coast of England, from Dover to Mevagissey, and apart from the question whether they could be taken in marketable quantities by the use of nets not now actually in use, it is a fact that they have been taken in marketable quantities at various places by means of nets regularly used every winter for the capture of sprats. The question, therefore, presents itself, why should these anchovies have been wasted while large numbers of imported anchovies are sold in this country at high prices? For these anchovies were practically wasted. When mixed with sprats at Torquay they are usually sold with them at the ordinary price of sprats, and the buyers object to them because they cause the sprats to "turn off." At Dover they were either thrown away or sold with the sprats unsorted. The average price paid to the fishermen for sprats at Torquay is 4s. a bushel. Anchovies may not be so plentiful every winter as they were last winter, but even if they only occurred at all once in five years or so, they might nevertheless be used in the proper manner instead of being sold as sprats. For anchovies when properly preserved are a valuable delicacy and always fetch a high price. In order to try to create a market for English anchovies I wrote a letter to the *Times*, which was published about January 10th, asking the importers of foreign anchovies into England whether any of them would be willing to purchase English anchovies. But I did not receive a single answer. I then wrote to Messrs. Burgess and Son, the Strand, London, who supply the English market with the most esteemed anchovies and anchovy preparations. They replied that if I sent them some English anchovies they would report upon them. Accordingly I sent them a few of the fish from Torquay on January 30th, and they reported that such fish would be perfectly useless to them for any of their manufactures. I then called at the warehouse and found that the firm imported all their anchovies from Gorgona preserved in brine, and that they had not found the size and flavour of the Torquay anchovies equal to those of the Gorgona fish.



I also wrote to Mr. Dunn, who is connected with a fish-curing factory at Mevagissey, and he told me that he had been trying experiments on them, but the results were still to be proved. He did not say whence he got the anchovies, but when I was at Torquay on January 30th I was told by a fish-buyer there that he had sent some barrels of anchovies to Mr. Dunn, who was willing to take more, but at that time no more could be got.

I have also examined the different preparations of anchovies sold in England. Anchovy sauce and anchovy paste could be made from English anchovies as well as from imported. Entire anchovies in brine are sold in small bottles; a bottle of those prepared by Burgess and Son costs 10½d. and contains about seventeen fish. French anchovies prepared in Paris are also sold in England. These are preserved in oil and put up in smaller bottles than Burgess's Gorgona anchovies; each bottle contains a smaller weight of fish, but the price is the same. The individual French anchovies are smaller than Burgess's and no larger than those I have obtained at Plymouth and Torquay. Then there is another kind of preserved fish sold as "Norwegian anchovies." These are small fish packed in little wooden barrels, and preserved in salt and bay leaves and pepper. When I was at Torquay, Mr. Slade, who kindly assisted me greatly in my inquiries there, told me that these "Norwegian anchovies" were not anchovies at all. I had never looked at them myself, so I bought a barrel and examined its contents, and to my surprise found that the fish it contained were nothing but sprats. All the fish in the barrel were of the same kind, all were without exception of the species *Clupea sprattus*. I paid 1s. 9d. for this barrel and found it contained 111 sprats weighing 2 lbs. 5 oz. Fresh sprats are sold retail in England at 1d. per lb. I bought another barrel in Plymouth and examined its contents with the same result. So here we have the curious anomaly that at Torquay genuine anchovies are caught and wasted, while sprats brought from Norway are being sold at about 8d. per lb. These barrels of "Norwegian anchovies" are labelled merely "Finest selected, C. L. & S." The contents are not otherwise described. But, as far as I understand the Merchandise Marks Act, goods imported into this country must now be labelled with a true and accurate description of their character, and I hope the proper authorities will not be long in compelling the Norwegian exporters to label their pretended anchovies as sprats. When that is done there will be more prospect of obtaining a sale for genuine English anchovies.

It seems to me that the creation of a trade in English anchovies lies with Mr. Dunn, of Mevagissey. His energy and experience will enable him without difficulty to prepare anchovies in such a way as to

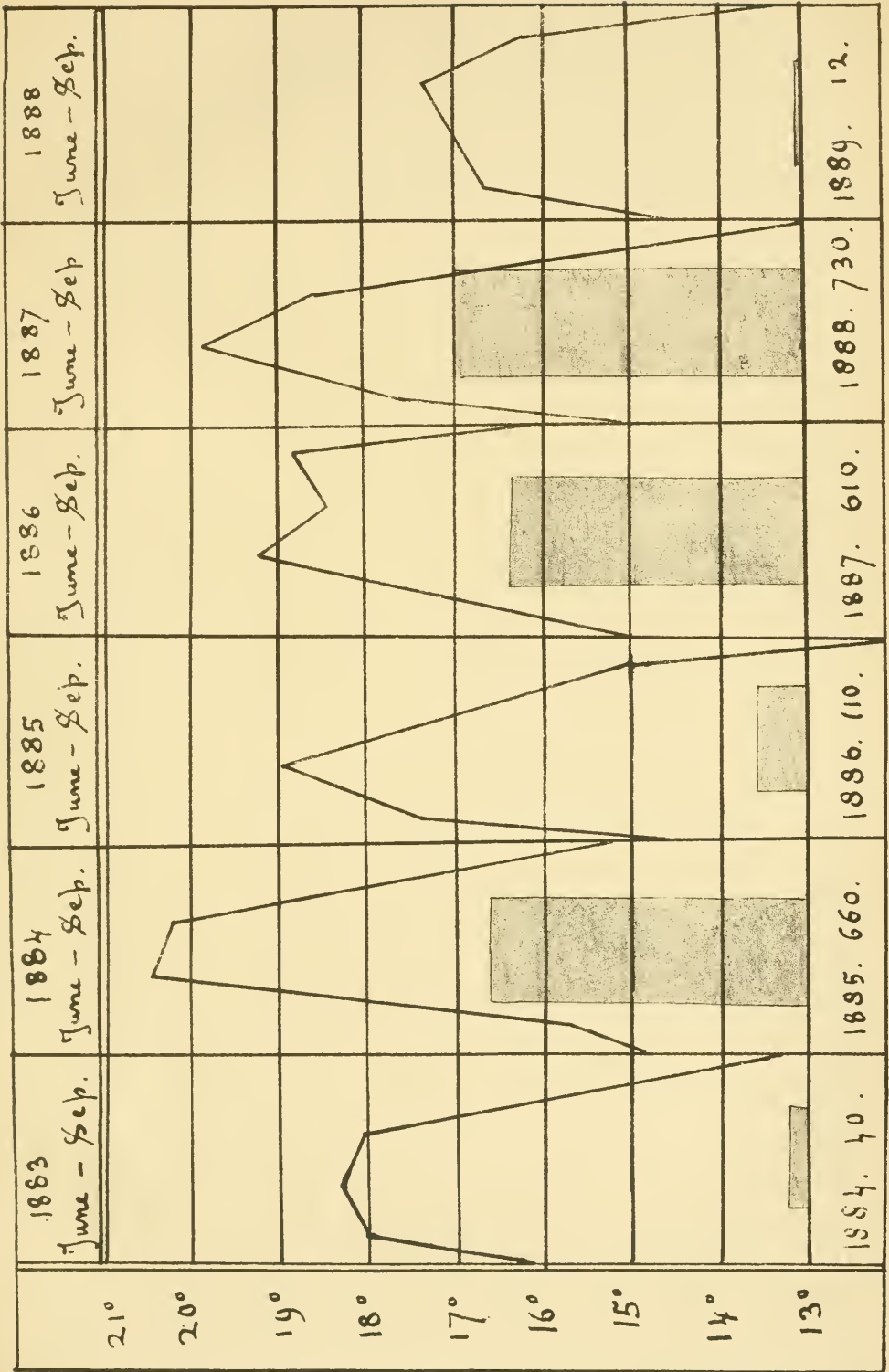


make them as palatable if not more so than Gorgona or French anchovies. I therefore advise all fish buyers in future who meet with anchovies at Torquay or elsewhere to communicate with Mr. Dunn. Other manufacturers will follow Mr. Dunn's lead, and the time may come before long when anchovies will be sought with special nets along the whole south coast, instead of being taken as now accidentally along with sprats. The anchovies imported by Burgess and Son from Gorgona are somewhat larger than the English specimens I have seen, but I do not believe they have any real superiority in quality. I have eaten the English anchovies boiled in the fresh condition and found them delicious, and I have no doubt that when salted they would be as good as the Italian or French fish. Dutch anchovies are sent in the salted condition to Germany, Belgium, and other countries, but not to England.

## NOTES AND MEMORANDA.

**Probable Relation between Temperature and the Annual Catch of Anchovies in the Schelde District** (with Pl. XXIV).—Mr. C. J. Bottemanne, of Bergen-op-Zoom, the Inspector of Fisheries for Holland, has expressed in tables published *in extenso* in the Verslag omtrent den Toestand der Visscherijen in de Schelde en Zeeuwsche Stroomen for 1888, some very interesting statistics which have been condensed in Pl. XXIV of this journal. The temperature observations were made on the Rinkelaar guardship of the Ijerseke Bank of the Eastern Schelde (see Map, Pl. XXI) ; the amounts of the annual catch are taken from the official returns. It appears probable from these statistics that *the extent of the catch of anchovies in the Schelde district in any year is (at least largely) dependent on the temperature of the water during the midsummer months of the preceding year.* The curves in Pl. XXIV exhibit the temperature on the Ijerseke Bank during the months June to September from 1883 to 1888, the shaded blocks below them represent graphically the mass of anchovies *taken in the succeeding year, i. e.* 1884—1889 (the figures in the bottom line placed after the year indicate the total number of barrels). The only apparent exception is 1886, but, though the highest recorded temperature of this year is not great, the mean temperature in July to September was extremely and unusually high, as will readily be seen in the diagram. As an example of the valuable information which scientific observers may give to those interested in fisheries, Mr. Bottemanne, on receiving the statistics of temperature for 1888, warned the fishermen of the district last year not to go to trouble or expense about the anchovy fishery ; they persisted, however, and justified his advice by realising 12 barrels as against 730 barrels of the previous year.

Even more convincing, because more complete, are the observations made in the Zuyder Zee on the same point, which are tabulated in the Verslag van den Staat der Nederlandsche Zeevisscherijen for 1885 by Prof. Hoffmann, and extend over twenty-eight years, from 1857 to 1885 ; they entirely bear out the same conclusions as those made in the Schelde district.—G. H. FOWLER.



G. H. F. anderson.





*Halosphæra viridis*, Schmidt.—This marine alga was found here last spring. It has been observed at Naples, but its life-history is very imperfectly known. It consists of a hollow sphere from a quarter to half a millimetre in diameter, the inner surface of which is covered by a thin layer of protoplasm containing numerous chlorophyll granules embedded in it, and a large nucleus which is surrounded by a mass of protoplasm free from chlorophyll. These spheres float in great numbers close to the surface of the sea, and are carried about by the waves, having no motion of their own. F. Schmitz, the only observer who has recorded any observations on them, states (Mittheil. aus d. Zool. Stat. zu Neapel, Bd. i, 1879) that these spheres always make their appearance at Naples in January or February and remain till June, when they disappear. During that time he observed repeated division of the nucleus to take place, accompanied by spindle formation, as the result of which the contents of the sphere are converted into a large number of daughter-cells consisting each of a nucleus surrounded by a mass of protoplasm, to which the chlorophyll, now diffused, gives a dense green colour. These daughter-cells adhere to the wall of the sphere, which consists of two envelopes, an outer and an inner. The outer one bursts, and the inner one gradually dissolves away, setting free a number of zoospores to which the daughter-cells above mentioned have meanwhile given rise by subdivision. These zoospores are conical cells furnished with a pair of cilia springing from the basal end of the cell. They swim about freely. Beyond this their history has not been traced. Our knowledge of its development is thus insufficient to enable us to determine the systematic position of *Halosphæra*. Specimens found at Plymouth were sent up to London for examination in April last, but owing to defective conditions it was not possible to keep them alive long enough for observation. I hope an opportunity may be found of studying them under more favorable circumstances next spring.—HERBERT THOMPSON.

## PRICE LIST OF ZOOLOGICAL SPECIMENS.

THE following specimens suitable for class purposes and dissection are kept in stock at the Plymouth Laboratory, and may be obtained at short notice on application to the Director. Except where otherwise stated in the list, all specimens will be forwarded in alcohol; but those marked with an asterisk can be sent fresh if required, in which case the prices will be correspondingly reduced.

BOTANICAL CLASSES also can be supplied at short notice with fresh specimens of the commoner marine Algæ, e.g. *Ulva*, *Cladophora*, *Porphyra*, *Ceramium*, *Callithamnion*, *Polysiphonia*, *Gigartina*, *Rhodomenia*, *Pycnophycus*, *Cystoseira*, *Fucus*, *Halidrys*, *Laminaria*, *Himantalia*.

		<i>s. d.</i>
<b>Protozoa.</b>		
Amœboidea .....	various, fresh only.....	per tube 0 6
Thalamophora.....	" " .....	" 0 6
Heliozoa .....	" " .....	" 0 6
Ciliata .....	ZOOTHAMNIUM and others, fresh only.....	" 1 0
Rhynchoflagellata .....	NOCTILUCA.....	" 1 0
<b>Porifera.</b>		
<b>Calcarea—</b>		
Homocœla .....	*LEUCOSOLENIA <i>botryoides</i> , Bow.	" 1 0
Heterocœla .....	*GRANTIA <i>ciliata</i> , Johns.....	" 0 9
	<i>compressa</i> , Flem.....	" 0 9
<b>Non-calcarea—</b>		
Cornacuspongiæ.....	HALICHONDRIA <i>panicea</i> , Johns., per spec.	1/—2 0
Spiculispongiæ .....	SUBERTITES <i>domuncula</i> , Ndo. ...	" 1 0
	CLIONA <i>celata</i> , Grant.....	" 1 0
	OSCARILLA <i>lobularis</i> , Schmidt ..	" 1 0
<b>Hydrozoa.</b>		
Hydroidea gymnoblastea...	SYNCORYNE <i>eximia</i> , Allm. ....	per tube 1 0
	EUDENDRIUM <i>ramosum</i> , L. ....	" 1 0
	*MYRIOTHELA <i>phrygia</i> , Fabr.....	" 2 0
	TUBULARIA <i>indivisa</i> , L. ....	" 1/—2 0
	<i>larynx</i> , Ellis.....	" 1/—2 0
(Anthomedusæ) .....	SARSIA, LIZZIA, BOUGAINVILLEA, SYNCORYNE .....	" 1 0
Hydroidea calyptoblastea...	OBELIA * <i>geniculata</i> , L.....	" 0 6
	<i>dichotoma</i> , L. ....	" 1 0
	HALECIUM <i>Beavii</i> , Johns. ....	" 1 0

	s. d.
Hydrozoa.	
Hydroidea calyptoblastea... SERTULARELLA <i>Gayi</i> , Lmk.....	per tube 1 0
	<i>polyzonias</i> , L..... ,, 1 0
	*SERTULARIA <i>pumila</i> , L..... ,, 0 6
	AGLAOPHENIA <i>tubulifera</i> , Hincks ,, 1/—2 0
	ANTENNULARIA <i>antennina</i> , L., per colony 1/—3 0
	<i>ramosa</i> , Lmk. ,, 1/—3 0
	*PLUMULARIA <i>setacea</i> , Lam. .... per tube 0 6
(Leptomedusæ) .....	OBELIA, THAUMANTIAS .....
	,, 1 0
Discomedusæ .....	AURELIA <i>aurita</i> , M. Edw..... each /3—2 0
	* <i>hydra-tuba</i> & <i>ephyræ</i> ... per tube 1 0
Stauromedusæ.....	HALICLYSTUS <i>octoradiatus</i> , Clark
	(LUCERNARIA <i>auricula</i> , Johns.), per doz. 3 0
Anthozoa.	
Zoantharia .....	*ACTINIA <i>mesembryanthemum</i> , Ell., each /3—2 0
	*ANEMONIA <i>sulcata</i> , Penn..... ,, /3—1 0
	*ADAMSIA <i>palliata</i> , Bohad..... ,, /6—2 0
	<i>Rondeletii</i> , D. Ch..... ,, 1/—2 6
	*TEALIA <i>crassicornis</i> , Müll..... ,, /3—2 0
	*BUNODES <i>gemmaceus</i> , Ell..... ,, /3—1 0
	*POLYTHOA, sp..... ,, /6—2 0
Madreporaria .....	*CARYOPHYLLIA <i>Smithii</i> , Johns. ... ,, /6—1 6
Alcyonaria .....	ALCYONIUM <i>digitatum</i> , L....per colony 2/—3 6
	GORGONIA <i>verrucosa</i> , Pall... ,, 2/—3 6
Ctenophora.	
	HORMIPHORA <i>plumosa</i> , Ag..... per tube 1 0
Turbellaria.	
	*LEPTOPLANA <i>tremellaris</i> , Müll.... ,, 2 0
Nemertea.	
	LINEUS <i>marinus</i> , Mont. .... each /6—3 0
	AMPHIPORUS <i>pulcher</i> , Müll. .... per tube 1 6
	TETRASTEMMA, various sp. .... ,, 1 6
Polychæta.	
	*NEREIS <i>pelagica</i> , L..... ,, 1 0
	EUNICE <i>sanguinea</i> , An. and Edw. ,, 1 0
	*EULALIA <i>viridis</i> , Oerst. .... ,, 1 0
	*LEPIDONOTUS <i>squamatus</i> , L..... ,, 1 6
	HERMIONE <i>hystrix</i> , Kbg. .... ,, 1 6
	*CIRRHATULUS <i>tentaculatus</i> , Mont. per tube 2 0
	*ARENICOLA <i>piscatorum</i> , Lam. .... each 0 3
	CHÆTOPTERUS, sp. .... each 1 0
	SABELLARIA <i>spinulosa</i> , Leuck..... per tube 1 0
	*POLYCIRRHUS <i>aurantiacus</i> ..... ,, 2 0
Gephyrea.	
	THALASSEMA <i>Neptuni</i> , Gaertn. .... each 1 0
	PHASCOLION <i>strombi</i> , Theel ..... ,, 1 0
Hirudinea.	
	PONTOBELLA <i>muricata</i> , Risso ..... ,, 0 6
Chætognatha.	
	SAGITTA <i>bipunctata</i> , Q. and G..... per tube 0 6

		<i>s. d.</i>
<b>Arthropoda.</b>		
Cladocera .....	EVADNE <i>spinifera</i> , Kr.....	0 6
	PODON <i>intermedius</i> , Lilljbg. .... per tube	0 6
Copepoda .....	CETOCILUS <i>septentrionalis</i> , Goodsir ..	0 6
	DIAS <i>longiremis</i> , Lilljbg. ....	0 6
	ANOMALOCERA <i>Patersonii</i> , Tmpltn. ..	0 6
	HARPACTICUS <i>fulvus</i> , Fischer ...	0 6
	CORYCÆUS <i>anglicus</i> , Lubbock ...	0 6
	CALIGUS, sp. ....	0 6
Cirrhipedia .....	LEPAS <i>anatifera</i> , L. .... per bottle	2 6
	SCALPELLUM <i>vulgare</i> , Leach .... per tube	1 0
	BALANUS <i>Amphitrite</i> , Darw. ....	1 0
	CHTHAMALUS <i>stellatus</i> , Ranz. ...	1 0
Amphipoda.....	*GAMMARUS <i>locusta</i> , Fabr. ....	0 6
	*ORCHESTIA <i>littorea</i> , Mont. ....	0 6
	CAPRELLA <i>linearis</i> , Latr. ....	0 6
Isopoda .....	*IDOTEA <i>emarginata</i> , Fabr.....	0 6
	<i>tricuspidata</i> , Desm.....	0 6
	LIGIA <i>oceanica</i> , Linn. ....	1 0
	BOPYRUS <i>squillarum</i> , Latr. .... each	1 0
Schizopoda.....	MYSIS, various sp. .... per tube	1 0
Leptostraca .....	*NEBALIA <i>Geoffroyi</i> , M. Edw.....	1 6
Cumacea .....	Various .....	1 6
Decapoda macroura .....	*PALÆMON <i>serratus</i> , Penn..... each	0 4
	PANDALUS <i>annulicornis</i> , Leach ... per tube	1 0
	*CRANGON <i>vulgaris</i> , Fabr. ....	1 0
	*HOMARUS <i>vulgaris</i> , Edw..... each	2/6—5 0
	*PALINURUS <i>vulgaris</i> , Latr.....	2/6—10 0
Decapoda anomoura .....	GALATHEA <i>strigosa</i> , Fabr.....	1 0
	various sp. .... per tube	1 0
	PAGURUS *Bernhardus, Linn. .... each	0 6
	<i>Prideauxii</i> , Leach .....	0 4
	<i>cuanensis</i> , Thomp. ....	0 4
	* <i>lævis</i> , Thomp..... per tube	1 0
Decapoda brachyura .....	*CARCINUS <i>mœnas</i> , Linn. .... each	0 4
	*CANCER <i>pagurus</i> , Linn. ....	1/—5 0
	*PORTUNUS <i>depurator</i> , Leach .....	0 3
	<i>puber</i> , Linn. ....	0 4
	*STENORHYNCHUS <i>tenuirostris</i> , Bell ..	0 3
	*PORCELLANA <i>longicornis</i> , Penn., per tube	1 0
	<i>platycheles</i> , Penn., per doz.	1 0
Pantopoda .....	PYCNOGONUM <i>littorale</i> , Müll. ....	1 0
	PHOXICHILUS <i>spinus</i> , Mont.....	1 0
	NYPHON <i>gracile</i> , Leach .....	1 0
<b>Mollusca.</b>		
Gasteropoda.		
Polyplacophora .....	*CHITON, various sp..... per tube	1 0
Streptoneura zygo-branchia.	*PATELA <i>vulgata</i> , Linn. .... per doz.	2 0
	HELICION <i>pellucidum</i> , Linn..... per tube	1 0



Mollusca.		s. d.
Gasteropoda.		
Streptoneura azygo-branchia.	*TROCHUS cinerarius, Linn..... per tube	1 0
	zizyphinus, Linn..... per doz.	2 0
	*LITORINA littorea, Linn. .... per tube	1 0
	rudis, Mat. .... ,	0 6
	*BUCCINUM undatum, Linn. .... each	0 6
	*NASSA reticulata, Linn. .... per tube	1 0
	incrassata, Ström. .... ,	1 0
	*PURPURA lapillus, Linn..... per doz.	1 0
Euthyneura	APLYSIA punctata, Cuv. .... each	0 9
opisthobranchia.	DORIS tuberculata, Cuv. .... ,	0 6
	bilamellata ..... per tube	1 6
	GONIODORIS nodosa, Mont..... ,	2 0
	ÆOLIS papillosa, Linn..... each	1 0
	coronata, Forbes ..... ,	0 6
	rufibranchialis, John. .... ,	0 6
Scaphopoda.....	DENTALIUM entalis, Linn. .... per tube	2 6
Cephalopoda.		
Decapoda .....	*SEPIOLA atlantica, D'Orb..... ,	2 0
	LOLIGO Forbesii, Stp. .... each 1/—3	0
Octopoda .....	*ELEDONE cirrhosa, Lamk..... ,	2/—4 0
Lamellibranchiata.		
Isomya .....	*CARDIUM edule, Linn. .... per doz.	1 6
Heteromya .....	*MYTILUS edulis, Linn..... ,	2 0
Monomya .....	*OSTRÆA edulis, Linn..... each	0 8
	*PECTEN maximus, Linn... per doz.	3 6
	opercularis, Linn. .... ,	2 6
Polyzoa.		
Entoprocta .....	PEDICELLINA cernua, Pallas ..... per tube	2 6
Ectoprocta.		
Cheilostomata.....	BUGULA plumosa, Linn. .... ,	1 0
	turbinata, Alder..... ,	1 0
	*SCRUPOCELLARIA reptans, Linn. ,	1 0
	MEMBRANIPORA pilosa, Linn..... ,	0 6
	ALCYONIDIUM gelatinosum, Linn. ,	1 0
	*FLUSTRELLA hispida, Fabr. .... ,	1 0
Ctenostomata .....	BOWERBANKIA imbricata, Adams ,	1 0
Cyclostomata .....	*CRISIA eburnea, Linn..... ,	1 0
	IDMONEA serpens, Linn. .... ,	0 6
Echinodermata.		
Crinoidea .....	*ANTEDON rosacea, Linck ..... per doz.	3 0
Asteroidea .....	*ASTERIAS rubens, Linn ..... each	0 6
	glacialis, Linn..... ,	0 6
	*ASTERINA gibbosa, Penn. .... per doz.	1 6
Echinoidea .....	ECHINUS esculentus, Penn..... each	1 0
Ophiuroidea .....	OPHIOTHRIX fragilis, Müll. .... per doz.	2 6
	OPHIOLYPHA lacertosa, Penn. ... ,	2 6

		s.	d.
<b>Echinodermata.</b>			
Holothuroidea .....	HOLOTHURIA <i>nigra</i> , Peach. ....	each	1 6
	CUCUMARIA <i>frondosa</i> , Gunner.....	„	0 6
	OCNUS <i>brunneus</i> , Forbes.....	per tube	1 6
	PLUTEUS, AURICULARIA, and BIPINNARIA		
	larvæ .....	per tube	2 0
<b>Chordata.</b>			
Urochorda.			
Ascidiae simplices.....	ASCIDIA <i>scabra</i> , O. F. M.....	„	1 6
	<i>aspersa</i> , O. F. M. ....	per doz.	2 6
	PHALLUSIA <i>mamillata</i> , Cuv.....	each	1 6
	STYELA <i>grossularia</i> , Van Ben. (LARVÆ),		
		per tube	2 6
Ascidiae sociales .....	CLAVELLINA <i>lepadiformis</i> , O. F. M. „		2 6
Ascidiae compositæ .....	BOTRYLLUS, various sp. ....	per colony	1 6
	LEPTOCLINUM <i>gelatinosum</i> , M. Edw. „		1 6
	MORCHELLIUM, sp. ....	„	2 0
Eucrania.			
Elasmobranchii .....	ACANTHIAS <i>vulgaris</i> , Risso... fresh, each		0 4
		in spirit „	0 8
	SCYLLIUM <i>canicula</i> , Cuv..... fresh „		0 4
		in spirit „	0 8
	RAIA <i>batis</i> , Linn. .... fresh „	1/—2 0	
		in spirit „	2/—10 0
	<i>clavata</i> , Linn. .... fresh „	1/—2 0	
		in spirit „	2/—8 0
Teleostei .....	GADUS <i>pollachius</i> , Linn..... fresh „		0 6
		in spirit „	1/—2 0
	<i>morrhua</i> , Linn. .... fresh „		0 9
		in spirit „	1/—3 0
	PLEURONECTES <i>platessa</i> , Linn., fresh „		0 6
		in spirit „	1/—2 0
	LABRAX <i>lupus</i> , Cuv. .... fresh „		2 0
		in spirit „	3/—4 0

It must be understood that the above does not pretend to be a complete list, even of the commoner species procurable at Plymouth. A more extensive list is given in No. II (old series) of this Journal. Reference may also be made to special reports on different groups published in this Journal, and application for any particular British species should be made to the Director.

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# Journal of the Marine Biological Association.

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The British Association for the Advancement of Science, 22, <i>Albemarle Street, W.</i> .....	£500
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1888 Balkwill, F. H., 3, <i>Princess Square, Plymouth</i> .....	<i>ann.</i>
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- 1885 Gaskell, W. H., F.R.S., *Trinity College, Cambridge* ..... C.
- 1885 Gaskell, E. H., *North Hill, Highgate, N.* ..... C.
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- 1885 Glennie, W. R., *Berkeley Lodge, Wimbledon*..... ann.
- 1884 Godwin-Austen, Lieut.-Col. H. H., F.R.S., *Nore, near Bramley, Guildford* ..... ann.
- 1884 Gonne, William, 32, *Sussex Gardens, W.* ..... £26 5s.
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- 1884 Heathcote, Fredk. G., *Trinity College, Cambridge* ..... C.
- 1884 Herdman, Prof. W. A., *University College, Liverpool* ..... ann.
- 1884 Herschel, J., Col. R.E., F.R.S., *Observatory House, Slough, Berks.*... C.
- 1884 Herschel, Sir W. J., Bart., *Lawn Upton, Littlemore* ..... ann.
- 1884 Heywood, James, F.R.S., 26, *Palace Gardens, W.* ..... C.
- 1889 Heywood, Mrs. E. S., *Light Oaks, Manchester*..... C.
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- 1885 Hill, Alex., M.A., M.D., *Downing College, Cambridge*..... ann.
- 1888 Hodge, H. Cotty, *Redland House, Vinstone, Plymouth* ..... ann.
- \*1884 Holdsworth, E. W. H., F.L.S., F.Z.S., 84, *Clifton Hill, St John's Wood, N.W.*..... ann.
- 1884 Hope, Robert Charles, F.S.A., F.R.S.L., *Albion Crescent, Scarborough* ann.

1889	Howell, Mrs. F. Bullar, <i>Ethy, Lostwithiel</i> .....	ann.
1887	Howes, Prof. G. Bond, F.L.S., <i>Science and Art Department, South Kensington</i> .....	ann.
1884	Hudleston, W. H., M.A., F.R.S., 8, <i>Stanhope Gardens, South Kensington, S.W.</i> .....	ann.
1885	Hurst, C. Herbert, Ph.D., <i>Owens College, Manchester</i> .....	C.
1885	Hurst, Walter, B.Sc., <i>Owens College, Manchester</i> .....	ann.
1884	Huxley, Prof. T. H., LL.D., F.R.S., 4, <i>Marlborough Place, Abbey Road, N.W.</i> .....	£21
1888	Inskip, Capt. G. H., R.N., 22, <i>Torrington Place, Plymouth</i> .....	ann.
1890	Jackson, C. L., <i>Hill Fold, Bolton</i> .....	ann.
1885	Jackson, W. Hatchett, M.A., F.L.S., <i>Pen Wartha, Weston-super-Mare</i> .....	ann.
1887	Jago-Trelawny, Major-Gen., F.R.G.S., <i>Coldrenick, Liskeard</i> .....	C.
1885	James, C. H., <i>Ingleside, Mutley, Plymouth</i> .....	ann.
1890	Jenkins, William, <i>Ocean Collieries, Treorgy, Glamorganshire</i> .....	ann.
1889	Jennings, Wm. Henry, 58, <i>Emma Place, Stonehouse</i> .....	ann.
1890	Johnson, Prof. T., B.Sc., F.L.S., <i>Royal College of Science, Dublin</i> ..	ann.
1890	Jones, W. V., 49, <i>George Street, Plymouth</i> .....	ann.
1888	Keen, Miss, 1, <i>St. James's Place, Plymouth</i> .....	ann.
1884	Kellock, W. B., F.L.S., F.R.C.S., <i>Stamford Hill, N.</i> .....	ann.
1884	Kent, A. F. S., 33, <i>New Street, Salisbury</i> .....	ann.
1885	Langley, J. N., F.R.S., <i>Trinity College, Cambridge</i> .....	C.
1888	Latter, O. H., <i>Charterhouse, Godalming, Surrey</i> .....	ann.
1885	Lea, A. S., M.A., <i>Trinity College, Cambridge</i> .....	ann.
1884	Lewis, George, 88, <i>Portland Place, W.</i> .....	ann.
1888	Lloyd, Fred. H., 5, <i>Gertrude Terrace, Exmouth</i> .....	ann.
1884	Lloyd, Thomas, <i>Winchester</i> .....	ann.
1884	London, The Lord Bishop of, <i>The Palace, Fulham, S.W.</i> .....	ann.
1888	Lopes, The Rt. Hon. Sir Massey, Bart., <i>Maristowe, Roborough, South Devon</i> .....	ann.
1884	Lovell, Miss Matilda S., <i>Fairlawn, Swanmore, Ryde</i> .....	ann.
1887	Lundgren, F. H., 29, <i>St. Bartholomew's Road, Camden Road, N.</i> .....	ann.
1885	Macalister, Professor A., F.R.S., <i>St. John's College, Cambridge</i> .....	ann.
1884	Mackrell, John, <i>High Trees, Clapham Common, S.W.</i> .....	C.
1886	MacMunn, Charles A., <i>Oak Leigh, Wolverhampton</i> .....	ann.
1889	Makovski, Stanislaus, <i>Fairlawn, Red Hill</i> .....	ann.
1885	Marr, J. E., M.A., <i>St. John's College, Cambridge</i> .....	C.
884	Marshall, Prof. A. Milnes, M.D., D.Sc., F.R.S., <i>The Owens College, Manchester</i> .....	£25
1884	Mason, Philip Brookes, <i>Burton-on-Trent</i> .....	ann.
1885	Matthews, J. Duncan, <i>Springhill, Aberdeen</i> .....	ann.
1884	McAndrew, James J., <i>Lukesland, Ivy Bridge, South Devon</i> .....	ann.
1884	McIntosh, Prof. W. C., F.R.S., 2, <i>Abbotsford Crescent, St. Andrews, N.B.</i> .....	C.
1884	Michael, Albert D., <i>Cudogan Mansions, Sloane Square, S.W.</i> .....	C.



