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BY

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Report No. 4 (1921)

THE FISHERIES OF NORWAY AND DENMARK.

NOTES GLEANED DURING A VISIT IN 1920

BY

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I.—PRELIMINARY.

Norway, Japan, and Newfoundland are the three countries in the world where fisheries bulk so largely in the national economy that their development is accounted one of the major cares of Government. In Japan the primitive methods of fishing universally employed till recent years, have been elaborated and expanded in a wonderful manner during the past 20 years by the fostering care of the department charged with their improvement; the central and local Governments have been lavish in their expenditure and, as seen to-day in the enormous expansion of the Japanese fisheries and associated industries, this expenditure has been recouped to the nation many thousand-fold.

Norway, a much smaller country than Japan, with a sparse population and limited funds at her disposal, has been equally enterprising and, for her resources, even more generous in expenditure upon development. The problems in Norway have been and are to a large extent different. In Japan, a hermit kingdom till only two generations ago, the world had to be searched for methods that were improvements on the cruder indigenous ones; Norway on the other hand had a fishing reputation second to none for individual enterprise and for the excellence of the methods pursued. Her fishery fame dates back to the early days of the Hanseatic League, whose long-headed merchant princes, with true Teutonic foresight and power of organization, settled in Bergen and

made that city the centre of the herring trade—herrings appear in the League's coat-of-arms. Whatever their faults of arrogance and trade monopoly, these early Germans undoubtedly organized the Norwegian fisheries on a commercial basis; they it was who directed the adventurous viking spirit into commercial enterprises requiring equal courage and daring but without the futility of the old bloody feuds and forays. The lesson was well learned and to-day we find Norwegians pioneering fishing industries to the verge of the Antarctic circle, supported even there by the resources of the home Government through the medium of the Fisheries Department. In Norway therefore, the importation or adoption of new methods has not been the main object. Rather has it been the intensive study of means for the improvement of existing methods, and help to the fishing community to take full advantage of new inventions to this end.

Knowing this, and being already familiar from personal observation with the Japanese methods of fishery administration, I was anxious when on leave last year to have an opportunity of visiting Norway, and there ascertaining on the spot, as well the broad principles of administration as the details of fishery organization. I felt that with a fairly complete knowledge of the methods found successful in these two countries, I should be in a better position to elaborate schemes suitable for our peculiar needs in India. My proposals to this effect, were very kindly approved by the Madras Government. I desire also to thank the officials of the India Office for their courtesy in facilitating the necessary arrangements, and for putting me in communication with Mr. A. E. Hefford, who had been deputed by the Bombay Government to visit Denmark and Norway on a fisheries mission having almost identical aims with my own. The unfailing kindness and courtesy I met with everywhere is the most abiding memory I shall have of this visit to Scandinavia. Of the many who afforded me most material help, it seems invidious to make mention of particular names; however I cannot let this occasion pass without taking the opportunity to express my especial gratitude to Commander C. F. Drechsel, Secretary-General of the International Fisheries Commission, Mr. Asserson, Director of Fisheries in Norway, Captain F. V. Mortensen, Director of Fisheries in Denmark, and Mr. Fensmark, Manager of the Danske Frysnings Company's brine-freezing cold storage at Esbjerg. Also to Prof. Knudsen of Copenhagen for much valuable advice in regard

to the choice of hydrographic instruments. The enquiry occupied a little over six weeks. I landed at Esbjerg in Denmark on 5th August 1920. There, by the courtesy of Herr Fensmark and others, I was able to learn full details of the Ottesen method of brine-freezing; to see what is probably the latest and most up-to-date fish cannery in Scandinavia, and to renew my acquaintance with the merits of the Danish seine, first seen in 1909 during experiments in its use from the Irish fisheries steamer "Helga." Of these and of the wonderful homogeneous fleet of nearly 400 motor-cutters that are the pride of this port, I shall have much to say in the proper place.

Thence I passed to Copenhagen where Commander Drechsel most kindly put me in communication with the Director of Fisheries, with Prof. Knudsen and Prof. Johannes Schmidt. I had the privilege of seeing some of Prof. Schmidt's wonderful plankton hauls from the breeding places of the European eel situated in the Western Atlantic, which he was fortunate enough to discover last year, and thereby to crown with success the labours of long years of research. After Copenhagen, I visited Christiania where I learned of the success attending the stocking operations conducted in Norway by Dr. K. Dahl for the improvement of the fish population in the inland waters of that country. As we are doing in Madras, so in Norway I find that the object now in view is not solely to improve these waters from the sporting standpoint by improving the breeds and stocks of trout, but also to ensure that the food supply of the general population be increased even if the fish that be employed are valueless for the angler's purpose. The ethnological collections both there and in Copenhagen also afforded valuable information for my researches on the evolution of the various types of fishing boats and their bearing upon race origins in the East.

The remainder of my stay in Norway was divided between Bergen, Stavanger and Trondhjem, and this period was the most valuable, as it brought me into touch with the personnel of the Fisheries Administration, afforded insight into the current technique of canning and brine-freezing (other than the Ottesen system) and gave opportunities to study the invaluable share in fishery progress occupied by societies and other public bodies of a voluntary nature, but to which Government help in varying extent is usually afforded.

A. NORWAY.

II.—THE ADMINISTRATION AND ORGANIZATION OF FISHERIES IN NORWAY.

In Norway, the welfare of the fishing industries is looked after by the Department of Fisheries, one of the constituent sections of the Ministry of Commerce.

At its head is a Director responsible to the Minister of Commerce. The headquarters are situated in Bergen as being more suitable for several weighty reasons than Christiania. Among these the principal are its central situation on the Norwegian coast line, and the fact that having been the centre of the herring trade from time immemorial, its population by association has an absorbing interest in fishery development, such as Christiania with its more varied interests does not possess; finally the existence there of the Bergen Museum, an institution founded through the munificence of the citizens. This museum, wholly unlike the ordinary conception of a provincial museum, pulses with activity and has long been a great scientific centre, with a strong scientific staff engaged upon pure research; amongst its activities was the establishment of a Biological Station at Bergen and this has been of the greatest assistance to the Fisheries Department, for, by arrangement, much of the department's oceanographic work has been carried out by the staff of the Biological Station.

Partly by co-operation with non-governmental institutions and societies such for instance as that just mentioned, the department is able to carry on its operations with a comparatively small technical staff. The most important of these comprise two technical or practical experts, three biological experts, a Superintendent (chemist) of the experimental station with two assistants, and a librarian (who is also a biologist and assists the biological experts). Two lady assistants are provided for statistical and similar work, and there is suitable but limited provision of messengers and laboratory attendants.

The technical experts are men of practical acquaintance with seafaring and fishing. The senior of these is Captain Iverson, master of the *Michael Sars*; to him is given the investigation of practical fishery problems, such as the adjudication of rights in disputes between fishermen, supervision of the enforcement of fishery regulations and the like. The second has charge among

other matters of the registration and numbering of fishing boats (other than open boats).

The three scientific experts are all trained biologists. Each has a definite subject assigned for investigation, the value of extreme specialization having been proved here to be the only sound way in the investigation of fishery problems. In deciding what line of research should be followed by each expert, primary account was taken of the fishes of supreme economic value to the country. It was recognized that however interesting a general investigation of all species of fishes may be, limited means and the necessity to arrive at conclusions as quickly as possible if the fishing industry were to be benefited materially, required that effort must be concentrated on definite problems. Accordingly, to one of these workers has been assigned investigation of everything pertaining to the life-history of members of the cod family; the second occupies himself with parallel researches upon the herring family, while to the third is allotted the investigation of the plankton of Norwegian seas. The work done by the last named is largely complimentary to that of the second, for it is upon the seasonal abundance of plankton that most of the movements of the herring depend. Study of plankton is also necessary for the extension of our knowledge of the larval histories of the great majority of our food fishes; the herring is almost the only exception to the rule that the eggs of food fishes are pelagic, floating freely in the surface waters of the sea. The study of plankton is further bound up with the physical and chemical investigation of variations in the density, temperature and chemical character of sea water, as these factors influence and control the abundance particularly of the plant organisms present, which in turn controls the abundance or scarcity of the small animals that feed on this food. The greater part of these investigations is carried out in the laboratories of the department's headquarters at Bergen. The advantages of carrying on these researches at headquarters, where there are the best facilities for reference to literature and for intercommunion with other workers, are deemed sufficient to outweigh the advantages of work in an outstation laboratory in the midst of the particular fishery to be studied, for such a location means the isolation of the worker, delay in procuring literature and the loss to the Director of the advantage of frequent discussion with the expert of the problems on hand. The last named consideration is valued

highly, and justly so, by the administration. A working compromise is arrived at by occasional visits to the fishing grounds, usually in the fishery investigation vessel *Michael Sars*, aboard of which vessel laboratory facilities are ample. Much of the material required for use by the cod and herring experts is supplied to them with much saving of valuable time, by the part-time employment of two travelling assistants who procure samples as required at the different fishing centres. These men, who are non-commissioned army officers, are paid daily wages; their employment is seasonal and lasts for about six months in each year. The Biological Stations at Bergen and Trondhjem work in close collaboration, and in special enquiries are able and willing to afford the department and its experts invaluable assistance.

Chemical and bacteriological work is carried on under the charge of another expert; these enquiries deal primarily with industrial problems, among the principal being those connected with the canning trade, and the fish and whale oil industry, and in analyses for private parties of materials used in fishing industries.

The operations of the department are best shown by a study of the budget, and of the way in which this is prepared. The Norwegians are so intensely individualistic and independent in character that the Governmental machine must have the full confidence of the people if the purse-strings are to be loosened. The bureaucratic methods which have suited Japan in the past would not be tolerated for a week in Norway. The administrative machine must be run in accordance with the wishes of the people and they must have an effective voice in its control and policy. To achieve this, each year after the Director of Fisheries has prepared his budget estimates, the various items become the subject of a conference between him and the Fishery Council (*Fiskeriraad*). In addition to discussing the budget proposals, the Council debates any other subject affecting fishery interests that may be brought up by the Director or by the members themselves. The nineteen members are representatives elected by the principal fishery societies and other local fishery bodies of each coastal district. Care is taken that this advisory body shall be truly representative of every interest in the industry. The members receive their travelling and out-of-pocket expenses to and from Bergen and during the duration of the conference, which lasts usually for over a week. This Fishery Council is a valuable means

for the harmonious and profitable working of the department; it serves the extremely useful purpose of bringing the fishing and trading interests into personal relations with the Director and his experts; the views and schemes of the department are elucidated and threshed out in friendly discussion with hard-headed practical men, often with extremely valuable results; the grounds of possible misunderstandings are cleared away before they arise, and the Director is able, at the end of the conference, to go to Government with the full confidence of having the fishing trade at his back; he is able to say to the Minister that the trade approves his proposals and estimates, and this means that the financial section of the Government is virtually bound to find the money required to finance the schemes proposed, unless it is prepared to brave the resentment of one of the two most powerful industries in the country. This Fishery Council then is a powerful instrument in the satisfactory working of the department. It is at once a check on extravagance and on unpractical proposals and a strength to the department when its schemes are endorsed. The Council has no executive power, but naturally it would be inexpedient to do other than pay heed to its decisions, hence the proposals are prepared with such care and detail that with advance knowledge of the feeling of the industry there is seldom occasion for any serious conflict of opinion. The estimates are submitted in draft form under main heads or sections usually numbering between 40 and 50; each head is explained in the accompanying text in as great detail as is considered necessary. The budget draft submitted to the Fishery Council is entitled "Proposals for the grant of supplies for the arrangements concerning sea-fisheries in the Budget for the year ending 30th June . . . , submitted by the Director of Fisheries."

Last year the Fishery Council devoted a full week to the consideration of the estimates for the year 1921-22, each item being considered and discussed seriatim. If a strong difference of opinion is manifested a vote is taken to decide the finding of the meeting. The budget for the year in question is the largest ever submitted to the nation; the proposals were received cordially and the Director, who met the views of the Council to the greatest extent possible, had the satisfaction of getting all his schemes through, the chief modification being that the Council *increased* the estimate to the extent of Kr. 37,430 on a total submitted of

Kr. 2,991,175, bringing the final figure to Kr. 3,028,605, a sum much larger than in the years before the war when half a million kroner was considered sufficient. This sum contains, however, an extraordinary item of Kr. 1,000,000 (say £50,000), as the year's contribution towards the cost of construction of the new administration buildings at Bergen. (This amount I may mention is not to lapse if unexpended in whole or in part. By a special arrangement with the treasury it is to be put aside and employed as and when required. The building will cost much more than this, and it is intended in this way to spread the sum required over the next two or three years.)

Taking the present value of the kroner as 20 to the sovereign (normally the exchange in pre-war days was about 18), the budget total amounts to over £150,000 (say Rs. 22½ lakhs), a large sum for a small country like Norway with a population of barely 2½ millions.

A study of the main heads contained in the budget as finally sanctioned by Parliament is perhaps the best possible way of arriving at a clear understanding of the far-reaching and diverse lines of work carried on by the department and of gauging their relative importance. At present I have not the details of the estimates for 1921–22 which amount to rather more than double those for 1920 21. Hence I must give those for the latter year. These may be summarized as follows:—

	Kr.	Approximately Rs.
1. Administration and scientific services, including the cost of the weekly paper *Fiskets Gang*, published by the Department	163,250	1,22,400
2. Upkeep of the investigation steamer *Michael Sars*	12,900	9,700
3. Subsidy to the "Norwegian Fishery News" (*Norsk Fiskeritidende*) published by the Norwegian Fisheries Society Bergen	11,000	8,250
4. Cost of the Annual Reports and other departmental publications	10,000	7,500
5 and 6. Salaries and expenses of five fishery inspectors and two agents in foreign countries (England and Germany) ...	55,700	41,800

	KR	Approximately RS.
7. Promotion of the export trade	20,000	15,000
8. Stipends to fishermen and fish curers sent to other centres to study the methods of fishing and curing employed there	15,000	11,250
9. Education of fishermen in navigation and marine-motor technique ...	81,000	60,750
10. Fishery experiments	25,000	18,750
11. Grants to local fishery associations ...	93,700	70.275
12 to 28. A long series of items to cover the expenses of policing the great seasonal fisheries at various localities on the coast	349,170	2,62,500
29. Telegraphic reports on market conditions, supplied to the fish trade during the great seasonal fisheries	30,000	22,500
30. Contribution to the International Council for Fishery Research	4,700	3,525
31. Branding of mackerel, etc.	20,000	15,000
32. Provision of drinking water for the fishing fleets at out-stations	50,000	37,500
33. Lobster and fish culture at the Flodvig Hatchery and the Trondhjem Biological Station	27,800	20,850
34. Biological statistics concerning the herring and cod fisheries	8,500	6,375
35. Instructors in improved curing methods (cod)	6,000	4,500
36. Subsidy to the whale fishery in the Antarctic	2,090	1,500
37. Repatriation of shipwrecked fishermen ...	2,000	1.500
38. Grant on account for the construction of the new Fisheries Administration building at Bergen ... ... (Permitted to accumulate if not used during the year for which voted.)	100,000	75,000
39. Cost of a new motor vessel, 65 feet long, for inshore research	40,000	30,000

	KR.	Approximately RS
40. Development of motor engines for fishing boats	20,000	15,000
41. Scientific investigations on small herring and bristling	38,500	28,875
42. Registration and marking of fishing boats (a new item)	104.000	78,000
43. Revision of the law on fat herrings ...	7,000	5,250
44. Expenses of a committee to inquire into what regulations are necessary for the better conduct of the drift-net fishery (lights on buoys, etc.)	5,000	3,750
45. Promotion of co-operation among fishermen	30,000	22,500
46. Loans to fishermen for boats, motors, etc.	5,000	3,750
47. Committee to inquire into a scheme for the re-insurance of fishing boats already insured in small societies ...	5,000	3,750
48. Contribution to the Bergen Fishery Museum towards expenses of participating in the Kristiania Fishery Exhibition	1,000	750
49 and 50. Expenses connected with the supervision of the Lofoten Cod Fishery	33,000	24,750
51. Contribution to the cost of a new research vessel for the Trondhjem Biological Station	30,000	22,500
	1,406,220	10,54,850

On the credit side of the budget the only items are two—

	KR.	RS.
Receipts from the Experimental station ...	2,400	
Do. Branding operations ...	30,000	
	32,400	= 14,300

The budget for 1921-22 is much greater, partly because of the increased cost of labour and materials, partly because of the vigorous development necessary to counteract the many disastrous sequelae of the war, and still more to the inclusion of the extraordinary item of Kr. 1,000,000 of non-recurring expenditure for the new administration building in Bergen (at the present time the administration is housed in a rented building at a considerable distance from the sea and like that of the Madras Fisheries department quite inadequate to meet the largely increased requirements of the staff). In next year's budget the administration charges are set down at the large sum of Kr. 292,350 (Rs. 2,19,262). While the bulk of this is for salaries, it also includes an allotment for the expenses incurred by the members of the Fishery Council when attending the Annual Conference.

A sum of Kr. 15,000 is set apart for the expenses of various committees of inquiry, a dozen in number in this latest budget. This system of delegation to committees is a great feature of the administration at the present time; in part it has been adopted owing to the lack of staff in the department itself adequate to cope with so many and varied new inquiries; the plan, in spite of obvious drawbacks, has justified itself, and has been increasingly made use of in recent years.

After the provisional budget proposals have been discussed in detail by the Fishery Council, the members take the opportunity of discussing any subject of interest to the industry and several days are usually devoted to this. Thereafter the Director of Fisheries, after giving due consideration to all modifications in the estimates urged by the Council, submits the amended draft proposals, accompanied by a full account of the discussions in the Fishery Council, to the Minister for Commerce, who, if he has no objection to take, forwards it to the Parliamentary Budget Committee of the Development departments. This Committee after considering it with due regard to the financial position of the country, report upon it and it is then incorporated in the general national budget for submission to Parliament. This final statement contains, be it noted, not merely a bald list of items with the individual appropriation required placed opposite each one; to each head is appended a short explanatory note. This is found particularly useful in curtailing discussion and obviating submission of unnecessary questions and resolutions. The estimates pass through

three printed editions; the first with the Director's detailed explanations is laid before the Fishery Council, the second goes to the Ministry of Commerce and thence to the Budget Committee with the comments of the Fishery Council and the Director's replies; and then finally with the notes curtailed and made as concise as possible, it goes before Parliament.

III.—CO-OPERATION AND STATE LOANS TO FISHERMEN.