- 1884 Milne-Home, Col., *Higher Barracks, Exeter*..... ann.  
 1885 Mitchell, P. Ohalmers, B.A., *McLean Place, Dunfermline* ..... ann.  
 1885 Mocatta, F. H., 9, *Connaught Place, W.*..... C.  
 1886 Mond, Ludwig, 20, *Avenue Road, Regent's Park, N.W.*..... C.  
 1884 Moore, Thomas John, C.M.Z.S.L., Curator Free Public Museum,  
*Liverpool*..... ann.  
 1884 Morgan, Prof. C. Lloyd, *University College, Bristol*..... ann.  
 †1889 Morley, Earl of, *Prince's Gardens, S.W.* ..... ann.  
 1885 Morris, John, 13, *Park Street, Grosvenor Square, W.*..... £21  
 1885 Morrison, Alfred, 16, *Carlton House Terrace* ..... £52 10s.
- †1884 Newton, Prof. Alfred, M.A., F.R.S., *Magdalene College, Cambridge*... £20.  
 1888 Nicholson, Henry Martyn, 38, *Torrington Place, Plymouth* ..... ann.  
 1884 Noble, John, *Park Place, Henley on-Thames* ..... ann.  
 †1884 Norman, Rev. Canon, M.A., D.C.L., F.R.S., *Burnmoor Rectory, Fence  
 Houses*..... ann.
- 1885 Oliver, Prof. F. W., *Royal Gardens, Kew*..... ann.  
 1884 Ommanney, Admiral Sir Erasmus, C.B., F.R.S., 29, *Connaught  
 Square, W.*..... ann.  
 1884 Ormerod, G. W., M.A., F.G.S., *Woodway, Teignmouth* ..... ann.
- 1885 Paget, Sir James, Bart., F.R.S., 1, *Harewood Place, Hanover  
 Square, W.* ..... C.  
 1884 Parker, J. J., 54, *Eaton Terrace, S.W.* ..... ann.  
 1884 Parker, Prof. W. Newton, *University College, Cardiff*..... ann.  
 1884 Parsons, Chas. T., *Norfolk Road, Edgbaston, Birmingham* ..... ann.  
 1887 Pechey, Miss Edith, M.D., *Cumballa Hill, Bombay* ..... ann.  
 1888 Peek, Sir Henry W., Bart., F.Z.S., *Wimbledon House, Wimbledon*... C.  
 1885 Phillips, Chas. D. F., M.D., 10, *Henrietta Street, Cavendish Square,  
 W.* ..... C.  
 1889 Phillips, George, 1, *Victoria Place, Stonehouse* ..... ann.  
 1885 Pochin, H. D., *Bodnant Hall, Eglwysbach, Denbighshire* ..... C.  
 1884 Potter, Michael C., M.A., *Herbarium, New Museums, Cambridge* ... ann.  
 1884 Powell, Thos. Harcourt, *Drinkstone Park, Woolpit, Bury St.  
 Edmunds* ..... C.  
 1886 Power, D'Arcy, M.A., F.R.C.S., 26, *Bloomsbury Square, W.C.* ..... ann.  
 1886 Power, Henry, F.R.C.S., 37A, *Great Cumberland Place, W.* ..... ann.  
 1888 Prance, C. R., M.D., 18, *Princess Square, Plymouth* ..... ann.  
 1885 Pritchard, Urban, 3, *George Street, Hanover Square, W.* ..... ann.  
 1884 Pye-Smith, P. H., M.D., 54, *Harley Street, W.* ..... C.
- 1884 Radford, Daniel, *Mount Tavy, Tavistock* ..... ann.  
 1884 Ralli, Mrs. Stephen, *Cleveland House, Clapham Park* ..... £30  
 1885 Ransom, W. B., *Trinity College, Cambridge* ..... C.  
 1888 Rawlings, Edward, *Richmond House, Wimbledon Common*..... ann.  
 1887 Riley, W., *Newcastle House, Bridgend, Glamorganshire*..... ann.  
 1884 Rowe, J. Brooking, F.S.A., F.L.S., *Mulgrave Street, Plymouth*..... ann.  
 1885 Ruscoe, John, *Albion Works, Henry Street, Hyle, near Manchester*... ann.
- 1889 Sanford, W. A., *Nynehead Court, Wellington, Somerset*..... ann.

- 1885 Saunders, Rev. J. C., M.A., *Downing College, Cambridge*..... ann.  
 1884 Schäfer, Prof. E. A., F.R.S., *University College, Gower Street, W.C.*... ann.  
 1888 Scharff, Robert F., Ph.D., *Science and Art Museum, Dublin*..... ann.  
 \*1884 Sclater, P. L., F.R.S., Sec. Zool. Soc., 3, *Hanover Square, W.*..... ann.  
 1884 Sclater, W. L., *Indian Museum, Calcutta*..... ann.  
 1885 Scott, D. H., M.A., Ph.D., *The Laurels, Bickley, Kent* ..... C.  
 \*1884 Sedgwick, A., M.A., F.R.S., *Trinity College, Cambridge* ..... C.  
 1888 Serpell, E. W., 19, *Hill Park Crescent, Plymouth* ..... £50  
 1885 Sheldon, Miss Lilian, *The Field, Stroud* ..... ann.  
 1884 Shipley, Arthur E., M.A., *Christ's College, Cambridge* ..... C.  
 1886 Shore, T. W., M.D., *Sunny Bank, Church Lane, Hornsey, N.* ..... ann.  
 1889 Simpson, Francis C., *Maypool, Churston Ferrers, R.S.O., S. Devon* ann.  
 1889 Slade, Lieut. E. J. Warre, R.N., *H.M.S. Rodney, Chatham*..... C.  
 1884 Sladen, W. Percy, Sec. Linn. Soc., *Orsett House, Ewell, Surrey* ..... ann.  
 1884 Sowerby, William, *Royal Botanical Society, Regent's Park, N.W.* ... ann.  
 1884 Spencer, J., 121, *Lewisham Road, Lewisham, S.E.* ..... ann.  
 1888 Spencer, Prof. W. Baldwin, M.A., *University of Victoria, Melbourne* ann.  
 1884 Spring-Rice, S. E., 9, *Wilton Street, Grosvenor Place, S.W.*..... C.  
 1884 Stalbridge, The Rt. Hon. Lord, 12, *Upper Brook Street, W.*..... ann.  
 1884 Staples, Alderman, 87, *Avenue Road, Regent's Park, N.W.* ..... ann.  
 \*1884 Stewart, Prof. Chas., P.L.S., *Royal College of Surgeons, Lincoln's Inn Fields, W.C.* ..... ann.  
 †1884 Sutherland, The Duke of, K.G., *Stafford House, St. James', S.W.* ... C.  
 1888 Swain, W. Paul, M.R.C.S., *The Crescent, Plymouth* ..... ann.
- 1889 Taylor, Thomas George, 6, *St. Mary Street, Stonehouse* ..... ann.  
 1884 Thompson, Prof. D'Arcy W., *University College, Dundee* ..... ann.  
 1890 Thompson, Herbert, B.A., 35, *Wimpole Street, W.*..... ann.  
 1884 Thornycroft, John I., *Eyot Villa, Chiswick Mall*..... ann.  
 1888 Thurston, Edgar, *Government Central Museum, Egmore, Madras* .. ann.  
 1888 Tripe, Major-General, 3, *Osborne Villas, Stoke, Devonport* ..... ann.  
 1889 Tweedy, W. Gage, 8, *Athenæum Terrace, Plymouth* ..... ann.  
 1885 Tylor, E. B., D.C.L., F.R.S., *Museum House, Oxford*..... ann.
- 1884 Upcher, Henry R., *Sherringham, Cromer* ..... ann.
- 1888 Vallentin, Rupert, 18, *Kimberley Road, Falmouth* ..... ann.  
 1884 Venning, Mrs., 3, *Wingfield Villas, Stoke Devon*..... £50  
 1884 Vines, Professor Sydney H., M.A., D.Sc., F.R.S., *Botanical Gardens, Oxford*..... ann.  
 1888 Vosper, Samuel, *Stonehouse, Plymouth*..... ann.
- 1884 Walker, Alfred O., *Nantyglyn, Colwyn Bay, N. Wales* ..... ann.  
 1884 Walker, P. F., 36, *Princes Gardens, S.W.* ..... ann.  
 †1884 Walsingham, Lord, F.R.S., *Merton Hall, Thetford*..... £20  
 1890 Waterhouse, Edwin, *Feldemore, Dorking* ..... ann.  
 1888 Weiss, F. Ernest, *Birch Bank, Christ Church Road, Hampstead, N.W.* ..... ann.  
 1884 Welch, H. Kemp, 32, *Onslow Gardens, S.W.*..... ann.  
 1890 Were, Nicholas, 9, *Osborne Place, Plymouth*..... ann.  
 1890 Wilson, J. B., *Grammar School, Geelong, Victoria*..... ann.

- 1884 Wilson, Scott B., *Heather Bank, Weybridge Heath* ..... C.  
 1884 Woodall, John W., M.A., F.G.S., *St. Nicholas House, Scarborough*... ann.  
 1888 Woods, G. W., F.I.C., F.C.S., *Ballagawne, Riggindale Road, Street-*  
*ham, S.W.* ..... ann.  
 1884 Woollcombe, W. G., M.A., F.R.A.S., F.L.S., *Cathedral Close, Exeter* ann.  
 1886 Woollcombe, Surgeon-Major R. W., 14, *Acre Place, Devonport* ..... ann.

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#### IV.—Associate Members.

- 1889 Alward, George, 11, *Hainton Street, Great Grimsby*.  
 1889 Caux, J. W. de, *Great Yarmouth*.  
 1889 Dannevig, Capt. G. M., *Arendal, Norway*.  
 1889 Dunn, Matthias, *Mevagissey*.  
 1889 Olsen, O. T., F.L.S., F.R.G.S., *Fish Dock Road, Great Grimsby*.  
 1889 Ridge, B. J., 3, *Gainsboro' Place, Mutley, Plymouth*.  
 1890 Roach, W., *Sussex Street, Plymouth*.  
 1889 Shrubsole, W. H., 62, *High Street, Sheerness-on-Sea*.  
 1889 Sinel, Joseph, 2, *Peel Villas, Cleveland Road, Jersey*.  
 1890 Spencer, R. L., *L. and N.W. Dépôt, Guernsey*.  
 1890 Wells, W., *The Aquarium, Brighton*.  
 1889 Wilcocks, J. C., *May Cottage, Shoreham, Sussex*.  
 1890 Wiseman, Fred., *Buckland House, Paglesham, Rochford, Essex*.

## MARINE BIOLOGICAL ASSOCIATION.

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### Report of the Council, May, 1890.

THE Council has met nine times during the past year, and the attendance has been fully up to the average of previous years.

The business transacted by the Council has had reference—

1. To the maintenance and general efficiency of the Laboratory.
2. To the prosecution of special investigations on economic subjects.
3. To the financial position of the Association.

1. It was found necessary to alter the communications between the storage reservoirs and the pumps of the Laboratory at Plymouth, and orders were given to Messrs. Leete, Edwards, and Norman to supply a new valve-box, connection-pipes, &c. The cost of these alterations has been considerable, but it is satisfactory to note that the results have been very beneficial, and have produced a marked improvement both in the working of the pumps and in the water in circulation.

The Director reports that there was some little trouble over the sea water in June and July, 1889, during the hot weather, and during the alterations to the supply-pipes, which prevented more than one of the storage reservoirs being in use; but that since then, and especially after the alterations were completed, the water has been of admirable quality, and all the animals have done remarkably well.

Great improvement has lately been effected in the Aquarium at a very trifling cost, by hanging curtains between the top of the fronts of the tanks and the ceiling, so that all the light reaching the spectator must pass through the tanks. Previous to this there appears to have been an excess of light in the tanks, and the fish now appear to be much more comfortable, and keep nearer to the glass fronts.



The following fish, molluscs, and crustacea have spawned in the tanks during the past year :—

The Plaice (*Pleuronectes platessa*).  
 The Flounder (*Pleuronectes flesus*).  
 The Pouting (*Gadus luscus*).  
 The Poor Cod (*Gadus minutus*).  
 The Rockling (*Motella tricirrata*).  
 The Lucky Proach (*Cottus bubalis*).  
 The Spotted Dog-fish (*Scyllium canicula*).  
*Chiton cinereus*.  
 The Whelk (*Buccinum undatum*).  
 The Purple (*Purpura lapillus*).  
 The Sea-hare (*Aplysia punctata*).  
 The Sea-lemon (*Archidoris tuberculata*).  
*Goniodoris nodosa*.  
 The Lobster (*Homarus vulgaris*).  
 The Crawfish (*Palinurus vulgaris*).  
 The Shrimp (*Crangon vulgaris*).  
 The Prawn (*Palæmon serratus*).  
*Idotea tricuspidata* and *emarginata*,

as well as other species not so well known.

The personnel of the staff and servants remains unchanged, with the exception of the fisherman, W. Roach, who left in October. His place has been filled by E. G. Heath, a trawl fisherman of great experience.

The Council sanctioned the purchase, in July, 1889, at a cost of £250, of a small steam-launch, the "Firefly," which has been of great service. Being half decked, and only thirty-eight feet long, this launch is only suitable for local expeditions, and its purchase in no wise diminishes the necessity for a sea-going steam-vessel for carrying on investigations on food-fishes. The "Firefly" is very economical in coal and water, and has entailed no extra expense in working. The Association now possesses three boats—the "Firefly," the "Mabel," a three-ton hook and line fishing-boat presented by Mr. Bourne, and the "Anton Dohrn," a rowing-boat bought in 1889.

Trawling, dredging, surface netting, and shore hunting have been carried on continuously during the year, and examples of interesting species, many of which are new to the district, have been added to the list since the last report.

The standard collection of species is making good progress, the collection of Decapod Crustacea being remarkably complete.

2. The researches on food-fishes and crustacea carried on under the direction of the Council have made considerable progress.

The Director of the Association, Mr. G. C. Bourne, has continued his observations on the pelagic fauna in the neighbourhood of Plymouth, and was also able through the courtesy of Capt. Aldrich, R.N., to make an expedition off the south-west coast of Ireland in H.M.S. "Research" in July last, for the purpose of comparing the surface fauna at the entrance of the Channel with that of the Channel itself. Some interesting observations have been made in connection with the presence of multicellular floating algæ in spring months and the presence of mackerel, which it is hoped may lead to practical results.

The Director has made observations and collected notes on the destruction of immature fish in various localities, and has been able, with the kind co-operation of the medical staff of the Deep Sea Mission to Fishermen, to arrange an extensive inquiry into the presence of immature fish in deep waters in the North Sea, and their movements and destruction by beam trawling. This inquiry is in progress, and promises to be full of interest.

In connection with the destruction of immature soles in the estuary of the Thames the Director has been making arrangements for keeping young soles in enclosed ponds with the view of rearing them to a marketable size, as is done in the Adriatic. For various reasons these experiments have been delayed, and are not yet in progress.

Experiments are also being made on the possibility of cultivating soles in fresh water, and it has been proved that the adult sole may be kept in fresh water.

In conjunction with Dr. G. H. Fowler, the Director has studied the natural history of the oyster, and through the kindness of Lord Revelstoke he has been able to arrange a series of practical inquiries on the natural history and propagation of the oyster in the river Yealm.

The Naturalist of the Association, Mr. J. T. Cunningham, has been chiefly occupied during the past year with a treatise on the common sole, which is now ready for publication.

Mr. Cunningham also has gathered much valuable information about the occurrence of the anchovy in English waters, and the possibility of an English anchovy fishery. A full account of the anchovy is given in the last number of the *Journal*, vol. i, No. 3.

In the early spring of this year Mr. Cunningham made several expeditions to procure the ova of soles and other flat-fishes. He was able to secure and artificially fertilize a much larger number of soles' ova than on any previous occasion, and the fertilized ova were successfully hatched and the larvæ reared, up to the period of the absorption of the yolk-sac, in the aquarium.

On the 13th March this year the plaice in the aquarium were found to be breeding. The Director and Mr. Cunningham collected a large number of their fertilized ova and transferred them to suitable hatching apparatus. The ova hatched out by the 18th March, and the larvæ were kept alive in specially isolated tanks till April 2nd. By this time the yolk-sac was completely absorbed, but the larvæ, although apparently healthy, could not be induced to feed. They died off very suddenly, evidently for want of food, on April 3rd and 4th, having lived fifteen days after hatching.

A second batch of ova was procured on March 28th, and the eggs were hatched out on April 3rd and 4th. These larvæ were placed in a tank and fed with the pelagic organisms caught in the tow-net. They paid no attention to this food, so on April 22nd they were fed with crushed crab, which they appeared to like, for on the following day their intestines could be seen full of food. In spite of this they began to die on April 24th, and all were dead by the 26th.

Thus in the second experiment the larvæ were kept alive twenty days after hatching, a considerably longer period than in previous experiments at Plymouth, and, what is more important, they were induced to feed. These experiments show that some steps have been made towards success. None of the larvæ underwent metamorphosis, but Mr. Cunningham has procured some young plaice, flounders, and brill, already "flattened," and these are thriving in the tanks and feeding regularly.

Arrangements have been made with the Fishery Board for Scotland for carrying on an investigation on the food of the common sole in connection with the work done by the Board on the food of other fishes.

Mr. W. Bateson was working on the sense-organs and habits of fishes, with the view of showing the possibility of using artificial or preserved baits in sea fishing, from April to October, 1889. The results of Mr. Bateson's investigations have been published in the Journal, vol. i, No. 3.

Mr. Weldon continued his investigations on the artificial rearing of lobsters last year. His experiments were apparently turning out successfully when an accident caused the loss of his larvæ and apparatus. This year the artificial rearing of lobsters is being proceeded with by means of a different form of apparatus suggested by Dr. Fowler's successful method of raising the young of *Idotea*.

In addition to his experiments on lobsters Mr. Weldon is engaged on important scientific investigations on the variation and natural history of the Decapod Crustacea.

The following gentlemen and ladies have been engaged on inde-

pendent scientific researches in the Laboratory since the date of the last report :—

Mr. W. F. R. Weldon, M.A., F.R.S., St. John's College, Cambridge (*Decapod Crustacea*) ; Dr. G. H. Fowler, B.A.Oxon. (Studies in Descent) ; Mr. M. C. Potter, M.A.Cantab. (Marine Algæ) ; Mr. S. F. Harmer, M.A.Cantab. (Development of *Polyzoa*) ; Mr. T. T. Groom, B.A.Cantab. (*Cirrhropedia*) ; The Rev. Canon A. M. Norman, D.C.L. (Crustacean Fauna) ; Mr. A. O. Walker, F.L.S. (*Amphipoda*) ; Prof. T. Johnson, B.Sc.Lond. (*Florideæ*) ; Mr. A. E. Shipley, M.A.Cantab. (*Gephyrea*) ; Dr. Hans Driesch, Jena (Heliotropism in *Hydroidea*) ; Mr. P. C. Mitchell, B.A.Oxon. (Histology of *Tunicata*) ; Mr. T. H. Riches, B.A.Cantab. (Nephridia of *Mollusca* and *Crustacea*) ; Mr. Herbert Thompson, B.A.Cantab. (Development of *Crustacea*) ; Miss Marion Greenwood, Newnham College, Cambridge (Physiological Studies) ; Miss L. Ackroyd, Newnham College, Cambridge (Morphology of *Nebalia*).

3. Among the receipts of the past year the Council have to acknowledge the following subscriptions and donations :—£100 from Lord Revelstoke ; £100 from Sir Henry Thompson ; £100 from the Grocers' Company ; £200 from the Fishmongers' Company (annual grant for five years) ; £500 from H.M. Treasury (annual grant for five years).

From annual subscriptions and compositions £143 was received, £61 interest on investments, and £185 for rent of tables and sale of specimens.

The expenditure, as shown in the Treasurer's account presented herewith, amounted to £2924, of which £398 was paid to Mr. Inglis for balance of his fees as engineer, £417 for structural alterations and additions, £112 for bait investigation, and £250 for a steam-launch.

The Association now has in hand, in cash and invested, £1398, excluding the trust funds.

The Council have great pleasure in acknowledging the generous assistance which has lately been afforded to the Association by the Fishmongers' Company, by Mr. J. P. Thomasson, M.P., and Mr. Frank Crisp.

The Fishmongers' Company, in addition to substantial grants which they have already made to the Association, have undertaken to contribute £400 per annum to the funds of the Association for a period of five years from the present date.

Mr. J. P. Thomasson has kindly offered a sum of £250, to enable the Council to retain the services of the Naturalist, Mr. J. T. Cunningham, for another year.

Mr. Frank Crisp has kindly given a sum of £120 (£60 per annum



for two years) to meet the expenses of special investigations on the culture of sea fishes in enclosed ponds. The Council take this opportunity of placing on record their appreciation of the interest and confidence shown in the work of the Association by these liberal donations.

The thanks of the Association are due to Prof. Haeckel for a copy of his work on the *Siphonophora* ; to Col. Richardson, R.A., for a number of ichthyological works from the library of the late Sir J. Richardson ; to Mr. J. W. Clark for back numbers of the Philosophical Transactions of the Royal Society and other books ; to Messrs. J. and A. Churchill for the current numbers of the Quarterly Journal of Microscopical Science ; and to Messrs. Agassiz, Giard, Marion, the United States Fish Commission, the Naples Zoological Station, the officers of the Norwegian North Atlantic Expedition, and other individuals and societies for copies of their publications.

The Council desire to express the indebtedness of the Association to the Council of the Royal Society for kindly permitting the Association to hold the periodical meetings of the Council and Association in their rooms.

In July and August, 1889, the Council was in correspondence with the Fishery Board for Scotland and the Fisheries Department of the Board of Trade, with reference to the possibility of procuring scientific information on the alleged destruction of immature fish by beam trawling in deep waters.

Subsequently the Council determined to make an application to H.M. Treasury for a further grant of money in aid of special researches on food-fishes. The Chancellor of the Exchequer kindly consented to receive a deputation on the subject on May 15th.

The deputation was introduced by the Right Hon. Joseph Chamberlain, M.P., and Sir Edward Birkbeck, Bart., M.P.—Prof. Burdon Sanderson, F.R.S. ; Dr. John Evans, F.R.S. ; Mr. Ed. Marjoribanks, M.P. ; Mr. E. L. Beckwith, and Prof. E. Ray Lankester spoke in favour of the objects of the deputation.

The following were also present:—Lord Montagu ; Admiral Mayne, M.P. ; Sir W. Bowman, Bart., F.R.S. ; Sir Henry Thompson ; Mr. T. B. Bolitho, M.P. ; Sir Lyon Playfair, K.C.B., M.P. ; Mr. E. B. Poulton, F.R.S. ; Prof. Flower, C.B., F.R.S. ; Mr. Palmer ; Mr. E. W. H. Holdsworth ; Mr. Adam Sedgwick, F.R.S. ; Mr. G. W. E. Loder, M.P. ; Mr. W. Bickford Smith, M.P. ; Prof. Jeffrey Bell ; Prof. Michael Foster, F.R.S. ; Mr. P. L. Sclater, F.R.S. ; Prof. Chas. Stewart ; Mr. G. F. Romanes, F.R.S. ; and Mr. Howorth, M.P. The Duke of Abercorn, the Earl of Ducie, the Earl of Morley, and several others were unavoidably prevented from attending.

The Council regret to have to announce that Prof. Huxley, who

since the foundation of the Association has been its President, has found it necessary to withdraw from the office which he has held with so much honour and advantage to the Association. The Council desire to express their warm appreciation of the eminent services rendered by Prof. Huxley to the Association, and their great regret that he should be unable to continue his office.

The following is a list of Officers and Vice-Presidents as proposed by the Council for the year 1890-1.

*President.*—Prof. E. Ray Lankester, F.R.S. (elected October 8th, 1890).

*Vice-Presidents.*—The Duke of Argyll, K.G., F.R.S.; The Duke of Sutherland, K.G.; The Duke of Abercorn, C.B.; The Earl of St. Germans; The Earl of Morley; The Earl of Ducie; Lord Revelstoke; Lord Walsingham, F.R.S.; The Right Hon. A. J. Balfour, M.P., F.R.S.; The Right Hon. Joseph Chamberlain, M.P.; Prof. G. J. Allman, F.R.S.; Sir Edward Birkbeck, Bart., M.P.; Prof. Flower, C.B., F.R.S.; Prof. Huxley, LL.D., F.R.S.; Sir John Lubbock, Bart., M.P., F.R.S.; Prof. Alfred Newton, F.R.S.; Sir Henry Thompson; Rev. Canon Norman, D.C.L., F.L.S.; Captain Wharton, R.N., F.R.S.

*Council (elected members).*—Prof. F. Jeffrey Bell, F.Z.S. (British Museum); W. H. Caldwell, Esq., M.A.; Frank Crisp, Esq., V.P. and Treas. Linn. Soc.; W. T. Thiselton Dyer, Esq., C.M.G., F.R.S. (Royal Gardens, Kew); John Evans, Esq., D.C.L. (Treasurer R.S.); Prof. C. Ewart, M.D. (Edinburgh); A. C. L. G. Günther, Esq., F.R.S. (British Museum); E. W. H. Holdsworth, Esq., F.L.S., F.Z.S.; E. B. Poulton, Esq., M.A., F.R.S.; G. J. Romanes, Esq., F.R.S.; P. L. Sclater, Esq., F.R.S. (Sec. Zool. Soc.); Adam Sedgwick, Esq., F.R.S.; Prof. Charles Stewart, P.L.S.; W. F. R. Weldon, Esq., M.A., F.R.S.

*Hon. Treasurer.*—E. L. Beckwith, Esq.

*Hon. Secretary.*—Prof. E. Ray Lankester, LL.D., F.R.S.

Statement of Receipts and Payments for Year ending 31st May, 1890.

	£	s.	d.	£	s.	d.
To Balance from last year, made up as follows:	500	0	0			
Trust Fund, Bait Investigation.....	340	4	0			
"    Steam Launch .....						
Less Deficit on General Account .....	840	4	0			
	142	16	9			
H. M. Treasury .....				697	7	3
" Fishmongers' Company (2 years) .....				500	0	0
" Annual Subscriptions .....				400	0	0
" Founders .....				127	18	0
" Composition Fees .....				300	0	0
" Rent of Tables, Sales of Journal, Spectimens, &c. ....				15	15	0
" Interest on Investments and Deposits .....	185	5	0			
	61	9	1			
" Sale of Investment:				246	14	1
£500 North-Eastern 4½% Debenture Stock				705	1	2

Examined and found correct,

STEPHEN E. SPRING RICE,  
C. STEWART,  
W. PERCY SLADEN,  
EDWIN WATERHOUSE,  
Auditors.

£2992 15 6

20th June, 1890.

BALANCE SHEET, 1890.

	£	s.	d.	£	s.	d.
By Buildings, Plant, &c.:						
Lecte, Edwards, & Co.—Tanks, &c.....	267	11	6			
I. C. Inglis—Balance of Fees as Engineer	193	3	0			
Disbursements .....	205	12	3			
Berry & Co.—Additions and Alterations	147	7	6			
Trust Funds:				815	14	3
Expended for Bait Investigation .....	112	10	3			
Purchase of Steam Launch.....	250	0	0			
Salaries and Wages:				362	10	3
Director .....	200	0	0			
Naturalist .....	250	0	0			
Wages and Salaries of Assistants, &c....	357	3	8			
Stationery, Office Printing, Postage, &c.....				807	3	8
Printing and Illustrating Journal.....				95	6	1
Gas, Water, Coal, Oil, &c. ....				145	2	8
Stocking Tanks with Fish, Feeding and Maintenance .....	128	2	10			
Glass, Chemicals, Apparatus, &c. ....	75	2	9			
Maintenance and General Repairs .....	130	13	3			
Rates and Taxes .....	45	2	4			
Boat Hire .....	30	17	6			
Travelling Expenses .....	28	4	6			
Library .....	2	10	0			
	53	2	6			
Balance forward, made up as follows:				493	15	8
Trust Fund, Bait Investigation .....	387	9	9			
"    Steam Launch .....	90	4	0			
Deficit on General Account .....	477	13	9			
	204	10	10			
				273	2	11
				£2992	15	6
Investment held 31st May, 1890:						
£900 Fourth Bridge Railway 4% Debenture Stock at 125....	1125	0	0			

(N.B.—The above price is that current on 1st June, 1890.)

### The Director's Report.—No. 4.

DURING the summer months the Laboratory has been well filled, the following gentlemen having occupied tables *in addition to six* of those named in the Report of the Council (p. 360) :

Dr. W. B. Benham, University College, London (*Polychæta*).

Mr. M. F. Woodward, Normal School of Science, South Kensington (*Mollusca*).

Mr. E. A. Minchin, Keble College, Oxford (*Porifera* and *Gregarinida*).

Mr. W. G. Ridewood, British Museum of Natural History (*Clupeidæ*).

Mr. W. W. Welch, Oxford (*General Zoology*).

Besides these gentlemen Mr. W. T. Hughes, Mr. E. de Hamel, and Mr. G. W. Tait spent a fortnight at the Laboratory in general zoological study.

The two years during which the Laboratory has been open have been by no means unproductive of permanent result. In addition to the papers published in this first volume of the Journal and in the two numbers of the old series, which constitute in themselves a serious contribution to science, those in the list following embody the results of work done here, while several more are, of course, in progress :

**Sanderson, Prof. W. Burdon, and F. Gotch.**—*The Electrical Organ of the Skate*, part ii. Journ. Physiology, x.

**Harmer, S. F.**—*On a New Species of Dinophilus*. Proc. Camb. Phil. Soc., vi.

**Weldon, W. F. R.**—*The Variations occurring in certain Decapod Crustacea*. 1. *Crangon vulgaris*. Proc. Roy. Soc., xlvii.

**Driesch, Dr. Hans.**—*Heliotropismus bei Hydroidpolyphen*. Zoologische Jahrbücher, v.

**Beddard, F. E.**—*On certain Points in the Structure of Clitellio*. Proc. Zool. Soc., 1888.

**Beddard, F. E.**—*Notes on some British Species of Pachydrilus*. Proc. Roy. Phys. Soc. Edinb., 1889.



Cunningham, J. T.—*On Secondary Sexual Characters in Arnoglossus*. Proc. Zool. Soc., 1890.

Johnson, Prof. T.—*Dictyopteris; Remarks on the Systematic Position of the Dictyotaceæ*. Journ. Linn. Soc., 1890.

Johnson, Prof. T.—*Observations on Brown and Red Seaweeds*. Rep. Brit. Assoc., 1890.

MacMunn, C. A.—*Contributions to Animal Chromatology*. Quart. Journ. Micr. Sci., xxx.

Thirty naturalists have occupied tables in the Laboratory for longer or shorter periods, several of them on more occasions than one. There is every reason to hope that this number will grow steadily larger; the existing accommodation for eleven (including the staff) can easily be increased when necessary at small cost. It is also worthy of notice that live and dead specimens have been supplied to nearly every University and College which offers a zoological course to its students, and to many private individuals.

With this constantly enlarging sphere of usefulness, however, **the want of a suitable vessel is every day more strongly felt**; even in the best of weather it is not advisable to go more than two or three miles from shore in our little steam-launch, and it is frequently impossible to go outside the Breakwater. With a larger vessel, not only would it be possible to supply material to the naturalists working in the Laboratory in greater abundance and variety (commanding as we could the rich stretch of coast from Mount's Bay to Tor Bay), but it would be *in the power of the Association for the first time to undertake continuous and systematic investigations into the problems of the spawning-grounds, nurseries, and migrations of food-fish*, valuable work such as the "Garland" is at present doing for the Scottish Fishery Board. A Laboratory is only half, although a necessary half, of the equipment required to attack fishery problems. As far as possible its work has been supplemented by occasional expeditions on trawlers, &c., but observations made in this way are necessarily scattered and incomplete. A vessel able to keep the sea in any weather with the fishing fleets would cost between £2000 and £3000, and if maintained the whole year round with a full crew would probably not cost less than £1200 per annum. *The "Special Steamboat Fund" was practically exhausted by the purchase of the steam-launch*; and the Association has no funds sufficient either to purchase or to maintain this absolute necessity of its efficiency.

With regard to the present number of the Journal, which completes the first volume, special attention is called to Mr. Cunningham's successful rearing of larval fish (p. 370), which is of the

greatest importance in connection with the destruction of immature fish in the estuaries of many rivers by shrimpers and others. The removal of young and comparatively helpless fish from the reach of their natural enemies and the rearing of them at small cost, which Mr. Cunningham shows to be perfectly practicable, may easily develop into a profitable industry. The notes on the Plymouth herring fishery by Mr. Wm. Roach (p. 382), who was for more than two years the fisherman in the employ of the Association, are also of the greatest interest.

Several investigations, to which reference has been made in previous journals, are still in progress.

Mr. G. C. Bourne resigned the post of Director of the Laboratory in August last.

G. HERBERT FOWLER,  
*Director ad interim.*

## Notes on Recent Experiments relating to the Growth and Rearing of Food-fish at the Laboratory.

REFERENCE has been already made in the Report of the Council to the successful (artificial) fertilization and hatching of the eggs of the sole, and to the study of the plaice eggs which were *naturally* fertilized and hatched in the aquarium. With regard to the rearing of lobsters, Mr. Weldon and Mr. Fowler have contributed the following notes on their experiments :

### I. THE REARING OF LOBSTER LARVÆ.

In the intervals of other and more pressing work we have made during the months of June and July a few experiments on the rearing of lobster larvæ ; and although for various reasons these experiments were not successful, a few notes on the methods pursued and the conclusions deduced may prove of use to others engaged in the same task. It is possible that the cause of failure was merely that the eggs had suffered in being brought in, from the struggles of the mother lobsters ; certainly a very large number of larvæ died in the act of hatching, too weak to extricate themselves from the shell. The shortness of the hatching season, however, prevented the undertaking of new and special arrangements for carrying them. Other possible causes of failure were want of space and the difficulty of providing a suitable food. As to the question of space, most pelagic organisms cannot bear to be confined within narrow limits, whether vertical or horizontal ; they must, if they are to thrive, have a large superficial range, as well as a considerable depth of water to which they may sink when such physical conditions as light and heat demand it. As the Association had unfortunately no funds to place at our disposal for this special purpose, the largest body of water available was a tank of sixty-three feet superficial area, and containing about 600 gallons ; the water was in constant circulation, and formed part of the

general system of the aquarium. Rock-work was arranged for the mother lobsters, and the inflow and outflow were guarded by "smut-wire" screens; the surface was constantly broken by a current through a fine "rose." In this tank the larvæ flourished better than elsewhere, but we were unable to keep them alive for more than twelve days after hatching. Part of the tank was boarded over for shade, but the larvæ appeared to avoid this dark part, and to select shady corners in the well-lit area. So long as they were strong they remained at the surface, and only sank to the bottom when beginning to turn red (the recognised symptom of weakness). They exhibited no liking for the rock-work.

The problem of a suitable food was not entirely solved in spite of many experiments. The yolk of a hard-boiled egg, crushed crab (*Carcinus mænas*, *Portunus depurator*), boiled liver, the contents of the tow-net (at that period chiefly *Noctiluca* and Copepoda), and live shrimp larvæ, were all partially, none absolutely, successful. The first three are *seen* and eaten with avidity when floating as small particles about one to six inches below the surface; when at the surface or on the bottom they are apparently not touched, and it was not advisable to keep pouring finely divided food constantly into the tank owing to the danger of fouling the water; shrimps placed in the tank to eat the sunken food ate the larvæ by preference: shore-crabs were found to answer better as scavengers, but cannot take up fine particles. Finding that food is only taken when at this position in the water, we caused small brackets to be suspended about four inches below the surface, on which the food (crushed crab) was placed in common red flower-pot saucers; the larvæ swarmed into the saucers, and perished miserably. This occurred partly because they were attracted by the bright colour and unable to leave it, partly because the sides of the saucer were so steep that they found difficulty in getting out. An ordinary white saucer, however, with less steep sides produced nearly the same mortality. That the brightness of the saucer was largely the cause of death was demonstrated by placing an *empty* saucer on the bracket, into which they crowded and died. The brackets were then blackened by charring, and the food placed directly upon them; it was not touched. Large pieces of food suspended from wooden spits were seldom touched. It was definitely concluded from these experiments that whatever food is used must be floating in the condition of small particles at a short distance below the surface, *i.e.* in the same position as the natural pelagic food of the larvæ at sea, whether this consist of Copepoda, other Decapod larvæ, trochospheres, fish ova, or other members of the pelagic fauna. As to the other two forms of food tried, the *Noctiluca* were



apparently eaten, the shrimp larvæ (*Mysis* stage) certainly were attacked; and from the fact that the young lobsters attack and devour each other it is probable that Decapod larvæ form at any rate part of their usual food. The contents of a tow-net taken near the Eddystone on August 6th, which held a young lobster, consisted chiefly of *Megalops* and *Mysis* stages of Decapoda.\*

The qualification for success in all experiments of this kind is the reproduction, on a small scale and under the control of the experimenter, of the essential factors in the environment of the animal to be reared. The conditions which seem to us most likely to yield success, both in hatching fish and lobsters, are the following:—The establishment of a large and deep pond (say 1000 square feet in area, and 2—3 fathoms deep at some places) on a rocky coast, the levels being so arranged that it should stand always about four fifths full, while the remaining fifth should fill through filters on the top of ordinary and spring floods, emptying slowly on the ebbs. A flora should be allowed to form in the pond for a year or so before it is required for hatching purposes; and all predatory animals should of course be kept down. At a higher level than this pond should be two or three lesser ponds, kept well stocked with breeding animals whose larvæ are likely to serve as food (crabs and shrimps), communication with the lobster pond being maintained by guarded siphons which would carry over the larvæ, but not the adults. While these would supply one element of food, the daily tide would bring an additional quantity of pelagic organisms, which could be supplemented by the tow-net, and, if necessary, by artificial food (crushed crab, &c.). The ova and embryos of common fish would probably prove a most appropriate pabulum, cheaply and easily obtainable by artificial fertilization; but we had no opportunity of experimenting with them during this hatching season.

The mere hatching of the eggs of the lobster, whether they are left on the mother, or are stripped from her and hatched in appropriate apparatus, presents, of course, no difficulties; it is easy to turn myriads of young lobsters loose in the sea with a very small expenditure; but the general belief that over-fished grounds can be replenished in this way is still open to very serious criticism. There is as yet no proof that this procedure has produced or can produce any effect whatever in restocking depopulated areas. We do not desire to discuss this question here. Our experiments were a preliminary attempt to ascertain in what manner young lobsters might best be reared in large numbers to the age at which they assume the characters and habits of the adult; to achieve this is simply

\* Young stages of the lobster have been rarely taken in the surface tow-net by the Association both by day and by night, but never elsewhere than at the surface.

a matter of experience, *i. e.* of continued experiment. It has already once (1885) been done by Captain Dannevig in Norway; and if any benefit come to the lobster fishery by turning the newly hatched larvæ loose in their most helpless phase, greater success will certainly attend the planting of over-fished grounds with young lobsters at the age at which they sink to the bottom and assume the habits of concealment of the adult.

## II. THE REARING OF LARVAL FISH.

By J. T. CUNNINGHAM, M.A., F.R.S.E.

**The Flounder** (*Pleuronectes flesus*, Linn.).—On May 3rd of the current year I received from Mr. Dunn, of Mevagissey, about 200 young flounders (*Pleuronectes flesus*), collected in the shallow pools left in Mevagissey Harbour at low tide; and on May 7th Mr. Dunn sent another large consignment of the same kind of fish. I put the greater number of them into two shallow table-tanks, one of these tanks being in the aquarium and exposed to a good deal of light, the other in the Laboratory and somewhat dark.

These young flounders were at the stages of development represented in fig. 5, Pl. XVII, and fig. 1, Pl. XVIII of my *Treatise on the Sole*, the great majority at the younger of these two stages. They were very transparent with the exception of the eyes, which were fully pigmented and had a brilliantly metallic appearance. The metamorphosis in these was begun, but by no means completed; the left eye was approaching the edge of the head, and nearly all the pigment-cells had disappeared from the left side of the body. They rested for the most part on the bottom, but frequently swam about in the water in a slanting position. One of these was measured, and found to be 12·7 mm. ( $\frac{1}{2}$  inch) in length, 5·1 mm. ( $\frac{7}{8}$  inch) in breadth.

Some of them were slightly more advanced; these were much more opaque, with more pigment on the upper side, and with the eye of the lower side on the very edge of the head. One of them measured 11·5 mm. in length and 5 mm. in breadth.

The tanks in which these young flounders were placed were arranged thus: the bottom was covered with fine sand, except where at one end there was gravel, separated from the sand by a wooden plank, and filling up a space below the slate partition which separated this tank from the next. Water, flowing into the tank in a couple of small jets, passed through the layer of gravel, so that the level in the tank containing the flounders was always the

same as in the next tank, which contained an overflow pipe. In this way a constant flow of water was maintained in the tank without causing any strong current at the outflow, so that the small fish could neither escape nor be injured by a strong current of water towards the outflow.

I fed these young fish at first with minute Crustacea, procured by sifting a quantity of weeds from the shore in water. In this way numbers of small Copepods, Amphipods, and Isopods were separated from the weeds, and were then put into the flounder-tank. The little fish took this food eagerly, but the labour of preparing it was considerable. I therefore soon gave up this method, and fed the fish with chopped worms (*Nereis*, *Nephtys*, &c.). The minced worms were strained through a vulcanite sieve, and only the smaller particles were given to the young fish. As the fish grew older other kinds of food, such as chopped Pecten and pilchard, were occasionally given, but the fish always took worm with most eagerness. During my absence from the Laboratory between July 1st and August 13th the fish were regularly fed by the attendant, and on my return I found that they were all in a healthy condition, and that they had grown very considerably, although the size of different individuals varied very much. On August 19th, of two specimens from the tank in the aquarium one measured 6.7 cm. ( $2\frac{5}{8}$  inches) in length, the other 8 cm. ( $3\frac{3}{16}$  inches). These specimens were not the largest in the tank, but I believe that they were above the average size of the whole number. As the fish are very active, and always more or less concealed by the sand, it is, of course, impossible to ascertain the minimum and maximum size, or the average size, without killing the whole number. But it is clear that in three and a half months many of these fish have grown from about  $\frac{1}{2}$  inch in length to 3 inches.

**The Brill** (*Rhombus lævis*, Gottsche).—On May 21st of the current year boys and fishermen brought to the Laboratory a number of the young of this species. They were found swimming near the surface of the water in Sutton Pool, and were taken out either by hand or with a tin pot. There had been a south wind on that and the previous days, and the fish were found at flood tide. I put twenty of these into the tank in the aquarium, where the young flounders were.

On June 11th I received fourteen more of the same species in about the same stage. Those placed with the flounders were observed to catch and devour them, so that I had another tank prepared after the same fashion, and placed all the brill in this by themselves. I could only find seventeen in the flounder-tank, so that the total number of brill isolated in the tank devoted to them

was thirty-one. After the brill were separated from the flounders they were fed with chopped worm, which they ate very sparingly. I was unable to get any other living fish which they seemed to appreciate; to small shore-fish such as gobies they paid no attention. I was afraid that they would not eat enough of the worm to nourish themselves, but on my return to Plymouth after my holiday I found that they were alive and had grown a great deal. They still continue to live on worms, occasionally varied by *Pecten* and pilchard, but they never feed eagerly and voraciously as the flounders do. It is possible that in the natural condition young brill prey upon smaller fishes, and that then they grow faster than my specimens have on the diet supplied to them. But I could not afford to feed them on living young flounders, and I shall have to find some future opportunity of comparing the growth of the captive specimens with that of free individuals.

These young brill when brought to the Laboratory were 2.2 to 2.56 cm. ( $\frac{7}{8}$  inch to 1 inch) in total length. They all possessed a large air-bladder, and were able to sustain themselves for an indefinite time at the surface or in mid-water; but they frequently rested on the sand at the bottom of the tank, and after a few days they swam less and less above the bottom. Their metamorphosis was nearly complete, but the eye of the lower side (the right) was either on the edge of the head or only slightly within the edge on the upper side. The dorsal fin did not extend forwards in front of the right eye as it does in the adult, but only overlapped that eye for about one third of its longitudinal diameter. The anterior dorsal fin-rays were simple and undivided externally. Scales in the skin were not visible externally.

On August 23rd I took out one of these brill and preserved it in spirit. It measured 6.65 cm. ( $2\frac{5}{8}$  inches) in total length, 4.45 cm. ( $1\frac{3}{4}$  inches) in greatest breadth. It was in all respects closely similar to the full-grown adult. The first five of the dorsal fin-rays were divided into two branches at the ends; and, in the first two, indications of further subdivision were visible. The dorsal fin extended forwards in front of the transverse level of the right eye. The circular scales were distinctly visible all over the upper (left) side by the aid of a simple lens.

Thus these brill have grown from about 1 inch to over  $2\frac{1}{2}$  inches in length in two and a half months.

**Five-bearded Rockling** (*Motella mustela*, Linn.).—Several specimens of the young of this species were brought to the Laboratory on May 21st, having been caught in Sutton Pool along with the young brill. When brought in they were about an inch long. One species of *Motella* was spawning in our tanks in April of the present year,



and the present species probably spawns about the same time, so that the young specimens obtained from Sutton Pool were probably three or four weeks old. They were placed with the young flounders, and thrived well, feeding on the chopped worm supplied to the latter. One killed on August 19th was  $3\frac{1}{8}$  inches long (7.9 cm.).

**Grey Mullet** (*Mugil chelo*, Cuvier).—Last year a number of the young of this species were brought to the aquarium by Mr. W. Bateson, and are mentioned in his paper in the previous number of this Journal. These little fish were taken in the open sea, but there can be no doubt that they were hatched the same year, though in which month it is not easy to decide. When obtained by Mr. Bateson in July and August they were about  $\frac{3}{4}$  of an inch long. I obtained some of the same species this year in Cawsand Bay on May 14th, which were 11 mm. ( $\frac{7}{16}$  inch) in length. These were, in all probability, from their almost larval appearance, not more than one month old, so that probably the species spawns in April.

Some of Mr. Bateson's specimens have been living in the aquarium tanks up to the present time (August, 1890). One of these killed on August 25th measured 5.7 cm. in length ( $2\frac{1}{4}$  inches). Another specimen, brought in from the sea this year, is somewhat larger, but not more than 3 inches long; this specimen is doubtless also in its second year, and has probably grown a little more in its free condition than the captive specimens.

Both these young mullet and the adults in the tanks are fond of a kind of food which no other fish has ever attempted to eat, namely, the dirty-looking, fleecy vegetable growth which covers the sides of the tanks and the rock-work.\* I have watched both the young and old individuals browsing almost like cattle on this growth. The stuff is of a dark brown, almost black, colour, and has a ragged offensive appearance. Examined by the microscope it was found to consist chiefly of Diatomaceæ. It was composed of interlacing filaments, formed by the filamentous species of Diatoms, covered by sessile or separate forms; among the Diatom filaments were also some others belonging to another class of Algæ, the Cyanophyceæ; these resembled the genus *Tolypothria*, and were of a bluish-green colour. (The plants were examined by Professor T. Johnson, who is at present studying at the Laboratory.) This vegetable growth was found in abundance in the stomach and intestines of the young mullet killed on August 25th. It is somewhat surprising to find a fish, which belongs to the highest class of animals, living directly on Diatoms, which are among the most lowly organised of plants.

The mullet in our tanks will eat sparingly of other kinds of food,

\* This growth occurs also in other aquaria; for instance, at Amsterdam and at the Crystal Palace.—ED.

provided it be soft. Mr. Bateson fed his young specimens on minced worm ; the adults will also eat worms, chopped *Pectens*, roe or milt of herring and pilchard. In fact, they nibble at almost any kind of soft food, but never swallow large pieces greedily, as many species of fish do.

Our mullet are also occasionally seen to take up a little of the gravel at the bottom of the tank, and eject it again from the mouth.

It is well known that grey mullet are usually found in the neighbourhood of docks, piles, piers, harbours, &c., and that they ascend estuaries. It is probable that they always live close to the shore, and never go into deep water far from land. Considering this natural habit and the mode of feeding observed in our tanks, it may reasonably be inferred that this species feeds largely on Diatoms and other lowly organised Algæ, which always form a coating over the surface of submerged masonry, wood, or iron, and over rocks. It is interesting to note that the structure of the fish is peculiarly adapted for such a mode of feeding. In the first place, the jaws, instead of projecting to a point as they do in predatory fishes, are extremely blunt, so that the lips form almost a straight line transverse to the axis of the body. This form of the mouth, as in the muzzle of herbivorous ruminants, is especially adapted for browsing on vegetable growths covering a flat, hard surface. Secondly, there are no teeth in the jaws ; the edge of the lower jaw is sharp and straight, while the upper lip forms a thick elastic pad against which the lower jaw can bite. This arrangement reminds one of the jaws of a ruminating animal, such as a sheep or an ox, in which the cutting edge formed by the incisors of the lower jaw bites against the hard toothless pad formed by the gum of the upper jaw.

But these and other peculiarities in the structure of the grey mullet are not exclusively adapted to feeding off hard surfaces. Dr. Günther states that the fishes of this genus feed on organic substances which are mixed up with the sand or mud. Day mentions that they are observed in an aquarium to suck in the sand, the coarser portion of which they again eject. They are frequently seen to do this in our tanks, but they never feed industriously in this way as they do off the surface of the rocks and sides of the tanks. Day also mentions that various minute molluscs, both bivalves and Gasteropods, small Crustacea, and fragments of *Zostera* and *Confervæ*, have been found in mullets' stomachs.

It is evident, therefore, that, unlike most marine fishes, the grey mullet lives largely, though not exclusively, on plants, and particularly on the lowest forms of Algæ, especially the Diatomaceæ. The internal organs of these fishes, which differ so much from those of the majority of fishes, and resemble in many respects those of grami-

Fig. 1.

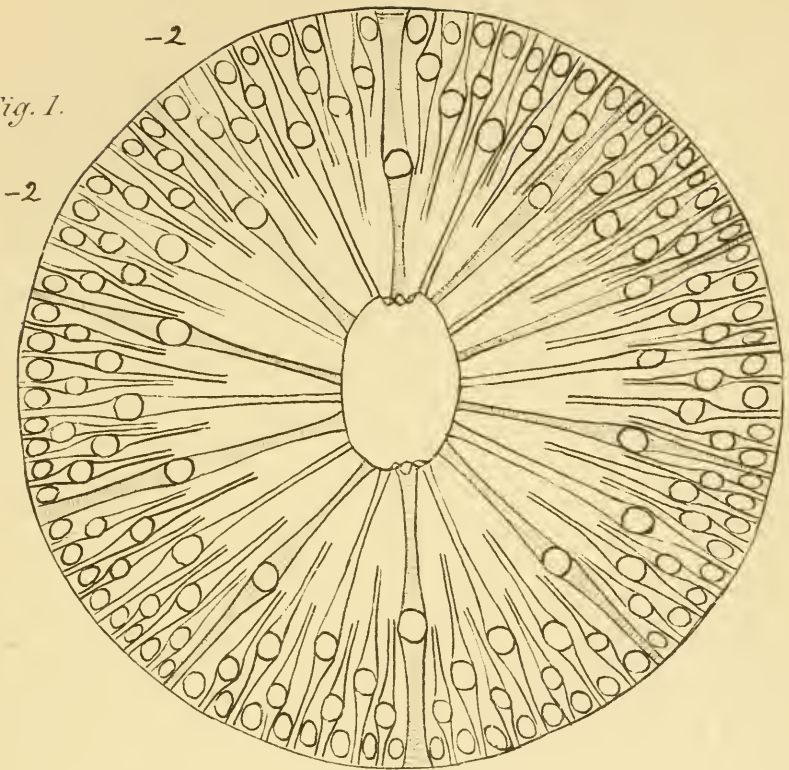
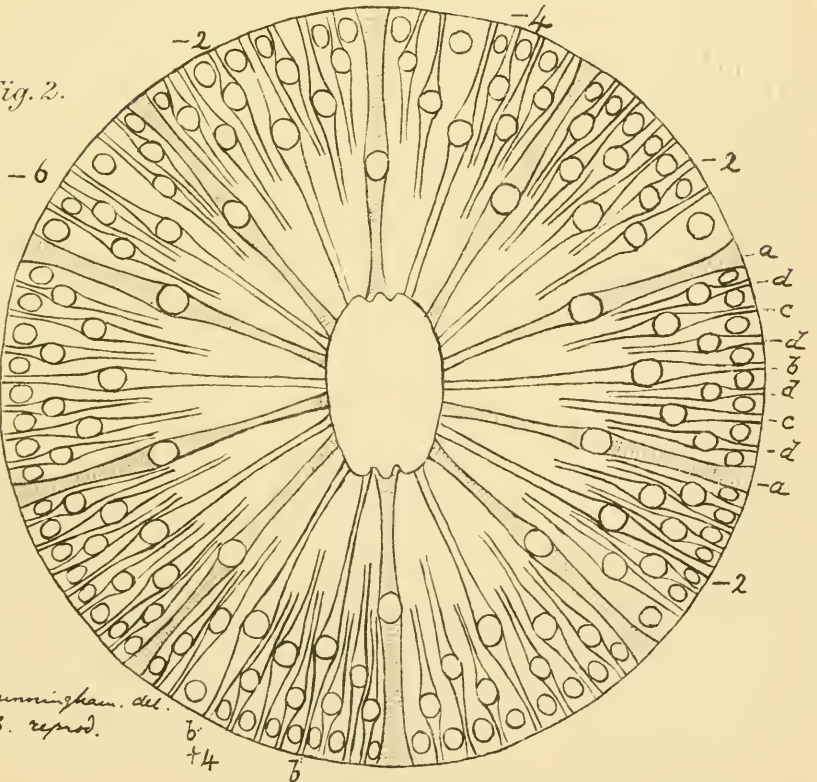


Fig. 2.



J. T. Cunningham, del.  
E.C.B. reprod.





nivorous birds, are especially adapted to this peculiar kind of food. Teeth are entirely absent, those of the pharyngeal bones being replaced by horny papillæ above and horny ridges below. The gill rakers have the form of lamellæ running transversely to the gill arches, and the whole pharynx thus forms a filtering apparatus, minute nutritious organisms being prevented from passing through the gill apertures and swallowed, while coarse hard substances are ejected from the mouth. The pyloric portion of the stomach forms a globular gizzard, lined with a tough epithelium and surrounded by a thick and strong muscular layer, and thus similar to the gizzard of the majority of birds. The intestines are also extremely long and convoluted, as, for example, in a common fowl; and there is also some resemblance to the entrails of the latter in the soft texture and yellowish-green colour.

The fact that grey mullets feed on Diatoms probably explains the following. On May 9th Mr. Dunn sent me a young specimen  $\frac{7}{8}$  of an inch long, on which there was a tuft of brownish-yellow threads projecting from the side of the head. At first sight it seemed as though an abnormal growth of the gills had taken place. But on examination I found that the tuft was attached by a kind of stem to the ventral edge of the right operculum, and had nothing to do with the gills. Under the microscope the growth was seen to consist of branched transparent gelatinous tubes filled with frustules or cells of a Diatom; the Diatom itself forms the branching tubes. It is a Schizonema; the species is probably *S. Dilwynii*. It is likely that a frustule of this Diatom had at some time or other passed by accident from the pharynx of the fish through the gill clefts, and had then adhered to the operculum and commenced to grow.

**Breeding of the Poor Cod and Pouting.**—Several specimens of each of these two species, *Gadus minutus* and *Gadus luscus*, have been living together in a tank of the aquarium since the summer of 1889. In March of the present year most of them were seen to be swollen with ova, and floating eggs were found in the tank. I was too much engaged to collect a number of the eggs and hatch them, but in order to determine the character of the eggs I squeezed a female of each species on April 8th, and examined the ripe ova which were thus expelled. The eggs of both species resembled those of the cod, whiting, and haddock in all respects except size; that is to say, the yolk was perfectly homogeneous and without oil-globules, and the perivitelline space, or space between the egg and its envelope, very small. The diameter of the egg of *G. minutus*, including the envelope or shell, was 1.02 mm.; that of *G. luscus* very slightly larger, namely, 1.05 to 1.15 mm.

Report on the Surface Collections made by Mr. W. T.  
Grenfell in the North Sea and West of Scotland.

By

**Gilbert C. Bourne, M.A., F.L.S.**

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With Plate XXV.

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MR. WILFRID GRENFELL, the Superintendent of the Mission to Deep Sea Fishermen, has most kindly arranged to carry on a series of observations on the pelagic fauna and the fishes of the seas traversed by the Mission boats in the course of their work. The following report gives an account of the pelagic fauna collected in the North Sea during the early spring, and in the west of Scotland and Kinsale Harbour during the summer. The collections were preserved in picro-sulphuric acid and spirit, and were forwarded to Plymouth for examination. Owing to pressure of work, and to my leaving Plymouth somewhat unexpectedly, I have not been able to make a thorough investigation of all the collections, but have worked out the Copepoda with care, and have confined myself to short notes on the other species.

Fourteen bottles were sent from the North Sea, the stations being—

No. 1.—February 28th. East of Winterton shoal. The surface-net was used for twenty minutes just below the surface at 10.15 a.m. Temperature of the air  $35.5^{\circ}$ , of the surface  $42^{\circ}$ , of the bottom  $39^{\circ}$  F. A heavy swell.

No. 2.—February 28th. Three to four miles W. of No. 1. Net sunk some fathoms below the surface. Temperature at surface  $41.5^{\circ}$  F.

No. 3.—March 1st, 10 a.m. Winterton shoal. Temperature of air  $38.5^{\circ}$ , of surface  $42^{\circ}$ . Wind N.N.W.

No. 4.—March 1st, 12.30 a.m. Within a mile or so of No. 3. About fifty miles E. of Yarmouth.

No. 5.—March 3rd. On Winterton shoal, Yarmouth bearing W.S.W. forty-five miles. Net sunk below surface. Temperature the same as No. 3. Bright sun.

No. 6.—March 3rd, 8.30 p.m. N.E. edge of Winterton shoal, about sixty miles E.N.E. of Yarmouth. Temperature of air  $30^{\circ}$ , of surface  $41.2^{\circ}$ . Wind E., moderate.

No. 7.—March 4th, 9.40 a.m. Fifty miles due E. of Winterton shoal. Lat.  $52^{\circ} 41'$ . Wind W. Temperature of air  $41.5^{\circ}$ , of surface  $41.5^{\circ}$ , of bottom  $39.5^{\circ}$ . "Strong sickly smell."

No. 8.—March 5th, 10.5 a.m. On Winterton shoal. Forty-five miles W. of Yarmouth. Temperature of air  $43^{\circ}$ , of surface  $41.25^{\circ}$ , of bottom  $40^{\circ}$ . Wind N.N.W., fresh. Bright sun after snow and sleet on previous night. Contents of tow-net had offensive smell.

No. 9.—March 6th, 5.30—6.30 p.m. Lat.  $53^{\circ} 12'$ , about sixty miles E. of Cromer on shoals of the Lemon. Temperature of air  $40.25^{\circ}$ , of surface  $38.5^{\circ}$ . Strong breeze from N.W. by W. with a heavy swell.

No. 10.—March 6th, 7.30—8.30 p.m. Lat.  $53^{\circ} 14'$ , on Black Bank. Temperature of air  $41^{\circ}$ , of surface  $40.5^{\circ}$ .

No. 11.—March 7th, 7.30—8.30 a.m. Between Black Bank and shoals of Lemon. Temperature of air  $44.5^{\circ}$ , of surface  $40^{\circ}$ , of bottom  $38.5^{\circ}$ .

No. 12.—March 9th, 1.15—2.15 p.m. East of shoal of Lemon. Temperature of the air  $39^{\circ}$ , of the surface  $40^{\circ}$ . Weather squally, with sunshine in intervals. Heavy gusts from N. by W.

No. 13.—March 9th, 7.30—8.30 p.m. About one mile N.W. of No. 12. Temperature of air  $37^{\circ}$ .

No. 14.—March 10th, 7.30—8.20 p.m. The Lemon shoal bearing N.W. by W. Temperature of air  $47^{\circ}$ , of surface  $42^{\circ}$ . Heavy wind from W.S.W.

The collections made in the first eight stations are described by Mr. Grenfell as smelling sickly and offensive. This was evidently due to the floating Algæ which cause the well-known "foul water" on many parts of our coast during the spring months. There was abundant evidence of these Algæ in the collections, but when the ship moved further north to Station 9 the offensive smell was not noticeable, and there are but few Algæ and Diatoms in the catch.

The first eight gatherings contained an abundance of Teleostean ova and larvæ in different stages of development. It is nearly impossible to identify the ova after they are preserved in spirit, but a considerable proportion may safely be identified as plaice ova from their large size. The greater part of the newly hatched larvæ were Pleuronectids, of what species could not be determined. In No. 6 there were several larvæ of *Clupea harengus*. One larval

herring about an inch long was taken in No. 12, and herring larvæ were abundant in the last haul, No. 14. As a considerable proportion of the ova showed only a small blastodisc, it is evident that they must have been emitted not far from where they were taken, viz. on Winterton shoal.

The bulk of material taken in each haul was considerable (with the exception of No. 2), but consisted mostly of the commoner species of Calanidæ. The other contents were as follows:

*Appendicularia*. Not abundant, in 3, 4, 6, and 8.

*Sagitta*. All the gatherings; most abundant in 1, 5, 10.

Larvæ of *Pagurus*. 1, 2, 3, 4, 6, and very abundant in 5 and 13.

*Cumacea*. A few specimens in each gathering. I am not able to determine these with certainty before going to press for want of Sars' works, but they appear to be *Eudorella truncatula*.

*Mysidæ*. No. 14 consisted chiefly of *Euphausia*.

*Proto ventricosa*, O. F. M. Isolated specimens occurred in the first six gatherings.

*Evadne Nordmanni*. A few in 5 and 9.

*Tomopteris*. A single specimen in 4 and in 13.

*Cyphonautes*. In 1, 3, and 5. Not numerous.

*Bipinnaria*. A few in 9 and 11.

*Otenophora*. Several Cydippidæ too much damaged for recognition in 4, and a single *Pleurobrachia* in 8.

*Medusæ*. Several damaged beyond recognition in 4.

*Coscinodiscus concinnus*. All the gatherings; particularly abundant in 11.

The Copepods consisted chiefly of Calanidæ, the species represented being—

*Cetochilus septentrionalis*, Goodsir.

*Clausia elongata*, Boeck.

*Paracalanus parvus*, Claus.

*Temora longicornis*, Müller.

*Temora velox*, Lljb.

*Centropages hamatus*, Lljb.

*Centropages typicus*, Kröyer.

*Dias longiremis*, Lljb.

#### CYCLOPIDÆ.

*Cyclopina littoralis*, Brady. A few specimens were taken in most of the gatherings, but a very large proportion of the Copepoda in No. 9 consisted of this species, which, according to Brady, is rarely taken in large numbers.

*Oithona spinifrons*, Boeck.



## HARPACTIDÆ.

*Longipedia coronata*, Claus. A few specimens in 1, 6, and 11.

*Eutерpe gracilis*, Claus.

*Stenhelia ima*, Brady.

## HERSILIIDÆ.

*Hersiliodes Canuensis*, nov. sp. Pl. XXV, figs. 1—6.

Form of the body cyclopoid, robust. The first thoracic segment united with the head, the remainder free. Pleuræ of the thoracic segments well developed and prominent. Abdomen of three somites, the first swollen, with the posterior angles produced into short spines, with a small moveable spine exteriorly. Second abdominal somite also produced posteriorly into short spines. Second and third abdominal somites equal in length, the length of the first being relatively to the second as 4 to 3. Furca very short, half as long as the last somite, with three long hairs, and one shorter internally; two short spines on the outer edge. Antennæ 6-jointed, the first, second, fourth, fifth, and sixth joints subequal in length, the third joint twice as long. Mandibles, maxillæ, and maxillipedes characteristic of the genus. Fifth pair of swimming feet flattened as in *H. Thompsoni*, and provided with three flattened and serrated spines, with a single seta internal to the innermost spine.

Two specimens in No. 11. These are probably at a young stage, as shown by the 6-jointed antennæ, but they differ so markedly from the described species of the genus, that I have felt justified in ranking them as a separate species, and have named them after M. Eugène Canu, whose researches have greatly improved our knowledge of the family. In the form of the fifth pair of swimming feet and in the internal maxillipedes *H. Canuensis* closely resembles *H. Thompsoni*, but differs from it in the details of the second antennæ, mandibles, and maxillæ, and in the shape of the cephalothorax and free thoracic and abdominal segments.

In addition to the collections from the North Sea, Mr. Grenfell sent me four bottles collected in the west of Scotland, and one from Kinsale Bay.

A. June 6th. Oban Bay. Midnight. Wind N.W., slight. Contents: *Hormiphora plumosa* abundant. Many Medusæ, unrecognisable.

## COPEPODA.

## CALANIDÆ.

*Cetochilus septentrionalis*, Goodsir.

*Clausia elongata*, Boeck.

*Temora longicornis*, Müller.

## CYCLOPIDÆ.

*Oithona spinifrons*, Boeck.

## HARPACTIDÆ.

*Stenhelia ima*, Brady.

*Diosaccus tenuicornis*, Claus.

*Westwoodia nobilis*, Baird.

*Harpacticus chelifer*, Müller.

*Peltidium interruptum*, Goodsir.

*Oniscidium armatum*, Claus. As far as I am able to determine, this is the first record of *O. armatum* from British coasts.

*Idya furcata*, Baird.

B. Great Minch. Ten miles S. of Stornoway in Lewis. Temperature of air  $57^{\circ}$ , of surface  $51.5^{\circ}$ . Calm. Full of bad-smelling green Algæ.

Contents: Many Teleostean ova. Many Medusæ and Ctenophora, too much damaged for recognition. Megalopa stages of Brachyura. *Euphausia*. Very few Calanidæ, mostly *Temora longicornis* and *Clausia elongata*. A single young Gadoid, probably *Gadus merlangus*.

c. June 14th, 8 p.m. N.W. of Cape Wrath. Temperature of air  $49.5^{\circ}$ , of surface  $51.25^{\circ}$ .

Consisted almost entirely of the commoner species of Calanidæ, with *Cyphonautes*, *Evadne Nordmanni*, and *Podon intermedius*.

d. Ardnamurchan Point. Temperature of air  $53^{\circ}$ , of surface  $51^{\circ}$ . Calm.

A single young Gadoid, probably *Gadus carbonarius*, and a single young *Trigla*. Abundant Ctenophora, probably *Hormiphora plumosa*. Large numbers of young stages of *Corystes cassivelaunus*. A few common Calanidæ, and *Westwoodia nobilis*, *Harpacticus chelifer*, and *Trebius caudatus*.

e. Kinsale Bay. May 15th. Temperature of air  $50.25^{\circ}$ , of surface  $50.75^{\circ}$ . Wind S.W., light.

Contents: Larval Pleuronectidæ, including one *Solea*. Larvæ of *Terebella* and *Holothuria*. Veliger larvæ very abundant. Many Medusæ damaged beyond recognition. Megalopa stages of Brachyura, Copepods, Calanidæ, chiefly *Temora longicornis* and *Dias longiremis*. Cyclopidæ, *Oithona spinifrons*. Corycæidæ, *Corycæus anglicus*.





Fig. 4.

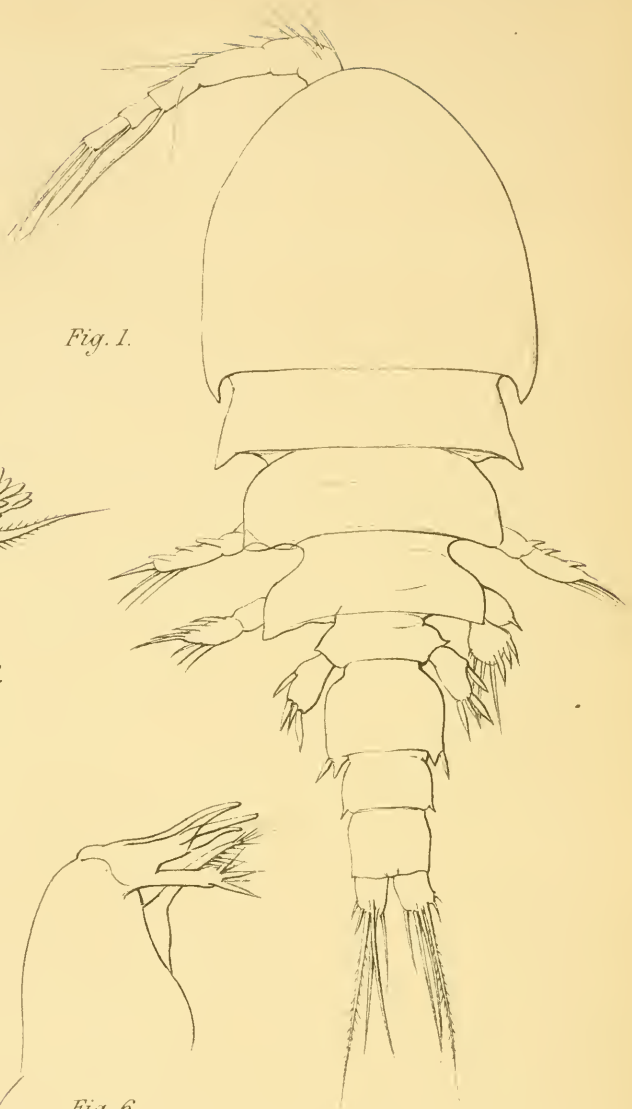


Fig. 1.



Fig. 3.



Fig. 6.

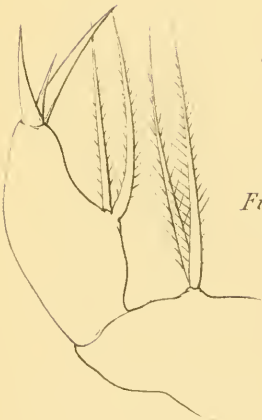


Fig. 5.



Fig. 2.



## DESCRIPTION OF PLATE XXV,

Illustrating the Report on the Surface Collections made by Mr. W.  
T. Grenfell in the North Sea and West of Scotland.

FIG. 1.—*Hersiliodes Canuensis*, nov. sp. Dorsal view of the entire animal.

FIG. 2.—*Idem*. Second antenna. Zeiss D, oc. 2.

FIG. 3.—Mandible. Zeiss F, oc. 2.

FIG. 4.—Maxilla. Zeiss D, oc. 2.

FIG. 5.—Internal maxillipede. Zeiss D, oc. 2.

FIG. 6.—External maxillipede. Zeiss D, oc. 2.

## Notes on the Herring, Long-line, and Pilchard Fisheries of Plymouth during the Winter 1889-90.

By

**William Roach,**

Associate Member, Marine Biological Association, Plymouth.

### I. THE HERRING FISHERY.

[THE herring fishery is carried on at Plymouth during the winter months, when the adult herring seek the inshore waters for spawning. Besides these, however, the so-called "harbour herring" are taken in the summer and autumn; these appear to be the produce of the last spawning season, *i. e.* six months to a year old. Mr. Cunningham has shown me specimens taken in the Cattewater in May, 1889, which vary from  $3\frac{1}{2}$  to 5 inches in length. Those which are at present being brought to the Laboratory (September, 1890) are 9 or 10 inches in length, but their reproductive organs are still at an extremely early stage of development. Further observations on these harbour herring are much needed, and are being gradually made.