One of my objects in visiting Norway was to ascertain the lines upon which co-operation is organized among the fisherfolk, as I had heard that a new departure had been made there whereby fishing gear might be insured against loss by co-operative means. Hardly could I have gone to a country less advanced in this direction, and before I left the country the reason become plain. The Norwegian, enterprising and adventurous, is because of these very qualities, so self-reliant that he becomes individualistic, a characteristic shared in fully equal degree by his Scots brethren. Because of this, he is averse to the mutual-help associations characteristic of people in whom the Mediterranean stock predominates. Because of his racial origin, the Norwegian is learning very slowly indeed the value of co-operation in the sense we know it in parts of Germany, in Italy and in India.

In agriculture a good beginning has been made of late years, the example of Denmark being an object lesson not to be despised. The purchase of food-stuffs and of manures has been put largely upon a co-operative basis as in Denmark, and also the disposal of dairy produce. In fisheries the tale, as I have said, is otherwise, and so far as I can find the only societies formed are for the mutual insurance of their boats against loss or damage. The facilities thus afforded are widely taken advantage of, but so far as gear is concerned, the subject I was specially interested in, it appears that only in one or two exceptional cases is there sufficient mutual trust among the fishermen to permit of the insurance societies providing for the insurance of fishing gear. A few of these are now moving in this direction, and when I was in Bergen, the Director of Fisheries kindly gave me a copy of the rules proposed for this purpose in one case. These rules are not yet settled between the society and the department. The reason the latter is

interested is to ensure that the rules be framed soundly, both for the protection of the members and in the State's interest, as the re-insurance by the State through the Fisheries Department of such insurance is a scheme contemplated and under investigation. The rules are most simple. They provide for a gear insurance section in a boat insurance mutual society already in existence; the accounts of the new section are to be kept separate, and the benefits are to be extended exclusively to the members of the boat section only. Gear without the boat may not be insured. As further precautions against fraud, which is the stumbling block generally to gear insurance, the gear is to be inspected annually before the opening of the fishery—for the present, herring nets and the accessory gear alone may be insured—and of the value so assessed, not more than two-thirds may be insured. The premium to be charged was still under discussion when I left Norway; it was tentatively put at 3 per cent. In addition to this each member on admission to the society pays a small sum (not yet settled) on each net and on each cable with its accessories of buoys, etc.; these sums will probably be fixed at 20 to 30 ore (2½ and 3½ annas) and Kr. 2 50 (Rs. 2), respectively. It is still doubtful whether this gear insurance will be taken up largely. Mutual trust is essential to its success, and as the opportunities to practise fraud in regard to claims for the loss of old nets are many, the temptation to do so is so great, that even among associations of men noted for their exceptional honesty there is distinct hesitancy about embarking upon this new scheme of gear insurance.

Apart from the mutual insurance of their boats, there are few co-operative societies in operation. At the same time the need for outside capital to enable new and better boats to be built has been urgent for many years; to meet this demand the Government as far back as 1889 established a loan fund for the purpose of assisting fishermen to purchase boats and fishing gear. This fund which became known as *The Old Sea-Fisheries Fund*, was commenced with an original capital of Kr. 200,000. This was gradually increased to Kr. 3,950,000.

Interest on loans was fixed at 3 per cent per annum (subsequently reduced to 2½ per cent); loans were repayable in 10 or 15 years. Security was given in mortgages on the vessels and gear and in insurance policies; loans were granted up to three-fourths of the

value of new vessels and two-thirds that of older vessels; not more than Kr. 15,000 was advanced on any one keel. The fund also provided loans up to two-thirds of the value for the purchase of new vessels of large types, suitable for fishing, these loans being covered by communal or other similar guarantees. Loans were also granted for the erection of works for preparing and curing fish; these loans were similarly guaranteed. A second loan fund called *The New Sea-Fisheries Fund* was established in 1900; the amount originally voted was Kr. 500,000, subsequently increased to Kr. 900,000 and then reduced to Kr. 250,000. The object was to provide for loans for purchasing and fitting out steamers for sea-fisheries. Interest was charged at the rate of 4 per cent per annum and loans were re-payable during the course of ten years. Security was given in mortgages on the vessels and gear and in insurance policies. The extent of each loan did not exceed 50 per cent of the vessel's value and no loans were granted on vessels more than 5 years old.

The Finmarks Fund was established in 1905 with a third allocation, originally Kr. 200,000, gradually increased to Kr. 500,000. This was a special fund for assisting fishermen in Finmarken who were, however, also entitled to loans from the other funds. Conditions for loans were practically the same as in the case of The Old Fisheries Fund, only the rate of interest was 2½ per cent and the maximum amount advanced on each boat was Kr. 3,000 and on motor-boats Kr. 4,000.

At the close of 1915 the sums advanced by these three funds were as follows: –

			KR.
74	loans on	steamers	1,290,600
10	do.	curing establishments, etc.	128,000
1,341	do.	other vessels and motor boats ...	3,511,993
		Total ...	Kr. 4,930,593

In January 1919 the Ministry of Commerce introduced a bill for the establishment of a Norwegian Government Fisheries Bank; when introducing this bill the Minister stated that the sums which were available from the above mentioned three funds had become entirely inadequate in view of the very considerable increase of capital used in the Norwegian fishing industry and that it was also necessary to provide money to assist fishermen in effect-

ing extensive repairs to their vessels and in purchasing gear, etc., it was also considered that loans might be granted to fishermen's associations or co-operative institutions formed for the purpose of treating fish and selling fishery products.

The bill, which became law on the 1st August 1919, provided for a Norwegian State Fisheries Bank which should grant loans—

(*a*) for purchasing, rebuilding or carrying out extensive repairs to hulls and engines of fishing vessels,

(*b*) to ship-mortgage associations for fishing vessels,

(*c*) for erecting or altering ice-houses, freezing, drying and similar establishments for the preservation or working of fish products,

(*d*) to fishermen's associations formed for the purpose of purchasing fishing tackle, gear, etc.

The funds of the bank amount to five millions kroner with a reserve fund of Kr. 750.000; these funds are to be provided by the Government; interest on the capital is to be used for paying expenses of administration, covering losses from loans granted at a lower rate than is paid by the bank for the money and losses from mortgagors or guarantors; any surplus of interest is to be added to the reserve fund until it reaches Kr. 1,250,000, after which it is to be added to the capital. The reserve fund is to be drawn on for covering loss of interest; if it falls below Kr. 750,000, the difference is to be made up from the Exchequer.

Loans taken up by the bank are to be guaranteed by the Government; the bank has the authority to issue Bearer Bonds which will be guaranteed by the Government. The Bank cannot take up loans for an amount exceeding ten times the capital.

Regarding loans for purchasing, rebuilding or carrying out extensive repairs to fishing vessels, the law states that these shall only be granted to Norwegian citizens and, by preference, to fishermen who assist in the working of the vessel in question; loans shall be covered, either wholly or in part, by communal guarantee and, if possible, by a mortgage on the vessel and the sum for which it is insured. Loans are to be granted on motor and sailing vessels and on fishing steamers of not more than 50 tons gross. The conditions on which loans are granted vary according to the tonnage, as follows:—

(1) Under 4 tons (including open boats)—Loans granted up to four-fifths of the value. Interest 3 per cent per annum and

loans repayable within eight years. Full communal guarantee required.

(2) From 4 to 25 tons—Loans granted up to three-quarters of the value. Interest 3½ per cent for vessels between 4 and 15 tons and 4 per cent between 15 and 25 tons. Loans repayable within ten years. Security : first mortgage on the vessel and, in addition, a communal guarantee for 30 per cent of any possible loss.

(3) Over 25 tons—Loans granted up to two-thirds of the value. Interest 4½ per cent and loans repayable within 10 years. Security : the same as (2) above.

All vessels in respect of which loans have been granted must be kept insured for at least 75 per cent of their value ; they must also be kept in proper repair and be subjected to annual surveys by the Fisheries Inspector.

With reference to loans to ship mortgage associations for fishing vessels, the law states that such loans can be granted against Bearer Bonds issued by such associations, whose statutes must have the Royal approval.

Loans for erecting or altering ice-houses, freezing, drying and similar establishments for the preservation or working of fish products may be granted to Norwegian subjects or to associations ; preference is to be given to fishermen or fishermen's associations ; no loans will be granted to canning or similar factories. Security is to be given in a first mortgage on the works and their insured value, and a communal guarantee for 50 per cent of any possible losses. Interest at the rate of 5 per cent per annum is to be paid and loans, which shall not exceed 75 per cent of the value of the works, shall be repaid within 20 years.

Loans may be granted to fishermen's co-operative associations for the purpose of buying fishing tackle, gear, etc., if the statutes of the association have been approved by the King, and if the association has at least 50 members who own vessels, gear, works, etc., to a value of at least Kr. 40,000. Detailed rules have been drawn up as to the constitution, membership, etc., of such associations. Loans granted to them shall bear interest at the rate of 4 per cent per annum, they shall be repayable within 11 years and shall not exceed one-third of the total value of the vessels, gear works, etc., owned by the members.

The Norwegian Government Fisheries Bank is to have its head-quarters in Bergen with branches at other places to be decided

by the King. The Board is to consist of three members and three deputies. Two of the members and their deputies are to be elected by the Storthing and the others by the King. The Director of Fisheries may be called in as an advisory member of the Board.

I was informed by the Director of Fisheries that the Bank is not likely to commence operations before 1921, as it has, up to the present, been found impossible to secure suitable premises in Bergen.

IV.—TECHNICAL EDUCATION.

At the present time the only branches of education provided by the Department of Fisheries are strictly practical and technical. The two most important do not centre round the technique of fishing methods as we should expect. They aim at making the inshore fisherman better fitted to handle his boat successfully and to the best advantage; this in practice widens his field of operations as it gives him confidence in himself and his boat to operate at greater distances from port; his radius of action is extended. To effect this object, the department has initiated a scheme for the instruction of fishermen in the two related subjects of navigation and marine-motor management.

Both of these have till now been taught in the simplest of ways. No expensive buildings were necessary, or desirable, in view of the fact that the coast line measures not less than 1,500 miles, with fishing towns and villages scattered along the whole length. Few of the fishermen could be expected to attend if only one or two or even four schools were established as even the nearest would usually be at a long distance from their home; the only alternative was to send the schools to the fishermen and this has been accomplished by the employment of perambulating instructors. All the teachers of navigation and motor technique are itinerant; a programme of work is mapped out for them, care being taken to arrange the time to be spent at each particular centre with due regard to the local seasonal fishing requirements, the best period for the purpose being obviously that when the fishermen's attention is not absorbed in the prosecution of their calling.

The course in navigation is of an elementary nature compared with that provided for men who are destined to be navigating officers in the mercantile marine. In Norway the latter subject is in charge of a special officer, termed Director of Naval Instruction,

not connected with the Fisheries Department; the schools or colleges under this officer are located in the principal sea-ports: like all educational centres in Norway where the newest and most conspicuous building in any town or village is nearly always the local college or school, the naval colleges are admirably staffed and equipped.

For the instruction of fishermen in the theory and practice of marine-motor technique, the services of a teacher from the School of Engineering are requisitioned. The importance of this subject is appreciated so keenly that the Fishery Council in the discussion on the 1920-21 budget pressed for an increased appropriation on this head and eventually a sum of Kr. 50,000 was voted by Parliament for more numerous courses in motor instruction. It is significant of the foresight of the Norwegians that in the same year Kr. 60,000 (Rs. 45,000) was voted to the Agricultural Department for instruction, demonstration and experiment in the application of the internal combustion motor in its different forms and purposes to agricultural needs. The Fisheries Department has now amplified its methods in a similar direction and is experimenting with perambulating motor-instruction boats, in which the teachers will be able to visit the most out-of-the-way fishing villages.

The navigation course extends over a period of two months; that on motor management usually for one month; the latter may however be shortened if necessary by having the demonstrations and lectures at closer intervals.

The fact that the item of Kr. 81,000 provided in the budget of 1920-21 for the education of fishermen in navigation and motor work is raised to Kr. 107,200 in that for 1921-22 is evidence of the importance attached to the subjects taught and the energy with which extension of facilities is being prosecuted. Diplomas are given by the department to those who pass at the examinations held to test the proficiency attained by the students in these courses of navigation and motor technique.

In addition to the courses of instruction in these subjects given by the teachers employed directly by the department, important work in the same subjects is carried on by several of the larger and more important fisheries societies, largely with the help of generous subsidies from the department. These grants are almost entirely given conditionally for specific purposes, and among these the teaching of navigation and of motor

mechanics form two of the larger headings—Kr. 15,280 for navigation and Kr. 4,220 for motor technique in the budget 1920–21.

Apart from the specific budget head "Education of Fishermen," a great deal is done and much money spent by the department on items that may as justly be classed as education, as are navigation and motor mechanics. *The most important of these is the provision of instructors in improved methods of curing codfish.* The sum expended is not great (Kr. 6,000 = Rs. 4,500) in view of the keen competition of Newfoundland in the dried codfish trade in foreign markets. That it is profitable and adequate seems proved by the fact that the quality of the Norwegian product is acknowledged to have improved greatly of late years, with the consequence that Newfoundland, finding the competition hard to face, deputed a commission to visit Europe last year to investigate the situation and devise means to face this increasingly severe Norwegian competition. One of the commission visited Norway when I was there with a view to learn what was possible of this improved technique and of the trade methods pursued by Norwegian traders. The improvements made are in large part due to the employment of the instructors alluded to, and this is proving one of the most useful activities of the department. The instructors once more, are peripatetic, travelling from town to town and village to village.

Closely related to this form of technical education is the scheme whereby the department pays fishermen and fishcurers stipends and travelling expenses to enable them to visit important fishing centres both at home and abroad to study on the spot the methods employed in fishing and fish-curing. Kr. 10,000 was spent on this most practical form of education in 1919-20, Kr. 15,000 in 1920–21 and now in the 1921–22 budget the allotment has been raised to Kr. 54,000, so satisfactory has been this method of widening the horizon of the men selected. These people, chosen carefully for their superior intelligence, on return home are found to have lost much of their innate conservation and seldom fail to put into practice any improvement in method that has struck them during their deputation as suited to their particular local conditions. Each of them becomes an unpaid demonstrator, one of the conditions on which he is given the opportunity to study other methods.

The department spends money also upon popularizing a more extended use of fish in the household cuisine of the masses and upon an attempt to make the canning of crabs a cottage industry.

As regards the former the system of employing travelling instructors is again adopted. The lower classes in Norway retain much of the primitiveness of the old viking life and quantity is more regarded than quality; methods of cookery are often rude and too frequently, just as in the traditional English workman's cuisine, not nearly the best is made of the food treated. More especially is this the case in regard to fish. Hence one of the department's minor activities is to send lady teachers of fish-cookery to various populous centres to demonstrate better and more tasty modes of treating fish for the table. The main object of the department is primarily to popularize the use of fish in towns and so to increase the consumption and demand for fish. Incidentally it assists in raising the standard of living and in improving the health of the workers.

The development of crab-canning as a home-industry has been attempted by the Society for the Promotion of Norwegian Fisheries, the most important of the Norwegian fishery societies. The work is carried on with the help of a grant from the department (Kr. 900, 1921-22). In Norway, the large edible crab *(Cancer pagurus)* is common on many parts of the coast line but nowhere in sufficient quantity to warrant the establishment of a fully equipped cannery built and run for this specific purpose; neither has it been found practical for the sardine canneries to include crab-canning even as a side line. The numbers available are too limited and the supply too erratic to make the proposition worth consideration in a cannery which must turn out thousands of tins a day if it is to be a commercial success. Hence the attempt has been made to devise a canning plant of the utmost simplicity at a cost within the means of the ordinary inshore fisherman, who owns perhaps one small row-boat and a number of crab-pots, the whole operated by himself and a boy. The society makes arrangements for the supply of tins—bodies and covers—to the worker, greatly simplifying the proposition, which is then resolved into instruction in the proper manner of *(a)* the extraction of the flesh of the crab, after cooking, *(b)* the attractive packing of this into the body of the tin, *(c)* soldering on the cover, *(d)* testing, exhausting, and tipping, and *(e)* sterilizing. An itinerant

teacher is employed to teach the rudiments of the principles involved in successful canning, to teach soldering and to demonstrate the various steps in the process. Sterilization or processing is done by means of immersion in pans of boiling water.

The apparatus used is necessarily of the simplest nature; a trestle table, a couple of hammers, a brazier and soldering iron, and an iron boiler or kettle, comprise the essentials, the containers being bought ready made. The actual canning is carried out by the fisherman himself with the help of his family. The society assists also in disposing of the worker's products and gives every possible encouragement to fishermen to embark on this small industry and to maintain a high standard of quality. Whether the industry will have more than ephemeral success is doubtful; Norwegian fishery experts are by no means unanimously in favour of the experiment; adverse critics point to the difficulty of maintaining an even standard of quality and the possibility of bad or careless packing and processing with consequences harmful to the consumer; they point to the difficulty of any man carrying on successfully two distinct trades. Conversely the advocates of the scheme point to the notable successes of certain of the men who have taken it up; on the whole I believe the experiment has justified itself, not so much perhaps in regard to the main object of the original promoters, that of creating an extensively carried on home-industry, as in giving opportunities to enterprising men to learn the principles of canning and to lay the foundation of enterprises that may develop into self-contained canning factories carried on upon a commercial scale.

V.—THE ROLE OF FISHERY SOCIETIES.

The part played in Norway by non-official associations formed for the promotion of the fishing industry in all its branches is of the greatest importance, particularly in the direction of catering for local requirements. They are found in the chief sea-coast fishing towns (Bergen, Trondhjem, Stavanger, Aalesund, Kristiansund), and in most centres where fishing is carried on upon an extensive scale. They originated generally from private initiative, relying largely for their resources upon the generosity of the citizens and the trade and upon contributions from the local communes and municipalities. With growth and wider aims, the aid of the State, through the Fisheries Department was sought and obtained,

and at the present day the major portion of the expenses of these societies is met by a contribution from the State. This is given subject to the society raising locally a sum equal to not less than one-quarter of the amount contributed by the State. Except in most exceptional cases, the State's contribution is earmarked for specific subjects, a very useful safeguard. The societies have to furnish an annual report to the Director of Fisheries detailing their operations, particularly in respect of the specific items for which State help was forthcoming. They also submit annually to him their budget estimate for the coming year; this forms the basis upon which the Director frames his own estimates in connexion with the working of these bodies. Usually he is in such close touch with them in their local operations that he is able to accept their proposals with little or no modification.

The largest of these non-official bodies is that located in Bergen, the "Society for the Promotion of Norwegian Fisheries." It is housed in a handsome building whereof the most complete Fishery Museum and Technical Library I have seen anywhere, are the principal features; the secretary and office staff are given well-lighted roomy accommodation that is in itself an object lesson of what this should be. The budget proposals for 1920–21, submitted for approval to the Director of Fisheries, furnishes except in one item, a clear insight into the very practical working of this premier society, viz.:—

	KR.
Administration	10,000
Fishery Museum	7,400
Library	700
Oyster and shell-fish culture	3,500
Development of the fishery in Vestland	2,200
Travelling expenses	2,000
Fishery school in Bergen	600
Experiments in the storing and transport of fresh fish	1,500
Development of the crab fishery and of crab canning as a home-industry	600
Propaganda for the greater employment of herring and fish (sic) in the household...	3,000
Miscellaneous	1,000
	KR. RS.
Kr.	33,800 = 25,350

Towards this the society applied for a State grant of Kr. 21,350 (Rs. 16,012).