The nets used up at Saltash for these harbour herring are, Mr. Roach informs me, used three to a boat, 7 score 7 meshes in depth and 44 fathoms to the rope, that is, 132 fathoms long, with buoy-lines 1 fathom deep. Those used in the Sound vary with the size of the boat. The smaller boats have two or three nets, 12—13 score meshes in depth, and each 40—42 fathoms long; buoy-lines 4—5 fathoms apart, and 2 fathoms long; the latter are shortened up a fathom at low water. The boats used outside the Breakwater have three to four nets each, 13—14 score meshes deep. The next boats (9-ton dandy hookers, 36 feet long, 10 feet beam, worked by 4 men) use ten to twelve nets, 15—16 score meshes deep. The largest boats are decked, use sixteen to eighteen nets, 16—18 score meshes in depth, with 3-fathom buoy-lines; they are worked by 6 men. The proper herring mesh for full-roed fish is

33 meshes to the yard. The Cawsand fishermen who fish in Cawsand and Whitsand Bays use moored nets.—G. H. FOWLER.]

NOTE.—The symbol > implies that the number given was the greatest catch by any single boat; a number without this implies the total amount of fish landed.

Date.	Number per boat.	Locality.	Price per 100.	Remarks.
1889.				
Oct.				
23	40 >	Rum Bay	—	—
24	500 >	Batten Bay	5/6	Quality good.
26	400 >	"	4/6	Very scarce up to 10 p.m., when the fish rose in the slack water.
30	1000 >	Cattewater	4/6	—
31	1500 >	Inside Batten Breakwater	4/6-5/0	These are probably not the coast fish, but harbour fish which have been driven down by foul water following the heavy rains.
Nov.				
1	500 >	Inside Mallard Buoy	4/0-5/0	—
2	400 >	Rum Bay	6/0	Quality good.
	2000	Cawsand Bay	—	Taken in moored nets.
4	400 >	Rum Bay	5/0	No fish from Cawsand Bay.
5	300 >	Sound, East Channel	4/6	} Wind W.; threatening.
	700	Cawsand Bay	—	
6	Very few	—	—	Fine, calm. Herring fishing discontinued for a time, as the coast fish had not made their appearance.
11	200-300	Saltash and St. Germaus	3/6	—
	500 >	Cattewater	3/3-3/6	These fish used to be taken in large quantities some years ago at Laira with long seine nets. Now the fish do not appear to go so far up, and the seining industry in the estuaries has diminished.
12	3000 >	Saltash Bridge	3/6	These fish were probably caught in tuck seines, as they were so small that they would have passed through the meshes of the large seines.
13	None	—	—	Wind S.E.; very fine.
14	—	—	—	No herrings in Plymouth Sound or the Cattewater, but a few thousands taken by 27 small boats near Carr Green, 3 miles above Saltash. The fishermen there use 3 nets, threescore and seven meshes in depth, and 44 fathoms to the rope, making a total length of 132 fathoms. The buoy-lines are one fathom deep. They only fish in slack water, because, when the tide is running strong, they drift against the ships. Herrings are always taken there at this time of year when the weather is fine, and they only come to the Sound when there is a great freshet after rain.
18	None	—	—	Many of the boats took out their nets, and dried and put them away, anticipating a bad season.

Date.	Number per boat.	Locality.	Price per 100.	Remarks.
Nov. 27	600 >	Rum Bay	3/0	No quantity of fish arrived yet, probably owing to the east winds, which are noticed to keep not only herring but whiting off the coast.
28	100 >	Batten Bay	2/0	The low price is due to large consignments from W. Cornwall, which are two days old on arrival, and are sold at 1/0 per 100, depreciating the home catch.
29	3000 >	Cawsand Bay	1/6	Caught in moored nets. These are not the same fish as those caught by the Saltash fishermen; the scales of the latter come off much more readily than those of the coast herrings, caught for the first time to-day. Since the beginning of the month from 60,000 down have been taken by large and small boats in St. Ives Bay. They have since decreased there, and increased at Penzance, where they had from 20,000 down. Finally, they have fallen off at Penzance, and have appeared at Plymouth, their last spawning place, but they are still very hard.
30	6000 >	Cawsand Bay	—	Caught in moored nets. They have not yet appeared in the Sound.
Dec. 2	3000 >	2 miles S.W. of Penlee Point	1/3	Caught by six large boats.
3	10,000 >	Cawsand Bay	1/2	Moored nets.
	4000 >	2 miles S.W. of Penlee Point	1/3	—
	8000 >	Cawsand Bay	1/2	Moored nets. Owing to the strong S.E. winds it has been difficult to underrun the moored nets in Cawsand Bay; otherwise the catches would have been better.
4	10,000	Whitsand Bay	3/0-1/6	Wind E.N.E. No herrings in the Sound or in Cawsand Bay. The Cawsand fishermen made the whole catch, having moved their moored nets to Whitsand Bay. The herring is a "lee fish," moving backwards with the wind. They will remain in Whitsand Bay till the wind shifts and drives them out. A west wind is the best for Plymouth Sound.
6	800 >	N. of Eddy-stone	2/0	Wind E.N.E. The fish in Whitsand Bay are caught in moored nets, the others by the large drift-boats.
7	1200	Whitsand Bay	1/6	
	4000	Off Rame Head	1/11	
	10,000 to 12,000	Whitsand Bay	1/6	Moored nets taken from Whitsand Bay. Wind W., very light. 10,000 herrings brought in by pilchard-boats, made 2/0 per hundred.
9	—	—	—	
10	Several thousand	Cawsand Bay	1/8	Moored nets. Wind W., fresh. The drift herrings always make more money than those taken in moored nets, the latter being so many hours dead in the water.
	Several hundred	Plymouth Sound	1/11	—



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Date.	Number per boat.	Locality.	Price per 100.	Remarks.
Dec. 11	400	Plymouth Sound	1/11	No great quantity as yet in the Sound.
-	8000	Cawsand Bay	—	Moored nets.
12	400 >	Plymouth Sound	2/1	—
	6000	Cawsand Bay	1/10	—
13	Small catches	Plymouth Sound	—	—
	2000-3000	Cawsand Bay	—	—
14	3000 >	Plymouth Sound	1/6	New grounds to Melampus Buoy.
15	3000 >	N.W.-N.E. of Breakwater	1/6	—
16	3000 >	West Channel	1/7-1/8	New grounds to Melampus Buoy; largest catches on the slack water (flood), 10 p.m. Wind W.
17	4000 >	N. & S. of the Breakwater	1/6-2/0	—
	6000	Cawsand Bay	1/6	—
18	3000 >	½ mile S. of the Breakwater	2/0	—
		Fort to E. end of Breakwater		
19	1800-2000	Outside Breakwater	} 2/9-3/3 }	Owing to stormy weather from the west the large boats had to return without shooting their nets.
	500 >	West Channel		
	8000	Cawsand Bay	2/6	
20	1000 >	Outside Breakwater	} 2/6-3/9 }	Rise in price due to diminished catches in the west.
	400 >	Inside Sound		
	9000	Cawsand Bay	2/6	—
21	Few hundreds	Mid Sound	4/9	} Stormy.
	8000	Cawsand Bay	2/6	
23	2000 >	Near Melampus Buoy	4/4	Fish very fine; will spawn in about a fortnight.
24	2000 >	Inside Breakwater	3/4-3/6	150 sail in the Sound. Fish full.
	10,000	Cawsand Bay	2/6	—
	10,000 >	6 miles S. of Mothecombe	2/6	All full-roed.
25	1500 >	E. of Melampus	3/4-3/9	—
26	20,000 >	Off Mothecombe	2/6	Taken by large-decked boats from Penzance.
	Few hundreds	Cawsand Bay	1/7	—
27	30,000 >	Mothecombe; Breakwater Light, clear of Mewstone to S.	1/4-1/9	Taken by large boats on the evening slack water. Twilight, midnight, and daybreak, the best three times for herring. Some of these fish are already shotten; they then go away, probably into the Channel, as the mackerel men fishing 15-20 miles S.S.W. of the Eddystone get them in their nets in April, after which they begin to fill again. Very few herrings now being taken in the Sound; they have probably gone up the harbour to spawn, the weather being fine and the water clear. The Salt-ash fishermen are taking several thousand. If the weather keeps fine they will come down, nearly all shotten.

Date.	Number per boat.	Locality.	Price per 100.	Remarks.
Dec. 27	6000	Cawsand Bay	1/7	—
28	400 >	Sound	—	—
	7000	Cawsand Bay	1/3	—
	20,000 >	Mothecombe	1/3	Taken again by the large-decked boats. The Sound fishery has completely stopped, owing to a strong, cold east wind for 2 or 3 days. If the present S. wind continues the fish will probably return.
30	20,000 to 5000	"	1/3	
	Few hundreds	Cawsand	—	—
31	40,000 >	S. of Mothecombe	3/0	—
1890. Jan. 1	7000 >	S.S.W. of Mothecombe	4/0-4/9	—
2	4000 >	"	{ 5/2 best, 2/6 secds. }	—
	1500	½ mile S.E. of Breakwater		4/10
3	5000	Mothecombe	2/8-2/10	The Sound fish are in good condition, and therefore make more money than the outside fish, which are mostly shotten.
	450	E. Channel	4/10	
	Few hundreds	Cawsand Bay	3/0	—
4	20,000 >	S. of Mothecombe	2/0-2/6	Very stormy; few boats out.
	200-300	Sound	3/0-3/3	Too bright a moon for a good catch at night.
	2000	Cawsand	2/0	—
6	400-500	Sound	3/0-4/0	No large boats out; strong wind and rain from the south.
	7000	Cawsand Bay	4/0-2/0	—
7	300-400	Sound	3/0-4/0	Stormy; never many taken in bad weather. Three parts of these herrings are shotten now.
	9000	Cawsand Bay	3/0-4/0	Nearly all shotten.
8	2000 >	Sound	3/3-3/6	New Grounds to Melampus Buoy. Nearly all shotten, and yet fetching a good price, as there is no other fish in the market.
	10,000	Cawsand Bay	2/0-2/4	—
9	3000 >	W. Channel	2/0-3/6	Strong wind and rain.
10	800 >	"	2/0-3/4	The heavy seas have driven the herring out of Cawsand Bay. None being taken at St. Germans and Saltash.
11	3000 >	E. Channel	—	The herrings have left the Sound; none with the large boats in Bigbury Bay. Only one or two per cent. full.
	Few hundreds	Cawsand Bay	—	—
14	Few hundreds	Sound	—	Shotten.
	5000 >	Outside Breakwater	5/0-5/4	A fresh shoal of fish, three parts full, taken just after midnight. Fine; night wind S.W.
16	3000 >	"	{ Full 3/6-4/0 Shotten 2/0 }	—
18	500 >	Sound		1/5-1/11
	2000 >	Outside Breakwater	4/6-5/6	Full-roed, and now spawning. Very stormy; wind S.
	4000 >	Cawsand Bay	1/6	Shotten.

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Date.	Number per boat.	Locality.	Price per 100.	Remarks.
Jan. 21	1000 >	Sound	2/8-3/4	Small boats trying all round and outside the Sound; the large shoal which was outside last week has been broken up by the bad weather, and has come inside the Sound; only about 25 per cent. full. Stormy; wind S.
23	1000	W. Channel	3/0-3/8	Stormy. 10 per cent. still full.
24	400 >	Sound	3/2-3/4	Wind W.S.W., very squally. Nearly all fish shotten.
25	300 >	W. Channel	3/0	—
27	1800 >	Outside Breakwater, Panther to Shagstone	4/7-4/8	20 per cent. of these full; those inside the Breakwater all shotten.
30	8000 >	Panther to Shagstone	1/9-2/0	Sound fishery abandoned. The fish outside so ripe that the ova run out when touched; the buyers do not care for them when so ripe.
31	6000 >	½ mile S. of Panther to Mewstone	2/4-3/4	Fresh shoal of full-roed fish; now 6 or 7 years since full-roed fish appeared so late; last year none a fortnight after Christmas.
Feb. 1	1000 >	Shagstone to Mewstone	2/0-2/6	Half were shotten. The former shoal between Panther and Shagstone have spawned and gone into deeper water. The fishing has not been so good this year, the old localities ( <i>e. g.</i> Bovisand, Cawsand, and Batten Bay) have been failures; probably because of the heavy ground seas prevalent this year, which seem to have driven the fish on to rockier ground, such as between the Panther and the Shagstone. Wind W., calm.
2	700 >	„	2/0	Wind N.W., slight.
4	300-100	W. of Shagstone	2/0-2/2	Calm.
6	400 >	E. Channel	1/0	Shotten. Wind E., strong.
7	1000-300	„	{ 2/6 full 1/4 shotten	} Wind E., strong.
8	500-100	„	1/4-1/8	—
11	800-500	New Grounds to Melampus	2/0	20 per cent. still full.
12	800 >	„	—	—
13	800-100	New Grounds	1/4	2 per cent. full.
14	200 >	—	0/10	Only 4 or 5 boats working; the fishery is practically over.

## II. THE LONG-LINE FISHERY.

Long-lining no longer pays in this port, as there is so much time wasted in waiting for bait. The boats are worked by four men, and the profits are divided in five and a half shares, apportioned thus:—To the four men one share each; to the owner, for the boat, one share; for the long-line or bolter a half-share. The owner, there-

fore, apparently takes one and a half shares, but of this he pays a quarter of a share to the skipper, while at least half a share must be devoted to the expense of maintaining the bolter in proper condition; he receives, therefore, only three quarters of a share clear for the boat and bolter. Years ago it used to pay; the boats were then much smaller, and only used from 600 to 800 hooks; now they have 1500 to 2000 hooks per boat.

On February 4th, for instance, I find from my notes that all the long-liners were in harbour for want of bait. The same thing happened on March 1st. Bait was scarce almost all the winter, while at the close of March matters were so bad that pilchards had to be sent by train from Falmouth, costing 12s. per 1000 and 5s. per 1000 for carriage, each boat requiring 800 (the large pilchards make two baits, the smaller only one). One boat on this occasion used a bait of half squid and half pilchard, and took  $4\frac{1}{2}$  cwt. of conger, two dozen rays and skates, and six ling, making £6. The other boats had pilchard bait only, and took 2 cwt.,  $\frac{3}{4}$  cwt., and three conger respectively, making £2 to £3. One who took only one conger made £7 by rays and skates. The mixed bait of pilchard and squid is found to be the best; the latter, however, depends upon the trawlers, in their turn dependent on the weather; while the scarcity and expense of the former will be seen from the tables given below.

### III. THE PILCHARD FISHERY.

Date.	Number per boat.	Locality.	Price per 1000.	Remarks.
1889. Oct.				
23	20,000	—	17/0	Taken by one boat; 3 other boats took 700-800 per boat.
25	10,000 >	Penlee to Eddystone	15/0	Hake, 3 dozen and less, 8/0-10/0 per doz.
26	200 >	Eddystone	25/0	Stormy, cold; wind E.
30	200 >	—	—	—
Nov.				
1	300 >	W. of Eddystone	25/0	—
5	8000 >	„	20/0	Spur dog-fish ( <i>Acanthias vulgaris</i> ) innumerable, eating both fish and gear.
6	—	—	—	Very scarce, not enough for bait; 3 doz hake in 15 fath.
7	5000 >	5 miles outside Eddystone	11/0-15/0	5-6 doz. hake, at 9/0 per doz.
8	7000 >	Outside Sound	12/0	7-8 doz. hake, 9/0-9/6.
9	6000 >	4 miles outside Breakwater	10/0	Few doz. hake, at 8/0.
11	20,000 >	10 miles S. of Plymouth	9/0-10/6	—



FISHERIES OF PLYMOUTH DURING THE WINTER 1889-90. 389

Date.	Number per boat.	Locality.	Price per 1000.	Remarks.
Nov. 12	5000 >	2 miles N. of Eddystone	10/0	—
13	9000 >	2 miles N.W. of Eddystone	15/0-16/0	Taken by Mevagissey boats. As the seine fishery in the W. has so far proved a failure, it is so much the better for the drift-nets, as all the buyers are at Plymouth.
14	8000 >	„	15/0-16/0	Good demand, as there are ships here waiting to be loaded for W. Cornwall.
15	3000 >	E. of Eddystone	15/0-16/0	—
16	Few hundreds	N. of Eddystone	17/6	Mostly purchased by the hook-and-line whiting-boats, of which there are 60-70 sail here.
18	1000 >	6 miles E. of Eddystone	15/0	—
19	1000 >	—	—	Very bad season; 200 sail of boats here, the large boats taking out the pilchard-nets, and substituting mackerel-nets. Hake also fallen off; a W.S.W. wind wanted, as the E. wind always keeps the fish off this coast.
20	1000 >	E.S.E. of Eddystone	16/0	—
21	2000 >	—	—	Most boats had no fish at all.
22	Very scarce	—	—	Three boats out of a hundred landed 300 fish each.
29	5000 >	N.W. of Eddystone	—	—
30	2500 >	„	17/6	—
Dec. 2	8000 >	5 miles S.W. of Penlee	17/6	—
3	15,000 >	2 miles outside Eddystone	16/6	Only 8 boats with good catches.
6	800 >	N.W. of Eddystone	17/4	8 boats.
7	Few hundreds	—	—	—
10	10,000	4 miles S. of Rame Head	17/0	—
11	20,000 >	6 miles S.W. of Penlee	17/0	—
12	5000	„	17/6	—
13	Few hundreds	—	—	—
14	30,000 >	Between Penlee and Eddystone	11/0-16/6	—
16	15,000 >	8-10 miles S. of Mewstone	15/0	—
17	25,000 >	6 miles S. of Stoke Pt.	14/0	—
18	15,000 >	—	13/0-15/0	—
21	20,000-10,000	—	17/0	Only 4 boats out, the weather being so bad from S.W. They saw what almost always indicates a good catch, viz. the gannets diving from a great height.
24	17,000	2 miles N.W. of Eddystone	14/0-15/0	Very stormy.
26	20,000 >	Rame Head to Eddystone	14/0-15/0	20 boats.

390 HERRING, LONG-LINE, AND PILCHARD FISHERIES OF PLYMOUTH.

Date.	Number per boat.	Locality.	Price per 1000.	Remarks.
Dec. 27	20,000 >	½ mile S. of Penlee	12/0-13/0	30 boats. One boat took 40,000, which carried the nets to the bottom; got them back without much damage.
28	20,000 >	Rame Head to Eddystone	11/0	Half the boats are now in the East Channel for herring. Hake very scarce, 33/0 per doz.
30	30,000 >	S. of Penlee	11/6	—
31	40,000 >	„	10/6-11/0	Smallest boats almost sinking under their catches. Weather very fine. Taken at midnight after the moon went down.
1890. Jan. 1	10,000 >	S. of Mewstone	9/0-11/0	—
2	10,000 >	3 miles outside Breakwater	4/0-11/0	—
3	7000 >	Various localities	8/0	Most of these fish taken by briming (cf. p. 250). Market glutted.
4	Few thousand	—	8/0	—
11	50,000 >	3-5 miles S.W. of Rame Head	8/0-10/0	The fish seem to be travelling S.W. Wind S.W., light.
15	20,000 >	S. of Rame Head	5/0-8/0	—
16	None	—	—	Stormy; wind S.

[These extremely valuable notes will be continued in the next number of the Journal.—G. H. F.]

## Notes on the Hydroids of Plymouth.

By

**Gilbert C. Bourne, M.A., F.L.S.**

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With Plate XXVI.

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DURING the two years which I spent at Plymouth I collected a number of notes on the occurrence and distribution of the Hydroidea of the district, with the intention of giving a full account of the representatives of the group in the Plymouth area. My unexpected departure has prevented my carrying out this intention, but it has seemed to me worth while to publish my notes, fragmentary as they are, in the hope that they may be useful to my successors, and particularly because the list of the Hydroidea given in Part ii of the first series of this Journal is very imperfect. The list of species now given is incomplete, and had I had the time to search more closely for the inconspicuous and deep-water forms I should have been able to add largely to it. One species, which I only succeeded in obtaining twice, appears to be new to science.

### Gymnoblastera.

#### *Family* CLAVIDÆ.

##### CLAVA MULTICORNIS, *Forskål.*

This well-known species is very common in tide pools on the rocks below the Hoe, and inside Penlee Point. I have also found it in Wembury Bay.

##### CLAVA CORNEA, *T. S. Wright.*

A small colony with ripe gonophores growing on *Fucus serratus*. Drake's Island, February 11th, 1888.

*Family* HYDRACTINIIDÆ.HYDRACTINIA ECHINATA, *Fleming*.

Fairly common on shells of *Buccinum undatum*, from ten to twenty fathoms. Duke Rock. Mewstone. Bigbury Bay.

*Family* PODOCORYNIDÆ.PODOCORYNE CARNEA, *Sars*.

A few specimens from old shells, ten to twenty fathoms. The Medusa is common outside the Breakwater in summer months.

*Family* CORYNIDÆ.CORYNE VAGINATA, *Hincks*.

Several fine colonies of this species from rock pools in Wembury Bay, June and July, 1890. Also on previous occasions from Drake's Island and Bovisand Bay. Gonophores May to August.

CORYNE PUSILLA, *Gaertner*.

Drake's Island, May, 1890. A good specimen, with gonophores, from Whitsand Bay, July 11th, 1887, appears to belong to this species.

CORYNE FRUTICOSA, *Hincks*.

A few polypes, without gonophores, collected by Mr. Heape, appear to belong to this species.

SYNCORYNE EXIMIA, *Allman*.

A fine specimen, with gonophores, on an old piece of rope, one mile south of the Mewstone, May 11th, 1889.

*Family* MYRIOTHELIDÆ.MYRIOTHELA PHRYGIA, *Fabricius*.

This fine and interesting species is common in the neighbourhood of Plymouth. The gonophores are large and ripe from May to



August, and the peculiar free zooid may easily be procured during these months. Habitat on the under sides of stones near low-water mark. East side of Drake's Island. Near Picklecombe Fort. Bovisand Bay. Mewstone. Wembury Bay, very common immediately below Wembury Church. Duke Rock, seven fathoms.

*Family* EUDENDRIIDÆ.

EUDENDRIUM RAMEUM, *Pallas*.

From the Eddystone, thirty fathoms. Not common.

EUDENDRIUM RAMOSUM, *Linn*.

Very common. Duke Rock. Off the Mewstone.

EUDENDRIUM CAPILLARE, *Alder*.

Growing on worm tubes and on *Antennularia antennina* off Stoke Point, April, 1889. Duke Rock.

*Family* ATRACTYLIDÆ.

PERIGONIMUS REPENS, *T. S. Wright*.

Growing on the legs of a crab, deep water, July 19th, 1888. From *Turritella* shells, two miles south-west of Rame Head.

PERIGONIMUS VESTITUS, *Allman*.

Brought in by a trawler, May, 1890.

BOUGAINVILLEA RAMOSA, *Van Beneden*.

Drake's Island, August 11th, 1888.

*Family* TUBULARIIDÆ.

TUBULARIA INDIVISA, *Linn*.

Not common at Plymouth. Rock pools, south side of Drake's Island, August 11th, 1888. Whitsand Bay.

TUBULARIA LARYNX, *Ellis and Solander*.

Growing profusely on the Duke Rock Buoy, and on other buoys in the East Channel, September, 1889.

TUBULARIA BELLIS, *Allman*.

Growing in profusion on stones at extreme low-water mark, north side of Breakwater, May, June, and July, 1890.

CORYMORPHA NUTANS, *Sars*.

Five specimens of this species were taken by Mr. Heape in Whitsand Bay in about three fathoms, below Fort Tregantle, on May 17th, 1887. Though we have dredged constantly in the same locality, we have never succeeded in obtaining another specimen.

**Calyptoblastea.***Family* CAMPANULARIIDÆ.CLYTIA JOHNSTONI, *Alder*.

Ubiquitous on algæ and on other hydroids.

OBELIA GENICULATA, *Linn*.

Very common, growing preferably on *Laminaria*. It has appeared in the aquarium, and covers many of the standpipes and gratings where there is a steady and continuous current.

OBELIA DICHOTOMA, *Linn*.

Attached to worm tubes, Whitsand Bay; and from trawl refuse near the Eddystone.

OBELIA LONGISSIMA, *Pallas*.

From trawl refuse outside the Eddystone.

CAMPANULARIA VOLUBILIS, *Linn*.

From shells, Duke Rock Buoy.

CAMPANULARIA RARIDENTATA, *Alder*.

On weeds, trawl refuse, May, 1890.

CAMPANULARIA FLEXUOSA, *Hincks*.

Very common in rock pools beneath the Hoe, and on weeds.

CAMPANULARIA ANGULATA, *Hincks*.

From the shore, Bovisand Bay, July 27th, 1889.



Fig. 1.



Fig. 2.





CAMPANULINA ACUMINATA, *Alder*.

From trawlers, May, 1890.

Family LAFOËIDÆ.

LAFOËA DUMOSA, *Fleming*.

This species, var. *robusta*, is not uncommon in twenty fathoms near the Eddystone.

LAFOËA FRUTICOSA, *Sars*.

From Stoke Point and from trawl refuse near the Eddystone.

CALYCELLA SYRINGA, *Linn*.

A very common species, growing profusely on roots of *Laminaria*.

CUSPIDELLA COSTATA.

Growing on weed, trawl refuse, May, 1890.

Family HALECIIDÆ.

HALOIKEMA, nov. gen.

*Generic Characters*.—Stems erect, simple or sparingly branched, ringed. Hydrothecæ pedicellate, hydranths large, non-retractile.

HALOIKEMA LANKESTERII, n. sp. Pl. XXVI, figs. 1, 2.

Shoots erect, springing from an interlacing creeping stolon, composed of many distinct joints, simple or sparingly branched. Hydrothecæ alternate, sometimes borne on a short pedicel, one or a pair separated by a variable number of joints, generally not more than three, tubular, with a slightly everted rim. Hydranth very large, elongated, fusiform, with a single circlet of sixteen to twenty filiform tentacles, non-retractile. Hydranths and cœnosarc of a deep brown colour. Reproduction unknown.

I have only obtained this species twice—near the Duke Rock Buoy, May, 1889, and at the southern end of Jennycliff Bay, May, 1890. I kept the last specimen alive for some weeks in the aquarium in the hope of studying the reproduction, but all the specimens eventually died without producing gonophores.

This is a fine and very distinct species, easily recognisable from

its very large, deep brown, and absolutely non-retractile polyps. It grows on flat stones at a depth of seven fathoms. It is closely allied to the genus *Halecium*, which it resembles in the form of the polyp and the character of the hydrothecæ; in habit it comes nearest to *H. tenellum*. The ringing of the stem, the pedicillate hydrothecæ, and the non-retractile polyp, which is relatively much larger than the partially retractile polyps of the genus *Halecium*, are sufficient to warrant its being placed in a distinct genus. I have named the species after Professor E. Ray Lankester, to whose energy and enthusiasm the Marine Biological Association owes its existence, and to whom I am personally indebted for much kindness and advice.

*HALECIUM BEANII*, *Johnston*.

Very common. Duke Rock. Bigbury Bay. Off the Mewstone.

*HALECIUM HALECINUM*, *Linn*.

Very common, and generally taken with the preceding species.

*Family SERTULARIIDÆ.*

*SERTULARELLA POLYZONIAS*, *Linn*.

Common and generally distributed on clean stony ground, seven to twenty fathoms.

*SERTULARELLA GAYI*, *Lamoureux*.

Wembury Bay. Cawsand Bay. Duke Rock. Eddystone. Common.

*DIPHASIA PINASTER*, *Ellis and Solander*.

Very common in trawl refuse. South of Eddystone.

*SERTULARIA ARGENTEA*, *Ellis and Solander*.

Plymouth Sound. Start Point. Trawl refuse from Eddystone.

*SERTULARIA PUMILA*, *Linn*.

Growing in profusion on rocks and weeds between tide-marks.

*SERTULARIA CUPRESSINA*, *Linn*.

Common in trawl refuse from the Eddystone, and very common in forty fathoms near the Wolf Rock.

SERTULARIA ABIETINA, *Linn.*

Common in trawl refuse.

HYDRALLMANIA FALCATA, *Linn.*

Very common in twenty fathoms. Two specimens only taken inside the Sound, north of Batten Breakwater, and probably thrown overboard by trawlers.

THUIARIA ARTICULATA, *Pallas.*

Wembury Bay. Stones and shells off Mewstone.

## Family PLUMULARIIDÆ.

ANTENNULARIA ANTENNINA, *Linn.*

This and the next species are common, growing on rocky ground inside the Sound, and outside up to twenty fathoms.

ANTENNULARIA RAMOSA, *Lamarck.*

Hincks gives, as a diagnostic character of this species, "Hydrothecæ separated by a single joint." This is not correct. It is invariably correct for the basal portion of a branchlet, but towards its termination two joints are often seen between two hydrothecæ. The same author erroneously says, "Gonothecæ single;" they are in fact paired, one pair at the base of each branchlet. The gonothecæ are single in *A. antennina*, and this difference affords a good specific character.

AGLAOPHENIA TUBULIFERA, *Hincks.*

August to October. Not uncommon from Wembury Bay and off the Mewstone. I am not quite sure of the identity of this species. In most of the specimens I examined the corbula has invariably the spur mentioned by Hincks as characteristic of this species, but the hydrothecæ are exactly those of *A. pluma*, everted, patulous, and strongly dentated, quite unlike those of *A. tubulifera*, Hincks.

AGLAOPHENIA PLUMA, *Linn.*

Common on the fronds of *Halidrys siliquosa*, Bovisand Bay, and off Mewstone.

AGLAOPHENIA MYRIOPHYLLUM, *Linn.*

A few specimens brought in by trawlers from deep water.

PLUMULARIA FRUTESCENS, *Ellis and Solander.*

From Wembury Bay.

PLUMULARIA CATHARINA, *Johnston.*

Not uncommon. Duke Rock. Winter Shoal. Off Stoke Point.

PLUMULARIA SETACEA, *Ellis.*

Common in the Sound. The variety of branched and luxuriant habit mentioned by Hincks (*Brit. Hydroids*, p. 297) is very common, generally growing on *Halichondria panicea*.

PLUMULARIA SIMILIS, *Hincks.*

Jennycliff Bay. Rocks below Laboratory. Common.

PLUMULARIA ECHINULATA, *Lamarck.*

Growing on weed; not very common.

PLUMULARIA PINNATA, *Linn.*

Common. Duke Rock. Barnpool. Off Mewstone.



## A Complete List of the Opisthobranchiate Mollusca found at Plymouth ;

WITH FURTHER OBSERVATIONS ON THEIR MORPHOLOGY, COLOURS, AND  
NATURAL HISTORY.

By

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With Plates XXVII and XXVIII.

THIS paper is intended to furnish a complete list of all the species of Opisthobranchiate Mollusca found up to this time by the Marine Biological Association at Plymouth, together with various notes upon their morphology and natural history. The Nudibranchiate section of the group has, however, already formed the subject of a preceding report published in this Journal,<sup>1</sup> so that species which have not since been taken are recorded here by their names only, a fuller account of them being given in the previous report. All the species there recorded are distinguished in this paper by asterisks (\*) affixed to their names. I have had the advantage of several works upon the classification of the group which have recently appeared, notably Carus's excellent *Prodromus Faunæ Mediterraneæ*, vol. ii, part 1, 1889 ; Bergh's *Die cladohepatischen Nudibranchien* (*Zoolog. Jahrbüch.*, v, 1890 ; for a copy of this admirable work I am indebted to the author) ; and Norman's *Revision of British Mollusca* (*Ann. Mag. Nat. Hist.*, VI, vol. vi, No. 31, 1890, pp. 60—91). I must also mention Vayssière's *Recherches Zoologiques sur les Mollusques Opistobranches du Golfe de Marseille—I. Tectibranches* (*Ann. Mus. Hist. Nat. Marseille, Zool.*, II, 1885, Mém. No. 3) as having been of great service ; and I regret that up to the time of going to press the second part of M. Vayssière's work has not arrived at the Laboratory, and I have been unable to refer to it.

Since my Report on the Nudibranchiata was in type last year Prof. Herdman<sup>2</sup> has published several papers upon the value of

<sup>1</sup> Garstang, *Report on Nudibranchiate Mollusca of Plymouth Sound*, *Journ. Mar. Biol. Assoc.*, N. S., vol. i, No. 2, 1889, pp. 173—198.

<sup>2</sup> Herdman, *On the Structure and Function of the Dorsal Papilla in Nudibranchiata*,

colour in this group of animals, extending the observations of Giard upon protective colouration, and supporting Wallace's view that the colours of *Æolids* are generally "warning colours as a sign of inedibility." In conjunction with Mr. Clubb<sup>1</sup> he has also published an account of a number of experiments designed for the verification of these views. Having been myself occupied from time to time in similar experiments, a few of the decisive results were communicated to Mr. Poulton, who has inserted them in his recent work on *The Colours of Animals* (Int. Sci. Series, London, 1890, pp. 199, 200). I hope soon to give an account of the results of other experiments.

In this paper I have taken the opportunity of correcting some mistakes of classification and nomenclature which had not been avoided in my report on the *Nudibranchiata*.

It is a pleasant task to express my sincere thanks to those who have generously helped me in the investigations here described, and particularly with regard to *Aplysia*. I am especially indebted to Dr. Norman and to Mr. A. R. Hunt.

## OPISTHOBRANCHIATA.

### Sub-order 1.—TECTIBRANCHIATA

(= OPISTHOBRANCHIA PALLIATA, Lankester).

#### A. CEPHALASPIDEA.

#### Family—SCAPHANDRIDÆ.

##### 1. SCAPHANDER, *Montfort*.

##### 1. SCAPHANDER LIGNARIUS, *Linnaeus*.

This species is frequently obtained by trawlers on the Eddystone trawling-grounds; it does not live in the Sound, but has been taken off Penlee Point.

#### Family—BULLIDÆ.

##### 2. HAMINEA, *Leach*.

##### 2. HAMINEA HYDATIS, *Linnaeus*.

Several large specimens were dredged in the estuary of the river Rep. Brit. Assoc., 1889, Section D; and Quart. Journ. Micr. Sci., xxxi. Prof. Herdman kindly sent me copies of these papers, which, though containing views similar to some expressed in my previous Report, were written for the most part before its publication.

<sup>1</sup> Herdman and Clubb, *Third Report on Nudibranchiata of L.M.B.C. District*, Trans. Liverpool Biol. Soc., iv, 1890, pp. 150—163; and *Nature*, June 26th, 1890, pp. 201—203.

Yealm in August of this year, and were brought back alive to the Laboratory. About twelve more specimens were obtained there on another occasion in September. Empty shells may often be found on the shores of the Yealm; probably, therefore, the species frequents this estuary.

Clark states, in his History of the British Marine Testaceous Mollusca, 1855, "Twenty years ago I observed hundreds of these creatures swimming [by means of their pedal flaps] and creeping on the fine mud in the lakes of the Mount Pleasant Warren, near Exmouth; they, however, suddenly disappeared from the locality, and not one has been seen for many years."

Cocks, in 1849, recorded the species as common in Falmouth Harbour.

*Family*—PHILINIDÆ.

3. PHILINE, *Ascanius*.

3. PHILINE APERTA, *Linnæus*.

This species is common on sandy bottoms, in Cawsand Bay and especially in Whitsand Bay. The animal is said to be able to swim, but I have not myself seen it progress in this way.

4. PHILINE PUNCTATA, *Clark*.

I have only seen one specimen of this small species, found among some *Bowerbankia* dredged in the Sound. Clark recorded it as inhabiting the littoral zone at Exmouth along with *P. catena*, which was "rare amongst algæ in the sheltered pools." Cocks found it among shell sand at Falmouth, rare.

B. ANASPIDEA.

*Family*—APLYSIIDÆ.

4. APLYSIA, *Linnæus*.

5. APLYSIA PUNCTATA, *Cuvier*.

- |                   |                 |  |
|-------------------|-----------------|--|
| APLYSIA PUNCTATA, | <i>Cuvier</i> . | Blochmann, Mittheil. Zool. Stat. Neapel, v, 1884,<br>pp. 28—49.                            |
| —                 | —               | <i>Cuvier</i> . Vayssière, Ann. Mus. Hist. Nat. Marseille, 1885,<br>Mém. No. 3, pp. 68—71. |
| —                 | —               | <i>Cuvier</i> . Gwyn Jeffreys, British Conchology, v.                                      |

- APLYSIA HYBRIDA*, *Sowerby*. Forbes and Hanley, *British Mollusca*, iii, pp. 554—556.  
 — *DEPILANS*, *Pennant*. Clark, *Brit. Mar. Test. Moll.*, pp. 271, 272.  
 ? — — *Linnaeus*. Blochmann, l. c., pp. 32, 33.  
 ? — — *Linnaeus*. Vayssière, l. c., pp. 65—68.

The specimens of *Aplysia* in our collection have been taken as follows :

- I. North of the great Breakwater, November, 1886 : two young ones, in trawl.
- II. Mouth of the river Yealm, July 18th, 1887 : six, large and small, in dredge.
- III. North of the Shagstone, February 2nd, 1888 : one dredged.
- IV. Mouth of the Yealm, October 20th, 1888 : many little ones, dredged or trawled.
- V. North of Batten Breakwater, November 12th, 1888 : nine or ten, all young, in trawl.
- VI. Estuary of the Yealm, opposite coastguard station, May 25th, 1889 : a dozen very large specimens.
- VII. Mouth of the Yealm, September 20th, 1889 : one small specimen, of pure brown colour with white spots.
- VIII. Cawsand Bay, October 3rd, 1889 : one, much smaller in size, about  $\frac{3}{4}$  inch long, bright rose-red in colour, with white spots.
- IX. Duke Rock, May 8th, 1890 : one considerably larger specimen, of a bright pinkish-red colour, dredged with a quantity of *Delesseria sanguinea*, of exactly the same colour.
- X. Middle of Sound, August 14th, 1890 : one very small specimen,  $\frac{3}{16}$  inch in length, found by Mr. Tate on a stone brought up in the trawl. In this beautiful little individual the shell was still uncovered, being without any reflexed fold of the mantle. The colour of the animal was almost the amethyst-purple of Alder and Hancock's figure of *Æolis Landsburgii*, but deeper and redder.

In addition to these a few other small or moderate-sized specimens (1—2 inches) have been taken, but have not been recorded. In the summer of last year several such individuals were generally brought up on weeds at each haul of the trawl along the inside (north) of the great Breakwater.

All our specimens belong to the second of the two subdivisions of the genus *Aplysia* defined by Blochmann (l. c., p. 29). The pleuropodia<sup>1</sup> ("epipodia," "parapodia," *Schwimmlappen*) are fused

<sup>1</sup> See under *Oscanius membranaceus*, infra, p. 419.



posteriorly from their origin on the foot to the level of the exit of the pallial (anal) siphon. The edge of the mantle-folds, reflexed over the shell and fused, bounds a circular aperture conducting to the shell, but is never raised up into a tubular prominence. The opaline gland behind the genital aperture is not lobulate (grape-shaped) with a single pore, but consists of a number of large unicellular bottle-shaped glands opening separately to the exterior. Anteriorly, however, as Vayssière has observed in *A. punctata* (l. c., p. 54), these elongate gland-cells are bunched together, and in my specimens have a single excretory pore which it is quite easy to discover.

**Colour.**—The colour of our smallest specimens has always been of a more or less bright and deep rose-red, generally if not always sprinkled with opaque white spots. At this stage our *Aplysiæ* correspond with Rathke's "species" *rosea* and Thompson's *nexa*. Our largest specimen measures (preserved in alcohol and consequently much contracted) 3 inches in length,  $1\frac{5}{8}$  inches in height, and  $1\frac{1}{4}$  inches in breadth. Its shell is figured of the natural size on Pl. XXVIII, fig. 9; the structure of the central teeth of its radula is shown in fig. 7. When alive this individual probably measured rather more than 6 inches in length in a state of complete extension. The colour of this specimen and of the other large ones dredged in May last year was olive-green,<sup>1</sup> of various shades and intensities. An individual which was living in the tank in the Laboratory for some time in the autumn of last year, and measured about 4 inches in length during extension, was of a pure brown colour; while the specimen dredged on the 8th of May this year was kept alive for some time, and being of a bright pink-red colour at the time of capture had changed in a month's time (June 6th) to a brownish red, and by the 23rd of June to a deep red-brown. Its colour when captured was just that of the alga *Delesseria sanguinea*; on the 6th of June it was exactly that of *Iridæa edulis*. Thus this species changes its colour with growth from a violet, purplish, or rose-red colour, through brownish red and brown to olive-brown or olive-green. There is considerable variation, as is well known, but these are, I believe, the chief changes which occur. Vayssière attributes the different colours of specimens of *A. punctata* at Marseilles to the nature of the bottoms upon which they are found (l. c., p. 69), but I may remark that the living *Aplysia* whose colour-changes I observed was kept under the same conditions for the two months during which it was under observation.

<sup>1</sup> In recording a specimen found on the shore at St. Andrews, Prof. McIntosh remarks, "No spots or other markings were present on the dull olive hue of the body" (Mar. Inv. and Fish, St. Andrews, p. 84).

**Markings.**—The markings of our specimens I have studied only in the preserved condition. In some of the smaller specimens no markings at all are to be observed, but as others preserved in the same way show very conspicuous markings it is probable that conclusions drawn from these preserved specimens are valid. The largest of the small specimens in which markings are absent, measures  $1\frac{3}{4}$  inches long in a fair state of extension. Where present, the marking of the integument is always due to small grey dots, either pale or dark, slightly elongate in form, which may be grouped in various ways. They may be evenly dispersed over the whole of the integument, forming no rings and leaving no clear spaces, or, though arranged in the same way, may be distributed over only a limited portion of the integument, viz. on the back of the head and on the upper portion of the sides of the body. It is, indeed, generally the case that, as Brock has described for *A. punctata* (Blochmann, l. c., p. 34), the marking does not extend to the foot and inner side of the pleuropodia, but is limited to the upper surface of the body. The most usual type of marking, however, consists in the dots being so distributed (either over the whole surface of the integument or over the upper portion only) as to leave round or elliptical clear spaces from which all markings are absent. The spaces may be either definitely bounded by a close series of dots or not very definitely bounded; there is every gradation between these two conditions. The former of these conditions is represented in Mrs. Gray's Figures of Molluscous Animals, vol. ii, pls. cxxxviii, cxxxix, and cxlii, both for *A. depilans* and *A. punctata*; the latter condition is shown on pl. cxlii\* for *A. depilans*. The dots in most specimens show a great tendency to be arranged in a certain order, either in straight or curved lines, or in the form of hexagonal, circular, elliptical, or irregular markings, enclosing clear spaces of small diameter. But there is every gradation between these small dot-bounded spaces and the large ones mentioned above. In a number, though not the majority, of individuals, the dots enclosing these small circular spaces may be so continuous as to produce very definite ring-like spots. These are chiefly to be found on the head and neck, and more rarely on the sides of the body. In our largest specimens the marking consists largely of a reticulum formed by lines of pigment-dots running in all directions, crossing one another and anastomosing, here and there leaving large or small clear unpigmented spaces, with indefinitely bounded edges.

So far as the marking is concerned, therefore, some of our smaller specimens have the positive characters of *A. punctata* as described by Blochmann and Vayssière; but many of the smaller ones, as well as all the largest ones, could equally well be placed—so far as the

marking is concerned—in the species *A. depilans* (= *fasciata*) of their descriptions.

**Radula.**—In 1875, 1877, and again in 1878, Mr. A. R. Hunt,<sup>1</sup> of Torquay, obtained a number of *Aplysiæ* in Torbay of various sizes, some of which were of the ordinary English type, the species *punctata* of Blochmann and Vayssière, the largest of these having a radula with fifteen completely formed lateral teeth on each side in a single transverse row, while others were of very much larger size, and are referable to the species *depilans* of the same naturalists, the smallest having, according to Mr. Hunt, twenty-six completely formed lateral teeth on each side of the median row. Mr. Hunt, however, by examining a series of radulæ of different sizes found that the number of lateral teeth as well as the number of transverse rows was dependent upon the age (size) of the individual, and arrived at the conclusion that probably his large specimens were not specifically distinct from the smaller ones, but were simply unusually large individuals of the common English species, *A. punctata*, Cuvier.

I owe to Mr. M. F. Woodward, of South Kensington, my acquaintance with Mr. Hunt's papers, which were published in a journal not generally known to zoologists, and had escaped my notice. Mr. Woodward had intended to re-investigate the matter himself, but upon finding that I was engaged in an examination of the Plymouth *Aplysiæ* very courteously referred me to Mr. Hunt's papers, and, as I am pleased to acknowledge, helped me in various other ways.

As to growth of the radula in either *Aplysia depilans* or *punctata*, the comparatively recent papers of Blochmann and Vayssière render little assistance. Blochmann figures the radula and teeth of a single average-sized specimen of each "species," and gives their respective formulæ; while Vayssière remarks upon the variability in the dental formulæ of *A. punctata*, and describes the structure of the teeth of an average specimen, but for *A. depilans* gives a similar description, and regrets having obtained no young individuals (l. c., pp. 67, 61). From Blochmann's account, again, I cannot gather that he has examined young specimens of this latter species, for he gives the size of the animal as from 10 to 20 cm., and only mentions "quite young individuals" as being *possible* exceptions to the general rule as to the markings of the species (l. c., p. 32).

Is there a possibility that the young *Aplysia depilans* is no other than *Aplysia punctata*?

On Pl. XXVIII the structure of the central tooth and of three

<sup>1</sup> Hunt, *On some Large Aplysiæ taken in Torbay in 1875*, Trans. Devonshire Assoc., vol. ix, 1877, pp. 400—403; *On the Growth of Aplysiæ in Torbay*, Trans. Devonshire Assoc., x, 1878, pp. 611—617.

adjacent lateral teeth of a median transverse row is represented for five Plymouth *Aplysiæ* of different sizes. Fig. 3 represents these teeth in a very small specimen, whose radula measures 1.05 mm. in length by 0.6 mm. in breadth, and consists of twenty transverse rows, its formula<sup>1</sup> being (8.1.8) × 20. The central tooth consists of a broad but short basilar portion, deeply excavated behind, and a transverse projecting ridge, arising from the basilar portion in its anterior half, directed posteriorly, and made up of five well-developed cusps, of which the median is the largest and has five serrations on each side, while the internal and external lateral cusps are smooth, the external cusp being smallest. The posterior excavation of the basilar portion of the tooth will be referred to as the "posterior bay;" a similar but smaller excavation in front will be called the "anterior bay." The structure of the tooth in a very young specimen being understood, the modifications entailed by further growth can be most accurately shown by a series of measurements, although the striking nature of the changes is more graphically shown on Pl. XXVIII.

Mr. Hunt has very kindly lent me a number of the preparations made by him in 1877 and 1878, so that I have been able to incorporate the results of a re-examination of them with those obtained from Plymouth specimens. These results are contained in the accompanying tables. For the "species" *A. punctata* (Nos. 1—10) the measurements and observations show—

- (1) That the radula may attain a size of 8.8 mm. in length by 5.4 mm. in breadth, considerably larger than that figured by Blochmann (6 × 4), and may consist of forty-four transverse rows of teeth, the lateral teeth numbering (according to age) from eight to nineteen. Blochmann gives twenty rows and thirteen lateral teeth for this species at Naples, while Vaysière has observed from thirty-five to thirty-six rows and sixteen lateral teeth at Marseilles.
- (2) That the basilar portion of the central teeth may increase in breadth (according to age) from 0.15 mm. to about 0.4 mm., when it begins to be reduced in width (Nos. 9 and 10), and that it increases in height regularly (with age) from 0.025 mm. to 0.15 and even 0.2. In several of the radulæ (Nos. 5, 6, 8, 9, and 10) this increase can be actually observed by comparing the heights of the central teeth in front and of those

<sup>1</sup> In my formulæ for the teeth of *Aplysia* the three, or sometimes four, rudimentary lateral teeth at the extremities of the transverse rows are always included. In comparing these formulæ with those given by Mr. Hunt it should be remembered that Mr. Hunt counts only the perfectly developed lateral teeth.



further behind. This increased height is due to additional chitin formation at the *posterior* margins of the teeth, and it thus comes about that the "posterior bay" may be entirely obliterated (Pl. XXVIII, fig. 7). This has not before been observed for *A. punctata*, and breaks down one of the previously maintained distinctions between the central teeth of *A. punctata* and *A. depilans*.

- (3) That with age the central cusp of the central tooth becomes less prominent and much more obtuse (Nos. 7, 9, and 10); that the external lateral cusp becomes reduced in size, and may even disappear (Nos. 5, 9, and 10); and that the internal lateral cusp also becomes reduced in size, and, while quite smooth in young individuals, may become in older specimens irregularly serrated on its external edge (Nos. 6, 9, and 10).

Turning now to the results in the case of the few radulæ of *A. depilans* which I have been able to examine, it is seen that, as in *A. punctata*, the radula varies in size and number of rows very largely according to age. My smallest radula (No. 11) is a fragment only, and possesses thirty-one lateral teeth. It is obviously, however, an older specimen than my largest *punctata*, for it is 1.6 mm. wider, and probably possessed fifty rows of teeth originally. The central teeth differ remarkably from those of my largest *punctata* in being of much smaller size in every way.

The next (No. 12) is a little larger (0.5 mm. wider), and possesses fifty-six rows of teeth, while the number of lateral teeth increases remarkably in passing from the front to the back of the radula. There are thirty-two lateral teeth behind and twenty-three in front. This radula in this respect, therefore, approaches *A. punctata* very closely, for in No. 10 the lateral teeth were seventeen in front and twenty behind. As regards number of teeth, therefore, there is no ground for specifically separating these two forms. The width of the central teeth is still much smaller than in Nos. 9 and 10, but, as in them, the width shows a crescendo followed by a remarkable diminuendo in size, passing from the front to the back of the radula. It is impossible to avoid the inference that in the growth of this individual the width of the central tooth has never exceeded that which it attains at the climax of its crescendo (0.3 mm.), and therefore Nos. 9 and 10 (in which the tooth attains a width of 0.4 mm.) cannot easily be regarded as stages in its growth. This inference is also strengthened by the other measurements of the central teeth of the radula, and by comparison with Nos. 13 and 14, which exhibit an *increase* in the size of their teeth with age. This

increase indicates growth through stages possessing central teeth of smaller, not of larger, size.

At the same time I cannot place the same confidence in inferences drawn from measurements of the teeth in Nos. 12, 13, and 14, for these teeth are shrunken and distorted, owing to the method in which the radulæ were mounted. No. 8 was also mounted dry, and it may be noticed that the teeth in this specimen show a considerable reduction in width compared with Nos. 7 and 9. As it has been shown above that in many points of structure increased age brings about a closer and closer resemblance of the teeth of *A. punctata* to those of large examples of *A. depilans*, I am inclined to give more weight to this trustworthy evidence than to that afforded by the shrunken teeth of Nos. 12, 13, and 14; and in the absence of any definite statements upon the matter by Mediterranean zoologists I think considerable grounds are afforded by this examination of the teeth for regarding *A. depilans* as merely *A. punctata* modified by further growth. I trust that the subject may receive more conclusive treatment in the hands of a naturalist upon a coast where large *Aplysiæ* are more common than they are with us in England. It is especially needful that the young *A. depilans* should be identified and described.

While upon the subject of the teeth of *Aplysia* I may add that Dr. J. E. Gray, in his Guide to the Distribution of the Mollusca in the British Museum, 1857 (p. 200), gives a description of the teeth of *A. depilans* and *A. punctata* which is very difficult to understand. For *A. depilans* he describes a radula having a formula 12·1·12, of which the central tooth is "distinct and truncated, *triangular, dilated beneath*,<sup>1</sup> with an arched front edge; apex truncated, reflexed; reflexed part subcordate, dark, with three large toothlets in front." Is this a true *depilans* at an early stage? For *A. punctata* he says, "Central tooth with the base on each side expanded; apex recurved, *with one sharp point lobed on both sides*; lateral teeth about thir een."

Curiously enough, this latter description is very applicable to the figure given by Mr. Jabez Hogg<sup>2</sup> of the central tooth of an *A. hybrida* from Torbay, which numbered "seventy-two rows of divergent teeth," but possessed "numerous laterals." Certainly I have seen no *A. punctata* having this number of rows of teeth or this structure, although Mr. Hogg's figure closely corresponds with that given by Vayssière for *A. punctata*. I wish to thank Mr. Hogg for his kindness in lending me a copy of his original paper at a time when it was impossible to obtain one from the libraries. Fig.

<sup>1</sup> The italics are mine.

<sup>2</sup> *The Lingual Membrane of Mollusca*, Trans. Micr. Soc., xvi, N. S., pl. x, fig. 42.

41 of his paper represents the teeth of an *Aplysia* taken in Vigo Bay, having "forty rows of divergent teeth; the median broad, produced at the base, reflexed, *tricuspid*; *centre cusp prolonged and serrated*." This *Aplysia* received no specific name in print, but Mr. Hogg has added in his own copy the word *punctata*, an identification which there is every reason to believe to be correct, although the shape of the posterior margin of the basilar portion of the tooth is unusual. Mr. Gwyn Jeffreys, however, confused matters by taking this radula for that of an *A. depilans*, and that of Mr. Hogg's *A. hybrida* (Fig. 42) as the normal one of *A. punctata*. Mr. Hunt follows Gwyn Jeffreys' identification, but suggests that "70" is an accidental misprint (l. c., 1877, p. 401), or that the numbers 40 and 70 should be transposed. The latter of these suggestions is impossible, because the central tooth of the radula of an *Aplysia depilans* numbering seventy rows is not so distinctly tricuspid, nor is the centre cusp prolonged and serrated. It is best, I think, to leave this confusion unsolved, and to hope that the radulæ of *Aplysia*, as well as the other structures, may be investigated and described again for the different species *at different stages of growth*.

**Shell.**—The shell of our Plymouth *Aplysia punctata* is figured on Pl. XXVIII (figs. 8 and 9) for two individuals of different ages, the larger shell (represented of the natural size) being taken from the individual numbered "10" in the table of measurements. This shell is considerably larger than that figured by Vayssière for *A. punctata*, and is intermediate in character between that shell and the shell of *A. depilans*, just as Vayssière's shell is intermediate in character between those shown in my figs. 8 and 9. Canon Norman has kindly forwarded to me a shell of *A. depilans* from Palermo, which I have represented by fig. 10. It is much broader than that of the same species figured by Vayssière, and its left edge is much more curved, the margin of the anal excavation also sloping continuously forwards (in the natural position), and not forming a true "bay" like that of Vayssière's. As Dr. Norman has stated (Rev. Brit. Moll., l. c., p. 69), Mr. Hunt's large shells closely correspond with those of Mediterranean *A. depilans*. I have been favoured with three of the shells of the Torbay *A. depilans*, and the two largest agree in character with the shell sent me by Dr. Norman, the curvature of the left side being a little less convex; but the smallest of the three, measuring  $1\frac{1}{2}$  inches long by 1 inch wide, has its anal margin sloping away much more and is less flattened than the larger ones. It approaches the shell of *A. punctata* in this respect. Indeed, when the shell of the young *A. depilans* is described I doubt if it will be distinguishable from that of *A. punctata*, even if it is not the same.

**Gill.**—The gill of our specimens corresponds with Blochmann's figure of the gill of *A. punctata*, except that it is larger in our larger individuals. It is divided, of course, into a series of lamellæ, but it shows even in our largest specimens no trace of the bilobed appearance figured by Blochmann for *A. depilans*.

**Mantle.**—I have cut sections of the mantle of four specimens, large and small, but cannot confirm Blochmann's statements as to the presence of cilia over the upper surface.

**Breeding Habits.**—I have only one fact to adduce under this head as regards Plymouth specimens. An individual of a brown colour, measuring nearly 4 inches when extended, was living in the Laboratory for some time in the autumn of last year, and several times deposited eggs in the form of slender gelatinous strings of a brown-pink colour.

Lo Bianco<sup>1</sup> states that *A. depilans* spawns at Naples from March to August, and *A. punctata* from April to August. *A. limacina*, on the other hand, spawns all the year round, although especially in the summer.

Dr. Norman has observed *Aplysia punctata* spawning at Conne-mara, and some of the shells of these individuals, according to Mr. Hunt,<sup>2</sup> measure only  $\frac{5}{8}$  inch in length.

Mr. Hunt has also called my attention to a statement by Gwyn Jeffreys, which is in itself a strong argument for the unity of the two species *punctata* and *depilans*. In a *Report on Dredging among the Channel Islands*,<sup>3</sup> prepared for the British Association, Mr. Jeffreys states, "It was also noteworthy that *Aplysia depilans* and *punctata* (usually considered distinct species) copulated when a pair was placed in a vessel of sea water."

**Attitude.**—I have often observed small *Aplysiæ* of about an inch in length, when kept in a dish or aquarium, attach themselves firmly by the posterior portion of the foot to the sides of the dish, extend their bodies out at full length, and remain in this condition motionless for hours together. As these small *Aplysiæ* have just the colour of many red seaweeds among which they are generally dredged, I am inclined to compare this habit with that of *Geometer* larvæ, which extend themselves also in a similar way, and are coloured like the twigs upon which they are attached. These little *Aplysiæ* have a very inanimate appearance in this condition, their tentacles and pleuropodia being rendered prominent (the latter being generally compressed or rolled together), and simulating the stunted branches of many

<sup>1</sup> *Notizie Biolog. rig. spec. il Periodo di maturità, ecc.*, Mitt. Zool. Stat. Neap., viii, 1888, pp. 415, 416.

<sup>2</sup> *Loc. cit.*, 1878, p. 615.

<sup>3</sup> *Rep. Brit. Assoc.*, vol. xxxv, Birmingham, 1865.



weeds. It is often extremely difficult to distinguish a small *Aplysia* when among red weeds. The colour of large *Aplysiæ* is generally that of the littoral *Fuci*, and of somewhat smaller specimens that of *Laminaria*. It is perhaps significant that an *Aplysia* migrating with growth from deep water to the shore would pass through algæ coloured first red, then brown, and finally olive-green. These are the stages of its own colour-changes.

## MEASUREMENTS OF TEETH OF

ANIMAL (inches).		RADULA (millimetres).	
No.	Length $\times$ breadth $\times$ height.	Length $\times$ breadth.	Formula.
1	L. $\frac{3}{16} \times$ B. $\frac{3}{32}$	1.05 $\times$ 0.60	(8.1.8) $\times$ 20. Three lateral teeth on each side rudimentary
2	$\frac{7}{16} \times \frac{3}{16} \times \frac{5}{16}$ (contracted)	2.0 $\times$ 1.5	(12.1.12) $\times$ 23. Four laterals rudimentary
3	$\frac{13}{16} \times \frac{3}{8} \times \frac{3}{8}$ (extended)	3.0 $\times$ 2.5	(12.1.12) $\times$ 25. Three laterals rudimentary
4	Mr. Hunt's No. 11, loc. cit., 1877, p. 402. Shell (wet) $\frac{3}{8}$ inch long	4.30 $\times$ 2.75	$(\frac{13}{14} \cdot 1 \cdot \frac{13}{14}) \times 31$ . One lateral tooth more behind than in front. Three rudimentary laterals
5	$2 \times \frac{7}{8} \times 1 \frac{3}{16}$ (contracted)	5.4 $\times$ 3.2 (the breadth ought to be a little more, owing to a crease in the mounted radula)	(16.1.16) $\times$ 33. Four lateral teeth rudimentary
6	$2 \frac{3}{8} \times 1 \frac{1}{8} \times \frac{3}{4}$ (extended)	5.3 $\times$ 3.4. This radula is of about same breadth behind as No. 5, but is narrower anteriorly	(15.1.15) $\times$ 35. Four laterals rudimentary
7	$1 \frac{1}{4} \times \frac{1}{2} \times \frac{7}{8}$ (much contracted). From Yealm, 18th July, 1887	4.5 $\times$ 3.6. More short and broad than usual	(16.1.16) $\times$ 30
8	Mr. Hunt's No. 12, loc. cit., 1877, p. 402. Shell (wet) $\frac{7}{8}$ inch $\times$ $\frac{3}{4}$ inch	6.6 $\times$ 4.4 (mounted dry and somewhat shrunken)	13.1.13 (front). 15.1.15 (middle). 17.1.17 (behind). Three rudimentary laterals, 44 rows

*Aplysia punctata* AND *depilans*.

		CENTRAL TEETH (millimetres).				
		Basilar portion.		Cusped ridge.		Notes.
Breadth.	Height.	Breadth.	Height.			
0·15	0·025	0·085	0·06	Central cusp with 5 serrations on each side. External lateral cusps well developed. Posterior bay large. (Pl. XXVIII, fig. 3.)		
0·25	0·05	0·11	0·08	Serrations as in No. 1. External lateral cusps reduced, in several teeth almost indistinguishable, being fused with the inner laterals. Posterior bay reduced. (Pl. XXVIII, fig. 4.)		
0·28	0·095	0·12	0·11	Serrations 5 or 6. External lateral cusps still more reduced. Posterior bay much filled up. (Pl. XXVIII, fig. 5.)		
0·30	0·12	0·125	0·09. Thus the median cusp does not project into the posterior bay	Serrations more variable in number than in above, from 3 to 7, but usually 4. External lateral cusps very rudimentary. Inner lateral cusps reduced and obtuse. Posterior bay nearly filled up; almost the condition of fig. 7.		
0·33	0·09 anteriorly to 0·12 and 0·13 in the middle and posteriorly	0·13 to 0·14	0·1 to 0·11	Serrations reduced in size, and only 3 or 4 distinct in most teeth. External lateral cusp lost in many teeth, very rudimentary in the others. As the numbers show, the median cusp projects into the posterior bay anteriorly, but does not reach it posteriorly. No irregular serrations on the lateral cusps.		
0·35	0·1 anteriorly to 0·2 and 0·4 in the middle of the radula and posteriorly	0·13 anteriorly to 0·15 posteriorly	0·13. Projects into the bay in front, not so behind; just as in No. 5	Serrations 3—5. Inner lateral cusps fairly well developed; occasionally bifid, or sometimes notched with small irregular serrations. External lateral cusps not so rudimentary as in No. 5. (Pl. XXVIII, fig. 6.)		
0·36	0·11 (through-out)	0·17	0·15 in front, reducing through 0·13 to 0·12, and even 0·11 behind	Central teeth closely resemble in general form those of No. 6 (Pl. XXVIII, fig. 6). Median cusp prolonged and acute in front of the radula; broader and shorter behind. Serrations well developed, usually 6. Inner lateral cusp well developed. External lateral cusp rudimentary, but distinct, and of same size as the most anterior serration of the median cusp.		
0·31	0·12 in front to 0·13 and 0·14 behind	0·13	0·11	Cusps normal, the central being a little obtuse, and having 5 or 6 serrations on each side. Posterior bay almost completely filled up; shape of basilar portion resembling that of Vayssière's fig. 58 ( <i>A. depilans</i> ).		

ANIMAL (inches).		RADULA (millimetres).	
No.	Length × breadth × height.	Length × breadth.	Formula.
9	$3 \times 1\frac{1}{4} \times 1\frac{1}{2}$ (contracted)	7·5 × 4·9	$(\frac{13}{10} \cdot 1 \cdot \frac{13}{12}) \times 42$
10	$3 \times 1\frac{1}{4} \times 1\frac{1}{2}$ (much contracted, and altogether a considerably larger individual than No. 9). Shell (wet) $1\frac{1}{4}$ inches long. (Pl. XXVIII, fig. 9)	8·8 × 5·4	$(\frac{17}{10} \cdot 1 \cdot \frac{17}{12}) \times 44$
11	Size ? Oxford specimen	Length ?, breadth 7·0	$(31 \cdot 1 \cdot 31) \times ?$ A fragment only. The 30 posterior rows are partially preserved, but only 20 have central teeth
12	Mr. Hunt's No. 1 or 2, loc. cit., p. 402. Shell (wet) $1\frac{3}{4}$ inches long	9·5 (in median line) × 7·5. Short and broad. Teeth a little distorted, having been mounted dry originally	23·1·23 in front, increasing posteriorly to 32·1·32. 56 rows



CENTRAL TEETH (millimetres).				
Basilar portion.		Cusped ridge.		Notes.
Breadth.	Height.	Breadth.	Height.	
0·38 in front, increasing regularly to 0·4, then reducing regularly to 0·37	0·12 in front, increasing to 0·15 behind	0·15 or 0·16	0·14 in front, decreasing gradually to 0·12, and even 0·115 behind	As in No. 7, the median cusp is prolonged and relatively acute in front, becoming more obtuse and shorter behind. Posteriorly it becomes remarkably broad and short, the angle made by its two sides being no longer acute, but almost or quite 90°. Serrations 3, 4, or 5. They form now a continuous series with the lateral cusps, being in the same straight line. External lateral cusp extremely reduced, indistinguishable in many of the teeth. Inner lateral cusp frequently showing irregular serrations.
0·40 in front, 0·42 in middle, 0·37 behind	0·16 in front, increasing through ·17 to 0·19 behind; a few teeth even measure 0·20	0·15, increasing posteriorly to 0·18	0·16, decreasing not quite regularly through 0·15 to 0·14 behind	The median cusp does not project into the posterior bay in any tooth, although it touches the edge anteriorly. Hardly a trace of the external lateral cusps. Serrations of median cusp fairly strong. The external edge of inner lateral cusps generally shows irregular serrations as in Nos. 6 and 9. The cusped ridge arises, as in all the above radulae, in the anterior half of the tooth. (Pl. XXVIII, fig. 7.)
0·28, decreasing regularly to 0·26 behind	0·15, constant	0·10	0·15 in front, decreasing to 0·14 behind	This is the first indubitable <i>depilans</i> . The radula is imperfect, but by comparing with No. 12 it probably possessed 50 rows originally. Central cusp broad, short, and blunt, trilobed, without serrations. Inner lateral cusps broad, short, with small irregular serrations as in Nos. 9 and 10. External lateral cusps entirely absent. Posterior bay quite filled up; shape very much as in the posterior teeth of Nos. 9 and 10. Anterior bay is partially obliterated, owing to additional deposit of chitin in front. Cusped ridge posterior in position.
0·26, increasing to 0·30, then decreasing a little irregularly through 0·26 to 0·22 behind	0·12 in front, rising to 0·14 and 0·15, with variations probably due to distortion	0·11, constant	0·10 in front, rising to 0·12 and 0·13, then decreasing to 0·11 and 0·10 (the cusps are completely worn down in front; allowing for this, there is probably a decrease in height from the very front of the radula)	Posterior margin of basilar portion convex (as in Blochmann's figure of <i>A. limacina</i> ) or arcuate, much as in my fig. 7. The cusped ridge arises in the posterior half of the tooth, owing largely to the additional chitin deposited anteriorly. Central cusp very rudimentary, as also the inner lateral. No trace of external lateral. Serrations, where present, in form of a variable number of small projections on each side of the median cusp, and on the diminished representative of the inner lateral (cf. Nos. 9 and 10). Anteriorly, and in the middle of the radula, the cusps form a broadly V-shaped serrated ridge; posteriorly they are merely serrations on a nearly straight line, as in Vayssière's figure of <i>A. depilans</i> .

ANIMAL (inches).		RADULA (millimetres).	
No.	Length × breadth × height.	Length × breadth.	Formula.
13	Mr. Hunt's No. 4, loc. cit., p. 402. Shell (wet) $2\frac{1}{4}$ inches long	12·7 × 10·0	30·1·30 in middle, 34·1·34 behind. 70 rows
14	Mr. Hunt's No. 5, loc. cit., 1878, p. 613	14·7 × 12·3	33 lateral teeth in front, increasing to 37 behind. 80 rows

*Postscript.*—The word “height” in reference to the central teeth is used in these Tables to denote what is in reality their “length.” The “height” of the basilar portion is its antero-posterior dimension in the middle line, *i. e.* the length of the line joining the median points of the anterior and posterior bays. The “height” of the cusped ridge is the length of the same line terminating posteriorly at the apex of the central cusp. The breadth of the basilar portion is its maximum breadth posteriorly.

Such a formula as  $\frac{1}{16} \cdot 3 \cdot 1 \cdot \frac{1}{16} \cdot 3$  was suggested to me by Mr. Weldon, to indicate the number of lateral teeth in an anterior and posterior row of the radula at the same time. This formula denotes an

CENTRAL TEETH (millimetres).				
Basilar portion.		Cusped ridge.		Notes.
Breadth.	Height.	Breadth.	Height.	
0·23, increasing, with variations due to distortion, to 0·38 behind	—	0·14 to 0·15	0·09 to 0·10	It is impossible to give accurate measurements for comparison with the preceding results, owing to the radulæ having been mounted dry, and the teeth being distorted. Posterior margin occasionally convex as in No. 12 (probably due to distortion), generally arcuate. The shape of the teeth closely corresponds with Vayssière's figure of <i>A. depilans</i> . The cusped ridge consists of a median unserrated projection, short and thick, and lateral wings bearing numerous minute irregular serrations. No trace of true lateral cusps.
0·38, fairly constant	0·12 to 0·14	0·16	0·08, varying slightly; never more than 0·10	The teeth are very low and broad; the posterior margin is generally arcuate. The most posterior teeth are very small and degenerate. In all the teeth the cusped ridge is prolonged into a line curved posteriorly on each side, which meets the posterior margin of the tooth, as shown in Blochmann's figure of <i>A. depilans</i> . The ridge is very simple, as in No. 13. No such definite cusps are to be found as are figured by Blochmann, whose specimen was probably much younger.

increase in the number of lateral teeth from 13 to 16 on each side, passing from the front to the back of the radula.