What the Director of Fisheries eventually budgeted for was the following:—

	KR.
Administration	6,000
Fishery Museum	3,000
Library	600
Oyster and shell-fish culture	2,800
Development of the fishery in Vestland	2,000
Travelling expenses	1,000
Instruction in fishery subjects at the Seamen's school	600
Experiments in storing and transport of fresh fish.	1,400
Crab-fishing development and crab-canning as a home-industry	500
Fish cookery propaganda	2,500
Miscellaneous	600
	RS.
Kr.	21,000 = 15,750

But the above subjects do not exhaust the activities of this society, for perhaps its most useful role lies in the preparation and publication of a monthly fishery journal called the *Norsk Fiskeritidende* ("Norwegian Fishery News"). This journal, prepared by the publishing Committee of a private society, is able to treat of matters with a freedom impossible in a Government office, in spite of the fact that the expenses of printing are borne by the State. It is able for example to discuss fishery subjects in an informal and popular way, and to incorporate notes that may be of interest and value to the trade but which in a staid Governmental publication might seem trivial and out of place. A private body is able to treat the advertisement question in a way impossible in a State department and the same applies to the means often needful to employ in securing a wide circle of readers. It is notorious that the average person has an innate horror of any Government publication; so many are dull and prosy in the treatment of their subject matter that the exceptions are overlooked and all are usually avoided and unread by the multitude. To give a clear idea of the extent to which these local Norwegian

societies are utilized in the development of the country's fisheries, the following list is provided of societies, together with the amounts of grants-in-aid recommended by the Director of Fisheries to Government for the year 1920–21, viz. :—

Society.	Government grant recommended by the Director of Fisheries.
Vadso Fishery Union	No grant asked for in 1920–21.
Vardo Fishery Union	
	KR.
Nordland Fishery Society	9,600
Namdalen do.	3,200
Fosen do.	5,200
Trondhjem do.	8,000
Smolen do.	6,800
Kristiansund do.	6,500
Grip Fishery Union	500
Sondmor and Romsdal Society ...	7,600
Aalesund Society	3,550
Sogn and Fjordan Fishery Association	4,850
Norwegian Fishery Society, Bergen ...	21,000
Hordaland Fishery Association ...	5,300
Rogaland do. ...	10,400
Ostland Fishery Society	11,800
Kristiania Fjord Fishery Development...	800
	Kr. 105,100

Items amounting to Kr. 11,400 were eventually deducted and the net sum finally voted by Parliament was Kr. 93,700. This grant as I have stated above is made upon the specific condition that each society shall raise in its own district by voluntary and communal contribution a sum amounting to not less than 25 per cent of the sum granted by Government.

The aims of the various societies necessarily vary with local requirements. Among these, besides those already mentioned when surveying the scope of work of the Bergen Society, the most frequently recurring are items for instructional courses in navigation and in motor technique, the encouragement of the inshore fisheries by open-boat fishermen, the upkeep of reading rooms for seamen and fishermen, and grants to communal and other

ice stores. These local societies have made wonderful strides in recent years and their usefulness cannot be overrated in the way they encourage mutual helpfulness, especially in regulating prices and in focussing attention upon the local needs of the industry. Perhaps their greatest value lies in the connexion they set up between the local trade and the Fisheries Department. They serve as intermediaries and interpret and regularize the local demands for Government help. An enormous amount of spade work is being done by these numerous societies, which constitute auxiliaries of the greatest value to the Fisheries Department, and enable it to concentrate upon larger problems, and those requiring special expert and scientific training. No feature of fishery administration in Norway impressed me more forcibly that did the activity and usefulness of these societies as supplementary to the wider organization provided by the Fisheries Department.

At the other end of the scale we find help on the ultra scientific side willingly given to the department by the two great Biological Stations of Bergen and Trondhjem. In these institutions pure research is the main object pursued, though as a matter of fact this is utilized specifically in some instances at the request of the department, in the elucidation of some problem of direct practical significance. Also at the Trondhjem Station, the hatching of plaice for the replenishment of the waters of the fjord is undertaken as an economic measure the expenditure on this head being met from the Fisheries Department's budget. Again, the physical observations of Professor Helland Hansen at Bergen have been practically important in the light they had shed upon fishery problems. The department's experts by working in close collaboration with the scientific staff of these Biological stations find their work facilitated and supplemented by this connexion to such an extent that were it not available, the department's scientific staff would have to be largely increased. One of the great lessons which the Fisheries Department of Norway gives to the world is the vast economy of utilizing every agency—popular as well as scientific—to supplement the work of its own officers.

VI.—NORWEGIAN BIOLOGICAL STATIONS.

Biological research in Norway, apart from the life-histories of the important food fishes, is carried on, not by the Fisheries Department staff, but by semi-private organizations, subsidized by

Government through the Education Department. There are three public stations, Drobak, Bergen and Trondhjem. The first is in reality a branch of the University of Christiania, 28 miles away. The second is intimately connected with the Bergen Museum, the Director being appointed by the Committee of Management of the Museum, while the third is practically independent and is not affiliated with any educational institution.

The station at Bergen is particularly interesting because of its history and organization. The funds for its establishment were derived in the main from the profits of the State liquor business, the Braendevinssamlag, since abolished, supplemented by generous donations from the citizens and public bodies of Bergen. A site for the building was found in a private park and the Museum undertook the organization and management of the station. The Museum itself is primarily operated by a society aided financially by the Bergen municipality and to a still greater extent by Government. Its management vests in a Governing Committee, whereof three members are appointed by the parent society, three by the Bergen municipality, and three by the Government, the Director of the Museum forming *ex-officio* the tenth. The society, aided by private donations, has been able to furnish most of the funds for the erection of the building, Government meeting the major portion of the annual expenditure.

This biological station has no official connexion with the Fisheries Department and economic reasons have had little to do with its inception and management; its aims professedly are primarily and solely pure research. But through the genius of its gifted Director, the physicist Helland Hensen, it has done more than any other agency in Norway to promote the advance of our knowledge of oceanography. In this subject it has specialized and its vacation courses of instruction in this subject have been particularly useful, and highly appreciated.

The Trondhjem Station is equally well equipped for biological investigation and unlike the other two stations, it links up directly with the Fisheries Department by accepting a subsidy of Kr. 4,000 to cover the expenses connected with the upkeep and operation of a plaice hatchery.

When I visited the station last year, I had the good fortune to be able to inspect the handsome new research vessel, the *Gunerus*, built specially for biological investigation. Dr. O. Nordgaard, the

Director, had great pride in informing me that the greater part of the cost, amounting to Kroner 200,000 (Rs. 1,50,000), has been met by private subscriptions. The vessel is fitted with a motor engine (of Swedish make) of 40 to 50 h.p., which also works successfully both the big trawl winch and the anchor winch. One engineer only is kept and Dr. Nordgaard mentions that the engine is so simple and easily run that this solitary engineer is able to spend a good deal of his time on deck and gives much help in carrying on the scientific work!

VII.—THE NEW FISHERIES HEADQUARTERS TO BE BUILT IN BERGEN.

The Administration of Fisheries together with the scientific staff are lodged in a rented building in the heart of the residential quarter of Bergen, not even on the sea front. The accommodation, good and even palatial as compared with anything that Fisheries have ever had in Madras, has become wholly inadequate to meet the rapidly growing requirements of the department, particularly on the scientific and technical side. The Director accordingly formulated proposals for the erection of a building by the State, planned specifically to give adequate accommodation for all the activities of the department, present and contemplated; these were submitted and approved by the National Fishery Council and with this backing the Government acquiesced and set apart Kr. 7,000 for premia to architects for the best plans submitted. The competition was keen, 27 sets of plans being sent in, so many of such high excellence that adjudication was found difficult.

To Madras which has recognized that before long it will be necessary similarly to take measures to give proper conveniences to the local Fisheries Department if utter stagnation is to be avoided, a study of these plans is most interesting for comparison with those of the building designed locally.

There will be three floors available for the Administrative staff, free from any loss of space for the storage of bulky articles such as stationery reserves, glassware, fishing apparatus and nets, and the hundred and one things that are required from time to time in fishery investigation both at sea and in the laboratory. All these items find accommodation in the basement floor, half sunk below the ground level.

The ground plan is similar to that of the Madras design, a main block with two wings, north and south. The main block, with the

exception of three rooms, is devoted to the purely administrative and trade sections, the Director, the Fishery Superintendents (technical experts), the editorial staff of the *Fiskets Gang*, the trade statisticians and the Fishery Council Chamber finding accommodation therein.

The southern wing is devoted to marine biology and hydrography; the northern to chemical and bacteriological investigation, to the analysis of material used or produced by the fish trade and to problems connected with the canning of fish.

To show the need for ample accommodation if work is to be carried on in a really satisfactory manner, these plans provide for a total of 75 rooms made up as follows :—

Ground Floor.

South wing	Rooms.	Main Block.	Rooms.	North wing.	Rooms.
Marine Biological Laboratories ...	2	Technical experts ..	2	Canning industry laboratories ...	2
Laboratory Superintendent	1	Secretary	1	Bacteriological laboratory ...	1
Laboratory store ...	1	"Michael Sars" ...	1	Offices	2
Students' room ...	1	Various offices ...	5	Lunch room ...	1
Lavatory	1	Trade statistics and "Fiskets Gang" Editorial office.	3	Lavatories	2
Watchman	1				
	7		12		8

First Floor.

Biological statistics.	2	Director's offices ...	2	Chemical laboratories	2
Offices	3	Director's private room ...	1	Chemical library ...	1
Work rooms ...	2	Draughtsman ...	1	Superintendent of Chemical laboratories	1
Lavatory	1	Main library ...	1	Offices	2
		Reading room ...	1	Reserve room ...	1
		Office rooms ...	4	Lavatory	1
		Lavatory	1		
	8		11		8

Second Floor.

Hydrographic laboratories ...	3	Fishery Council Chamber ...	1	Chemical analysis.	3
Offices for laboratories	2	Lecture Hall ...	1	Sound-proof room.	1
Photography ...	1	Plankton laboratory.	1	Offices	2
Lavatory	1	Offices for same ...	2	Lavatory	1
		Lavatory	1	Retiring room for Fishery Council.	1
	7		6		8

An ideal site for the building has been obtained in the public park at the seaward extremity of the peninsula of Nordnæs which divides the two deep inlets that form the two harbours of the city. Quite deep water is found at the foot of the rocks above which the building will be erected. When built, it will be the first prominent building seen by those who arrive at Bergen by sea, and the citizens are to be congratulated upon their public-spirited action in giving such a unique site over to this purpose; it is proof indeed, if proof be needed of the high estimation in which this Government department is held by the people at large.

The Government have also been particularly generous. Owing to certain considerations, not altogether financial, it was not deemed desirable to begin construction during the war, and since then other difficulties have arisen, causing postponement of the plans. To facilitate therefore the eventual operations Government have accorded the department the exceptional privilege of accumulating the annual sums voted by Parliament towards the cost of the project and in this way funds for the building are gradually accumulating, the total vote being spread over a number of years instead of swelling one particular year with a heavy item of extraordinary expenditure. It possesses the added advantage of protecting the project from any sudden change of attitude on the part of Parliament towards the project, a danger ever present in a democratic county, where party Government prevails. Work is to be begun at an early date.

VIII.—FISHERY PUBLICATIONS.

In Norway the rapid and wide dissemination of news of interest to the fishing trades is accounted one of the most useful and indeed essentially necessary duties of the Fishery Department and of the leading Fishery Societies. An important branch of the former concentrates attention upon the collection and editing of statistics from home waters and of market reports from home and abroad. To give satisfactory publicity to these, the department issues a weekly trade paper, the *Fiskets Gang*. It appears as a 12 to 16-page journal, the page size measuring 12 inches by 9 inches. Four pages are given over to advertisements. The regular contents comprise, among other subjects, (1) a concise review of the course of Norwegian fisheries during the preceding week, (2) telegrams

from all important fishing centres giving the catches and landings of fish for the same period, (3) information on the progress of mackerel and herring fisheries at home and abroad, (4) Consular reports on the fish trade, (5) publication of new laws and regulations affecting fishermen, such as that on the registration and marking of fishing boats, with explanations and illustrations where necessary and (6) statistical tables of the total catches of all food fishes from the beginning of the current year to date. Any other matter, domestic or foreign, directly of interest or value to the trade, that comes within the ken of the editor is included. The paper is of the greatest use to the fish-merchant and exporter by giving them reliable and unbiassed accounts of the state of the markets for their produce and of the factors that affect prices. It serves as a useful link in many ways between the department and the trade who appreciate highly the service thus rendered. It serves also to keep before the trade the fact that the department undertakes for a small fee the analysis of materials used in fish industries and of fish products. The advertisement pages are by no means the least useful feature of this little journal.

Besides the *Fiskets Gang*, the department issues a publication entitled *Aarberetning vedkommende Norges Fiskerier*. Several parts appear each year. These contain a series of detailed sectional departmental reports, the annual reports of the various fishery societies and unions, affiliated to or subsidized by the department, the debates of the Fishery Council, accounts of scientific work done by the experts of the department, statistics of the great seasonal fisheries and similar related matter. Technical and statistical information of a special nature, too long and detailed to find a place in such annual reports, is issued separately under various forms.

Apart from these departmental publications are those of the chief Fishery Societies. The most useful is the well-known *Norsk Fiskeritidende* published monthly by the "Society for the promotion of Norwegian fisheries," from its offices in Bergen. This monthly, of handy octavo size, runs usually to 38 or 40 pages of letterpress exclusive of advertisements. To a large extent it is complimental to *Fiskets Gang*, for while the latter caters chiefly for fish-traders and exporters and gives chief prominence to market reports and statistics, the *Norsk Fiskeritidende* devotes its space primarily to subjects dealing with the catching of fish. It is the

fisherman's paper *par excellence.* Its articles are frequently illustrated, always plainly and clearly worded, and with avoidance of the jargon of the professional scientist; as a result the paper is valued by fishermen and undoubtedly has a wide and beneficial influence in the direction indicated by the designation of the society. Its officials and the editorial committee are men of the people and as such are able to appreciate and counter the prejudices of the fisher classes and their intense dislike of anything that savours of patronage. The Norwegian is a plain man and if met on an equality is willing to learn but he would rather remain ignorant than be lectured by the superior person, particularly if he suspects him to be an armchair scientist.

B.—FISHERIES AND FISHERY ADMINISTRATION IN DENMARK.

IX.—DANISH FISHERIES.

The sea-fisheries of Denmark compared with those of Norway are relatively small, and homogeneous to a far greater extent. The coastline is long, but on the most productive sections, those to the west and north, the dangerous character of the coast limits the number of fishing harbours suitable to the needs of the larger craft of to-day to a very few, and this renders the control of operations by the administration a far simpler task than it is in Norway, where the number of fishing harbours is particularly numerous owing to the shelter given by the line of islands that front the coast for hundreds of miles. There are indeed only 23 ports of register in Denmark and many of these have but few boats sailing under their distinctive lettering.

Situated at the sea-gate to Germany, Denmark profits greatly thereby. Her trade, unlike that of Norway, is largely in fresh fish sent in ice inland to central Europe. This ensures usually good prices and a particularly profitable trade. The statistics of the past few years show how flourishing the fisheries are. In 1919, the latest year for which statistics are available, we find that the value of the fish landed at Danish ports was Kr. 54,112,300 (Rs. 40,58,422) as against Kr. 17,515,200 in 1913 and only Kr. 7,759,918 in 1900. The average price has also steadily tended upward within the same period, from Kr. 0·30 in 1913 to Kr. 0·61 in 1919. The total weight landed in 1919 was 88,928 metric tons.

The number of fishermen engaged was 20,599 in 1918, the value of the vessels employed Kr. 32,033,718, and of the fishing gear Kr. 20,335,778. In 1913, the number of men employed was only 17,697, the value of the vessels Kr. 12,059,763 and of gear Kr. 8,751,794. This great disparity in the value of boats and gear in 1913 and 1919 is due only in part to the universal rise in the cost of materials and wages; the greater part is due to the universal adoption of the marine motor in the Danish fishing fleet, which in turn influences owners to build their new boats of a larger size than formerly. The extent to which motors are used is shown by examination of the figures for 1919. In that year the

total number of fishing craft of all sizes and classes was 16,370. Of these 7,795 were small open boats used for inshore fishing, 3,914 were sailing boats and 4,661 were motor boats. The value of the last named was Kr. 29,377,383, while that of the row-boats and sailing boats together was only Kr. 2,656,335. As many as 544 of the motor boats were over 15 tons, valued at Kr. 12,783,000 (say an average value of Kr. 23,500 = Rs. 17,600 each); 1,129 were between 5 and 15 tons and 2,988 were under 5 tons net register.

X.—THE SNURREVAAD OR DANISH DEEP-SEA SEINE.

Denmark of all north European seaboard countries with important fisheries, is the only one that does not employ the steam trawler in her home waters. In its place the Danish fishermen have brought to perfection a form of net called by them the *Snurrevaad* and by others the Danish seine. It is used largely for the capture of plaice and haddock; the Danes consider it has many advantages over the trawl for comparatively shallow waters and their belief seems justified by the wonderful success of the great fleet of motor-cutters that employ it almost exclusively in their operations. In 1919 there were 5,401 of these nets in use, of a total value of Kr. 4,048,000.

Esbjerg, the chief Danish fishery port, is the home of the Snurrevaad, for it boasts the possession of a homogeneous fleet of nearly 400 motor cutters and yawls, almost all using this net. In 1919, this fleet landed 18,922 tons of fish at Esbjerg. Of this 2,205 tons were sent to the provinces, 2,000 tons to Copenhagen; of the remainder Germany took 11,600 tons, England 3,000 tons and Sweden 117. Haddock accounted for 13,672 tons of the fish landed at Esbjerg, plaice coming next with 4,940 tons.