I have seen, through the kindness of Mr. H. M. Gwatkin, the radula of a Guernsey *Aplysia* 9·5 mm. long by 6 mm. broad, distinctly intermediate in its characters between Nos. 9 and 10 on the one hand, and Nos. 11 and 12 on the other. Formula (21·1·21) × 53. Teeth resemble those of 9 and 10, but the breadth decreases from 0·37 mm. in front to 0·34 behind, without the anterior crescendo. This points also towards the unity of the two "species."

## C. NOTASPIDEA.

*Family*—PLEUROBRANCHIDÆ.5. OSCANIUS, *Leach*.6. OSCANIUS MEMBRANACEUS, *Montagu*.

Examples of this species have been occasionally brought to us by fishermen from the refuse of the beam trawl, but have been obtained very rarely in the Sound. A very large specimen was caught in a drift-net in 5 or 6 fathoms water off Jennycliff on January 24th this year, and another large one was trawled in the Sound exactly a month later. A few others had been taken in previous years.

The habits of congregation and migration of this species, as of other Opisthobranchs, are worthy of notice, and I add here therefore some observations made by other naturalists on the Devon and Cornish coasts.

Clark states,<sup>1</sup> "These animals are frequently met with in the coralline zone in summer, and in the winter are often washed ashore on the Warren sands at Exmouth in considerable numbers."

At Falmouth, thirty years ago, Cocks<sup>2</sup> found the species rare at Gwyllyn Vase under stones, and not uncommon in the Helford River.

At Torbay, according to Mr. A. R. Hunt,<sup>3</sup> "in December, 1873, and January, 1874, *Pleurobranchus (Oscanius) membranaceus* was very abundant in the bay." On February 7th Mr. Hunt took a large specimen with a landing-net "at the back of the new pier, floating about four feet below the surface." Immediately afterwards rough weather came on, and for more than four years Mr. Hunt saw only one specimen in Torbay. "The species was swept out of the bay, and probably driven on shore."

The broad foot ("pedal disc") of this species serves for swimming as well as for creeping. When swimming freely the animal is generally upon its back, but sometimes turns over either partially or completely. It moves slowly forwards in this way, alternately flapping, with wave-like contractions from before backwards, the two halves of its broad foot. The mantle-flaps assist also in the action. This power of swimming explains the capture of one of our specimens in a drift-net, as it does also of one of Mr. Hunt's with an ordinary landing-net.

<sup>1</sup> Clark, loc. cit., p. 269.

<sup>2</sup> Cocks, *Contributions to the Fauna of Falmouth*, Trans. Cornwall Polytech. Soc., 1849.

<sup>3</sup> Hunt, *Notes on Torbay*, Trans. Devon. Assoc., vol. x, 1878, pp. 189, 190.



The structure of the foot of *Oscanius* and its habits of locomotion are of interest as indicating the way in which the lateral folds of the foot (epipodia) of *Aplysia*, *Lobiger*, and other Opisthobranchs have probably arisen. As Cuvier originally pointed out, these lateral folds in reality correspond to the lateral portions of the undifferentiated foot of such forms as *Scaphander*, *Oscanius*, and *Haminea*. In *Oscanius* the sides of the foot are frequently folded over the body of the animal when at rest, and this habit is still more marked in *Haminea*. Now the animals are found to live on muddy bottoms, and a broad flexible expanse of foot is obviously advantageous for gliding over such surfaces (cf. *Alderia modesta*, which also creeps upon mud). But the habits of *Aplysia* are different. *Aplysia* lives upon algæ, and for creeping over the narrow stems and fronds of seaweeds a wide plantar surface would be not only unnecessary but disadvantageous; so we find that the median portion of the originally broad foot has become specialised for creeping purposes, while the lateral portions no longer form part of the plantar surface, but arise from the vertical sides of the median portion, and retain only their power of flapping for the purpose of natation. The series of forms illustrating the evolution of the lateral folds of *Aplysia* is so complete as to leave no doubt about the truth of this view; but at the same time it becomes almost impossible<sup>1</sup> to regard the epipodia of Opisthobranchs and those of *Haliotis* and the lower Prosobranchs as strictly homologous. On this account Von Jhering has proposed for the folds of *Aplysia* the term "parapodia," which has been adopted by Pelseneer, and in part by Vayssière. Professor Herdman<sup>2</sup> still regards the homology as possible, and therefore retains the name "epipodia" for the lateral folds of Opisthobranchs; but he justly objects to the term "parapodia," as being "already appropriated by a totally different structure in another group of animals." Perhaps the term "pleuropodia" would at the same time be free from this objection, and also prevent confusion with the epipodia of the *Rhipidoglossa*.

This species is well known to secrete from its general body-surface a fluid containing sulphuric acid, which reddens blue litmus strongly. As Bateson<sup>3</sup> has shown that food otherwise palatable is refused by fishes generally when it "has been soaked for a few minutes in dilute acids," there can be no doubt that this secretion is a great means of protection to the species from the attacks of fishes. I have tasted this fluid, and it is strongly acid; but I have

<sup>1</sup> See Pelseneer, *Sur l'Epipodium des Mollusques*, Bull. Sci. Fr. Belg., 1888, p. 192, &c.

<sup>2</sup> Herdman and Clubb, *Third Report on the Nudibranchiata*, Trans. Liverpool Biol. Soc., iv, p. 147.

<sup>3</sup> Bateson, *The Sense Organs and Perceptions of Fishes*, this Journal, N. S., vol. i, p. 247.

found no trace of it in either *Scaphander*, *Haminea*, or *Philine aperta*. Now the two latter forms, at any rate, are largely eaten by fishes,<sup>1</sup> and are inconspicuously coloured; while *Oscanius membranaceus* is not eaten by fishes, and is handsomely coloured with red-brown and yellowish markings. I am not sufficiently acquainted with this animal to be able to assert anything with regard to the degree of conspicuousness of these markings amid natural surroundings; but they would appear to be conspicuous, and to assist fishes in the recognition of a distasteful animal.

#### 6. PLEUROBRANCHUS, *Cuvier*.

##### 7. PLEUROBRANCHUS PLUMULA, *Montagu*.

A specimen of this species was dredged in the autumn of last year, south of the Mewstone, adhering to the under side of one of the valves of a dead *Pecten*. Mr. Bourne found another specimen on the shore at Wembury Bay early in May this year, and Dr. Fowler brought back another from the same shore in September.

At Falmouth, Cocks used to find it "not uncommon" under stones at Gwyllyn Vase, Swanpool, &c.

#### Family—RUNCINIDÆ.

##### 7. RUNCINA, *Forbes*, 1853

(= *Pelta*, Quatrefages, 1844; not Beck, 1838).

##### 8. RUNCINA CORONATA, *Quatrefages*.

RUNCINA HANCOCKI, *Forbes*. In Forbes and Hanley, Brit. Moll., iii, p. 612, pl. ccc, fig. 2.

This species was first obtained at Plymouth by Mr. Heape, who secured a single specimen. It was very abundant in the middle of April this year in tide-pools below the bathing pond, not far below high-water mark. The animals were to be seen creeping over brown muddy areas and weeds, but did not frequent the green weeds. The brown colour of the molluscs, although somewhat deeper than that of the surfaces upon which they were crawling, rendered them difficult to detect for some little time, but when once detected it was easy to find many more. When fully extended large specimens measured nearly  $\frac{3}{8}$  of an inch in length.

These pools contained, besides *Runcina*, large numbers of *Lima-*

<sup>1</sup> Verrill, *Rep. Invert. Anim. Vineyard Sound*, U.S. Fish. Rep., 1873, pp. 371, 372.

*pontia* crawling over the tufts of *Cladophora*. Curiously enough, when the largest pool was examined again in the following August not a specimen of *Limapontia* or *Runcina* was to be found, while I obtained several specimens of *Actæonia corrugata*.

On a subsequent visit (September 26th) I found half a dozen small ones, measuring from  $\frac{1}{16}$  to  $\frac{1}{8}$  of an inch in length, in this large pool and in another. Plainly the large specimens of April were congregating for spawning purposes, and afterwards probably died. In August the young *Runcinas* were too small to notice easily, while by the end of September they had grown to the size recorded. On this latter visit I found no *Limapontia* and no *Actæonia*.

Mr. Cocks records this species as not uncommon at Gwyllyn Vase, Falmouth, on algæ in pools, half-tide and low-water mark, May, 1852.

## Sub-order 2.—NUDIBRANCHIATA

(= OPISTHOBRANCHIA NON-PALLIATA, Lankester).

Section A.—ASCOGLOSSA, Bergh.

Family—ELYSIIDÆ.

8. ELYSIA, *Risso*.

9. \*ELYSIA VIRIDIS, *Montagu*.

The bright green variety of this species occurs in the estuary of the Yealm and Wembury Bay.

Inside the Sound several specimens have been taken of the variety named *olivacea* by Gwyn Jeffreys. On August 14th Mr. Tate discovered one of these upon a stone dredged near the Duke Rock, and Prof. Johnson brought me one found by him among some algæ trawled on the same day in the middle of the Sound. A week later I found two more crawling over *Cladophoræ* in a large tide-pool near high-water mark below the bathing pond. In this pool they were highly inconspicuous among the tufts of algæ. Other specimens were found in this and neighbouring pools during the same month. The colour of these littoral forms was always dull, either dark olive-green or brownish; in one specimen the colour was reddish brown.

M. Giard<sup>1</sup> has found in the spring of the year little *Elysiæ* hardly more than a centimetre in length, of a vivid red colour with blackish

<sup>1</sup> Giard, Bull. Sci. France et Belg., 1888, p. 502.

markings, the foot being of a clear yellowish red. This variety he terms *aurantiaca*.

Family—LIMAPONTIIDÆ.

9. LIMAPONTIA, *Johnston*.

10. \*LIMAPONTIA CAPITATA, *Müller*.

LIMAPONTIA NIGRA, *Johnston*. See Norman, loc. cit., p 91.

Large numbers of this species were found creeping over the tufts of *Cladophoræ* in tide-pools on the north-west side of Cawsand Bay, March 26th, 1890, and on the same green weeds in pools near high-water mark south of the bathing pond in the middle of April. In these latter pools I could not discover a single individual during August and September, although I visited them on several occasions.

Early in August a number of specimens were found creeping upon *Bryopsis plumosa* at low water, south-east of Drake's Island.

It cannot be stated of this species that it is inconspicuous when creeping over the green weeds which it usually frequents; its black colour renders it at once noticeable.

Mr. Thomas Scott<sup>1</sup> has recorded this species from "pools among the stones left dry at low water a little east of Newhaven Pier, August, 1887," and observes that it is not easily perceived except when crawling. I have myself found it at Lytham, on the Lancashire coast, in shallow muddy pools which receive fresh sea-water only at spring tides and are dried up during neap tides. The specimens were either creeping over the mud or over small green *Confervæ*. They were buried in the mud during the dry seasons, and appeared to survive them.

10. ACTÆONIA, *Quatrefages*.

11. ACTÆONIA CORRUGATA, *Ald. and Hanc*.

Six specimens were found creeping over *Cladophoræ* in a tide-pool south of the bathing pond on August 19th, 1890. None were to be found a month later. This species is one of Mr. Cocks's discoveries at Falmouth.

<sup>1</sup> *Some Additions to the Fauna of the Firth of Forth, with Notes of some Rare East Coast Forms*, Seventh Ann. Rep. Fish. Board for Scotland, 1889, pt. 3, pp. 324, 325.



## Family—PHYLLOBRANCHIDÆ.

11. HERMÆA, *Lovén*.12. HERMÆA BIFIDA, *Montagu*.

A single specimen of this very interesting species was discovered by Prof. Johnson creeping over a frond of *Delesseria hypoglossum* obtained at St. Peter's Point below St. German's River, on September 26th, 1889. In length it was  $\frac{3}{16}$  inch. The head, tentacles, and body were of a pale, delicate, transparent green colour; the lateral hepatic canals and their branches to the pleuropodial cerata were of a pink colour, exactly resembling that of the alga upon which the animal was feeding. The right hepatic canal extended almost to the posterior end of the body, the left ceased more anteriorly. The cerata (homologous in a general sense with the pleuropodial folds of *Elysia*, the lateral fins of *Lobiger* and *Aplysia*, and the dorso-lateral processes of *Lomanotus* and *Tritonia*) consisted of five large ones on each side alternating with one or sometimes two small ones. I cannot speak with any emphasis, having examined only this one specimen, but if this alternating disposition of the large and small cerata exists regularly in young individuals (cf. *Hermæa cruciata*, Agassiz<sup>1</sup>), a comparison can be made between the pleuropodia of this genus and the pleuropodial folds of *Tritonia*, which are also arranged in a waved line down each side of the back with alternately larger and smaller processes. The cerata were coloured like the hepatic canals, but differed in being transparent.

As Mr. Poulton has already stated in his recent work, *The Colours of Animals* (pp. 70, 200), I found that when a shadow was caused to pass over this active little Nudibranch it at once contracted itself, drawing in its head and erecting briskly its cerata. The reaction to shadows is correlated with the unusually large eyes of this species, and is paralleled by a similar reaction, as I shall show below, in a true *Æolid*, *Coryphella gracilis*.

The pink colour of the hepatic canals and their intra-ceratal branches disappeared in my specimen entirely after twelve days' captivity, apparently owing to its refusing to feed any longer upon the *Delesseria* which was placed in the same dish of sea water with it. On September 29th the colour was paler than at first, and a number of opaque white spots (mucous glands?) became conspicuous upon the rhinophores. Next day the colour of the hepatic branches was very much paler, hardly noticeable, but the faint rosy colour of the larger cerata and the greenish colour of the rhinophores were still persistent. The opaque white spots had attained a great development upon the rhinophores, head, and cerata. On October 8th

<sup>1</sup> See Verrill, *Rep. Invert. Vineyard Sound*, 1873, pl. xxv, fig. 175.

the animal was perfectly colourless and quite transparent except for numbers of opaque white spots on the rhinophores and cerata.

13. *HERMÆA DENDRITICA*, *Ald. and Hancock*.

We owe again our only examples of this species to Prof. Johnson, who, while examining some *Bryopsis plumosa* from a tide-pool from the south-east side of Drake's Island, discovered two individuals creeping on the weed, August 5th, 1890.

They applied themselves usually to the stem of the weed, and crawled about actively among the tufts and branches, being excellently concealed from observation by their form and the green colour of their hepatic canals. The mucus of the foot is very adhesive, and this enables the animals to cling tightly to the weed; it is indeed a most difficult thing to remove one forcibly from it. I repeatedly tried the experiment of passing a shadow over them, both when in the weed and when creeping openly on the bottom of a capsule, but never obtained the reaction of the cerata described above in *H. bifida*. The eyes, though conspicuous for a Nudibranch, were not so large, if I remember rightly, as in the latter species. The erection of the cerata may, however, be produced by touching the head with a blunt needle.

I tried also the experiment of adding a number of differently coloured algæ to the dish of sea water in which the *Hermææ* were living. On the first night the green weeds supplied were *Enteromorpha*, *Ulva*, and *Bryopsis*, and representing the red weeds was a tuft of *Antithamnion plumula*. Next day the *Hermææ* were on the *Enteromorpha* and *Ulva*, not on the *Antithamnion*. Some additional red weeds, *Rhodomenia laciniata* and *Spondylothamnion multifida*,<sup>1</sup> were then put in to afford more chance of the *Hermææ* meeting the red weeds in their peregrinations. In spite of this, on the next day, August 8th, one was crawling on the sides of the dish, the other was on the *Bryopsis*. Next day one was again on the *Bryopsis*, the other was swimming inverted at the surface of the water. Indeed, within the fortnight during which they were kept alive, they were frequently observed upon the green weeds, especially the *Bryopsis*, never on the red ones. This indicates with much probability that the green species of *Hermæa* avoids the red weeds upon which it would be conspicuous, and does not avoid the green weeds upon which it is concealed from observation.

As with *H. bifida*, the distinctive colour of these specimens faded entirely after a certain time of captivity. By August 13th the green

<sup>1</sup> I need hardly say that I owe the identification of many of these algæ to my friend Prof. Johnson, who has rendered me much help in this way during his visits to Plymouth.

colour had all disappeared, and the hepatic cæca were pure brown in one individual, yellowish brown in the other. This loss of the green colour was probably due to the creatures eating no more of the green weeds, for several days previously the *Bryopsis* had turned brown and died, and the *Hermæas* were not seen upon the *Enteromorpha* after August 7th.

*Section B.—CLADOHEPATICA, Bergh.*

*Sub-section—CERATONOTA, Lankester.*

*Family—TRITONIIDÆ.*

12. TRITONIA, *Cuvier.*

14. \*TRITONIA HOMBERGII, *Cuvier.*

This species is common on the trawling-grounds. Early in August I found half a dozen young specimens in various stages of growth feeding upon a large colony of *Alcyonium digitatum* brought in from the fishing-grounds.

I kept these young individuals (one inch and under) for several weeks in a dish containing algæ only—no *Alcyonium*—to see the effect of starvation upon their colour. They gradually lost almost all their characteristic flesh-colour, and became very transparent.

13. CANDIELLA, *Gray.*

15. \*CANDIELLA (TRITONIA) PLEBEIA, *Johnston.*

This species has not occurred so frequently this year.

*Family—DENDRONOTIDÆ.*

14. DENDRONOTUS, *Alder and Hancock.*

16. \*DENDRONOTUS ARBORESCENS, *Müller.*

This species has not again been taken.

*Family—LOMANOTIDÆ.*

15. LOMANOTUS, *Verany.*

17. \*LOMANOTUS GENEI, *Verany.*

LOMANOTUS GENEI, *Verany.* Cat. Anim. Invert. Mar. Golf. di Genova e Nizza, Genova, 1846.

— MARMORATUS, *A. and H.* Monograph.

— FLAVIDUS, *A. and H.* Monograph.

- LOMANOTUS PORTLANDICUS, *Thompson*. Ann. Mag. Nat. Hist., 3rd ser., v, 1860, pp. 48—51.
- HANCOCKI, *Norman*. Ann. Mag. Nat. Hist., 4th ser., xx, 1877, p. 518; 6th ser., 1890, pp. 80, 81.
- GENEI, *Ver.* Bergh, Verh. Zool.-Bot. Ges. Wien, xxxii, 1882, pp. 66, 67.
- VARIANS, *Garstang*. Journ. Mar. Biol. Assoc., New Ser., I, ii, 1889, pp. 185—189.
- EISIGII, *Trinchese*. J. V. Carus, Prodr. Faun. Mediterr., II, i, 1889, p. 207.

In my previous Report three specimens of *Lomanotus* dredged in June last year were externally described, and the inference was drawn that the specimens previously obtained on the English coasts (although originally described as possessing specific differences from one another), together with our three specimens, really were members of one and the same species; and I proposed to give this species a new name, *L. varians*, though in this proposal, as Dr. Norman points out in his recent Revision, and as others have mentioned to me, I was breaking a recognised "law of nomenclature." Dr. Norman, however, admits the probability of my conclusions except as regards *L. Hancocki*, which he holds to be distinct. Bergh,<sup>1</sup> on the other hand, brackets together *L. flavidus*, *Portlandicus*, *Hancocki*, and *varians*, leaving *L. genei* and *marmoratus* distinct, by which, however, he may have wished to indicate rather his views upon the degree of affinity between the "species" than his agreement upon the question of their unity.

What seemed to myself to be a remarkable thing on the supposition of there being but one English species was the fact recorded in my original account (l. c., p. 187) of two individuals, whose length did not exceed half an inch, bearing "pieces of spawn." The form of the spawn was certainly unusual, but as nothing was known about the spawning of *Lomanotus* there was no valid *a priori* objection to the view that this spawn was deposited by themselves. I was unwilling at the time to dissect the specimens or otherwise alter their appearance, but I have since found that the egg-strings belonged not to the *Lomanotus*, but to a remarkable parasitic Copepod, probably a species of *Splanchnotrophus*, which was buried in the viscera of the molluscs, its egg-sacs only being protruded.

Thus the possible physiological objection to the unity of the British species, viz. that two specimens had been stated to deposit eggs at an unusually early age—when only one fifth of the extreme size—cannot be now urged; and the question remains to be settled upon morphological grounds only.

On August 21st of this year I had the good fortune to meet with

<sup>1</sup> Bergh, *Die cladohepatischen Nudibranchien*, Zool. Jahrbüch., Abth. f. Systematik, Bd. v, 1890, p. 50.



eight additional specimens of *Lomanotus*. They were all small in size; the majority were  $\frac{3}{16}$  inch long, while the smallest was only  $\frac{1}{8}$  inch and the largest was  $\frac{1}{4}$  inch—just the size of Alder and Hancock's *Lomanotus flavidus*. They were fixed on the stem and branches of a colony of *Antennularia antennina* dredged in seven fathoms water between the Breakwater lighthouse and the Queen's Grounds buoy: their elongate and low form and pale orange colouration—exactly that of the Hydroid—rendered them so inconspicuous that similar specimens have probably been more than once passed over.<sup>1</sup>

Bergh,<sup>2</sup> in his recent revision of the *Cladohepatica*, remarks upon the absence of any knowledge of the bionomics of this genus; but it should be noticed that the occurrence of so many as eight young individuals upon a single hydroid colony points very strongly towards the conclusion that *Lomanotus* attaches its spawn upon or very near to the stems of zoophytes, and that the veliger-stage in the development is passed through in the egg, or that the free-swimming stage is of very short duration, for otherwise the larvæ would be dispersed over a wide area, and the chances would be greatly against the congregation of the young metamorphosed individuals upon a single hydroid stock. I have already shown that *Lomanotus* possesses a power of rapid motion through the water (l. c., p. 189), so that even if a free-swimming larval stage is absent in this genus the dispersal of the species can be readily effected by the movements of the adult.

The structure of these young specimens is shown very fairly by figs. 1 and 2 of Pl. XXVIII, representing two different individuals of the same size ( $\frac{3}{16}$  inch long), one seen from the side, the other from above. The form in a healthy and active individual is elongate and slender, being broadest just behind the rhinophores, and tapering gradually to the posterior extremity. Fig. 2 was drawn from a very active specimen, while alive, and shows the characteristic shape. Colour, a pale transparent orange, exactly that of the majority of healthy colonies of *Antennularia*. In some of the specimens the colour was enriched by red-brown spots on the tubercles of the rhinophoral sheaths and on the papillæ of the lateral (pleuropodial) folds. This red-brown pigmentation was quite absent in the smallest individual ( $\frac{1}{8}$  inch), but in the two largest was considerably developed, and gave the animal a more conspicuous appearance (not on the Hydroid, however, for the small oval sporosacs situated all down the stem have also a deeper colouration than the stem itself, and the

<sup>1</sup> I have indeed since found two other specimens in the preserved collection of *Antennularia ramosa*.

<sup>2</sup> Loc. cit., p. 50: "Die Lomanoten scheinen ziemlich träge Thiere zu sein, über deren biologische Verhältnisse nichts bekannt ist."

development of the pigment patches on the papillæ of the larger *Lomanoti* really served to render them inconspicuous). *Veil* absent in the smaller specimens, very small in the largest, but bearing two short tentacular processes on each side; these processes of the head appear before the veil itself, and existed in all except the smallest specimen, where the corresponding region was almost perfectly semi-circular in outline, and in the specimen next it in size, in which the future oral tentacles were, however, indicated by short and broadly rounded prominences. In one individual, however, there appeared to be only a single velar process on each side, corresponding in position to the inner of the two normally present. *Rhinophores* clavate, laminated; the laminae six to ten in number, not so closely set as in Alder and Hancock's *marmoratus*, and ceasing a little below the tip of the tentacle, which is smooth, conical, and not so sharply truncate as in the latter "species." *Rhinophores* in the larger specimens retractile within calyx-like sheaths, whose edges were produced into four, five, or six somewhat irregular processes, of either simple, papilla-like, digitate, or compressed triangular form; of these the postero-external papilla was in all cases the largest (see Pl. XXVIII, figs. 1 and 2, and cf. the descriptions of *L. flavidus* and *Portlandicus*). During life the rhinophores were constantly being retracted and protruded from the calyx-like sheaths, but some individuals kept their rhinophores retracted for hours at a time, while others were never seen to protrude them at all. In these latter cases the only part of the rhinophore visible was the smooth conical apex.

On account of the similarity in appearance between this condition of the rhinophores and that which Dr. Norman described as being the most striking feature of his *L. Hancocki* (l. c., 1877, p. 518; 1890, p. 81), I wrote to him to ask if the rhinophores of his specimen had been actually dissected out. With his usual courtesy he has informed me that he did not extract the rhinophores for examination, so that I cannot but be convinced that the appearance which these structures presented in his specimen of *Lomanotus* was due not in reality to the absence of laminae upon them, but to a temporary state of retraction within the sheaths.

*Pleuropodium* (= "pallial margin," "branchial curtain," "*margo dorsalis*," "*membrana papilligera*," "epipodial ridge") on each side in the form of an undulating ridge extending from the sheath of the rhinophore (at the part produced into the large postero-external rhinophoral papilla) very nearly to the posterior termination of the foot, where it approaches the corresponding structure of the other side. The ridge is produced into irregular, flat, triangular papillæ, of which four are larger than the rest, and mark the centres of the inward undulations. The ridge in reality consists, as was pointed

out in my former paper, of a series of four arcuate lobes having their concavities external (cf. *Hancockia*), and this statement is borne out by the development. In the smallest specimen ( $\frac{1}{8}$  inch long) the pleuropodium is represented only by a series of three small, broadly triangular processes on each side, the smallest posterior, recalling the condition of this fold in *Scyllæa*, *Glaucus*, and *Lobiger*;<sup>1</sup> the connecting ridge appears later, as in the case of the veil. In slightly larger individuals ( $\frac{3}{16}$  inch) an additional smaller process has appeared on each side of the first three (see Pl. XXVIII, fig. 1), and another triangular papilla has arisen posteriorly. The posterior papillæ are more separated, since the continuous ridge is formed first in front. The papillæ of the pleuropodia and rhinophoral sheaths of the two largest specimens were pigmented exactly as in Alder and Hancock's *L. flavidus*; and on account of their flexibility and contractility there is not in my own mind the least doubt as to the specific identity of these specimens and the so-called "*flavidus*," which was also obtained upon *Antennularia*. Foot normal in the larger specimens, although the transverse groove was not observed; in the two smallest individuals the anterior angles of the foot were not produced into recurved processes, but simply rounded.

It remains to add that the *eye-spot* is round and black, and situated under the transparent integument beneath the large postero-lateral tubercle of the rhinophoral sheath on the outside (Pl. XXVIII, fig. 1); and that in the smallest individual the *sheath of the rhinophore* consisted merely of a thickening of the skin around its base, whose only tubercle was this postero-lateral one. This tubercle was in direct continuity with the primary papillæ of the pleuropodial series—another detail in the resemblance of the young *Lomanotus* to *Scyllæa*.<sup>2</sup> This continuity persists throughout life, and can be seen in fig. 1 of my plate (cf. also Bergh, l. c. supra, 1882, p. 67).

Alder and Hancock's otherwise beautiful figures of *L. marmoratus* are seriously wrong in representing a continuity between the pleuropodium and the oral veil. There is a figure of a preserved *L. genei* in Mrs. Gray's Figures of Molluscous Animals, 1874 (*Gastropoda*, pl. ccxxi, fig. 2), which, though not so artistic, is much more correct in this respect. The continuity between the rhinophoral sheath and pleuropodium exists also in *Tritonia* and *Dendronotus*;<sup>3</sup> it is

<sup>1</sup> The pleuropodial fins of *Lobiger* are, according to M. Vayssière, folded over the back of the animal when at rest, as in *Aplysia*, *Haminea*, &c. It is of interest to notice that this habit is still persistent in *Lomanotus* (see Thompson, l. c., p. 50; and previous Report, l. c., p. 187).

<sup>2</sup> Cf. Alder and Hancock on *Scyllæa* (Monograph): "The orifice [of the rhinophoral sheath] inclines forwards, and there is a thin, arched, crest-like appendage behind it."

<sup>3</sup> Cf. Bergh (l. c., p. 5), *Bei den Dendronotiden, Bornelliden, und Scyllæiden verschmelzen die vordersten Papillen mit dem Stiele der Rhinophorien.*

especially well seen in *Candiella plebeia*; while in the Holohepatica a series of forms (*Idalia Leachii*, *I. elegans*, and *I. aspersa*) illustrates conclusively the transformation of the anterior portion of the pleuropodium on the one hand into rhinophoral filaments (*Ancula cristata*), and on the other into an almost complete rhinophoral sheath (*Thecacera pennigera*). A survey of the group, indeed, leads to the generalisation that wherever the pleuropodia extend into the head region, their anterior extensions either unite in front of the rhinophores (*Idalia*, *Triopa*, *Ægirus*, *Polycera*, *Goniodoris*, *Archidoris*, *Proctonotidæ*, &c.), or enter into special relations with them (*Ancula*, *Thecacera*, *Scyllæa*, *Lomanotus*, *Dendronotus*, &c.); and since rhinophoral sheaths do not occur in the forms with a closed pleuropodium (except in cases like *Lamellidoris sparsa* and *Ægirus punctilucens*, where the tuberculate character of the whole body surface is also shown in the raised margins of the rhinophoral fossæ), it appears probable that rhinophoral sheaths in all cases contain a pleuropodial element.

The *veil* of *Lomanotus* must not be confused with the apparently similar structure existing in (*e.g.*) *Polycera quadrilineata*, which is of pleuropodial nature. It is a true "oral veil," strictly homologous on the one hand with that of *Lamellidoris*, *Acanthodoris*, and *Ægirus*, with the paired "oral tentacles" of *Archidoris*, *Goniodoris*, *Triopa*, and *Ancula* (the rudiments of which also exist in *Polycera* and *Idalia*), and on the other hand with the oral veil of *Embletonia* and the paired "oral tentacles" of the *Proctonotidæ* and *Æolididæ*. It is of course homologous with the veil of *Tritonia*, *Dendronotus*, and *Doto*; but although the veil in these genera has not the form of the pair of elongate tentacles of the majority of *Æolids*, it is so plainly the same morphological structure that Bergh's<sup>1</sup> distinction between the two should not be too finely drawn, especially as his term "margo frontalis" (*Stirnrand*) could be applied with equal correctness to the pleuropodial veil of *Polycera*, with which the former structure has nothing to do. The same objection can be urged against the use of Fischer's<sup>2</sup> term "voile frontal."

The *anal papilla* is situated on the right side of the body, under the second primary pleuropodial papilla; it is not easily seen in the living animal, but is readily perceived in one which is well preserved as a slight projection.

The *heart* could be seen through the integument of these individuals as an oval structure situated at the level of the interspace between the first and second pleuropodial lobes; in one individual it was observed to beat sixty-five times in the minute.

<sup>1</sup> L. c., pp. 4, 49, &c.

<sup>2</sup> Manuel de Conchyliologie, pp. 526, 535, &c.



The largest individual was observed on one occasion, after irritation, to contract itself vigorously from side to side; but it did not actually progress in this way.

These new specimens of *Lomanotus* throw considerable light upon the question of the number of species. There can be no doubt that they are members, with *L. flavidus*, *L. Eisingii*, *L. Portlandicus*, and *L. Hancocki*, of one and the same species; and the largest of the three specimens described in the previous Report so plainly connects *L. Eisingii* with *L. marmoratus*, and this latter through our two other specimens is brought so near to *L. genei*, that I have very little hesitation in referring all the known forms to the species *L. genei* possessing the characters of the genus.

These specimens will form the material for some notes upon the anatomy of the genus at no distant date.

*Family*—DOTONIDÆ.

16. *Doto*, *Oken*.

18. \**DOTO FRAGILIS*, *Forbes*.

This species has been frequently taken as before.

19. *DOTO PINNATIFIDA*, *Montagu*.

I am glad to be able to add this rare species to the fauna. Two specimens,  $\frac{3}{8}$  inch long, were dredged by Dr. Beuham adhering to *Antennularia antennina* on the Queen's Grounds, opposite Picklecombe Fort, in August. One had eight, the other nine pairs of cerata. I carefully examined these specimens, and the colour and structure were in every respect as described by Alder and Hancock. On the stem of the Hydroid was some *Doto* spawn, no doubt deposited by one of these individuals. It was of a pale rose-pink colour, and arranged on the stem in a regularly zigzag line, as is often the case with the spawn of *D. coronata*.

20. \**DOTO CORONATA*, *Gmelin*.

Prof. Herdman<sup>1</sup> finds this species at Hilbre Island "invariably creeping on the under surfaces of ledges and stones on which are large colonies of the zoophyte *Clava multicornis*;" and in these conditions the molluscs are efficiently concealed, on account of the re-

<sup>1</sup> Herdman, *On the Structure and Function of the Dorsal Papillæ in Nudibranchiata*, Report Brit. Assoc., 1889, Sect. D, and Quart. Journ. Micr. Sci., xxxi, p. 56.

semblance of their cerata in brightness and similarity of colour and external form to the upper ends of the zooids of *Clava*.

It is an interesting fact that at Plymouth this species has never been found upon gymnoblastic Hydroids, but always upon Calyptoblasts, chiefly *Plumularia*, *Antennularia*, and *Sertularia*<sup>1</sup> (especially *S. pumila*). *Clava cornuta* and *multicornis* are to be found covering the under sides of stones and the bottoms of certain rock-pools on the shore, but I have searched these colonies in vain for a single specimen. Correlated with this dissimilarity of habit, Plymouth specimens very rarely show much of the bright rose-colour generally found in the species elsewhere. One such individual, however, was found creeping over a brightly coloured scallop-shell (*Pecten maximus*) upon which colonies of *Halecium* were growing. The *Halecium* had large quantities of the spawn of *D. coronata* attached round the bases of its stems, some of which no doubt had been deposited by this individual. If so, the *Doto* either was wise in keeping near the brightly coloured shell to deposit its eggs, or had been creeping over the Hydroid, in spite of its conspicuous coloration, with impunity.

Family—ÆOLIDIDÆ.

Sub-family 1.—ÆOLIDINÆ (= ÆOLIDIADÆ PROPRIÆ, Bergh).

17. ÆOLIS, Cuvier (*sens. strict.*).

21. \*ÆOLIS PAPILLOSA, Linn.

Three specimens only have been taken this year, under stones at low water; one in April at Drake's Island, another in May immediately below the Laboratory, and the third was found by Dr. Fowler on July 16th at the east end of Drake's Island. Mr. Vallentin found it abundant in the spring in Falmouth Harbour, on the under side of rocks at low water.