I dwell specially upon these statistics because it appears to me that the methods of fishing found successful in Denmark are those which will serve our purposes best in the development of the coastal fisheries of Madras. I feel that for various reasons we are not ready for steam-trawling in Madras; the leap from the catamaran and the canoe to this great engine for the wholesale capture of fish is too great and too sudden. Hence I look for guidance to Denmark, where the industry has developed on lines totally different from what it has done in Great Britain. It may be that the British have taken a longer view than the Danes; they have had the imagination and enterprise to put greater capital into the

business and seek a harvest often many hundreds of miles from home. The Danes have been content to work on narrower lines, to devote their energies to the thorough exploitation of their home waters, within at most a hundred miles from port. In this, as judged by their success and the wonderful progress of Esbjerg--the Chicago of Denmark, as they love to call it--they appear to have had their reward. Already great freezing works, cold storage installations, and canneries are springing up, with miles of new docks and quays, where mud flat and sand dune existed not six years ago. This it is that encourages me to press for development or at least for extensive experiment on lines which take due note of methods and apparatus that have been found so eminently successful under related conditions in Denmark.

The success of the Danes in the use of the snurrevaad and motor-cutter has not been lost upon the Norwegians whom I found paying great attention to them in 1920, with a view to their adoption on those parts of the Norwegian coast suitable for their employment.

The general dimensions of a modern motor-cutter as employed at Esbjerg are as follows:—

Length of deck (overall length)	...	14·4 metres.
Length on the water-line	...	12·6 ,,
Greatest beam	...	4·2 ,,
Height forward	...	3·0 ,,
Do. amidships	...	2·2 ,,
Do. aft	...	2·9 ,,

The gross register tonnage varies from 16—28 tons. These boats, termed "Haj" ("shark," Danish), are engined with motors from 30 to 40 h.p., the average being 35—40 h.p. The power installed is generally calculated to give a speed of 6 to 8 knots with a consumption of 150 to 175 kilogrammes of oil per day. The motors most favoured are the "Alfa" of Frederikshavn, the "Tuxham" and the "Neptune" of Kopenhagen; the "Avance" and "Bolinder" of Stockholm. A crew of four is sufficient to man and work this handy craft; one of the crew works the engine, but does not by any means devote the whole of his time to it.

The snurrevaad in itself is nothing but a large seine with long wings and hauling ropes. But in its application to operations in water from 10 to 25 fathoms and even more, the methods employed

are highly ingenious and withal simple. Described briefly it is as follows:—

On arrival at the spot considered likely by the skipper, a heavy anchor is put down and a buoy attached to the upper end of the anchor rope. To the same rope one of the hauling ropes is made fast; the cutter then takes a course that describes a sector of a large circle having the anchor buoy as the centre, paying out the rope and net as she proceeds; when all or nearly all of the net is payed out, the cutter turns towards the mark buoy and pays out the second hauling rope to its full extent. By the time this is nearly all out, the buoy should be reached. The end of the first hauling rope is then taken aboard and led, together with its companion, to a special reeling-in winch, worked off the motor engine. By a most ingenious arrangement the ropes as reeled in, are coiled down automatically on the deck, by an accessory device, patented by an Esbjerg firm, a great saving of labour to the crew. If the first haul be successful, the same operation is conducted again from the same centre, but over a different section of the circle around the buoy. A third and even a fourth haul may be taken from the same centre, new ground being covered each time, if plenty of fish be present.

The dimensions of a typical *snurrevaad* net as used in plaice fishing *(roedspættvaad)* are as follows:—

Length of wings (as given as Esbjerg), 26 metres (84 Danish feet).
Length of bag do. 10 ,,
Depth of wings at near end, 50 meshes.
Depth of bag at the mouth, 3 to 4 metres.
Mesh of the wings, 65 mm. knot to knot.
Mesh in the bag, 50 mm.
Mesh of the bunt or tail end, 45 mm.

A snurrevaad for haddock fishing (*kullervaad*) differs in several particulars as these fish are more active than plaice. The figures are:—

Length of each wing (as given as Esbjerg), 26 metres.
Length of bag (as given as Esbjerg), 15 metres.
Depth of wings at stick, 50 meshes.
Depth of bag at mouth, 7 to 8 metres.
Mesh of wings, 65 mm.
Mesh of bag and 1 fathom of wings, 45 mm.
Mesh of tail end, 35 mm.

When fishing in 10 or 12 fathoms, the bridle or hauling ropes are each 600 fathoms long; in 25 fathoms the length is increased to 900 fathoms. They can be used in considerably deeper water, even to 100 fathoms; with increased depth bridles or hauling ropes are made proportionally longer.

The cost of a new net (complete) in 1920 was from 500 to 600 kroner (Rs. 375 to Rs. 450).

Fairly smooth bottom is necessary for good results, and such we have in plenty on both our Madras coasts. Among the advantages possessed by this net are (1) the fact that it does not damage or crush the fish caught as does the trawl too often; a proportion may therefore be transported alive to shore in the fish-well installed in all these boats, (2) the capital required to build and equip one of these boats is not one-tenth of that required for a modern steam-trawler, (3) use by boats of a size small enough to enter harbours where 7 or 8 feet of water is all that is available and (4) low upkeep and running cost compared with a steamer; 4 hands are enough to man one of these motor-cutters.

The third of these advantages would be particularly useful on the Madras coasts, where Madras Harbour is the only one into which could enter an ordinary steam trawler with a draft of 10 feet or over. On 6 feet draft, such as the Esbjerg boats have, they could enter the harbours of Cocanada, Masulipatam, Tuticorin, Cochin, Beypore and Mangalore; these ports are therefore potential centres for fishing boats of this class.

XI.—THE ADMINISTRATION OF FISHERIES IN DENMARK.

The Fishery Administration is entirely regulative, statistical, and technical. The Director's offices in Copenhagen are modest and comprise no laboratories; he has no scientific experts on his staff, any help required on this side being obtained from scientific institutions usually connected with the Educational Department.

Apart from the purely supervisory and statistical duties of the department, which indeed take up a large portion of the attention of the officers, its activities chiefly concern the provision of financial assistance to fishermen to buy or build boats larger or more suitable to their needs, the provision of facilities for technical education, and the encouragement of co-operation among fishermen.

State loans.—Financial assistance is carried on by two methods; the first involves direct loans to the men themselves, the second is indirect, the money being distributed through the agency of co-operative associations. Under the former system Kr. 300,000 (Rs 2,25,000) is at present being utilized for loans direct to boat-owners; under the second, Kr. 200,000 (Rs. 1,50,000) is set aside to provide advances *in lump sums* to various co-operative societies, which are responsible for allocation in a proper manner. Direct loans are made upon the sole security of the vessel built, bought, or repaired; those to societies are upon the unlimited liability of the members—the whole of their property is pledged when they obtain admission to these societies. No society may be registered with a membership of less than thirty. The sum advanced may not exceed two-thirds of the total value or cost of the boat to be bought or built; in the case of second-hand boats, the advance may not exceed one-half the value. The method of repayment varies according to whether the loan is direct or indirect. When it is direct full repayment is nominally due within 11 years—in practice it is seldom less than 11½. During the first year no repayment of capital is asked for, merely the interest thereon. This is to allow for delays incidental to the commencement of any enterprise and to give time to the fisherman to rehabilitate his finances, strained usually in providing nets and gear and his share of the cost of the boat. Besides this, several months' more delay may be obtained for the payment of the initial instalment, by applying for the loan soon after one of the half-yearly dates (1st January and 1st July) on which instalments have to be paid in. The amount of annual repayment is fixed at one-tenth of the sum advanced, payable in half-yearly instalments.

In the case of loans obtained through a co-operative society no repayment of capital is required till the expiry of five years from the date the loan is made. During this period interest alone is paid. During the sixth year one-tenth of the amount must be repaid and the same sum annually thereafter till the debt is cleared off. This means therefore a 15-year period for repayment. The rate of interest is to some extent variable, being governed by the fluctuations of the bank rate. That current in 1920 was 4 per cent on loans made direct to fishermen, while that chargeable by societies is fixed at 5 per cent as a maximum. Every boat upon which a loan is made, must be insured for a sum sufficient to cover this advance, in an Insurance Society approved by Government.

The oversight of the insurance of fishing craft is another charge of Government, a special officer, termed Inspector of Insurances for fishing boats, being appointed to supervise the societies formed for this purpose. One of these is of great importance, its operations covering the whole of Denmark. Besides this, there are a number of smaller ones, purely local in their operations. The rules of some of these latter, being of more recent organization, are in certain respects better than those of the large society; I was informed that these improved rules will be adopted by the latter society when next its regulations are under revision. The rate of premium varies according to the locality in which the boats fish; in the protected waters of the Great and Little Belts and in certain sounds it is as low as 2 per cent, while for boats working in the North Sea it rises to $4\frac{1}{2}$ per cent.

Several of the local societies include a separate section for the insurance of nets and gear. As in the case of the Norwegian society mentioned previously, no one may become a member of the net-insurance branch unless he is already a member of the parent society and has his boat insured therein. The accounts also are kept separate and the greatest strictness is observed in ascertaining the correct valuation of the gear upon which insurance is desired; neither may it be insured for its full value—the owner must bear a substantial proportion of the risk on his own shoulders.

As in Norway all fishermen in common with seamen and land workpeople are compelled to be insured against injury or death in the pursuit of their calling on a system analogous to the British Workmen's Compensation Act.

The lines upon which technical instruction is afforded to fishermen approximate to those adopted in Norway, namely, facilities for the acquisition of the elements of navigation in so far as is suitable for a fishermen's vocation, and instruction in the running and care of marine motors. In one main respect the Danish method differs from the Norwegian; instruction is given at fixed centres and not by travelling teachers. This is due to the concentration of the Danish fishing industry at a comparatively few ports and to the comparatively short distance at which any outport is from one of the teaching centres.

In respect of navigation, there are three special schools maintained exclusively for fishermen. Each is given a subsidy to the extent of from Kr. 1,500 to Kr. 2,000 by Government, with extra grant

for every fisherman who takes the complete course. The amount contributed in this way is Kr. 15 per head per month. The fisherman student has also to pay a fee in addition, amounting usually to Kr. 20 per month. The course is held in the winter when work at sea is slack. In each school there is but one teacher; any man with the requisite qualifications may be appointed, such as a retired sea-captain, a harbour master or a pilot. The aim is to run the school as cheaply as possible, compatible with efficiency. Usually the teacher has some other calling or is a pensioner.

Motor instruction is run on similar lines.

The department has charge also of the registration of fishing boats. The law provides that all over 6 metres in length must be registered and numbered and have their port letter inscribed conspicuously on the bows. The initial registration is current so long as the boat remains in the same ownership, all that is incumbent upon the owner being to keep the marks and numbers in good order. If sold or the name changed, the certificate must be submitted for alteration.

The Norwegians, curiously enough, did not register and number their fishing boats until last year, when under the law of 5th December 1917, all fishing boats other than small open boats must carry distinguishing numbers and port letters. No fee is charged for registration.

This short and very incomplete note on Danish fishery organization cannot be closed without reference being made to the wonderfully useful "Yearbook of the Danish Fishing Fleet" edited by Mr. F. V. Mortensen, the Director of Fisheries. Outside of England, I know of no fisherman's handbook so useful as this. The fund of information contained is extremly well-chosen and extensive, ranging from a list of all registered fishing boats in Denmark with their number, tonnage, motor h.p. and ownership, to a polyglot list of the names of all common food fishes in six languages, or seven if we count the scientific name, which is also given. The laws on boat insurance, boat registration, State loans, and similar special enactments of interest to fishermen are given in full, together with particulars of all coast lights, harbour regulations and so on, far too numerous to catalogue here. The index of subjects contains 124 items and the little book—it is a small octavo of 7 × 4½ inches—runs to 388 pages; from this something of the extent of information contained may be inferred.

Further extension of the activities of the department are expected when the project matures of concentrating in one building, designed and built specially for the purpose, the three organizations which have bearing upon the welfare of the fisheries of the country. I refer to the scheme for a great institution which will house under one roof —(*a*) The headquarters of the "International Council for the Exploration of the Sea," (*b*) The National Fisheries organization, in charge of the Director of Fisheries, (*c*) Laboratories for marine biological research in charge of the University of Christiania.

C.—BRINE-FREEZING.

XII.—SCANDINAVIAN AND BRITISH METHODS.

One of the principal objects of my visit to Scandinavia was to observe at first hand the methods employed in the Ottesen and the Bull methods of brine-freezing. By the great courtesy of Herr C. C. Kyhne, Manager of the Danske Frysnings Company, the proprietors of the Ottesen patents, and of Herr Bull, the inventor of the "Blok" system, I was able to see both. The Ottesen Company were particularly kind as they arranged a special working demonstration at Esbjerg for my benefit. Besides these I had the wholly unexpected pleasure of seeing a third and very practical system, that of Mr. Nicolai Dahl, in ordinary commercial operation at Trondhjem, and also to see the original models of Wallem's system, which has given, it seems to me, the central idea for the apparatus devised by the Food Investigation Board in its experiments during and after the war at Billingsgate Market, London. Of this apparatus I was able to obtain full particulars. The only other important patents that I know of, taken out for brine-freezing, are those of Hesketh and Marcet (1889), Rouart (1898), and Henderson (1910). Of these the first two are vaguely stated as immersion of the objects to be frozen in brine brought to a very low temperature; so far as I am aware, they have not been elaborated in a commercial plant, hence may be disregarded. With the third, the Henderson, I was already well acquainted as the patentee had been in correspondence with Sir F. A. Nicholson, to whom he had communicated full details of this process, coupled with a general permission to use his patent in India without payment of any royalty. Both Sir F. A. Nicholson and myself have carried out experiments by this process with a considerable amount of success. Hence it may be useful here to review the systems with which I have now acquaintence, and which comprise all those of any commercial potentialities, viz., those of Wallem (1890), Henderson (1910), Ottesen (1913), Dahl (1913), Bull (1916) and the British Food Investigation Board's method (Adair and Piquè, 1918).

Before doing so, a few words are desirable upon the special advantages claimed for brine-frozen fish over fish air-frozen in an ordinary cold storage chamber. Put briefly these are (*a*) celerity

in operation, (*b*) retention of the natural appearance of fresh fish, (*c*) less loss of weight, (*d*) better keeping qualities when thawed out, (*e*) perfect naturalness of flavour and table appearance when cooked.

Celerity. – By any of the perfected brine-freezing methods herring can be frozen to the bone within half an hour, sprats in twenty minutes. If air-freezing were employed, at least twenty-four hours would be required. In the case of larger fish of about six pounds weight the period to freeze completely takes from one and a half to two hours compared with from thirty to thirty-six hours in air-freezing. Consequently in brine-freezing the time required to freeze a fish is from fifteen to twenty times *less* than if ordinary air-freezing be employed, obviously an advantage of the greatest value in the application of the freezing process to commercial purposes, and particularly in cases of sudden gluts.

The reason for the greater rapidity of the freezing process in an aqueous salt solution, "brine" as we term it, over the sharpest of sharp-freezing in air, even at much higher temperature than in the latter, is due to the fact that brine is much more efficient than air in abstracting heat from objects immersed in it. This follows principally from the great conducting power of water; air has a contrary property and is indeed an insulator, a property made use of daily by the employment of air spaces within walls to prevent the passage of heat. In freezing, therefore, the heat of the object treated is abstracted at a far greater rate when brine is employed than air.

To those who have no acquaintance with freezing principles, it may be mentioned that the reason solutions of salt (brine) are used is due to the fact that these mixtures have a much lower freezing point than pure water. The more highly concentrated the solution, the lower the freezing point. That of concentrated solution of common salt (sodium chloride) is — 21·2° C. (—6·16° F.), whereas for calcium chloride it is — 55° C. (— 58° F.). Because there is some penetration of the salt used, though it be very slight indeed, it is in practice found preferable to use a solution of common salt; this permits of the maintenance of a temperature quite low enough. Saturation is not necessary in practice and a satisfactory working solution is obtained by the addition of 3 lb. of common salt to each gallon of water.

The initial temperature of the brine before the immersion of the fish should be in the neighbourhood of — 15° C. (5° F.); fish do not

completely freeze until their temperature is reduced to — 9·4° C. (15° F.).

Appearance.—Air-frozen fish have often certain outward characteristics that condemn them in the judgment of the consumer. Consequently frozen fish—by which is meant air-frozen fish—fetch low prices compared with fresh fish in spite of all efforts to break down what the cold-storage firms declare is an unfounded prejudice; in the words of the fish salesmen "the British public will not buy frozen fish at any price if fresh fish be obtainable." The prejudice is, in fact, well grounded in the vast majority of cases. Impartial examination of average air-frozen fish shows unmistakable outward signs of deterioration in the sunken, cavernous eyes, and a slight but distinct shrivelling and wrinkling of the skin. On thawing, the fish, unless it possesses an exceptionally firm flesh such as the salmon has, assumes a flabby appearance wholly repellent and the wrinkling of the skin appears actually to increase. This soft flabbiness characterizes defrosted fish irrespective of the length of sojourn in the cold store; it is due to the rupture of the tissues in the manner mentioned below, whereas shrinking of eyes and skin is caused by the abstraction of water by evaporation during a prolonged period of exposure to cold dry air—in the case of air-freezing thirty to thirty-six hours with fish of 5 to 6 lb. in weight, and longer still when larger fish have to be dealt with.

When fish are frozen in brine, no loss of water by evaporation is possible; at the end of the process, the fish are absolutely of the same appearance as when they were put in, or rather they appear to have improved, being rigid and bright. The difference in the appearance of the eyes in fish frozen in brine and air respectively is perhaps the most marked feature; in the one, rounded and natural, in the other deeply sunken and dull; when thawed out, the difference in favour of the brine-frozen is intensified.

Loss of weight.—That an appreciably greater loss in weight takes place during air-freezing, is obvious from what has been said in the preceding paragraph upon the evaporation that takes place during the prolonged period necessitated by air-freezing.

Keeping qualities, and retention of flavour.—As already remarked air-frozen fish when thawed out, with certain exceptions due to specially hard and dense flesh, are flabby and soft, and in practice are found to go bad more quickly than either fresh fish or brine-frozen fish. Both the latter have almost identical keeping

qualities provided the frozen fish was absolutely fresh when treated. The reason for this great and vitally important difference is the mechanical effects caused within the cells and tissues of an animal (or a plant) by lowering the temperature to some point below freezing point (a fish does not freeze at 32° F. because of the saline constituents in the fluids and tissues). The effects are particularly marked in the case of muscle fibres and this is the economic fact of importance to us, for the edible parts of a fish are the great muscles that form the flesh of the body. These muscles are made up of extremely fine fibres, consisting of a delicate sheath enclosing stiff semi-gelatinous contents of highly complex chemical composition. It has been ascertained by microscopical and other means, that when such animal structures be subjected to temperature below that of the freezing point of water, the water contained within the thick semi-gelatinous contents of the fibre sheath, tends to separate out, gathering into drops which tend to run together to form large ones and to pass eventually through the sheath into the spaces between the fibres; this process goes on till the protoplasmic mass becomes honeycombed and converted into a shrivelled sponge-like frame-work. If the temperature be sufficiently low, the exuded water freezes and changes into ice crystals. The alteration thus produced are twofold—chemical and physical. The former consists principally in the separation of an essential compound, water, from the protoplasm of the cells (fibres), and its exudation into the spaces between; this if carried far enough definitely destroys the protoplasm; *it dies*, and as a consequence *post-mortem* change, *autolysis* it is called, becomes very rapid in thawed tissues altered in the way I have described by slow freezing. Among other chemical changes that ensue from autolysis, is one that is found to affect and destroy any particular flavour inherent in the flesh.

The physical change is more easily understood. It is common knowledge that water expands on freezing and that the more slowly freezing takes place the larger are the ice crystals produced. Consider then the disruptive effect on closely packed muscle fibres of the formation around them and within them of large ice crystals: on a microscopic scale the same mechanical effect is taking place that we see when a water-pipe bursts during frosty weather.

If, however, freezing takes place with great celerity as in the case of brine-freezing and we have seen that its rapidity is as 15 to

I compared with air-freezing, exudation of water from the fibres and the formation of large ice-crystals are entirely obviated. If the process be rapid enough the tissues remain physically and chemically almost entirely unaltered; the water within has been frozen almost in the molecular state. This is what happens in the case of brine-freezing and fully explains the difference in behaviour and appearance of air and brine-frozen fish after defrosting—the former soft and flabby with the cells and fibres collapsed, the protoplasmic contents dried up and altered, and the water formerly in combination within the cells and fibres, exuded and free among the tissues. Can it be wondered at that fish thus treated is insipid, flavourless, and ready to decompose still further? These ill effects are obviated by greater rapidity of freezing and this is attained more or less effectively in brine-freezing. Interesting proofs of the absence of chemical or physical change in living cells if frozen very rapidly have been afforded by experiments carried out by botanists and physiologists, who have shown that the life-activities of cells are not destroyed if frozen with great rapidity, and *may be resumed*, when thawed again. This is practical and conclusive proof, reinforcing satisfactorily the theoretical deduction to the same conclusion.

Methods of Brine-Freezing.

In the middle of last century prior to the introduction of mechanical refrigeration, the freezing of fish by immersion in a mixture of salt and ice was in commercial operation in America on quite an important scale. Subsequently artificial ice in Europe and America became so cheap that the rough and ready method of preserving fish for moderate periods and during transit by packing them in crushed ice became universal and still continues to hold its own in spite of manifold disadvantages.

An improvement upon the original brine and ice method was invented by Herr Wallem who about 1890 experimented in the refrigeration of fish. Models of his apparatus are preserved in the Trondhjem Fisheries Museum. His earlier model consisted of a barrel having longitudinally disposed deep ribs or baffle plates inside. After partially filling with a mixture of salt and crushed ice, the fish (herrings) to be frozen were put in and the opening closed, the barrel being then rolled along the ground to ensure constant movement of the fish within, for even at this early stage

the great advantage of continuous movement in accelerating the rate of freezing was recognized.

Wallem's second model was designed to obviate the crudity and inconvenience of rolling the barrel about on the ground. The later invention consisted of mounting the barrel lengthwise upon supports in such a way that it could be revolved readily by means of a handle attached to the end of an axial rod fitted at one end of the barrel. A square opening, provided with a hinged lid, permitted of the filling and emptying of the barrel. Whether Wallem's system was ever utilized commercially I do not know, but it is obviously directly related to the method elaborated in 1918 by the Food Investigation Board at Billingsgate Market, London, in the basal idea utilized in the latter design of a revolving cylinder provided with baffle plates (3) to keep the fish in motion during the duration of the process. The main differences are a great elaboration of the mechanical perfection of the process and the substitution of brine for the salt and ice mixture.

In its simplicity and adaptability to varying commercial needs by the provision of two different types of machine, this British design appears to be the most satisfactory of any until now devised. In its simpler form as seen working this apparatus consists of a number of large fish containers in the form of cylinders with perforated walls, revolving horizontally in a tank filled with brine. This tank has double walls at the bottom and both ends Evaporator coils fill the space between the floors ; that at one end is fitted with a filtering arrangement, while at the other are fitted one or more propellers to ensure the movement and circulation of the brine. The walls of each cylinder are made either of galvanized wire netting or preferably of galvanized iron plate with perforations of about $\frac{5}{8}$ inch diameter. Part of the cylinder wall is hinged in order to provide an opening for filling and unloading the cylinders ; in the inside three baffle plates, made of sheet iron, extend the whole length of the cylinder (*vide* Wallem's design of a barrel with similar baffle plates). The cylinders when required to be unloaded can be lifted out by hooks worked from an overhead crane. In the case of an apparatus of large size consisting of several cylinders, each may be filled with different kinds of fish requiring different times to freeze. The whole apparatus is placed in an insulated casing, with removable covers.

The second type of the apparatus is designed to freeze large quantities of the same kind of fish, the cylinders containing the fish entering and coming out of the brine automatically. It is needless to describe it here.

In operation, the tank is filled with brine made by dissolving 3 lb. salt in one gallon of water. For herrings this is cooled down to some point a little below 10° F. (— 12·2° C.). With other and less oily fish a lower temperature is required, for salt penetration depends upon two factors, the oily or non-oily character of the fish and the degree of temperature. The lower the temperature the less danger is there of salt penetration, similarly oily fish resist penetration much better than white-fleshed non-oily fish; for plaice the temperature should be as low as 0° F. (— 17·8° C.).

When the temperature has been reduced sufficiently, the cylinder is loaded with fish to about five-eighths of its capacity, and then lowered into the tank so that its spindle rests in the bearings provided. On one end of the spindle is a cogged wheel which engages an endless chain; this when set in motion turns the cylinder slowly; this rotation aided by the baffle plates keeps the fish in constant motion and so prevents them from adhering to one another and also from massing together and so taking a longer time to freeze completely.

The *Ottesen method* as developed in commercial practice is most practical. It is, however, in my opinion, inferior to the Billingsgate method in certain ways—(*a*) it has not such a perfect arrangement for keeping the fish in constant motion, though I admit that in working practice the movement obtained appears to be adequate, and (*b*) it entails more handling of the fish, for the freezing receptacles being smaller the operations are less automatic in operation. On the other hand it appears slightly simpler in design.

The Ottesen process has the merit of being in actual commercial use. A wealthy Danish corporation has acquired the Ottesen patents and has established large and well-equipped brine-freezing works and cold-stores at Esbjerg and Skagen in Denmark, at Gothenburg in Sweden, the North Cape in Norway, and Abo in Finland. The parent company, the Danske Frysnings Company, has a capital of Kr. 8,000,000.

The capacity of these factories is as follows:—

Esbjerg, a daily output of 30 tons of frozen fish and cold storage capacity for 550 tons.

Skagen, the same.

Gothenburg, 40 tons per day of frozen fish and cold storage for 1,200 tons.

North Cape, a daily freezing power of 20 tons and storage capacity for 400 tons.

Abo, the same as the North Cape installation.

The building at Esbjerg, which I had the privilege of inspecting with work in full swing, was specially designed, and appears admirable for its purpose. It consists of two floors; both appropriated in major part to the purpose of cold storage rooms.

The receiving room on the ground floor is furnished with deep washing tanks formed of concrete. Into these the contents of the fish boxes are emptied and rinsed in fresh water as quickly as possible to clean them from slime and dirt. Some fish as herring and mackerel do not stand even a short immersion in fresh water without deterioration, hence the need for celerity. The haddock on the other hand is tolerant and so constitutes one of the best fishes for freezing. Salt water is of course preferable but at Esbjerg the harbour water is too foul for the purpose!

As soon then as possible the washed fish are removed by means of hand nets and thrown on trestle tables alongside to be sorted out according to size, and placed, size by size, in different shallow wire-net baskets. It is necessary to do this for the size of the fish naturally controls the time required to freeze them, other conditions being similar (sardines take 15 minutes to freeze while salmon of good size require over two hours). The baskets are made with perforated zinc sides, and bottoms of square mesh galvanized iron wire-netting. Length 90 cm. by 50 cm. with a depth of 35 cm. These as filled are stacked in piles 7 baskets high, all containing the same grade of fish and secured by a special clamping frame. When complete each pile is considered a unit and is sent upstairs by a small electric lift to the freezing room.

The freezing room is on the first floor with the tanks sunk in the floor. Of these there are three series. At one side is a long row of small deep tanks or rather pits (18 at Esbjerg), each capable of taking a freezing unit of seven baskets. Parallel with these is a second series of three long tanks occupying the centre of the floor and outside of this is a third row of six other tanks. The latter tanks are where the brine is cooled to the necessary degree ($-14\frac{1}{2}^{\circ}$ C.), the interior being filled with coils of pipes containing CO_2.

The median line of tanks is for equalizing the temperature of brine from the different cooling tanks before it flows to the freezing pits. All these sets of chambers connect by high level piping in the following way:—each set of six fish-freezing tanks connect with one equalizing tank and each of these with two cooling tanks. A *low-level* pipe connexion also exists between the cooling tanks and the freezing tanks; in each of these pipes a propeller is fitted, drawing partially warmed brine from the freezing tanks to take the place of the cooled brine that flows out by the high level connexion first into the equalizing reservoirs and thence into the fish-freezing pits.

When the temperature in all the tanks is reduced sufficiently, i.e., to— $14\frac{1}{2}^{\circ}$ C., operations may be started by filling fish baskets in clutches of seven into the freezing pits after a final souse in fresh water in a small tank at the fore end of the line of freezing pits. An instruction board is hung at one end of the room on which is chalked the time at which the fish in each particular pit should be removed. This is necessary as the tanks are not all filled at the same time, and again one tank may contain small fish which require only one hour's immersion, while another lot of larger fish may require two hours to freeze.

A small overhead travelling electric crane is used for carrying the units to the pits and for lowering in and taking out. After freezing, the crane takes a clutch of baskets to a pit filled with fresh water and rinses them rapidly in it, partly to remove any dirt adherent and also to give a coating of frozen fresh water—"glazing" as it is technically termed.

From this point the baskets are carried to the packing tables, where the fish are rapidly transferred to wooden boxes lined with waterproof paper, and nailed down, the weight of each being marked legibly on the outside. After that they go to the cold storage rooms to await despatch. When more fish is received than can be dealt with in one day, it is stored with ice in an insulated store adjoining the receiving room. Here the fish can be kept absolutely good (in summer time in Denmark) for several days at an expenditure of 8 lb. ice to 20 lb. fish. The insulating material used throughout is tarred cork particles pressed into blocks.

To keep the fish fully frozen as long as possible when sending by rail in ordinary covered railway vans, the boxes are insulated roughly by surrounding the whole mass either with dried seagrass

(Zostera) or with wood shavings—the latter are preferable and cheaper, but are not always available. A 3-inch layer is laid upon the bottom of the wagon and up the sides and ends, as well as over the pile of fish boxes.

The Henderson process, patented three years before the Ottesen one, in essential features is the same in principle; its particular characteristic is a preliminary chilling of the fish, previously gutted, either in a weak brine of about 5 per cent strength or in a cold chamber (the former preferably according to Henderson's latest practice) at or just under freezing point, prior to immersion in a 20 per cent brine solution at a temperature between 5°—10° F. A circulation of brine is maintained during the freezing stage to accelerate the process. The patent provides also for the use in the freezing brine of a certain secret substance in minute quantity. There is some mystery about this, one writer speaking of it as a volatile harmless compound and another as "sugar or some innocuous material in very small quantity." Whatever it is, its absence appears to make no appreciable difference in the result, as judged by the numerous trials of this process made by the Madras Fisheries Department. The results were generally most excellent and there was never any question of the superior keeping quality of fish so treated over similar fish unfrozen, packed for rail transport in broken ice. The method, however, suffers from several minor objections:—

(*a*) it entails two handlings in freezing against one in the Billingsgate and Ottesen methods,

(*b*) the operation is slower, owing to the provision of a preliminary cooling tank and the extra handling entailed, and

(*c*) most serious of all, the slight salt taste sometimes imparted to the fish by their immersion in the chilling solution.

For all practical purposes, both the Billingsgate and Ottesen processes are preferable, as they suffer from none of the drawbacks inherent in the Henderson process.

The "Blok" system was patented in England in 1916 by Herr Henrik J. Bull, the Superintendent of the Chemical and Technical Experimental Laboratory of the Norwegian Fisheries Department. Its chief advantage was based on an alleged drawback in the Henderson and Ottesen process. Herr Bull pointed out that in both these, it is found that the frozen fish, by reason of their hard and stiff condition and frequently more or less curved form, cannot be

packed in boxes in an economical manner; comparatively few fish can be packed in one box and as a consequence the expenses of transport are considerably increased. By the Bull method it was claimed that this drawback was overcome. Shortly stated, it consists of placing the fish in shallow trays retained therein by removable wire net tops and bottoms, and frozen *in situ* into solid slabs of fish. The first procedure favoured was to freeze these slabs of fish in a mixture of salt and ice. This was quickly abandoned in favour of immersion in brine with means provided by means of a propeller at one end of the freezing tank to ensure circulation of the cooled brine, in a fashion closely related to that adopted in the Billingsgate method. At one time there was a great boom in Norway in favour of the "Blok" system and great hopes were founded upon its apparent practicability. It was pointed out that the method afforded a means to effect great economies in transport, and that if a van be filled with such frozen blocks superimposed in piles, one has a magazine of cold which of itself will keep the fish in perfect condition for a long time. There is also a great saving of space compared with the ordinary method of sending fish in boxes with broken ice packed amongst and around the fish. Only about 93 lb. of frozen fish can usually be put into an ordinary herring box, but by the "Blok" system over 150 lb. of frozen fish can be filled into the same box. Again, an ordinary fish box measuring $3 \times 2 \times 1\frac{1}{2}$ feet weighs when empty about 66 lb. and in it are packed 220 lb. of fish and about 110 lb. of ice. In the same box can be packed an average weight of 309 lb. of "Blok" frozen fish. The flesh of fish consists of about 80 per cent of water, hence it contains at least 75 per cent of ice and therefore a bulk of 309 lb. of hard frozen fish will contain or be associated with 231 lb. of ice, or more than double the quantity of ice used in the ordinary mode of packing. It will therefore bear a journey of double the length under the same conditions; concurrently it will reduce the freight to an extent of about 33 per cent on the same weight of fish.

The position theoretically appeared sound and exceedingly attractive. A company was formed and building operations were commenced. Unfortunately the late war at that particular time took such a turn as to preclude successful trade with Central Europe and the capital of the company was exhausted before any start could be made. The common mistake had been made of beginning

operations with a capital insufficient to endure any prolonged delay in reaching the profit-producing stage. I had the advantage of being shown the original experimental plant, installed in an outbuilding of the Bergen Biological Station, and of having the process and the vicissitudes of the promoting company explained in detail by Herr Bull, with whom I sympathize greatly in the extinguishment - for the time being only, I trust—of his hopes. The process has, I am convinced, substantial and real advantages of its own in regard to certain classes of fish.

There remains the Nicolai Dahl system to describe, a system that in spite of certain defects, appears to me the most practical and satisfactory of all in countries where ice can be obtained at a very low price. The only plant in Norway is situated at Trondhjem in the patentee's private packing house, and by Mr. Dahl's courtesy the opportunity was afforded me, when in Trondhjem, of inspecting it in detail and having its practical working explained by the inventor himself. Mr. Dahl, who has been working at the perfecting of his system since 1911, took out his first British patent in 1913. According to the specification the process consists in "causing the liquid (cold brine) to trickle down between the article from a point above the box or the freezing room (store, railway wagon, the hold of a vessel, etc.) in which the article is kept, thereby keeping the same constantly cool, while at the same time the liquid supplied has a preserving effect. In this manner the article will be thoroughly frozen in quite a short time without losing its fresh appearance, and thus without its commercial value being impaired. This is suitably and most advantageously attained by placing a freezing mixture of ice and salt at the bottom of the storage room, for instance the hold of a steamer, and utilizing the cooling and preserving qualities of the liquid generated from the said mixture."

Mr. Dahl is what is termed a self-made man, without the advantage of higher education, but extremely shrewd and long-headed. As may be inferred from this there are several points about his system, or rather about his way of employing it as seen during my visit, that outrages theoretical ideas, but to use the vulgar phrase "the proof of the pudding is in the eating," and the proof of Dahl's system is the fact that it is highly profitable and that it is in everyday operation in his packing house. The apparatus as worked in Trondhjem is located in a wooden single storey

building, unprovided with any special insulation. The freezing work is done on the ground floor, usually with the street door wide open. This room also contains the ice and salt stores, the salt, however, being simply piled in heaps on the floor. An ice-crusher breaks the blocks of natural ice employed in this factory into small pieces, and these by means of an electric hoist are carried to the roof and there shot down a shoot into two large square openings that lead directly into the two main compartments of the brine reservoirs in the basement beneath. Stretching right and left from the brine tank openings on the floor level is a long narrow platform with low sides, a few inches high. Along one side of the platform at a height of between 3 and 4 feet is the brine supply main, a $2\frac{1}{2}$ or 3 in. galvanized iron pipe fitted with short branches at intervals of about 3 feet. Each branch is fitted with a cock and a short length of rubber hose. One end of the brine main connects with the bottom of the brine reservoir in the basement; the other end is blind. A centrifugal pump is fixed at the beginning of the main.

The ice and brine reservoirs consist of two main compartments into which ice is fed, and an end compartment in which the cold brine accumulates and from which it passes to the brine main and centrifugal pump. An ingenious system of incomplete vertical partitions that act as baffle plates, causes the brine to pass through two masses of crushed ice before reaching the end reservoir. An essential feature of the system is the packing of the fish to be frozen, into trade boxes prior to be the freezing operation. These boxes, of a capacity of 50 kilos of fish (say 1 cwt.), are of special construction, the bottom being made of rather narrow boards spaced a short distance apart, so that the bottom permits of free drainage for any liquid that may find its way into the box. The boxes before being packed already have part of the cover nailed on, a strip along each side. As packed with fish the open boxes (the central board of the cover being still unplaced) are stacked in piles of three on the narrow brining platform, each pile directly opposite one of the short side branches with which the brine main is furnished. When sufficient boxes are ready for freezing the free end of the short rubber hose attached to each branch of the main is placed inside the open top of the uppermost fish box in each pile and the cock opened. Everything being now ready to begin operations, the centrifugal pump is started and this forces a steam of cold brine into the main and thence through the side branches in

steady flow into the topmost box of each pile. The cold brine as it rushes from the pipe, bathes the fish in the topmost box and thence passes by way of the slots in the bottom of the case into the box beneath and thence into the lowest one. From there it flows back along the sides of the freezing platform to the open mouth of the ice-filled reservoir to be rechilled by a double passage through broken ice, before it returns to the cooled brine reservoir to be re-circulated to the boxes of freezing fish. As undue dilution of the brine solution ensues because of the necessity to pass the somewhat warmed brine again through crushed ice, piles of salt are thrown into the gutters by which the used brine flows back to the ice boxes, to restore its strength.