In my former Report<sup>2</sup> I had occasion to refer to the resemblance of this species in colour and form to the Actinian *Sagartia troglodytes*, noticed and recorded by M. Giard, who also observed that the two creatures were frequently to be found in the same situations. As this is one of the most important of the "tests of mimicry" given by Wallace, I was inclined to regard *Æolis papillosa* as an instance

<sup>1</sup> Cf. McIntosh, Mar. Inv. and Fishes, St. Andrews, 1875, p. 86. Mr. Vallentin finds the species common at Falmouth on *Obelia geniculata*. I have found it on this Hydroid occasionally at Plymouth.

<sup>2</sup> L. c., pp. 175, 191. *Sagartia parasitica* on the former page was obviously an error, and I take this opportunity of correcting it.

of a species of *Æolid* evolved by the selection of the most *troglo-dytes*-like individuals of each generation. Since, however, it is only at Wimereux that the relations noticed by Giard to exist between the two animals are known even to approach constancy, and as similarly coloured specimens occur abundantly elsewhere, this view can be entertained at present only doubtfully. But as local colour-varieties of this species are not rare, the question could be settled almost conclusively if naturalists on the different coasts would notice whether the local race has or has not the special relations of mimicry to some locally abundant Actinian upon which it feeds or near which it lives. The colours of the local races ought to vary with the colours of such locally abundant species of Actinian. If they should be found to do so, then a strong case for true mimicry could be made out; if not, then selection of the individuals most resembling the locally abundant Actinian cannot have taken place, and the species, like its varieties, must find its causal explanation elsewhere.

#### 18. *ÆOLIDIELLA*, *Bergh.*

#### 22. *ÆOLIDIELLA ALDERI*, *Cocks.*

This rare species, discovered at Falmouth in 1848 by Mr. W. P. Cocks, and not recorded from any other part of the English coast (Mr. Cocks himself never saw it after 1849), was found in large numbers by Mr. Bourne and Dr. Fowler on the shores of the Yealm estuary between Fox Cove and Thorn Cove late in October, 1889, at low water; and has been taken on subsequent occasions, though in less abundance, from the same locality. The ground here is fairly firm, consisting chiefly of small stones with an admixture of coarse, slightly muddy sand, while old oyster-shells are scattered about. Most of the specimens have been found under these shells or under stones. A yellowish-white species of Actinian, *Sagartia* (sp. incert.), is very common here also, being found attached to the pebbles or even free, but generally in either case half buried in the sand, and shrinking into it at the slightest touch. It is very probable that this anemone constitutes a chief source of the *Æolid*'s food. Curiously enough, the *Æolid* and the Actinian are very like each other in colour and form, and it was easy when collecting the former to mistake at times half-buried specimens of the *Sagartia* for the Nudi-branch. This case may be, like that of *Æolis papillosa* and *Sagartia troglodytes*, one of true mimicry, and I am collecting facts bearing upon the matter.

Early in February this year, upon another visit to this locality, I could find only a few specimens of the *Æolid*, but whether the

reduction in numbers was due to migration into deeper water or to death (the weather just previously to my visit had been extremely cold) it was impossible to determine. One of the specimens secured on this occasion had probably been attacked a day or two previously by some fish, for its cerata were all extraordinarily small. They had plainly been knocked or bitten off,<sup>1</sup> and were in course of recrescence, for next day they were larger in size. These observations support the views proposed in my former Report (l. c., pp. 175 and 191) as to the significance of the structure, colouration, erectile power, and fragility of the dorsal cerata in *Æolids*. If the head of this species be touched with a blunt needle, it is at once withdrawn (almost telescoped into the body), and the cerata rise up from their recumbent position and become very prominent, like the quills of a porcupine. This reaction is instantaneous if the stimulus be strong enough.

The size of fifteen specimens taken on October 24th, 1889, varied from  $\frac{1}{4}$  inch to a little over 1 inch in length, only two specimens being under  $\frac{1}{2}$  inch. The smallest specimen,  $\frac{1}{4}$  inch long, had seven or eight rows of papillæ, while the anterior angles of its foot were rounded, not produced into recurved processes. In a specimen  $\frac{7}{8}$  inch long the number of rows of cerata was fifteen or sixteen. The white "ruff" round the neck, as Mr. Cocks stated, is a good and permanent specific character. It appears to be caused by the cerata of the first two rows having each a very short hepatic diverticulum, instead of one reaching to the tip of the papilla.

The colour of the dorsal papillæ varies from a pale greenish fawn-colour to a dark brown. The tips are yellowish, sometimes almost white. The basal portions of the cerata of the ruff are always coloured like those behind, the colour being in all cases due to the hepatic cæca.

### 23. *ÆOLIDIELLA GLAUCA*, *Ald. and Hancock*.

I found a single specimen of this species, nearly an inch in length, under a stone at low water on the shore beneath Lord Mount Edgecumbe's winter villa on October 11th, 1890. The animal was white in colour, the hepatic cæca being of a fawn-colour, deeper below than above. Much opaque white was scattered on the back of the head and body, on the oral tentacles, and on the cerata. The curious vermicular character of the cerata, the suddenly attenuated extremity of the broad foot, and other points, readily dis-

<sup>1</sup> The same was the case with a number of the posterior cerata in one of the individuals taken on October 24th.



tinguish this species from its allies. In general appearance this specimen much resembled an *Æ. Alderi*.

Sub-family 2.—CRATENINÆ.

19. CRATENA, *Bergh*.

24. CRATENA VIRIDIS, *Forbes*.

MONTAGUA VIRIDIS, *Forbes*. Ann. Nat. Hist., v, 1840, p. 106.

EOLIS VIRIDIS, *Forbes*. Alder and Hancock, Monograph, Fam. 3, pl. xxxii.

— GLOTTENSIS, *Alder and Hancock*. Monograph, Fam. 3, pl. xxix.

— ARENICOLA, *Forbes, MS.* Alder and Hancock, Monograph, Fam. 3, pl. xxxi.

— NORTHUMBRICA, *Alder and Hancock*. Monograph, Fam. 3, pl. xxxi.

Four individuals of this species have been taken. One small one was dredged on September 24th, 1889, in about ten fathoms water, a quarter of a mile south-south-east of the Mewstone, on weedless ground. It was found by Mr. Bourne creeping on a mass of *Lepralia foliacea*. It possessed nine transverse rows of cerata, the first half-row consisting of two very small cerata, the second half-row of three, the third and its successors of four, while the eighth and ninth half-rows consisted of three and of two cerata respectively. The four anterior rows were set closely to one another, and were separated by an interval from the posterior rows, which were placed behind each other at regular distances. The hepatic cæca were very dark green in colour, and all the tissues were permeated with a green tinge.

The second specimen, of the same size and colour, was dredged on similar weedless ground in October.

The third was considerably larger, and was found among Polyzoa and Hydroids by William Roach inside the Sound during the first week of November.

The fourth was a very young individual, dredged near the Duke Rock on a stone covered with *Eudendrium capillare*, February 18th, 1890. The colour—a greenish yellow—was confined to the hepatic cæca. The cerata were as contractile and muscular as the tentacles.

The three "species," *glottensis*, *arenicola*, and *northumbrica*, described in Alder and Hancock's Monograph, appear to be merely slight varieties or different stages of *Cratena viridis*. Only a single example of each type has been recorded. Our first specimen was undoubtedly of the same species as the type of *glottensis*, but differed from it in not having the tips of the cerata orange-coloured, nor were the rhinophores thickened at the tip. *Eolis arenicola* may be distinct, but Forbes's specimen was probably an exceptionally large

*Cratena viridis*. In contrasting *Eolis northumbrica* with *Eolis viridis*, Alder and Hancock entirely overlooked the fact that in Forbes's original specimen of the latter species the rhinophores were described as being "rugose, or wrinkled concentrically." It is a very common occurrence for an *Æolid* possessing "smooth" rhinophores to contract them so as to give them the appearance of being "ringed" or annulate in structure; and I cannot help regarding the appearance described in *Eolis northumbrica* as being probably a transient, and not a specific difference.

*Cratena viridis* has been found in greatest abundance at St. Andrews by Prof. McIntosh,<sup>1</sup> who notices how readily this species loses its characteristic coloration in captivity. I can confirm Prof. McIntosh's statement by my observations on our Plymouth specimens.

25. \**CRATENA OLIVACEA*, *A. and H.* (= *Cavolina olivacea* of 1st Rep., p. 183).

This species has not again been obtained.

*Sub-family 3.—TERGIPEDINÆ.*

20. *TERGIPES*, *Cuvier*.

26. \**TERGIPES DESPECTUS*, *Johnston*.

This species has not been noticed since my former Report.

21. *GALVINA*, *Ald. and Hanc.*

27. *GALVINA EXIGUA*, *A. and H.*

This species has been taken on two occasions. One specimen was found among *Halecium* and *Eudendrium* on stones dredged near the Duke Rock, March 27th, 1890. It possessed five rows of cerata, the first half-row consisting of three cerata, the middle half-rows of two, and the posterior of one. The dorsal tentacles were twice as long as the oral. The cerata and tentacles were banded transversely with belts of olive-green, and there were reticular patches of the same pigment upon the dorsal integument.

Another specimen, quite colourless, was taken on *Halecium* dredged near the same spot on April 9th. It was some time before this individual was noticed, owing to the perfect resemblance of its cerata in form and colour to the white elongate gonophores of the Hydroid.

<sup>1</sup> Loc. cit., p. 5.

28. \**GALVINA TRICOLOR*, Forbes (= *Cavolina Farrani* of 1st Rep., p. 193).

- EOLIS TRICOLOR*, Forbes. Ald. and Hancock, Monograph, Fam. 3, pl. xxxiv.  
 — FARRANI, Alder and Hancock. Monograph, Fam. 3, pl. xxxv.  
 — ADELAIDE, Thompson. Ann. and Mag. Nat. Hist. (3), vol. v, 1860, p. 49.  
 — — *McIntosh*. Mar. Inv. and Fish, St. Andrews, p. 86, pl. ii, fig. 11.  
 — ANDREAPOLIS, *idem*. Proc. Roy. Soc. Edin., 1864-5.  
 — ROBERTIANÆ, *idem*. Do. do.  
 — FARRANI, *idem*. The Marine Invertebrates and Fishes of St. Andrews, 1875, pl. ii, figs. 12, 13.  
 — TRICOLOR, Forbes. Friele og Hansen. *Bidr. til Kundsk. om de Norske Nudibranchier*, Vidensk. Selsk. Forhandl., 1875.

I have followed Friele and Hansen in uniting *G. Farrani* with *G. tricolor*.

Three individuals were found feeding upon *Obelia geniculata*, growing on *Laminaria*, on September 30th, 1889, measuring from  $\frac{3}{8}$  to  $\frac{1}{2}$  inch in length. One was quite white in colour, except for a faint tinge of fawn-colour in the cerata (due to the hepatic cæca), another was entirely orange-coloured, and in the third specimen the body was white, with deep orange-yellow patches on the back and on the front and sides of the head; the larger cerata near the median line were orange-coloured with a few markings of purplish umber, and the rest were of a much paler yellowish colour. All the cerata had white tips, bounded below by a narrow purplish ring, merging below into a ring of orange.

On October 2nd two more specimens were obtained under similar conditions, one being  $\frac{5}{16}$ , the other  $\frac{7}{16}$  inch long. The former was exactly like the first specimen here described, while the latter was white, with orange-tipped cerata and tentacles, the orange pigment being also traceable on the back as well as over the surface of the cerata.

Three days later four more individuals were found upon *Laminaria saccharina* dredged in the Cattewater, the weed having no *Obelia* growing upon it, but quantities of slender branching algæ and of a calcareous Polyzoan. They were from  $\frac{5}{16}$  to  $\frac{3}{8}$  inch long. In one individual the back was of a semi-transparent white, with patches of deep orange-red and a certain amount of reticulating purplish pigment. There was a broad patch of deep purple on the front of the head, while in front and at the sides of the rhinophores there were patches of deep orange-red. The oral tentacles and tip of the "tail" were orange-coloured. The cerata were of a violet colour, faint below, with conspicuous orange tips. Two other individuals were white with fawn-coloured cerata, spotted profusely with microscopic opaque white spots, and having white tips. One had

seven rows, the other eight, of cerata. In the latter specimen there was one reticulating violet spot on the anterior part of the back, and another more compact orange spot about the middle. The fourth individual was white, with orange-tipped cerata. The oral tentacles were entirely orange-coloured. The distal halves of the rhinophores were orange-coloured, the proximal white. The back showed a number of orange-coloured spots and faint traces of violet.

When an individual of this species is in motion the oral tentacles are kept in a nearly horizontal plane, constantly touching the surface upon which the animal is creeping; on the other hand, the rhinophores are kept erect, extending outwards and somewhat forwards, in this way testing obstacles in the water, which are out of the range of the oral tentacles. If the tentacles or dorsal integument be touched, the animal at once contracts and erects its cerata: this reaction cannot usually be produced by touching the cerata themselves, which possess little power of sensation. There is a slight break in the regular sequence of the rows of cerata after the fourth (or sometimes the third) row; here the heart may be seen beating.

The curious fact that all the specimens of this *Æolid* obtained by us in 1888 and 1889 were found during a limited period in late autumn, from the end of September to the commencement of November, coupled with the fact that the individuals taken at the beginning of this period were slightly smaller in size than those found in November, led me to make particular search for the species during the spring of this year. I examined repeatedly blades of *Laminaria* for this purpose, but found not a single specimen, but a bottom tow-net devised by Mr. Cunningham and worked in Cawsand Bay during May and June brought up, among the filamentous algæ so abundant there, a number of *Æolids* which I cannot but regard as the more advanced stages in the growth of this species. I was unable to devote much attention to them, but give here some notes drawn up after an examination of two individuals.

*Rhinophores* long; almost, if not quite, equalled in length by the oral tentacles. *Cerata* in about nine or more rows, four cerata in each lateral half of a transverse row, perhaps five in some, the external cerata being much smaller than the internal; inflated, semi-transparent, with tips orange-coloured in one specimen, whitish in the other. *Hepatic cæca* slender, sacculated, running up to the tips of the cerata; over the cerata a faint sage-green pigment spread. *Body* very slender when thoroughly extended, approaching  $\frac{3}{4}$  inch in length. The back covered with large conspicuous orange-red or almost crimson spots, each spot surrounded by an area of sage-green pigment consisting of a mass of microscopic sage-green dots. These also give rise to the faint sage-green pigment of the cerata.



There were no orange spots on the cerata. The rhinophores had a band of reddish pigment in the same region as the band of brown in *G. picta*.

In motion the oral tentacles were kept horizontal upon the bottom, and were then generally flattened out at the tips (cf. McIntosh on *Eolis Andreapolis*, l. c.). When the light was suddenly cut off from these individuals the action was followed by a slight erection of the tentacles, and by short restless movements of the head and anterior cerata—the animals having previously been quite still. But the cerata were not erected by this stimulus, although they were by touching the head as above described. The eyes were distinct, but not unusually large.

These two individuals were taken on May 14th. Two days later they had laid two ribbon-like pieces of spawn, which were not attached to the sides of the dish, but floating on the surface of the water.

On June 25th a smaller individual was obtained from the same place, orange-coloured all over, but possessing patches of a deeper reddish-orange and brownish colour on the back. The tips of the cerata were also more intensely orange-coloured.

On October 16th two very small specimens (2 mm. long) were found among *Obelia* on *Laminaria* trawled at Batten.

## 29. \**GALVINA CINGULATA*, Ald. and Hancock.

Another individual of this species was found on August 21st among *Cladophora* from either Drake's Island or below the bathing pond. It measured  $\frac{5}{16}$  inch in length. The lateral lines of olive-brown between the cerata were well marked, as also the patch of the same pigment behind the rhinophores. The cerata were arranged abnormally. Usually the rows of cerata on one side of the body are in the same transverse lines as those of the other side; but in this individual only the first and second rows were so arranged; the five succeeding pairs of lateral rows were arranged alternately, not in the same transverse lines. The heart was situated in the centre of the second transverse row of cerata.

### Sub-family 4.—CORYPHELLINÆ.

#### 22. *CORYPHELLA*, Gray.

## 30. \**CORYPHELLA RUFIBRANCHIALIS*, Johnston.

No additional examples of this species have been taken during the past year, unless further observations should confirm Trinchese's view that the two following "species" are merely varieties of *C. rufibranchialis*. Herdman<sup>1</sup> and Clubb, however, have had good

<sup>1</sup> *Third Report on Nudibranchiata*, l. c., pp. 140—143.

opportunities of investigating this question, and are convinced of the distinctness of the species *rufibranchialis* and *Landsburgii*.

31. *CORYPHELLA GRACILIS*, *Ald. and Hanc.*

Two individuals, agreeing with Alder and Hancock's description of this species, have been taken this year. One small specimen was dredged on May 13th in the Sound between the Duke Rock and Jennycliff, and another individual was obtained with the bottom tow-net in Cawsand Bay, July 7th. This latter specimen was kept alive for several weeks, and some time after its capture it was noticed that the hepatic cæca were of a ginger-yellow colour, like the original example of Alder and Hancock. I believe, however, that the colour was more reddish at the time of capture, and that it faded under the conditions of its captivity.

I was very much surprised to find that this individual responded to shadows as stimuli for the erection of its cerata, unlike any other nematocyst-bearing Æolid with which I have experimented. The reaction was like that exhibited in *Hermæa bifida* (*supra*), although not quite so rapid and complete. The eyes are conspicuous in this species, and relatively larger than in other Æolids which do not respond to this stimulus.

The opaque white spots at the tips of the cerata were not very regularly distributed: they were mostly in the form of semicircular patches on their anterior faces, as in *Facelina coronata* and *Drummondii*.

32. \**CORYPHELLA LANDSBURGII*, *Ald. and Hanc.*

Another individual of this species, half an inch in length and of an extremely slender and attenuated form, was trawled on the 25th September this year by Mr. Cunningham among Hydroids (*Obelia geniculata* on *Laminaria*, *Sertularella Gayi*, and a little *Antennularia*) near the Duke Rock. In colour and markings it was quite normal and very transparent.

*Sub-family* 5.—FAVORININÆ.

23. FAVORINUS, *Gray.*

33. FAVORINUS ALBUS, *Ald. and Hanc.*

Two individuals were found together on the under surface of a large flat stone at the east end of Drake's Island, low water, spring tide, November 22nd, 1889. On the same stone was the spawn of some Nudibranch (probably *Polycera quadrilineata*), in five or six circular ribbon-like patches; upon this spawn in captivity the

Æolids fed (cf. Alder and Hancock, Monograph). One of the individuals, more closely examined, was found to be  $\frac{3}{8}$  inch long, and was entirely of an opaque white colour except for the rhinophores, which were deeply pigmented brown over the lower two-thirds of their length. The distal portion was pointed at the tip, and opaque white in colour. The infra-apical bulb never assumed the form of the "button-like expansion" figured by Alder and Hancock; indeed, there was no trace of it at times. Just below the bulb, at the junction of the white and brown portions, the left rhinophore was curiously and abruptly bent forwards, and this condition was persistent. The rhinophores over their pigmented portion were finely perfoliate, the laminae apparently resembling those of *Facelina punctata*.

The cerata react to stimuli upon the head, as in *Galvina tricolor*; there is no reaction upon touching the back or the cerata themselves, or to shadows.

Opaque white spots were distributed upon the back, as described in the Monograph; they existed also at the tips, and occasionally over the whole external integument of the cerata.

This individual spawned on a stone a week after its capture, the spawn being exactly as described by Alder and Hancock.

Another small specimen,  $\frac{1}{4}$  inch in length, was taken with the bottom tow-net in Cawsand Bay on the 7th of July. The infra-apical bulb of the rhinophores was quite absent.

*Sub-family 6.*—FACELININÆ.

24. FACELINA, *Ald. and Hanc.*

34. \*FACELINA CORONATA, *Forbes.*

Two more specimens have been dredged near the Duke Rock; one on September 23rd, 1889, the other in July, 1890. Another fine specimen,  $1\frac{1}{8}$  inches in length, was found among *Obelia geniculata* on *Laminaria* dredged near the end of Batten breakwater (west of the Cobbler Buoy) on October 2nd, 1889: on the same piece of weed were two *Galvina tricolor*. The hepatic cæca were fawn-coloured, red at their extremities. Down the front of each of the cerata was a streak of opalescent blue; this characteristic coloration also existing, though more faintly, on the head, oral tentacles, and in patches on the back of the body. There was a more or less regular semilunar patch of opaque white on the anterior face of each of the cerata near the tip, and this was generally continued as a streak of white down the anterior face for a short distance.

On October 8th, 1890, a small specimen, not quite  $\frac{5}{16}$  inch in length, was found again among *Obelia* on *Laminaria* dredged in the Cattewater. The foot of this individual was broad and thin as in *F. Drummondii*,

not elongate and narrow as usually in *F. coronata*; its anterior angles were produced into long processes. The oral tentacles were very long and slender, rather over  $\frac{1}{8}$  inch in length (cf. A. and H. on this character in young specimens of *F. Drummondii*). Rhinophores perfoliate, with numerous laminae alternately larger and smaller, resembling those described and figured by Alder and Hancock for *F. Drummondii* much more than for *F. coronata* (where they are less numerous). When contracted the rhinophores appeared to be annulate, not perfoliate. Cerata very numerous, clustered, the first cluster being very large; very contractile and changeable in shape, capable of much elongation. Colour of body transparent white, with patches of opalescent blue spots on the head, back, along the oral tentacles, and on the anterior faces of a few of the larger cerata. Hepatic caeca granular, yellowish brown; no pink or red at all in this specimen. Crescentic patches of opaque white on the anterior faces of the tips of the cerata.

In all points of external form and in the colour of the hepatic caeca this specimen agrees much more with the descriptions of *F. Drummondii* than with those of *F. coronata*, but on account of its possessing the opalescent blue markings, characteristic of the latter species, and not known to occur in the former, I have referred it with some hesitation to the species *coronata*. The specimen described in my former Report under the provisional name of *Eolis Huxleyi* (l. c., pp. 194, 195) I am inclined now to regard as a young *Facelina coronata*, in which some of the cerata had been broken off anteriorly. In very many points it agrees perfectly with the young individual just described.

The long oral tentacles of *F. coronata* are naturally employed very differently from the short tentacles of *Galvina tricolor*; they are not kept motionless and flat in locomotion, but are swayed about, feeling the surface and the surrounding medium on all sides. It may be noticed in *Æolids* that the oral tentacles are as a rule particularly long where the dorsal tentacles are laminated or otherwise distinctively specialised for olfactory purposes. This increased development of the oral tentacles probably saves the rhinophores from many liabilities to danger. That this view of the correlation is not merely fanciful is borne out by the condition of the same parts in the *Holohepatica*, where the rhinophores are protected either by being retractile into sheaths (*Dorididæ cryptobranchiatæ*), provided with special tactile appendages (*Ancula cristata*, *Idalia*), correlated with special development for tactile purposes of the oral tentacles (*Goniodoris*) or anterior extensions of the pleuropodia (*Triopa claviger*, *Polycera*), or by having the laminated portion bent backwards (*Acanthodoris pilosa*, *Polycera*). When a *Facelina coronata* also is at rest



the rhinophores are frequently thrown back on the dorsum between the lateral halves of the first cluster of cerata.

35. \*FACELINA PUNCTATA, *Ald. and Hanc.* (= *Flabellina punctata*, 1st Rep., p. 192).

This species has not again been taken.

*Sub-family 7.—ANTIOPINÆ.*

25. ANTIOPA, *Ald and Hanc.*, 1848 (= *Janus*, Verany, 1844 ; not Stephens, 1835).

36. \*ANTIOPA CRISTATA, *Della Chiaje.*

Two more specimens have been taken : one, an inch in length, was trawled in the Sound between the Mallard Buoy and the Merchants' Anchorage on July 26th by Prof. Johnson, who found it among red branching weeds and *Laminaria* ; the other, also a large specimen, was discovered by Mr. Minchin in a tide-pool near the bathing pond late in August. It was creeping near the surface of the water over the *Cladophoræ* and other weeds of the pool, the delicate blue tips of its cerata being very conspicuous.

It is said by M. Giard<sup>1</sup> to be, at Wimereux, like *Thecacera pennigera*, particularly an autumn species feeding upon *Bugula*. Curiously enough, my friend Mr. Vallentin dredged an individual of each of these species at the same haul in Falmouth Harbour in the spring of this year, along with numerous oyster-valves covered with *Bugula flabellata*.

*Section C.—HOLOHEPATICA, Bergh.*

*Sub-section—ANTHOBRANCHIATA*,<sup>2</sup> *Goldfuss*, 1820 (= PYGOBRANCHIA, *Gray*, 1821).

*Family—DORIDIDÆ.*

*Sub-family—DORIDIDÆ CRYPTOBRANCHIATÆ, Bergh.*<sup>3</sup>

26. ARCHIDORIS, *Bergh.*

37. \*ARCHIDORIS TUBERCULATA, *Cuvier.*

As the colours of this species have a general resemblance to those

<sup>1</sup> Giard, *Bull. Sci. France et Belg.*, 1888, p. 502.

<sup>2</sup> For the classification of the *Anthobranchiata*, cf. Abraham, *Proc. Zool. Soc.*, 1877, pp. 196—269, pls. xxvii—xxx.

<sup>3</sup> Bergh, *Gattungen nordischer Doriden*, *Arch. f. Naturgesch.*, Jahrg. 45, Bd. i, pp. 340—369.

of the sponges upon which it usually feeds, and as these sponges are themselves very variable in colour, a number of differently coloured specimens of this Nudibranch were kept in one of the small tanks in the Laboratory, and fed under similar conditions upon the same pieces of *Halichondria*, which were obtained of as uniform a colour as possible. After several months no change was detected in the colouration of the Nudibranchs. The species cannot therefore be regarded as possessing the power of variable protective resemblance.<sup>1</sup>

My friend Mr. Rupert Vallentin has several times sent me large individuals of this species from Falmouth, which have been of a much paler colour than is usual at Plymouth, although such individuals occur.

With regard to the spawning period of this mollusc, I may add to my previous account that specimens which had been living in the aquarium for some time last winter were found to have deposited spawn early in January.

### 38. ARCHIDORIS FLAMMEA, *A. and H.*

Near the Duke Rock a sponge of *Desmacidon*-like appearance, with prominent oscula, but of a bright red colour, is very common; and while looking over a quantity of the sponge early in April last I found an individual of this species feeding upon it, in dimensions just under three quarters of an inch long and half an inch broad. The colour of the Nudibranch closely approached that of the sponge, but had a more orange tinge. There were a few scattered purplish spots in the middle of the back. The animal was very flattened in form and very changeable in shape. Rhinophoral fossæ very wide and capacious, and tuberculated at their edges. Rhinophores and branchiæ completely retractile. It was occasionally seen to float inverted at the surface of the water.

On a piece of the sponge preserved in alcohol for identification I subsequently found another, rather smaller specimen of the same species. It was in a conspicuous position on the sponge, and I must have overlooked it when alive owing to the similarity of its colour to that of the sponge.

If this species should be found to feed generally upon red sponges, the adaptation will be of considerable interest. Perhaps its rarity may be due, as in many other cases, to an insufficient knowledge of its peculiar habits. I am inclined to believe that the red Dorises

<sup>1</sup> Mr. Poulton (*The Colours of Animals*, 1890, p. 108) has mentioned the probable existence in this species of the power of adjustment of its colour to that of its surroundings. Prof. Stewart's specimens, however, were in all probability not *tuberculata*, but a distinct species.

which Prof. Stewart found upon *Hymeniacion sanguineus* (cf. my previous Report, p. 177) were large specimens of this species.

Another specimen, half an inch long, was again dredged on the same ground early in June.

It is important to prevent any confusion between this species and *Doris (Rostanga) coccinea*, which is also red in colour. The best character by which to distinguish them at once is the structure of the anterior portion of the foot: in *flammea* this is entire, and separated from the rest of the foot by a transverse groove only; but in *coccinea* it is split into two lateral portions, as in *Doris (Jorunna) Johnstoni* and *Doris (Platydoris) planata*. Alder and Hancock's two specimens were dredged in shallow water, Rothesay Bay, adhering to *Pecten opercularis*. Prof. Ed. Forbes dredged it off the Isle of Man in 25 fathoms. Dr. Norman has also found the species at Cumbrae, and Mr. Cocks recorded it in 1849 as "very rare, on stones at extreme low-water mark, spring-tide," at Gwyllyn Vase, Falmouth.

#### 27. JORUNNA, Bergh.

39. \*JORUNNA JOHNSTONI, A. and H. (= *Archidoris Johnstoni*, 1st Rep., p. 177.)

Three more specimens of this species have been obtained. One, half an inch in length, was found under a stone in a pool at Rum Bay on March 7th, and was very sponge-like and inconspicuous. Mr. Bourne also found two specimens on the shore at Wembury Bay, one early in May, and the other a month later.

The dark spots on the back of this animal have been constantly present, but very variable in position; they have the effect of rendering the darkly coloured rhinophores less conspicuous.

#### 28. PLATYDORIS, Bergh.

40. \*PLATYDORIS PLANATA, Alder and Hancock (= *Archidoris planata*, 1st Rep., p. 178.)

Two additional specimens have been taken. One, found at Drake's Island, August 14th, 1889, measures (preserved in spirit)  $1\frac{1}{8}$  inches long by  $\frac{9}{16}$  broad. The gill-plumes are six in number, the third on each side being deeply bifurcated. They were completely retractile, and when protruded appeared to be composed of two distinct lateral halves. The underside of the pleuropodium and the foot were orange-coloured; the pleuropodium in life was often upturned at the edge, showing its orange-coloured under-side. The radula of this specimen is very abnormal, there being three longitudinal series of great irregular teeth formed by the fusion of several of the slender normal ones. On one side two teeth in each row are thus

fused, being united by their bases and at their tips, leaving an enclosed space in the middle. The tips of these double teeth are broad, flat, and triangular. On the other side of the radula there is a row of double teeth resembling those just described, and also a row of large teeth formed in exactly the same way by the fusion of three of the ordinary slender hook-like teeth.

Another specimen was dredged near the Duke Rock on September 24th, 1890, measuring  $1\frac{1}{8}$  inches long by  $\frac{1}{16}$  broad when at rest, and  $1\frac{1}{4}$  inches by  $\frac{9}{16}$  inch when *en marche*. Colour precisely as in Alder and Hancock's figure. Gill-plumes, exactly as in the previous specimen, protruded from the wide fossa in two separate tufts, one on each side. Each of these lateral tufts was formed of three plumes, the third on each side being distinctly trifold and very broad, and all the plumes very pinnate in character. On several occasions I saw the tuft of one side retracted independently of the other, pointing to a power of independent contraction of the branchial retractors of each side. This division of the branchial plumes into two independently retractile halves is a very marked character, and has not, I believe, been recorded before.

This genus is distinguished from the *Aldisa*<sup>1</sup> of Bergh, among other characters, in having the anterior lip of the foot deeply split into two lateral halves. This species has comparatively long, slender, and pointed oral tentacles, and the teeth of its radula are not serrulate—characters which also distinguish it from species of *Aldisa*.

#### 29. ROSTANGA, Bergh.

41. \*ROSTANGA COCCINEA, Forbes (= *Archidoris coccinea*, 1st Rep., p. 178).

This species is taken so rarely that its habits remain still uncertain. Mr. Bourne found a fine specimen,  $\frac{3}{4}$  inch long and  $\frac{5}{16}$  inch broad, on the 1st of August at Drake's Island, low water. It was under a stone resting on black mud with weeds attached, along with *Nebalia Geoffroyi*. There was no sponge or other red substance near. Cocks, and Alder and Hancock found the species fairly common at Falmouth forty years ago.

*Sub-family*—DORIDIDÆ PHANEROBRANCHIATÆ, Bergh.

#### Goniodorinæ.

#### 30. ACANTHODORIS, Gray.

42. \*ACANTHODORIS PILOSA, Müll.

In addition to the previously recorded specimens, one was taken

<sup>1</sup> Bergh, *Gattungen nord. Doriden*, Arch. f. Naturgesch., lv, p. 348.



on the shore at Wembury by Mr. Bourne on the 5th of May this year, and on the 16th August Dr. Fowler dredged one large specimen,  $1\frac{1}{2}$  inches long, of a dark steel-grey colour, and five small ones,  $\frac{1}{2}$  inch long, of which two were almost entirely white in colour, and the rest were dark steel-grey.

Mr. Vallentin finds this species abundant at Falmouth on the Helford mud-flats, where young specimens are to be taken from the under sides of *Fucus*. Friele and Hansen (l. c.) also notice this habit.

### 31. LAMELLIDORIS, *Alder and Hancock*.

#### 43. \*LAMELLIDORIS ASPERA, *A. and H.*

This species has not been obtained since the date of the previous Report. It was not found by Cocks at Falmouth, and seems to be essentially a northern species.

#### 44. \*LAMELLIDORIS BILAMELLATA, *Linnæus*.

This species is common at Plymouth, as on most rocky coasts of the North Atlantic; curiously enough, it is not recorded by Cocks from Falmouth.

#### 45. \*LAMELLIDORIS SPARSA, *A. and H.*

This species has not been taken during the past year.

### 32. GONIODORIS, *Forbes*.

#### 46. \*G. NODOSA, *Montagu*.

This beautiful little species is very abundant at Plymouth, and I have made use of it for the purpose of testing some of Alder and Hancock's statements about the habits of migration of Nudibranchs. In his account of the Nudibranchiate Mollusca of St. Andrews Prof. McIntosh wrote concerning this species, "There is little to be met with at St. Andrews in support of the statement of the able authors of the Monograph in regard to the disappearance of the adult animal and the growth of the young; for the varying sizes occur throughout the entire year, fine full-grown specimens ( $1\frac{1}{4}$  inches) being found in December as well as in March, April, and May."

In order to examine into this matter, therefore, I began in the early spring of last year (1889) to keep a record of all the specimens of this species observed or captured. During February, and especially during March, April, and May, large individuals (1 inch long) were extremely abundant on the rocks below the Laboratory and

under the Hoe whenever they were visited at low water. They were congregated generally in groups of five or six together, but not infrequently I found isolated couples. They were most plentiful on rocks covered with the red gregarious Tunicate, *Styela grossularia*, and on this and elsewhere their spawn was abundant. Small individuals (*i. e.* of  $\frac{1}{2}$  inch and under) were not found upon the rocks at all, nor were they to be obtained with the dredge in deeper water. Veligers, however, were regularly taken during the early spring months in the surface-net. During June the numbers of mature individuals found on the shore, and at the same time the quantity of spawn, became appreciably reduced, and July found them more or less rare. Very small specimens were noticed in the contents of the dredge in June, and were frequently taken during July and August. My observations were here interrupted for several weeks, but on October 8th a specimen rather over  $\frac{1}{2}$  inch in length was trawled in the Cattewater; next day one of the same size was dredged on *Zostera* in Cawsand Bay, and on the 10th I found one also under a stone at extreme low water (spring tide) in Rum Bay. The dredge continued to bring up specimens between  $\frac{1}{2}$  and  $\frac{3}{4}$  inch long off the Duke Rock and elsewhere, but they were never in such numbers as were those of July. On November 22nd during a spring tide I found a large one on a stone at Drake's Island, and on the 25th in a small crevice of rock under West Hoe, rather high up between tide-marks, I found two large ones together. I could find none at this time under the bathing pond. I brought the two large ones to the Laboratory, and placed them in an aquarium; on the 6th of December one of them deposited some spawn, and another piece was laid three days later. On the 20th of February this year, full-sized mature specimens, in considerable numbers, were copulating and depositing eggs on the rocks below the Laboratory, below the bathing pond, and at Drake's Island. At Drake's Island one individual was under  $\frac{2}{3}$  inch in length.