The process is undoubtedly a wasteful one so far as ice and salt are concerned, and could not be used unless ice can be obtained at an extremely low price--the ice supplied to this factory costs only 15 kroner per metric ton, equivalent to about Rs. 11; if artificial ice were to be used the cost probably would be prohibitive. But under the conditions that prevail at Trondhjem, it is an undoubted fact that the system is operated successfully and profitably. As offsets to the great waste of ice and salt involved in the practice of this system are the small capital required to fit up a complete installation and the low running costs. The apparatus is extremely simple and inexpensive. The reservoir for the brine and ice may be made of wood, the circulatory system consists of a comparatively short length of iron piping with branches and cocks, and these with an ice-crusher complete the installation. The only power requisite is to work the pump and the little ice lift; power electricity is available everywhere in Norway--so this offers no difficulty in regard to capital expenditure.

The capacity of Mr. Dahl's Trondhjem plant is about 2,000 cases of frozen herrings per day, equivalent to 100 tons for the 24 hours. His plant can operate on 38 piles of three boxes each at one time. The freezing process takes usually about 1½ hour to completely freeze the contents of the boxes--rather less if the brine be specially cold or longer when reduced in frigor strength. The bulk of Mr. Dahl's frozen fish, herrings chiefly, goes to Germany, where it commands, so he informs me, a price *uniformly better* than that obtained for unfrozen fish despatched in broken ice. Usually the journey to Germany takes five days; for the first 10 hours of this period--as far as Hamar--the fish travels in ordinary covered

railway wagons; at Hamar it is transhipped into refrigerated vans and so passes to Central Europe.

A second plant, similar in operation to that at Trondhjem, is in operation at Gravarne near Gothenburg in Sweden. Mr. Dahl informs me that six other plants have been arranged for under his patent in California, for the freezing of salmon.

Those who have worked upon the brine-freezing of fish are unanimously of opinion, whenever the process selected has been properly carried out, that it offers incomparably greater advantages than air-freezing. Hence it is surprising how slow the British fish-trade generally has been to recognize the tremendous potentialities of the former process; even yet British firms eye it with conservative suspicion and disfavour, largely through want of discrimination between brine and air-freezing results. It was due solely to the exigencies of the war that the home authorities began to experiment and even the very successful outcome thereof has not made any appreciable impression upon those primarily concerned.

The French, who of recent years appear to have regained their ancient reputation for boldness of conception and for being least weighed down among the nations by the inertia of conservation, have gone much further, and 1920 saw the establishment by the French Government of a magnificent brine-freezing and refrigerating installation--so far as I know the finest in Europe—at L'Orient in Brittany. The plant is capable of producing 120 tons of ice per day, with ice storage capacity of 1,500 tons.

The object of the works is to deal satisfactorily with the cargoes of frozen fish received from another Government freezing installation at St. Pierre, off the Newfoundland coast, and also to treat whatever fish is caught locally in quantities exceeding the local demand for fresh fish.

The general method of operation in regard to local fish is as follows: the fresh fish is landed from the trawlers in boxes holding about 1½ cwt.; these are placed on electric trucks and taken into the factory alongside the tables for cleaning and sorting, on to which they are emptied. Very great care is taken in both operations, the fish being sorted both into varieties and sizes. They are then placed in wire-netting trays, each holding about one cwt., which are taken by an electric elevator over a monorail

to the freezing or the refrigerating tanks (both systems are employed), where they are at once placed in cold brine at the temperature of 5° F. for freezing or 23° F. for refrigerating. When frozen the trays are again picked up by the electric transporter and stacked ready for loading into railway vans or into the cold store chambers.

The time necessary for refrigeration varies usually from twenty to thirty minutes, and for freezing from 45 minutes to 2½ hours.

These fish-freezing works are designed to deal with a daily arrival and despatch of 400 tons of imported fish, in addition to freezing 30 tons of fresh fish, together with an output of ice of 120 tons.

With regard to India, if we can devise a method that will successfully counter the special disabilities attending all freezing propositions in a tropical country, its application on a large scale should, among other utilities, go far eventually to render it unnecessary any longer to turn immense quantities of wholesome sardines into manure. To canners, the application of brine freezing to their particular needs should prove an inestimable boon for stabilizing the industry; at small expense they would be able to ensure an ample reserve for use on the lean days when fresh fish are unobtainable, scarce, or high in price. In Scandinavia the utility of brine-freezing plants is already recognized by canners, and brine-frozen fish are now being utilized in this industry. Experiment has further shown that brine-frozen herrings are equal to fresh fish for kippering purposes.

The value of brine-freezing plants to obviate the waste that attends gluts is obvious; indeed this object is one of the principal reasons for the home Government's interest and experiments in this process.

Report No. 5 of 1921.

THE MADRAS MARINE AQUARIUM

BY

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INTRODUCTORY.

THIS aquarium has the distinction of being the only one on the Asiatic mainland; indeed, except for the ephemeral ones erected from time to time in Japan, it may be claimed as the first attempt of its kind east of Suez.

It was designed by Mr. E. Thurston during the last years of his tenure of the post of Superintendent of the Madras Museum; the present writer well remembers discussing the arrangement of the tanks with him, and giving what advice lay in his power, little thinking that the whirligig of time would bring him the responsible charge of its superintendence.

It was erected by the Madras Government primarily with a view to give the public an opportunity of learning something of the wonderful wealth of life in the sea at their doors, and partly to afford facilities for the study of the habits of marine animals. From the first it was an immense popular success, so much so that in 1912, the then Governor of Madras. Sir Arthur Lawley, decided upon enlarging it. The Fisheries Department had then come upon the scene and at the urgent representation of the writer that an aquarium is a necessity for efficient fishery research, Government decided to incorporate with the proposed new aquarium, a series of laboratories and offices suitable to form an up-to-date Fisheries Biological Station. Plans have been drawn out but as they are not likely to materialize for some years to come, the utmost has to be made of the existing aquarium.

The present building was opened to the public on the 21st October 1909. It remained in charge of the Superintendent of the Museum till 1919, when it was transferred to the Department of

Fisheries, for the two-fold reason that this department has particular need for aquarium facilities in the carrying on of its investigations of the life-histories of our local food fishes and because of the greater facilities it has for stocking and supervision. One outcome of the department's activities is the present descriptive guide; another is the installation of electric lighting and fans. That the improvements effected have been appreciated is proved by the great increase in the number of visitors who have paid for admission; in 1918–19 the total was 96,957 only, in 1919–20 it rose to 163,517.

On entering the main hall, five large tanks are seen on either side; a central floor pond for fresh-water animals and a number of table aquaria complete the accommodation available for the fishes and other animals on view. The aeration of the water in the tanks is dual, partly by the inflow of filtered sea-water from a high level reservoir, partly by means of an air compressor delivering air in a mist of tiny bubbles at the bottom of each tank. To obtain sufficiently minute division of the air stream, it is delivered under pressure through a filter candle hung in the tank. By this means the water is kept so well aerated that it is possible to maintain a permanent state of overcrowding seldom found except temporarily in the open sea. Unfortunately it is impossible to regulate this super-aeration to suit the varying constitutional susceptibilities of every kind of fish. Some suffer in consequence from a disease we may call "gas-eye." It arises from an excess of air finding its way into the blood stream, by absorption through the gill membranes; the outward sign of the disease is the partial protrusion of the eyeball. Some fish thus affected eventually recover, and all do so quickly if transferred to ordinary sea-water. The majority if left in the tanks and unmolested sicken and die, the actual cause of death being asphyxiation. But usually the sight of a protruding eyeball is the signal for an onslaught by its companions, particularly of certain species, who begin by viciously tearing out the offending eye and end by killing the victim if they can possibly manage it. Animal life in the sea has no place in its economy for hospitals and panjrapoles. As a consequence one never meets a cripple and very seldom a diseased animal in the sea; life there is for the healthy and the strong alone.

The recent installation of electric light enables the tanks to be brilliantly illuminated after dark; it is an improvement that has

been greatly appreciated. In some respects the fishes are actually seen to better advantage than under daylight conditions; troublesome reflections caused by bright sunshine pouring in through doors and ventilators are eliminated, while the flexibility permitted by the use of electric bulbs enables the tanks to be lit from the best possible angle. The fishes show perfect tolerance of this artificial lighting, however brilliant it may be.

All the fishes exhibited have been obtained in the neighbouring sea. Varied as is the collection, it represents but a tithe of the species common in Madras waters. Many, such as the hilsa, sardines and mackerel, are too delicate to stand handling and transport to the tanks. Others are unattractive or too bulky for exhibit and if accommodation is far too scanty to permit of showing all the interesting fishes procurable, practically none is available for the host of lower forms of life that constitute such charming features of public aquaria in Europe. We get in Indian seas gaudily coloured and quaintly fashioned crabs, wonderful spiny lobsters, huge prawns with antennæ a couple of feet long, sea-cucumbers in slashed dress of purple and canary yellow, crimson cushion starfishes covered with great knobs, lovely purple sea-urchins armed *cap-á-pie* with poisonous lances, jelly-fishes and violet siphonophores the hue of the deep sea, pelagic snails (*Janthina*) kept afloat by a wonderful raft of living bubbles, to say nothing of the myriad forms of coral life found on the reefs at Pamban, Kilakarai and Tuticorin. Scarcely any of these, for want of space, can be shown. No room in the large tanks can be spared even for the Octopus, that most fascinating and devilish-looking product of nature's fanciful marine handicraft.

DESCRIPTION OF EXHIBITS.

An aquarium handbook cannot describe the creatures living in the tanks in the precise order of their relationship to one another as found in a text-book of zoology. Of necessity many types are missing, either because they do not occur in Madras seas or because of difficulties in bringing safely to the shore or of maintaining in health when placed in the tanks. Active and delicate fishes of the sardine and mackerel families are particularly difficult to keep alive in captivity. Another source of trouble in placing fishes in their proper order in the tanks lies in the mental and moral attitude of certain species towards their fellows. As

with men, there are fishes with the predatory instinct highly developed; many are unabashed cannibals; others are of a nagging and bullying disposition, never happy except when teasing and snapping at others; another set revel in combats with their own or related species. It requires a large experience of the varying characters of the different kinds to know how to arrange "happy families" in each tank; sometimes individuals of the same species have to be kept apart to prevent quarrels and bloodshed. Hence the following notes cannot be arranged strictly in zoological order.

The whole of the illustrations in these pages are from original sketches by my assistants, Messrs. M. Ramaswami Nayudu, B.A., and K. R. Samuel.

TANK No. 1.

Indian waters abound in numerous species of sea-snakes. All are highly poisonous, with venom *much more deadly* than that of the cobra. Fortunately their disposition is sluggish; they never attack man unless trodden on or handled roughly, when, in fear and self-defence, they attempt to protect themselves by making use of their deadly poison. The few fatalities that happen among men are due to incautious barefoot wading about in shallows on coral reefs where these snakes are plentiful.

Till recently the sea-snakes in this tank had as companions a number of Muraenids (Sea-eels or *Pinnar pambu*), dogfishes and small sharks. They lived peaceably together, but the snakes were never able to get food as their more active companions gobbled all up before the slow-thinking snakes made up their minds to try for any. The sea-snakes were lately given the tank to themselves and now the larger species feed ravenously upon chopped up fish flesh, a curious change of habit, for in nature they prefer their food alive; in such a case the snake if it has the chance, seizes its prey towards the tail; its fangs pierce the flesh and almost instantly, within a couple of seconds, the fish gives a single convulsive writhe and subsides into immediate unconsciousness and death. Without at any time letting go its purchase the snake works its jaw-hold forwards along the body of its prey till it reaches the head when it opens wide its mouth and passes as much of the fish into its gullet and stomach as it can manage. If the fish be large—often a snake will kill and attempt to eat a fish as large as itself—the process of engulfment may take hours; during this time the tail of

the prey protrudes from the snake's mouth. They are fond of sardines, but spiny fishes they generally avoid.

A single small fish, one of the sea-perches, lives unmolested with these deadly snakes, and unconcernedly snaps up morsels of food from amongst their writhing coils at feeding time.

The colouration of the skin is generally inconspicuous, but one of the most deadly, *Hydrophis spiralis* (Tam. *Kadal sarai*), has developed a livery of black and golden chequers that renders it most conspicuous; this is generally believed to be an instance of *warning colouration*, a sign to any large predaceous fish that the wearer is dangerous; the value of this colouring is mutual—it prevents both creatures losing their lives, for though a shark or muraena may swallow and kill the snake, the latter would certainly inject a fatal dose of venom into the attacker before it died.

Sea-snakes are often plagued by the settlement upon their body of numbers of both acorn and stalked barnacles. The former of these pests are closely related to the little conical barnacles that often render rocks near high-water mark so painful to the barefooted visitor to the sea-side. Although they look more like a conical shellfish—a limpet with the apex of its shell cut off—in reality they are relatives of the prawns and sandhoppers as they belong to the same group, called in science **Crustacea**. The young of these acorn barnacles swim free in the sea for some days before they settle down and attach to some solid body—rock, sea-snake, turtle or even whale. The rest of their existence is spent in the same position; they exchange the pleasures of an unfettered life in the sea for the comfort of an ignoble but safe lodgment upon the body of some other animal (in this case) whose movements give the uninvited guest continual opportunity to capture food from the water around. The stalked forms are related similarly to the well-known ship-barnacles often found in myriads attached to the bottom of a ship that has returned from a long voyage.

More fortunate than turtles and whales, sea-snakes are able periodically to rid themselves for the time being of these unwelcome guests, for like land-snakes those of the sea shed their skin from time to time. As the time to do this approaches, a sea-snake becomes lethargic, floating passively just under the surface of the water. When in a thoroughly healthy condition as they now are these snakes shed their old skin in one entire piece; previously when in a state of starvation, the operation was tedious, the skin coming away in shreds.

TANK No. 2.

Various kinds of sharks and of their smaller relatives, the dogfishes, share this tank with ray-fishes and the snake-like members of the eel family. The sucker-fishes also are usually found in this tank.

As is well known, tropical seas swarm with many kinds of sharks, some attaining enormous dimensions. Fortunately man-eating species do not come near the shore in places where surf bathing is indulged in. They keep usually to deep water but the entrances to rivers and harbours, and anchorages frequented by steamers, have an attraction for them because of the quantity of garbage to be found there. The larger and more dangerous sharks are omnivorous and none too dainty in their tastes. On one occasion I found an enormous mass of feathers in the stomach of one—it surely must have made a meal of a feather pillow! The smaller species are often most exclusive in their dietary; some feed entirely upon crabs, others upon shellfish. All are usually most highly infected with parasites, tape-worms chiefly; books have been written on the wonderful adaptations evolved by these worms for retaining their hold upon the wall of their host's intestine. Hooks, suckers and imbedded bulbous heads are the chief devices employed; their variety is infinite, their suitability amazing for the purpose to be attained. And the names given by zoologists to these strange creatures are by no means the least wonderful of the strange things belonging to them. Imagine being christened *Hornellobothrium cobraformis* or *Myzophyllobothrium!*

But to return to the sharks and their relatives. These form a separate and strongly marked-off division of fishes, differing from all others in having a series of openings, called gill-slits, along each side of the neck. In the case of rays, which are flattened or disc-shaped fishes evolved from a shark-like ancestor, the neck being lost, gill-slits are found on the under side of the body some little distance behind the mouth. Another characteristic of the shark and ray family is the cartilaginous or gristly nature of the skeleton; there are no hard limy bones as in the bamin, sardine, or whiting. The form of the tail is also peculiar.

The ordinary shark is a handsome fish in the beauty of its "lines" and the sinuous grace of its movements. Usually their colours, like those of sea-snakes, are various shades of grey upon the back, white on the belly. But some of those forms which

we usually call dogfishes, are chequered and striped. One, the **Tiger Shark** (*Stegostomum tigrinum*), sometimes attaining a length of 15 feet, is striped with vertical bands of black in a wonderful way when young. He is the most brightly coloured of his tribe. The curious **Hammerheaded Shark** (Tam. *Kombau sura*) is common in these seas; young specimens are often entangled in drift nets and sometimes we are able to exhibit one in this tank. The reason of the name is obvious; each side of the head is prolonged laterally into a great rectangular projection, the eye being carried out with it. Large individuals are sometimes caught up to seven feet in length: these are accounted savage and are black-listed as man-eaters.

The **Rays** (*Thirukkai*) live on the bottom resting there upon their wide disc-shaped body; the upper surface is usually sandy coloured in life, so that as long as they remain quiet they are difficult to distinguish. Certain species have bright blue spots scattered over the back and others have various markings and marblings which probably are mimetic, that is, they harmonize with the colour of the bottom frequented by these particular species; a pebbly bottom or one marked by scattered clumps of low weeds and shells is imitated readily by fish with a tendency to brownish and whitish marbling. Among the most peculiar of the ray family are the **Electric Rays** (*Narcine indica* and *N. brunnea*). They get their popular name from the electric shock given out when touched. With an adult ray, the shock is so strong as to paralyse the hand and arm for the time being. Little ones of 6 or 8 inches in length, *usually shown in one of the table aquaria*, give out merely pleasurable thrills such as children love when handling toy electric batteries.

Nearly all the rays have long tails. Many have them whip-like in length and tenuity; these are often sold as curiosities by fishermen. Most of these whip tails are armed with one and sometimes two bony spines often a foot or more in length, closely barbed on either edge with cruel, backwardly-directed teeth. The wound inflicted by these formidable weapons is greatly dreaded by fishermen the world over; the hurt, besides being deep and severe, often festers and heals slowly. In some species actual poison appears to be secreted in a gland at the base of the spine.

The **Eel family** is represented in this tank by a true eel of a species very closely related to the common European species

(*Anguilla vulgaris*) and of similar habits. The form is snake-like, but unlike the snake, a distinct fin membrane runs like a crest along the greater part of the back and also on the under side of the tail. A little fin is also found on each side just behind the gill opening. The life-history of eels is perhaps the most wonderful of any known among fishes. The baby eel is hatched out in deep water far away from land and at first is a transparent pellucid little thing quite different from the adult. As it grows it gradually makes for the land; at last it reaches the mouth of some river together with multitudes of its fellows. By this time it has taken on something of the adult form,—a little wire-like fish and is now called an elver. In certain river estuaries these elvers congregate in their season in enormous numbers, all looking for some likely stream up which to swim. Although born in the sea, they now seek to pass inland till eventually they may be found in brooks and ponds, hundreds of miles from the sea. Gradually increasing in size the elvers change into the well-known olive brown snake-like eel and in this condition remain for several years. Sooner or later a new instinct arises, a desire to leave the quiet inland home and pass down to the sea regardless of all hazards. Simultaneously a brighter livery is assumed, the dark olive brown changing to a lovely golden yellow—a veritable bridal garment.

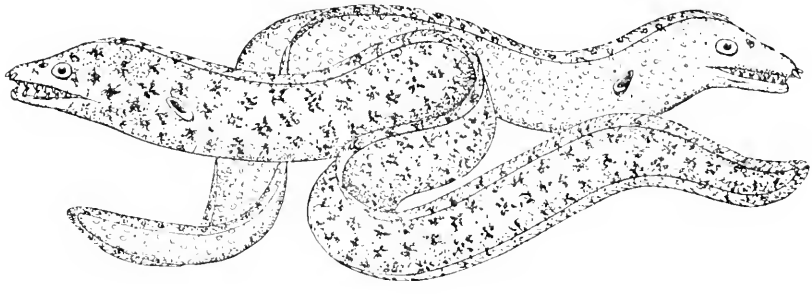

FIG. 1.—Two common Madras Muraenids.

Reaching the coast, the adult eels swim out to sea and there complete their life-cycle, by spawning. Presumably the old eels die thereafter, for no adult eel ever returns to the shallow waters near the land or to the rivers where it spent its earlier years. Only in 1920 were the breeding grounds discovered. Dr. J. Schmidt of Copenhagen, who has devoted many years of his life to this quest, at last succeeded and found them away on the far side of the

Atlantic, to the north-east of the Bahama Islands. The journey the young eels have to make to reach European rivers, is the longest migration known among the young of any animal.

Closely related to the eels, but without their interesting life story are the **Muraena group.** These Sea-eels (Tam. *Kadal vilangu*), as they may be termed, in contradistinction to the ordinary eel, which lives the greater part of its life in freshwater, are many in species and wonderfully varied in their colouring. Some are minutely spotted, others of black or brown colour are covered with a network of white or of orange lines, others are blotched and marbled. Some are nearly black, others orange yellow and many brownish in general tinting. They differ markedly from the ordinary eel in having no pectoral fins.

Were it not for their cruel faces, they might be termed handsome. Their looks do not belie them ; they are indeed cruel, ever hungry, ever on the watch for the unwary fish or crab. Their chosen home is among rocks. The honeycombed surface of a dead coral-reef is a favourite haunt, and I have actually been snapped at by one of these vicious creatures when walking over rocks at low tide. The beast heard my footsteps and suddenly darted his head out of the little pool where he lay and snapped at my foot. In this aquarium they show a peculiar gregarious habit. Till recently they were kept with the sea-snakes in tank No. 1. On one occasion, a new comer was put provisionally in No. 3 tank ; the next morning it was with its fellows in No. 1 tank. The attendant averred that this was a common habit, so, to test it further, another muraena was taken from tank No. 1 and placed in tank No. 3 ; it was restless from the first and, before long, came to the surface alongside the party wall dividing it from tank No. 2, reared its head and neck high enough up to get a purchase on the edge of the wall, and thereby pulled its body well up and then slid over into tank No. 2 ; repeating the process at the other side of this tank, it won home to its companions. In spite of this wish to be together, a smaller individual runs the risk of being devoured by his brethren if they be hungry.

Roman epicures were extremely fond of the muraena ; these fish were kept by the rich in stew-ponds and there are stories of the throwing of slaves into the muraena ponds as food for these voracious brutes.

Here or in tank No. 3, are generally to be found specimens of the curious **Sucker-fishes.** These fishes, sometimes called Remora, whereof "the shipholder," *Echeneis naucrates* (Tam. *Appukkutti*) is the most common species, are so called from the presence of a sucker-like organ on the top of the head. This sucker is compound, made up of a number of transverse plates set in an oval frame. By its help these fishes are able to attach to ships, whales, sharks, and turtles and so get carried about without effort on their part. They are commonly to be seen attached by the sucker to one of

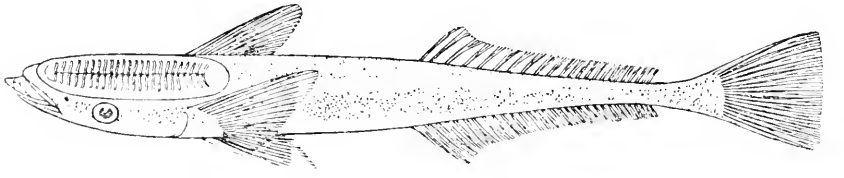

FIG. 2.—The Common Sucker-fish (*Echeneis naucrates*).

the walls of the tank. The power of adhesion of the sucker is marvellous; even a small sucker-fish of two feet in length will sustain a pail of water weighing over twenty pounds, if it be allowed to get a firm grip on the inside and then be lifted by the tail. Under water it can of course be made to drag a much greater weight with equal ease.

The refuse from a ship and the fragments from a whale's dinner furnish easily-got meals, but not infrequently they fall victims to a shark's hunger. The sucker is formed by a modification of the first dorsal fin.

Columbus, amongst other stories of the curiosities of the New World he gave to Castile and Leon, described how the sucker-fish was used by the Carib fishermen of the West Indies for the capture of turtle and fishes. With a cord attached to its tail, it was liberated from the canoe near the turtle to be captured; to this it attached, probably from no other reason than that it was a large solid mass, and held on tightly enough to permit the turtle to be hauled within reach. At the present day, this clever method of turtle-fishing appears to be unknown to the fishermen of Cuba. Parallel accounts have appeared of the practice of the same ingenious method on the Zanzibar coast, and it is said that Chinese fishermen also employ it. In our own tanks it exhibits

this habit of attaching to any large animal within its reach, even to a larger individual of its own species if this be the biggest fish in the tank. The habit has been acquired probably to enable it to gain its daily bread with the minimum of exertion. In other fishes (some of the gobies) a sucker is similarly formed by the modification of the ventral fins. In this case the use is not to facilitate transport without effort, but conversely to prevent being carried away by a strong current or the backwash of the surf. These particular gobies are but tiny fishes and have not the strength to withstand the force of water without the help of a specialized organ.

Our common species of Remora is banded longitudinally on each side with two conspicuous white bands enclosing a median dark stripe. Like many other fishes it has the power of suppressing or changing certain colour markings at will, and for a few minutes the white stripes along the sides often disappear.

A fish of quite a different family is sometimes mistaken even by fishermen for the common remora. This is the **Butterfish**, *Elacate nigra* (Tam. *Kadal virāl*). It has the same white bands enclosing a dark one along the sides and the slender form of the body adds to the resemblance. But it has no sucker and its habits are totally different. Instead of a picker-up of crumbs from rich men's tables, it forages for itself and its name of *kadal virāl* well describes its predatory nature and savage instincts.

TANK No. 3.

Among a crowd of pretty fishes in this tank, the palm of beauty must be given to one of the **Butterfly fishes** (*Heniochus macrolepidotus*) (Tam. *Sadakkan*). Its bold black and white banding and yellow fins arrest the attention. The dorsal fin carries a long yellow streamer often missing however, as it is too tempting to other fishes, who generally bite it off. *Heniochus* though slow moving is of a vicious nature and plays the bully towards the wounded or sick. A number of *Apogon aureus*, the marine goldfish, were at one time in this tank, and as these fishes are very susceptible to "gas-eye," one after another developed this ailment; no sooner did the eyeball protrude, than one or more of the *Heniochus* made an onslaught and plucked it out, afterwards attacking other parts of the body.

Another interesting fish here is the **Pearl-spot**, *Etroplus suratensis* (Tam. *Seththa-kendai*). Although small, it is likely to have great

economic importance in this Presidency; it has a fairly good flavour, looks well on the table and has the most valuable quality of being able to thrive as well in fresh water as in the salt and

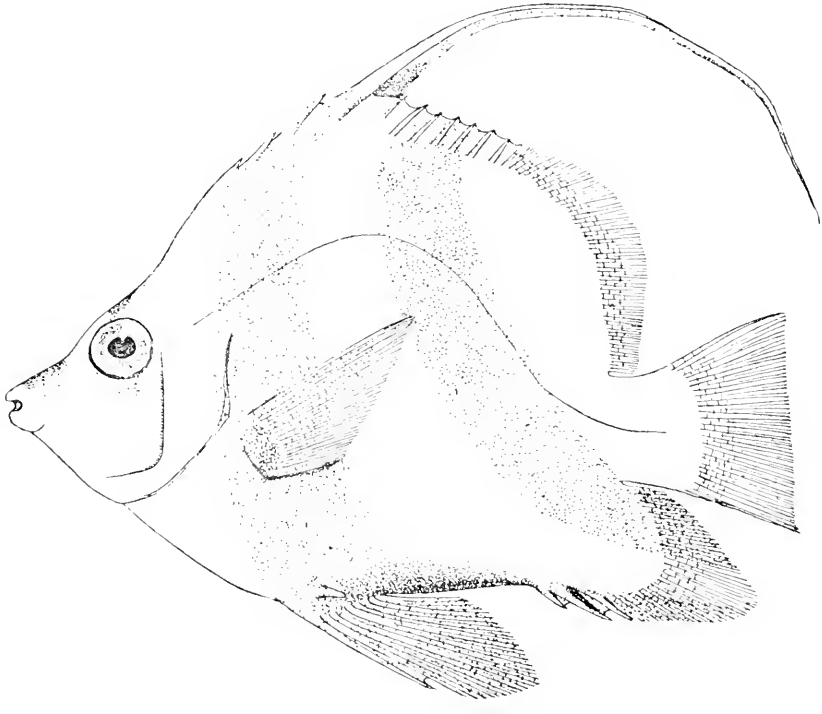

FIG. 3.—Yellow-finned Butterfly-fish (*Heniochus macrolepidotus*).

brackish waters of estuaries and backwaters. It lives equally well

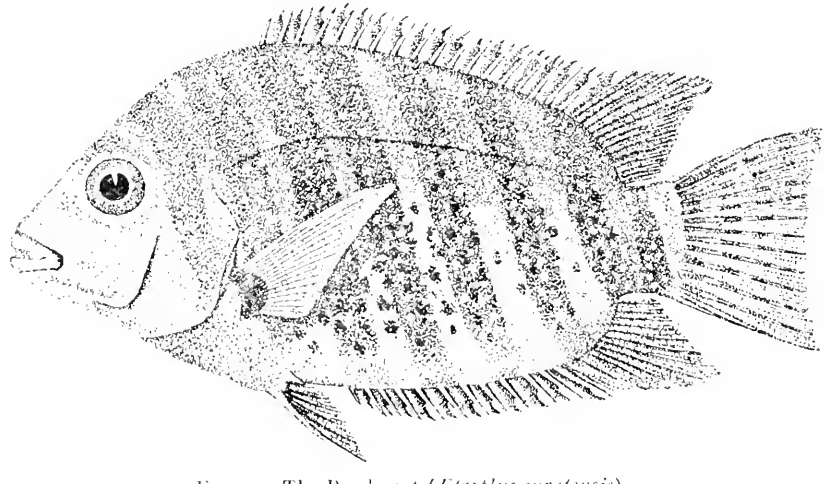

FIG. 4.—The Pearl-spot (*Etroplus suratensis*)

in the Adyar and the Fort moat as in the great irrigation tanks in Kurnool, away in the heart of Southern India. The female lays her eggs on the under sides of stones and logs; both male and female keep guard over the eggs till hatched, the male showing special solicitude. The Pearl-spot attains a foot in length and being largely vegetarian in diet and non-predaceous, is being used extensively by the Fisheries Department in improving inland waters by introducing it into tanks where it was previously unknown. It breeds both in salt and fresh water.

An interesting account of the breeding habits of this fish will be found in Vol. XII of the Madras Fisheries Bulletin, where Mr. N. P. Panikkar describes them in much detail.

Those Etroplus that live in fresh water are far paler in colour than those that live in estuaries; indeed the degree to which the bands are darkened is a fair index of the degree of salinity of the water where they live.

The pretty **Spotted Spade-fish**, *Scatophagus argus* (Tam. *Sippili*), so named *(argus)* from the rows of eye-like spots scattered over its silvery sides, is usually present in this tank, together with other of the many kinds related to the butterfly-fishes, all of which have the peculiarity of being flattened from side to side like the pomfret.

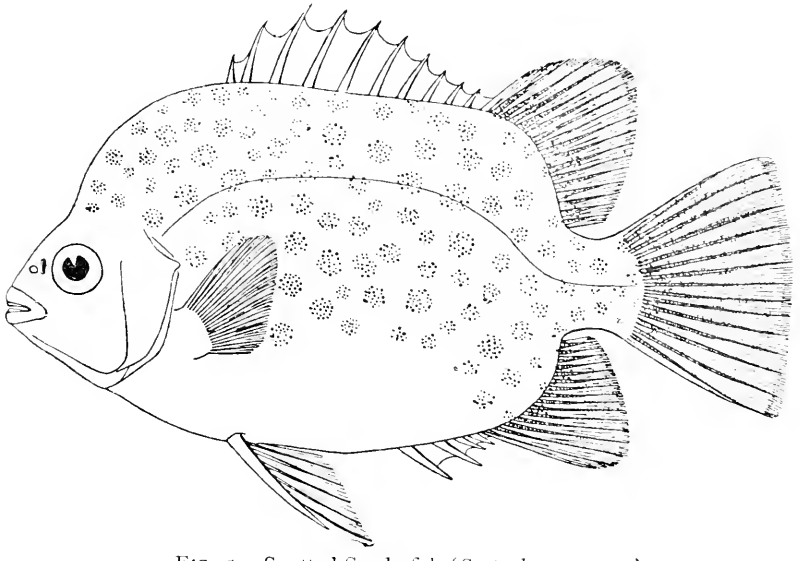

FIG. 5.—Spotted Spade-fish (*Scatophagus argus*).

Another inhabitant is **Cirrhitichthys aureus**, called *sangan* by our fishermen. It is a small fish, rose-tinted in faint longitudinal lines

and with numerous deeper-hued blotches. It has a peculiar habit of resting, tripod fashion, upon the tail and pectoral fins, folding down close to the body the intervening anal and ventral fins. It even moves about on the bottom by working the long pectoral finrays in the manner of legs.

Another pale red fish in this tank is the little **Scolopsis vosmeri** (Tam. *Kādai mīn*), remarkable for the presence of a great white patch on each cheek—possibly a "recognition mark," like the white buttocks of many antelopes and the little white bob-tail of the wild rabbit.

One of the few **Sea-Breams** of Indian waters, *Chrysophrys berda* (Tam. *Karuppu mattivan*), a stoutly built silvery fish, also lives in this tank.

Some of the **Horse Mackerels** and **Yellow Tails** (Tam. *Parai*), a common family in Madras waters, are occasionally on view in this tank, or in No. 6. They are silvery fish sometimes tinged on the fins with yellow, and with minute scales like the true mackerel. Their striking peculiarity is a row of bony shield-like

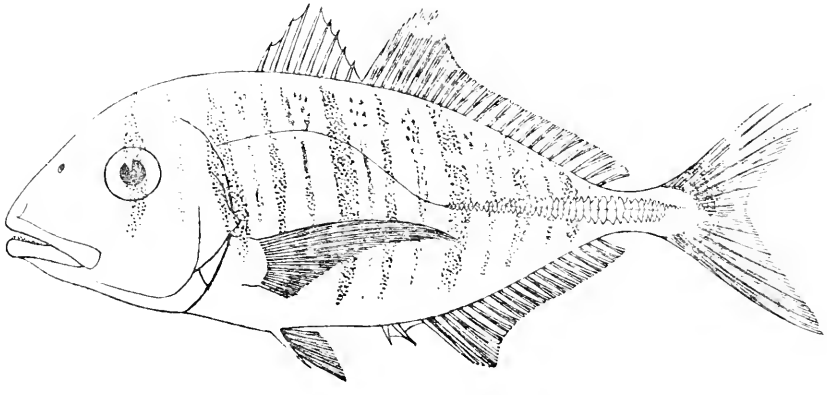

FIG. 6.—One of the Horse-Mackerels (*Caranx affinis*).

plates on either side of the tail. The larger species find ready sale although their quality cannot be classed as other than fair. Young ones have the habit of taking refuge under the umbrella-like disc of large jelly-fishes.

Examples of two common crawfishes of these seas, the **Spiny Lobster** (*Panulirus*) and the **Squat Lobster** (*Scyllarus*) are occasionally shown in this tank. Both have the curious habit of swimming backwards by means of a vigorous flipping of the

"tail." The dirty khaki colour of *Scyllarus* appears to be of great advantage in the struggle for existence, for they are very common on the Madras coast where many are caught in those fishermen's nets which sweep over the bottom. (See also page 93.)

TANK No. 4.

The **File** or **Trigger fishes** are represented here by several species, a brown one called *Balistes niger* (Tam. *Kuravan*), a deep blue one, which appears however of rich plum colour by electric light, *B. erythrodon* (Tam. *Pechchaikkuravan*), and a small orange-banded species *B. undulatus* (Tam. *Manjalvarikuravan*). Their English names are due to the presence of a great rough file-like spine in the first dorsal fin, that can be erected and locked in this position. The flesh is poor and in ill-esteem. In many people it produces poisonous effects, but the fishermen on this coast appear to be immune and eat large numbers, at least of the sober-hued species. It is possible that the more gaudy coloured species are the poisonous forms, and if so, the colouration here is of a "warning" nature.

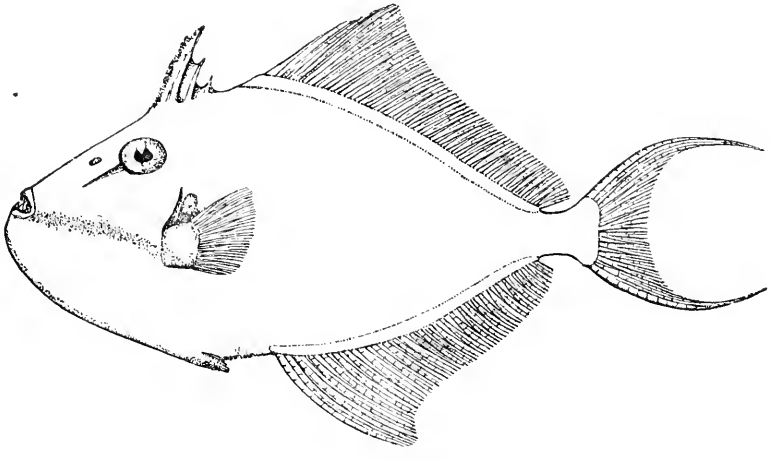

FIG. 7.—The Blue File-fish (*Balistes erythrodon*).

The Blue file-fish is exceedingly handsome, and has the peculiarity of having red teeth; the tail fin is strangely elongate and crescentic in this species. When resting on the bottom it lies over on one side. The smallest of these file-fishes, the striped *Balistes undulatus*, is extremely pugnacious towards its own kind; if two are in the same tank—males probably—they often indulge

in a fight to the death. They will attack and kill fishes considerably larger than themselves, for example one recently killed a young tiger-shark, a foot in length.