It is obvious from these facts that at Plymouth the habits of the species and its rate of growth are very much as Alder and Hancock found to be the case on the coast of Northumberland; and this induces me to believe that at St. Andrews also more detailed observations would lead to a similar conviction.

The rate of growth of the species is to some extent indicated by the following measurements of the individuals dredged at Plymouth during the present year up to the end of August.

June 26th.—One specimen dredged off the Duke Rock, just over  $\frac{1}{8}$  inch in length, and having three branchial plumes only on each side.

June 27th.—One specimen  $\frac{2}{16}$  inch long, taken among weeds with the bottom tow-net in Cawsand Bay.

July 7th.—Eight specimens taken in Cawsand Bay with the bottom tow-net, varying in size from  $\frac{1}{8}$  inch to nearly  $\frac{1}{4}$  inch when completely extended. The largest individuals had seven branchial plumes only, the largest being median and anterior.

July 11th.—One,  $\frac{3}{16}$  inch long when not fully extended (probably  $\frac{5}{16}$  inch when extended), dredged off the Duke Rock. I found it on a colony of the compound Ascidian *Fragarium elegans*, and it was apparently feeding upon it.

July 24th.—One,  $\frac{3}{8}$  inch long, on a stone dredged off the Duke Rock.

August 6th.—Three, the largest just over  $\frac{1}{4}$  inch long, dredged off the Duke Rock.

August 7th.—Two, just over  $\frac{1}{4}$  inch in length, dredged off the Eddystone in 25—40 fathoms, one mile south of the Hand Deeps.

August 11th.—Eight specimens, from  $\frac{3}{16}$  inch to just over  $\frac{3}{8}$  inch long, on stones dredged off the Duke Rock.

August 13th.—Three specimens dredged two miles south of the Mewstone, one being  $\frac{3}{16}$ , one  $\frac{3}{8}$ , and one  $\frac{7}{16}$  inch long. The first specimen possessed an unusually broad foot, which, when the animal was viewed from above, extended beyond the pleuropodial frill on each side. This specimen agrees, therefore, with Montagu's *Doris marginata*, and shows the probable correctness of his figure—contrary to the opinion which Alder and Hancock expressed in their Monograph.

August 18th.—One specimen,  $\frac{3}{8}$  inch long, on a stone covered with encrusting polyzoa and algæ, extreme low water, spring tide, east end of Drake's Island.

August 24th.—Two specimens, each  $\frac{7}{16}$  inch long and with eleven branchial plumes, found under a stone in Bovisand Bay at low water, neap tide, by Mr. M. F. Woodward.

August 25th.—One,  $\frac{3}{8}$  in. long, dredged between Picklecombe Fort and the Breakwater.

These statistics, in conjunction with the facts concerning last year's specimens, show conclusively that the eggs laid in the early spring have passed through their metamorphoses, assumed the specific form, and attained an average size of  $\frac{1}{8}$  inch towards the end of June. The young Nudibranchs grow in size, being  $\frac{1}{4}$  inch in length by the middle of July and  $\frac{3}{8}$  inch by the middle of August. In October the average size<sup>1</sup> is  $\frac{3}{8}$  inch, and by the end of November the specimens most frequently found are nearly  $\frac{3}{4}$  of an inch in length, while they may attain to maturity in December under exceptionally warm conditions.

<sup>1</sup> This average is probably a little too high for the individuals which are still some distance from the shore. On October 16th, of seven specimens dredged near the Duke Rock, one was  $\frac{3}{16}$  inch, one  $\frac{1}{4}$  inch, four  $\frac{5}{16}$  inch, and one  $\frac{3}{8}$  inch in length.

The same statistics show that the veligers are carried out to considerable distances from the shore and that after falling to the bottom and undergoing their metamorphoses they gradually make their way to the shore. This year I found the first individual which had so migrated on August 18th at Drake's Island; and a few days later, as we were doing some collecting on the shore at Bovisand, Mr. Woodward found two more. During July and August I could not find a single large or mature individual either on the shore or with the dredge; and this leads to the conclusion that the disappearance of the old individuals after the spawning has been accomplished is due, not to a re-migration into deeper water or to habits of concealment, but to death. *Goniodoris nodosa* is an annual, and dies when it has ceased to deposit its eggs in the spring and early summer (cf. Woodward, Manual of Mollusca, 4th ed., p. 12).

Young specimens differ from full-grown individuals in several points of structure as well as in size. The pleuropodial frill is relatively larger, and is generally freely scalloped at the edge. I have given a representation of the animal at this stage ( $\frac{1}{4}$  inch in length) on Pl. XXVII (fig. 4). The points formed by the scalloping are to be compared homologically with the filaments of *Idalia* and allied forms: they generally contain special aggregations of opaque white gland-cells, comparable with those of the pleuropodial filaments of *Ancula*, *Triopa*, &c. (cf. Herdman and Clubb, 3rd Rep., pp. 136 and 184; Friele and Hansen on *G. Danielsseni*, l. c., p. 72).

The specimens of the so-called *Doris Barvicensis* of Johnston which were found by Allman among the roots of *Laminaria digitata* in Courtmasherry Harbour in August and September, 1838 (see Thompson, 'Ann. Nat. Hist.,' vol. v, p. 87), and the *Goniodoris emarginata* of Forbes dredged in twenty fathoms off the Isle of Man in October, 1839 ('Ann. Nat. Hist.,' vol. v, p. 105), were undoubtedly young specimens of *Goniodoris nodosa* migrating to the shore.

Another difference of considerable morphological importance between the young and adult *Goniodoris nodosa* is to be found in the condition of the posterior portion of the pleuropodial frill. In young specimens the lateral portions of this structure are invariably discontinuous posteriorly, as represented in my figure: this condition is persistent in *Goniodoris castanea* throughout life, as it is in the closely allied genus *Idalia*. But as the animal grows the basal portions of the posterior terminations of these folds become connected together, and give rise to a continuous circular fold like that of *Archidoris*, which differs from the latter, however, in being deeply notched or emarginate posteriorly. This has been hitherto regarded as the final character assumed by the fold in the species, and ex-



cellent figures of this condition are to be seen in Alder and Hancock's Monograph. I find, however, that in very large individuals continuous growth may entirely obliterate all trace of the fusion which has taken place, so that a continuous, even, and circular fold is formed around the back (*nothæum*) of the animal, exactly as in *Archidoris*, *Lamellidoris*, &c. Pl. XXVII, fig. 6, represents this condition in a preserved specimen measuring  $\frac{1}{10}$  inch in length and  $\frac{1}{2}$  inch in breadth.

The process of growth thus described as taking place in the individual *Goniodoris nodosa* throws considerable light upon the question of the origin of the circular fold of *Archidoris*. It is many years since Huxley<sup>1</sup> suggested its homology (in part) with the paired "epipodia" of *Aplysia*; but although the suggestion has met with approval<sup>2</sup> little direct evidence has been collected in support of the view. The ontogeny of *Goniodoris nodosa*, however, shows conclusively that the circular fold has been arrived at by a process of posterior fusion of a pair of lateral folds; for the anterior union is clearly also secondary: the primitively discontinuous condition is persistent in *Polycera lessonii*. Therefore the origin of the circular fold of *Archidoris* and its allies from primitively paired lateral folds can no longer be considered as doubtful; and the existence of transition forms like the *Lomanotidæ* and *Ascoglossa* renders the homology of these paired folds with the "epipodia" (or better, "pleuropodia") of *Aplysia* almost certain.

In some way, perhaps, related to the fusion of the pleuropodia posteriorly is a curious transparent spot shown in my figure of the young *Goniodoris nodosa*, situated between the anus and the terminations of the folds. This was mistaken by Johnston (Ann. Nat. Hist., vol. i, p. 55) for a pore, but there is no perforation. Alder and Hancock rightly corrected this mistake, but fell into error in adopting Allman's explanation of it. Allman informed Mr. Thompson (Ann. Nat. Hist., vol. v, p. 88) that the pore-like appearance was "merely formed by the partial apposition of the edges of a slit existing in the posterior margin of the mantle, and which approximation is dependent on the will of the animal;" and Alder and Hancock followed him in stating that the spot was merely "caused by a deep indenture of the cloak." This is not the case, for the spot in question is simply an oval area from which the minute

<sup>1</sup> Huxley, *Morphology of the Cephalous Mollusca*, Phil. Trans., 1852.

<sup>2</sup> Cf. Lankester, *Mollusca*, Encycl. Brit., 9th ed., vol. xvi; Fischer, *Manuel de Conchyliologie*, 1887, p. 518 (Fischer's view is that the *nothæum* of *Doris* represents at the same time both the "epipodial" lobes of *Elysia* or *Aplysia* fused in the median line and the cephalic disc of *Philine*); Herdman and Clubb, *Third Report on the Nudibranchiata*, l. c., p. 147; also my *Report on the Nudibranchiata*, l. c., p. 181.

opaque white specks so freely scattered over the rest of the back are absent; it is not caused by the emargination of the pleuropodium, for it is situated anteriorly to the point of fusion, and can be seen to be independent of it. It is not always present.

Alder and Hancock's descriptions and figure of the radula of this species are incorrect as regards the structure of the large inner side-plates, inasmuch as they do not take into account a rhomboidal and thickened fold which invariably exists at the internal angle of each of these tooth-plates, comparable with a triangular fold found on the same tooth of *Lamellidoris* (cf. Pl. XXVII, fig. 5, and Alder and Hancock's figures of the radulæ of *Goniodoris nodosa* and *Lamellidoris depressa*). Bergh<sup>1</sup> has given more accurate descriptions of the teeth, but only figures the isolated plates. He gives the number of denticles on the inner plates as 25 (22—25) in an individual measuring 12 mm. in length and 4·5 in breadth, preserved in alcohol. In a larger specimen (nearly 1 inch in length) I found the denticles to vary in number from 24 to 27, while in an individual only  $\frac{7}{16}$  inch in length the average number was 17. In the latter specimen also the external side-plates show several regularly repeated indentations of the edge (fig. 5,  $\beta$ ), while those of old individuals are more oval in form, and have mere traces of these indentations. My fig.  $\beta$  does not well represent them.

Herdman<sup>2</sup> and Clubb have found a "second smaller denticulated ridge on the large lateral spines of the radula" in some of their specimens. It would be interesting to know whether the occurrence of this second ridge can be traced to any physiological cause or correlated with some other structural change.

#### 47. \*GONIODORIS CASTANEA, *A. and H.*

During the past year six more specimens of this species have been found. Two were dredged in the Cattewater, Oct. 8th, 1889, one being  $\frac{7}{8}$  inch, the other  $\frac{7}{16}$  inch in length. The latter specimen is figured on Pl. XXVII (fig. 1); the figure is accurate in every respect except that the tuberculate character of the sides of the foot is not so clearly apparent as it should be. The oral veil of this young individual differed considerably from the form which has been described as typical of the species, and showed a closer approximation to that existing in *Goniodoris nodosa*. The oral veil of an adult *G. castanea* is figured on Pl. XXVII, fig. 2; its anterior edge exhibits a double or sinuous curve on each side, but in this specimen the veil possessed

<sup>1</sup> Bergh, *Die Gattung Goniodoris*, Malakozoologische Blätter, Neue Folge, Bd. i, 1880, pp. 123, 124, and pl. iv.

<sup>2</sup> Herdman and Clubb, *Second Report on the Nudibranchiata*, Proc. Liverp. Biol. Soc., iii, p. 227.

only the median indentation, each tentacle having simply a gently convex or semi-crescentic anterior margin. Thus the young *G. castanea* approaches *G. nodosa* in the character of its oral veil, while the young *G. nodosa* approaches *G. castanea* in the structure of its lateral folds (pleuropodia). In both these specimens the transverse ridge usually found on the back was absent; its place was, however, indicated in each case by a transverse patch of white pigment.

The other individuals captured have each been of the full mature size. They were taken under stones between tide-marks, one at a time, at the following localities:—near the bathing pond, April 8th, 1890; below the Laboratory, May 17th,—some spawn also under the same stone and on neighbouring ones; in Rum Bay, July 19th, and another a few days later. One of these individuals deposited some spawn in a pie-dish in the form of a double coil, somewhat like that described in my former Report. It is figured on Pl. XXVII, fig. 3.

*Goniodoris castanea*, as Giard<sup>1</sup> has already stated, feeds upon compound Ascidians, usually *Botryllus*; he found it fairly common at Roscoff in the laminarian zone, and in colour it resembled very often the *Botrylli* of this zone, upon which it feeds (*B. Marionis*, *B. capucinus*, &c.).

The individual taken in April was on the under side of a stone covered with compound Ascidians, chiefly *Botryllus* and *Botrylloides*. It was situated in a flat patch of gelatinous material which, upon examination, proved to be the remains of a colony of *Botryllus*, upon which it had evidently been feeding. The colony was quite destroyed, only a few zooids remaining. The red colour of the Nudibranch and its profuse spotting of opaque yellowish white gave it a very perfect resemblance to a colony of a common *Botrylloides* on the same stone.

The individual taken on July 19th was also on the under side of a stone covered largely with flat incrusting colonies of *Botryllus*. On one of these it was fixed, and had already sucked completely a considerable portion of the colony. Its colours were not in detail those of the *Botryllus*, but Mr. Minchin, who was with me, agreed as to its inconspicuous appearance.

It should be noticed, however, that Graeffe<sup>2</sup> found this species at Trieste “under algæ and on hydroid polyps;” while Herdman<sup>3</sup> has dredged two fine specimens in deep water on different occasions, one off Spanish Head, Isle of Man, the other in Lamash Bay, Arran.

<sup>1</sup> Giard, Arch. Zool. Exp., ii, 1873, p. 487.

<sup>2</sup> See Bergh, *Die Gattung Goniodoris*, Malak. Blätt., i, p. 127.

<sup>3</sup> Herdman, *First Report on the Nudibranchiata*, Liv. Mar. Biol. Comm. Rep., i, 1886, p. 270; and *Notes on the Marine Inv. Fauna, Isle of Man*, do., do., p. 319.

33. IDALIELLA, *Bergh*.<sup>1</sup>48. \*IDALIELLA (IDALIA) ASPERSA, *A. and H.*

Only the two specimens described in my previous Report have been obtained by us.

34. ANCULA, *Lovén*.49. \*ANCULA CRISTATA, *Alder*.

Only four additional specimens have been obtained. Three were found on the north side of Drake's Island at low water, one about the middle of May and two on the 3rd of June. These individuals were mature, but a small one  $\frac{5}{16}$  inch long was taken with the bottom tow-net in Cawsand Bay on the 7th July. It bore a specimen of the remarkable parasitic Copepod, *Splanchnotrophus*, whose egg-sacs protruded through the back of the animal just in front of the anus. Two days later the parasite with its long tentacle-like processes had crawled out of the *Ancula*, which was only half its original size, and was being steadily devoured.

Professor Herdman<sup>2</sup> has found this species in extraordinary profusion at Hilbre Island during the breeding season; on one reef of rocks "for yards it was impossible to walk without treading on them, and handfuls were readily collected by scraping the specimens together from the mud-covered rocks." He also finds that the animal loses much of its conspicuous yellow coloration with age, and records some interesting observations on its means of defence against waves and strong currents (cf. A. R. Hunt, Journ. Linn. Soc., xviii, p. 265).

**Polycerinæ.**35. THECACERA, *Fleming*.50. \*THECACERA PENNIGERA, *Montagu*.

We have not yet obtained another specimen of this species. Mr. Vallentin dredged a single specimen in Falmouth Harbour during the spring among oyster-valves covered with *Bugula flabellata*.

<sup>1</sup> Bergh, *Ueber die Gattung Idalia*, Arch für Naturgesch., xlvii, i, p. 7. See also Norman on the name *Idalia*, loc. cit., p. 74.

<sup>2</sup> Herdman and Clubb, Third Report, p. 134; cf. also the Second Report, p. 227, and First Report, 1886, p. 270, and Thompson, Ann. Mag. Nat. Hist., 1860, p. 51.



36. POLYCERA, *Cuvier*.51. \*POLYCERA QUADRILINEATA, *Müller*.

Mr. Cunningham's bottom tow-net, designed for catching young flat-fish, brought up several specimens when shot in Cawsand Bay on May 14th and June 25th. The bottom here is sandy, and *Zostera marina*, *Ceramium*, *Antithamnion*, and other weeds are abundant<sup>1</sup> over certain areas. The Nudibranchs were among these weeds when caught. One individual possessed six frontal filaments, and no tubercles at all. The yellow colour was confined to the frontal and "branchial" (pleuropodial) processes, the rhinophores, and tips of the branchiæ.

Three fine specimens were taken by Dr. Fowler on a piece of drift weed at low water, east end of Drake's Island, on July 16th; and three more were found upon *Fucus* and *Ulva* by Mr. De Hamel between tide-marks near the same spot on August 18th. There was much spawn near them at the time of capture, and they continued to deposit it for many days. In captivity, though healthy and with plenty of weeds, they were reduced in size by the end of the month.

This species, as Alder and Hancock inferred, is undoubtedly herbivorous in habit; one or two of the specimens mentioned in my former report were dredged in weedless ground, but all the others have come from localities where algæ are abundant.

52. \*POLYCERA LESSONII, *D'Orb.*, var. *ocellata*,<sup>2</sup> *A. and H.*

At extreme low water on the north side of Drake's Island, June 3rd, I found what was almost certainly another specimen of this variety under a small stone. Unfortunately it was lost, owing to the breakage of a collecting bottle, and was not very closely examined beforehand.

37. TRIOPA, *Johnston*.53. \*TRIOPA CLAVIGERA, *Müll.*

Another specimen was again dredged off the Mewstone, about two miles south, in the middle of April. The pigment spots on the

<sup>1</sup> See Prof. Johnson's paper on *The Flora of Plymouth Sound*, this Journal, New Series, I, iii, pp. 297, 298.

<sup>2</sup> I have followed Dr. Norman in placing *ocellata* as a variety of *Lessonii*. Herdman and Clubb (Second Report, 1889, p. 227) have noticed the intermediate variations, but it is interesting to note that the type and the variety seem to live, as a rule, under different conditions of depth and food (see Alder and Hancock, Monograph).

back, as in the former specimen, were confined to a median row, excepting two or three small spots to the side.

### 38. *ÆGIRUS, Lovén.*

#### 54. \**ÆGIRUS PUNCTILUCENS, D'Orbigny.*

A single specimen of this Nudibranch was taken near the Duke Rock on September 26th of this year.

## DESCRIPTION OF PLATES XXVII AND XXVIII,

Illustrating Mr. W. Garstang's "Complete List of the Opistho-branchiate Mollusca found at Plymouth, with further Observations on their Morphology, Colours, and Natural History."

### PLATE XXVII.

FIG. 1.—*Goniodoris castanea*, A. and H. A young individual, enlarged, possessing oral tentacles of simple, semi-crescentic form.

FIG. 2.—*Goniodoris castanea*, A. and H. Head-region of a full-grown individual, enlarged, showing the double sinuous curve of the anterior edge of the oral tentacles. After Alder and Hancock.

FIG. 3.—*Goniodoris castanea*, A. and H. A coil of spawn of unusual form. Nat. size.

FIG. 4.—*Goniodoris nodosa*, Mont. A young individual, enlarged. The pleuropodial folds are freely scalloped, but, as in *G. castanea* (fig. 1), are discontinuous posteriorly. Between the anus and the posterior termination of these folds is an oval unpigmented spot, represented rather too conspicuously in the figure.

FIG. 5.—*Goniodoris nodosa*, Mont. *a.* Two transverse rows of the radula of a full-grown individual, magnified. Zeiss, obj. A, eye-piece No. 2, *cam. luc.* The denticulations of the inner side-plates ought to be about 24 in number. *β.* The external side-plates of a young individual,  $\frac{7}{16}$  inch long, more highly magnified. Zeiss, obj. A, eye-piece No. 4, *cam. luc.* The denticulations of the inner side-plates were 17 in number. In reality, the dimensions of the external side-plates are only  $\frac{2}{3}$  those of *a.*

FIG. 6.—*Goniodoris nodosa*, Mont. Posterior region of a large individual ( $\frac{1}{4}$  inch long  $\times$   $\frac{1}{3}$  inch broad, preserved in spirits), enlarged, showing the complete continuity of the pleuropodia behind.

### PLATE XXVIII.

FIG. 1.—*Lomanotus*. A young individual,  $\frac{3}{16}$  inch long, somewhat contracted, seen from the right side, and enlarged. The figure shows the continuity between the pleuropodial ridge and the postero-lateral tubercle of the sheath of the rhinophore. In this region of the sheath a diverticulum of the liver is seen to exist, as well as in each of the triangular papillæ of the pleuropodium. The eye-spot lies under the sheath of the rhinophore; the anal papilla is not represented. The two short oral tentacles of the right side are shown, as well as the right anterior process of the foot. Drawn from life; the animal, however, was not very healthy.

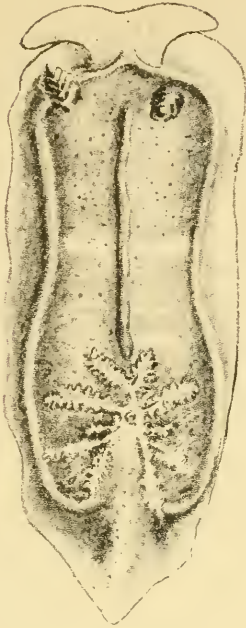


Fig. 1.

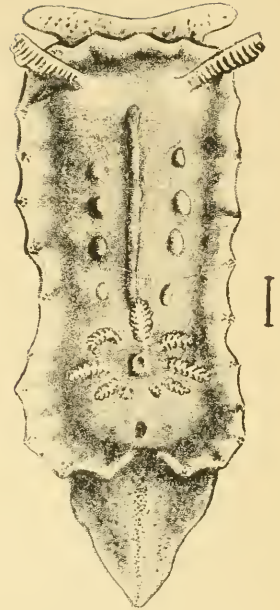


Fig. 4.

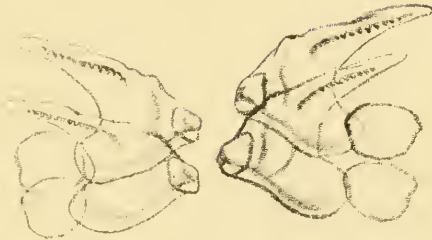


Fig. 5. a.



Fig. 5. b.



Fig. 3



Fig. 2.



Fig. 6.

Goniodoris.

u.g. autogr.





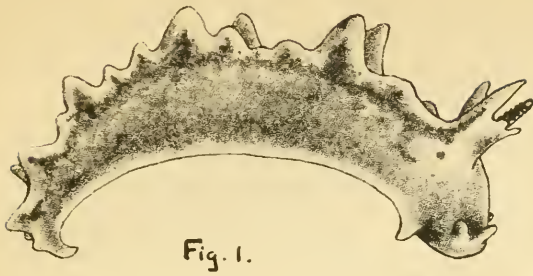


Fig. 1.

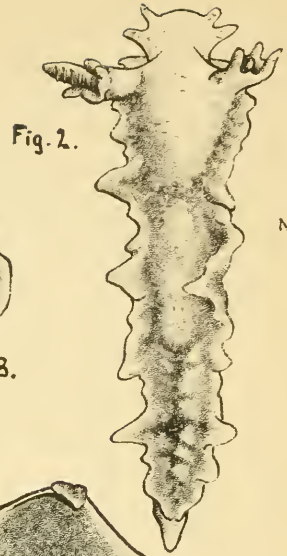


Fig. 2.

I  
N. S.



Fig. 3.



Fig. 8.



Fig. 4.

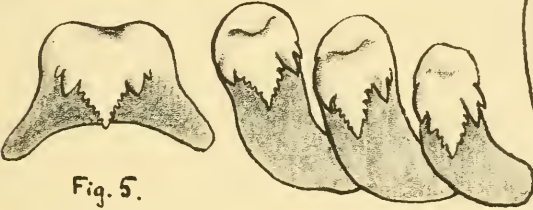


Fig. 5.

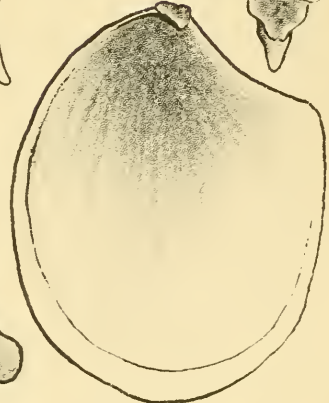


Fig. 10.

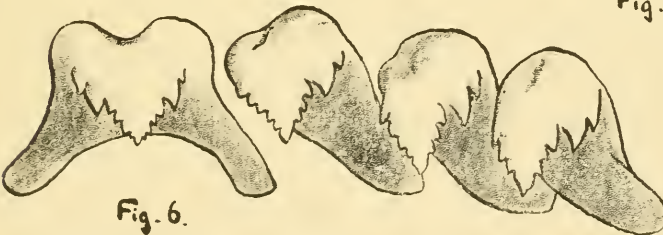


Fig. 6.



Fig. 9.



Fig. 7.

W. G. autogr.

*Lomanotus* & *Aplysia*.



FIG. 2.—*Lomanotus*. Representation of another, a very lively individual of the same size, *en marche*. The right rhinophore is retracted into the sheath, the left protruded. The pleuropodial papillæ are shown as naturally as possible. The diverticula of the liver are seen through the transparent skin. The heart is on a level with the letters N.S. in the figure. Drawn from life. N.S.=natural size.

FIGS. 3—7.—*Aplysia punctata*, Cuvier. The central tooth and three adjacent lateral teeth of a row about the middle of the radula of five individuals of different sizes, the outlines being determined by means of a *camera lucida*. Figs. 4—7 are all to scale, as seen with a Zeiss microscope, objective A, eye-piece No. 4. Fig. 3 represents teeth seen under higher magnification with a Zeiss, obj. D, eye-piece No. 2. All the radulæ were taken from specimens preserved in spirits; the buccal masses were boiled in a solution of caustic potash, the radulæ being mounted in glycerine jelly.

FIG. 3.—Animal,  $\frac{3}{16}$  inch long  $\times$   $\frac{3}{32}$  inch broad. Without markings in spirit.

FIG. 4.—Animal,  $\frac{7}{16}$  inch long  $\times$   $\frac{3}{16}$  inch broad  $\times$   $\frac{5}{16}$  high. Without markings.

FIG. 5.—Animal,  $\frac{1}{6}$   $\times$   $\frac{2}{3}$   $\times$   $\frac{2}{3}$ . Markings.—Integuments deeply pigmented with thick, somewhat elongate, black spots, arranged over the whole surface, but here and there leaving clear, unpigmented, round spaces, with indefinitely bounded edges. Small black rings on the head and sides of the neck, but inconspicuous owing to depth and regularity of the other markings.

FIG. 6.—Animal,  $2\frac{2}{3}$   $\times$   $\frac{3}{4}$   $\times$   $1\frac{1}{8}$ . Markings.—Finely pigmented all over, like the preceding, with a few unpigmented spaces.

FIG. 7.—Animal,  $3 \times 1\frac{1}{4} \times 1\frac{5}{8}$ . See text, p. 403.

FIGS. 8 and 9.—Shells, from under side, of Plymouth specimens of *A. punctata*, natural size. Owing to the method of preservation the calcareous layer cannot be shown.

FIG. 8.—Animal,  $1\frac{1}{4} \times \frac{1}{2} \times \frac{7}{8}$ . Markings as in the animal of Fig. 5, but without the small black rings.

FIG. 9.—Animal, the same as that of Fig. 7.

FIG. 10.—Shell of an *Aplysia depilans*, L., from Palermo, in Dr. Norman's collection, natural size, seen from below. The inner line represents the edge of the calcareous layer.

## NOTES AND MEMORANDA.

**Colour-changes in *Cottus bubalis*.**—On May 10th a specimen of this fish, of a brilliant carmine-red colour, was brought to the Laboratory. It had been caught in a lobster-pot in deep water. The ground colour was a very vivid carmine-red, and this was interrupted at places by black, white, and yellow markings. The black markings were distributed as follows :—There were streaks and bands on the head, a pair of irregular blotchings at the sides of the first dorsal fin, another pair at the sides of the second dorsal, and a pair at the base of the tail, also a pair of black patches on the bases of the pectorals. The white marks were opaque, and had a chalky appearance: there was a pair of these in the sides of the body opposite the first dorsal, and a pair of large patches on the sides of the first dorsal fin itself; there was a similar arrangement of white patches in the region of the second dorsal, and a patch on the middle of each pectoral, also a small white spot on the middle of the dorsal side of the head, and another at the dorsal part of each pectoral. Yellow bands alternated with red along the rays of the pectoral fins.

This specimen was placed in one of the table tanks in the Laboratory; at the bottom of the tank was coarse yellow gravel, while the sides were of black slate, and there were one or two large dark stones in the tank, behind which the fish usually concealed itself. The tank is very dimly illuminated.

On June 24th I examined the specimen, and found it was deep black all over the back and sides with the exception of the white markings, which were unaltered; there was not a trace of red about it. The ventral surface was of course light throughout the experiment.

I then placed the specimen in a pan painted red and strongly illuminated. In a day or two the colour was much lighter, having become a slightly yellowish brown without any red tinge. But the specimen died from accidental stoppage of the circulation in the pan before further observations could be made.

The ordinary specimens of the shore are black or dark brown on



the back, the sides being spotted or blotched with the same colour, while there are light markings similar in position to the white markings in the specimen described above, but yellow in colour, with brown spots scattered over them.

The occurrence of red specimens is mentioned by Day, who describes a male specimen of a brilliant carmine colour with white markings. My specimen was a female, so that the colour has nothing to do with sex. We have received several other specimens of the same red colour, but only the one above described has been yet subjected to careful observation.

It is evident from the above that the red colour is not permanent, so that red specimens do not represent a colour variety; the red colouration is evidently a temporary condition due to the action of light. Whether an ordinary shore specimen can be made to turn red by being exposed to light reflected from red surroundings has not yet been proved, but it has been shown that a red specimen soon loses its peculiar colour under the conditions above described. At the same time the change is not very rapid; in the above case it occupied more than a month. It seems probable that the red colour in nature is determined by the fact that the fish lives among red seaweeds. Probably in this case there is no alteration in the quantities of the differently coloured pigments in the skin, but merely an alteration in the expansion and contraction of the differently coloured chromatophores.—J. T. CUNNINGHAM.

**Palæmonetes varians in Plymouth.**—The estuary of the river Plym is connected, especially upon its left (eastern) side, with a number of small tributaries, whose waters are, even at their mouths, of very low density. In many of these tributaries *Palæmonetes varians* abounds. I have examined especially a large number of individuals from a stream which runs through Saltram Park, in the water of which I have found variations in density ranging from 1.010 to 1.018. From the position of the stream it is improbable that its density is ever much greater than 1.018, though a continuous rain might possibly reduce its specific gravity to a limit below 1.010.

The variability of the adult individuals from Saltram is very great. The following statement of variations observed in the characters of the rostrum will show how enormously the variations in this race exceed those indicated by the current diagnoses of the species.

Among 915 individuals of both sexes—

The apex was simple in	432 cases.
The apex was bifid in	483 „

One dorsal tooth only was present in	2 cases.
Two dorsal teeth only were	18 "
Three	123 "
Four	372 "
Five	349 "
Six	50 "
Seven	1 case.

Ventral teeth were absent in	3 cases.
One ventral tooth present in	276 "
Two ventral teeth	630 "
Three	6 "

The range of variation being so considerable, it is evidently unprofitable to compare this race with the published accounts, which are based on examination of ten or a dozen specimens of other races. Such a comparison will therefore be deferred until it is possible to obtain an extended series of observations, from which a fuller knowledge of the diagnostic characters and range of variation of the species may be obtained.

The development of *Palæmonetes* has been shown by P. Mayer,\* Boas,† and others to present a series of interesting variations. The races which inhabit those countries surrounding the Mediterranean—and which are found almost exclusively in fresh water—exhibit, as is well known, a more abbreviated development than the races of Northern Europe, which inhabit exclusively waters containing at least some admixture of salt.

It is curious that the attempt to grow the southern forms in salt water has not been successful.

In June last several gravid females were taken from the stream at Saltram, whose specific gravity was then 1.010, and placed in an aquarium in the Laboratory at Plymouth. The density of the water was diminished by 0.001 daily, so that in ten days it became quite fresh. The adult individuals fed freely, and seemed in no way disturbed by the change of density, while the eggs hatched in due course.

The larvæ at hatching were about 4 mm. long; the rostrum was in some cases, though not in others, provided with a single basal spine.

The inner ramus of the second antenna was unsegmented. The mandible was provided with biting teeth, but was not bifid. The exopodite of the second maxilla was large; and the four endites (of which the distal was divided) were provided with well-developed

\* Mitth. Zool. Sta. Neap., Bd. ii, p. 196.

† Spengel's Zoologische Jahrbücher, iv, p. 793.

biting hairs. The maxillipeds were well developed, each having a large exōpodite, used in swimming; while the five thoracic legs existed as mere buds, the first four being already bifid, but remaining folded beneath the thorax.

The larvæ moulted three or four times before attaining a proper "mysis" condition. After attaining this condition they were accidentally killed. They fed freely from a few hours after hatching during their whole lives.

The eggs from the abdomen of the mother measured rather less than 1 mm. in long diameter, and each female carried about 150.

The only difference between the larva here described and that shown by Boas to be characteristic of the northern salt-water form of *Palæmonetes* lies in the occasional presence, in the Plymouth larva, of the single rostral spine; and the facts above mentioned as to the variability of the adult rostrum may perhaps be considered to deprive this single difference of any great importance.

We have, therefore, in Plymouth a race of *Palæmonetes* which, while approximating in its habits to the races of Southern Europe, retains, in its development at least, a complete resemblance to those northern forms from which it is probably descended.

W. F. R. WELDON.

## ERRATA.

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On Plates I—VIII, for *Journal Mar. Biol. ass.* read *Journal Mar. Biol. Ass.* ;  
for *Planche* read *Plate* ; on Plates I—VI, for *G. C. Bourne del* read *J. T. C. del.*

Page 115, line 12, for *Gadus æglefinus* read *Gadus merlangus*.

„ 365, „ 15, „ *Treorgy* „ *Treorky*.



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