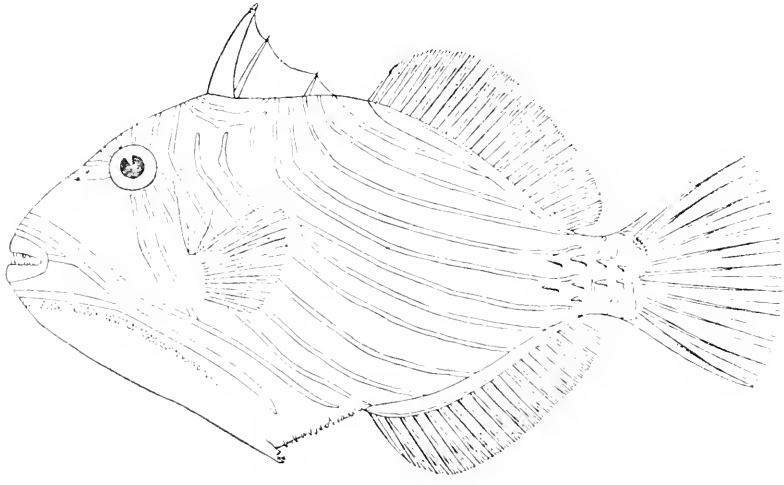

FIG. 8.—The Yellow-striped File-fish (*Balistes undulatus*).

Other fishes are the horizontally banded *Therapon jarbua* (Tam. *Palinkichān*), a little sea-perch very common in the sea and the backwaters about Madras. In numbers it makes up what it lacks in size and though of little market value, it has for that very reason much importance for the poor.

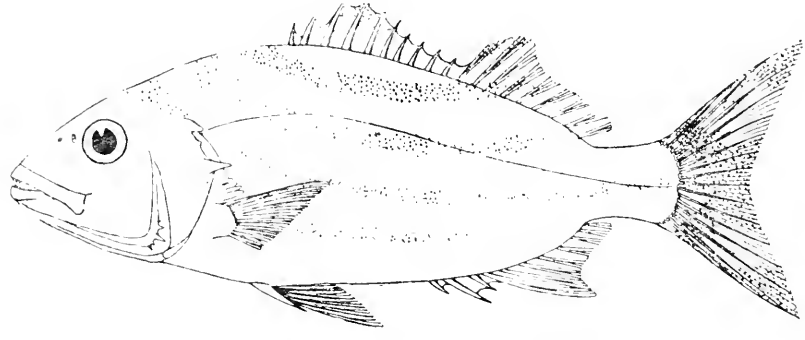

FIG. 9.—The Zoned Perch (*Therapon jarbua*). × $\frac{1}{3}$.

TANK No. 5.

A crowd of pretty fishes of diverse relationships are herded together in this tank. The prettiest and certainly the most striking in colouration is one of the **Sea Perches** or **Schnappers** called

Lutianus sebae (Tam. *Kondankaravāi*). It is common in the vicinity of Madras, but is never seen at Tuticorin. When first brought in from the sea its colour is magnificent—broad crimson bands crossing the body upon a snowy white ground. After a time the crimson fades to a deep rose, still most lovely in its contrast with the white. When excited and also during feeding time, the white ground colour assumes a rosy tinge. Young specimens are generally attacked by the larger ones when put together in the same tank. Another species, *Lutianus annularis* (Tam. *Kattupirioni*),

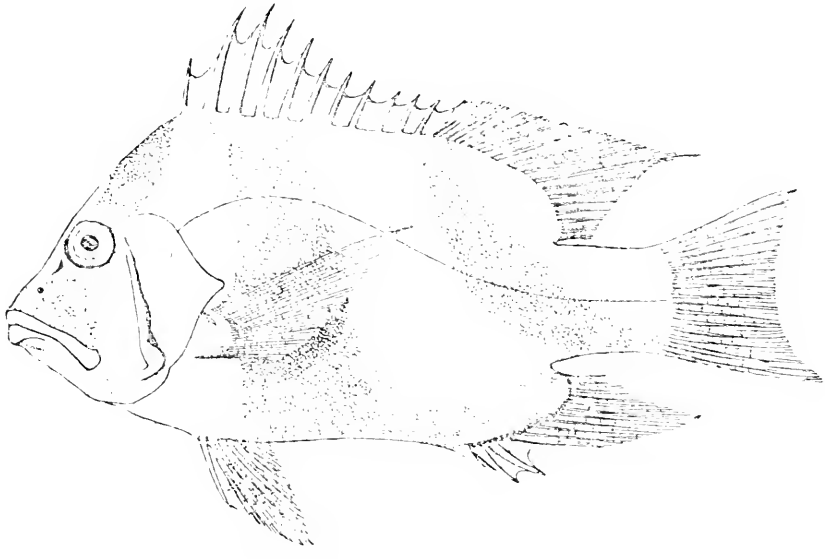

FIG. 10.—Banded Schnapper (*Lutianus sebae*). × $\frac{1}{5}$

is usually to be seen in this tank, its forehead marked by a longitudinal dark band with other bands on the body. At Tuticorin these body bands do not appear. Other species of this genus are often present in tanks Nos. 6 and 9.

Other noteworthy fishes here are the **Spinetails**, usually so much flattened in form and expressionless in features as to give an impression of artificiality—cardboard fishes ready to paste upon a screen as a decoration. They are easily recognized by the presence of a remarkable and powerful spine on each side of the fleshy part of the tail. Each spine has a sharp cutting edge and when erected—it lies when quiescent in a groove—serves as an efficient weapon of defence. Several species are shown. *Acanthurus lineatus* (Tam. *Varikkōzhimin*) is pale blue with yellow lines

while *Acanthurus matoides* is striped longitudinally with wavy blue lines on a brownish ground. When excited the colours intensify and darken. These spine-tails are quiet and inoffensive as a rule, but when excited, they become dangerous, and wounds inflicted by their spines are dreaded by the aquarium attendants.

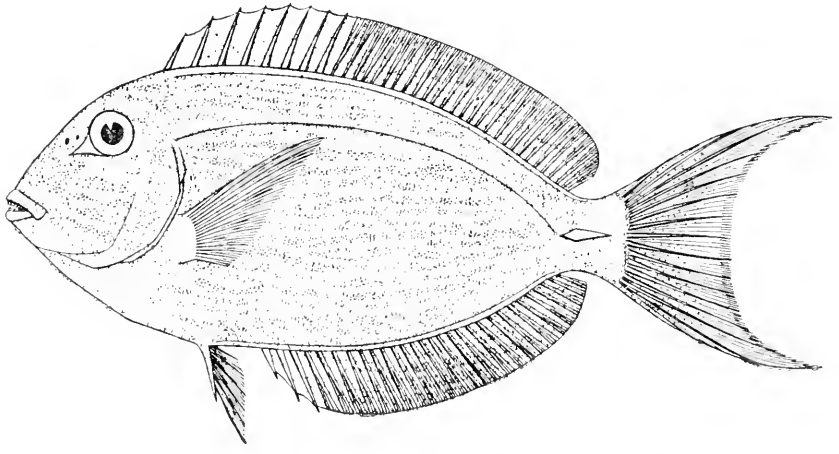

FIG. 11.—The Banded Spine-tail (*Acanthurus strigosus*).

The curious **Unicorn fishes**, *Naseus unicornis* (Tam. *Mullikkōzhimiu*) and *N. brevirostris* (Tam. *Puliikkōzhimiu*) are sometimes present; they seem much rarer than their relatives of the genus *Acanthurus*, from which they differ in their smaller and usually more numerous tail spines. Their distinguishing feature is a prominent bony projection, the caricature of a nose, jutting out from the forehead, between the eyes. To meet a shoal of these fishes, as the writer did once when on the bottom of the sea in a diving-dress, is a weird and uncanny sight, made more so by the unblinking stare of the great expressionless eyes.

Of gaudy **Parrot-fishes**, perhaps the brightest hued of all coral-haunting fishes, the pretty *Julis lunaris* (Tam. *Pachai-elimin*) is usually to be seen here, easily recognized by reason of the metallic sheen of the blended green and blue and orange that make up its colour scheme and the handsome crescentic form of its yellow tail, unfortunately often bitten down to a stump by its tank mates. The teeth are most powerful in this family, as well they may be, for they browse largely upon branched corals. They are not esteemed highly as food.

TANK No. 6.

The little **Goat fish** (*Upeneus indicus*, Tam. *Kalnavarai*) is one of the most interesting fishes here. It is closely related to the Red Mullet, so esteemed among Roman epicures, and like it, is excellent eating. Under the chin are two stiff white prong-shaped processes termed barbels; at rest these lie folded back in grooves, in use they are erected and employed to rake the sand in search of food. As the fish moves slowly over the bottom these barbels move alternately like two stiff legs and give the impression of being used for locomotion. In life the colouring, like that of the Red Mullet, is red streaked with lines of clear yellow; if the scales be scraped off, the bright scarlet of the skin shows up more clearly; European fishermen regularly do this to enhance as they think, its value.

Larger and more striking in general appearance are the **Butterfly fishes** belonging to the genera *Holocanthus* and *Chaetodon*. They are by far the most gaudy of tropic fishes, their haunts coral reefs and rocky banks abounding with bright coloured sea-fans. The majority are quite small, but the lovely **Emperor fish** (*Holocanthus imperator*, Tam. *Kullikôzhimin*), striped bright blue and canary yellow, reaches the length of about one foot. On the Tinnevelly coast the fishermen name this gorgeous beauty, the *Vannatthi* or "Dhobi's wife," a sly hit that will readily be understood. The varieties of these Butterfly fishes are as numerous and diverse as are those of the butterflies of the land. Some have blue sides marked with concentric oval white lines, others have bright blue stripes on a brown body, or a brown body with yellow shoulder spots and yellow fins, while many have broad dark bands, oblique or vertical, crossing the white or yellowish sides.

The **Chaetodons** are thick skinned and their colours so striking that they are favourites with the taxidermist; many museums in the world show quite large series of atrociously coloured fishes of this genus that deserve to be relegated to a special chamber for museum oddities and caricatures.

One foreign Chaetodon, *C. capistratus*, the so-called "Four-eye," remarkable for a great eye-spot on each side just in front of the tail, has the curious habit of tending other fish for the same purpose as the white paddy-birds pay such attention to the water-buffalo. The fishes thus served appreciate the service and will

open their mouths invitingly to the "Four-eyes" that these may search within for any parasites that may be there.

The **Jew fishes** or **Sciaenidæ** (Tam. *Kathālai*) are usually represented here by several species. They are amongst the most important Indian fishes of economic value; on the West Coast (where they are called *Kora*) they are caught in great quantity; around Madras smaller species abound and it is a curious fact that

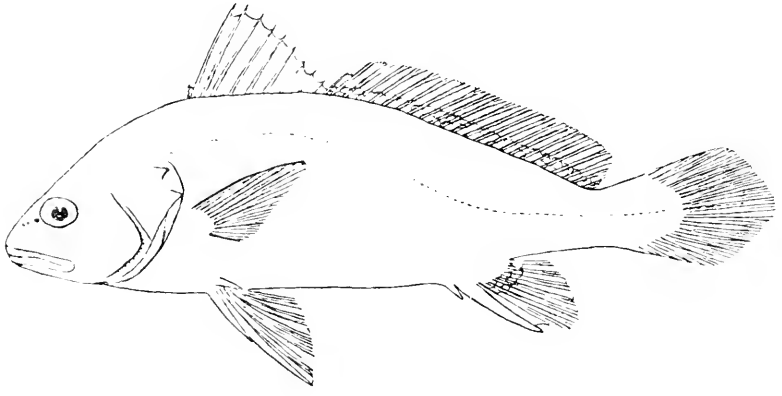

FIG. 12.—Jew fish (*Sciaena miles*). × ¼

while the large species are excellent eating, the small are soft-fleshed and insipid. The swim-bladders obtained from large Jew-fishes are dried and exported as "fish-maws" or "sounds" for conversion into isinglass.

Various other sea-perches are present from time to time; to enumerate them here would be tiresome and of little or of no service, as a coloured and named figure of each will be found in the frame along the upper edge of the tank.

TANK No. 7.

This tank is largely appropriated to a fine show of that magnificently ornate creature, **Russell's Scorpion fish** (*Pterois russelli*, Tam. *Thumbimin*), so named in honour of Dr. Russell, the first Englishman to make a scientific study of Indian fishes.* In some ways this is the most interesting and striking fish in the Aquarium. The fins have attained a size far beyond anything

* When stationed at Vizagapatam he made an extensive collection and in 1803 the East India Company published his descriptions of 200 of these, under the title *Fishes from the Coast of Coromandel.*

requisite for swimming; indeed it is notably slow-moving and lethargic, hence this monstrous development must have some other reason. Besides a great lengthening of the bony rays that support the fins, the membrane between them has been increased so greatly that the fins have come to simulate the frills and furbelows so common in ladies' dress in the Victorian age. And the fish is beribboned as well, for many of the fin rays are prolonged beyond the main frilling of the fins, while leafy outgrowths sprout from the lower border of the face. As the body colouring of shades of brownish red on a whitish ground is continued upon the fins

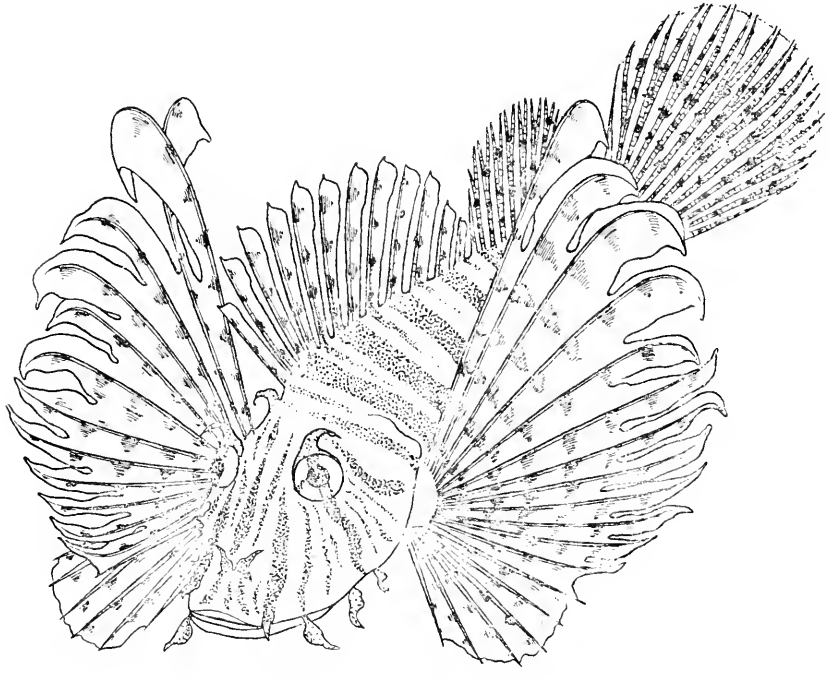

FIG. 13.—Russell's Scorpion-fish (*Pterois russelli*). × $\frac{2}{3}$

to the end of the uttermost fluttering ray-ribbon, the *tout ensemble* is peculiarly arresting. The fish's movements too are those of the mannequin on show; when it swims, it sails along very slowly and gracefully with a just perceptible fluttering of the great butterfly-like fins; it often halts for quite a considerable time as though asking for admiration and at times will even slowly rotate that one may view it from all points.

When in its favourite stationary attitude, its fins gently quivering, it has much the appearance of a stone decked with fluttering

red-brown seaweed. Some have suggested therefore that this is a case of protective colouration, but this I doubt. The quick-eyed people of the sea are not so easily deceived and in my opinion its colouration and form are more likely to serve as warning signs that their owner is an unpleasant morsel, and one best left severely alone. This seems the more reasonable as this fish is particularly bony and is able to inflict dangerous wounds with the spines of its dorsal fin, which are provided with poison glands. The aquarium attendants have, if anything, more fear of handling this fish than they have of the deadly sea-snakes.

Possibly the weed-like appearance of this fish has a secondary mimetic purpose, for while I do not think that large fish that might prey upon it would be deceived, this may happen in the case of the tiny fish and fry that it feeds upon. Their outlook in life is so circumscribed that they may well take the mass of fluttering reddish ribbons to be a bunch of weed and so approach it in misplaced confidence with fatal results.

In the same tank are several examples of a large-eyed brilliant copper-red fish which may appropriately be called the **Blotch-eye** (*Myriopristis murdjan*; Tam. *Mundakankākāsi*), of a genus that had many representatives in byegone days and whose fossil

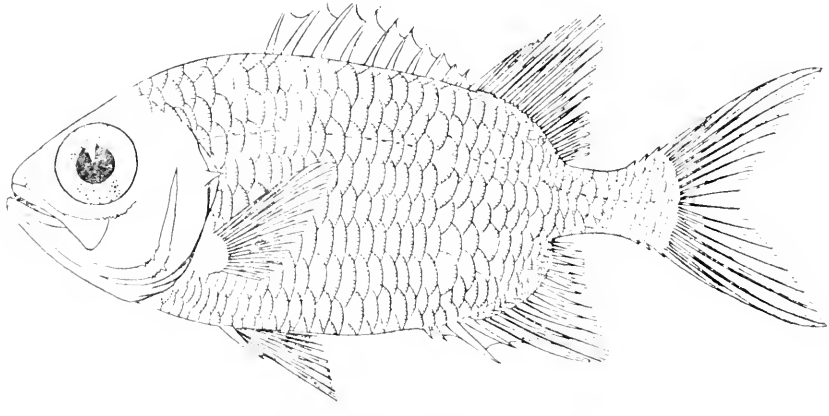

Fig. 14. Blotch eye (*Myriopristis murdjan*).

remains are common objects in geological museums. They often suffer from "gas-eye" and in this condition are unable to maintain themselves in a horizontal position; instead however of floating head up they float vertically with the tail up. A remarkable dark blotch passes through the eye, with another behind the gill cover

or operculum; the tip of each fin is also ornamented with a similar dark blotch.

Closely akin to the well-known Pomfrets are the curious Bat fishes whereof the **Black Bat-fish** is the commonest. In these fishes the dorsal and anal fins are so excessively elongated as to give the body a crescent-like form—a weird black crescent moon traversing a slow and stately orbit within the limits of this small tank. In the young condition one of these fishes (*Platax vespertilio*), often found in inshore pools on the rocky coast of south-west Ceylon, has been noted as simulating in form and colour a dead leaf, resemblance heightened by its habit of reclining on one side for minutes at a stretch.

Examples of two species of yellow **Angler-fishes** are always present in this tank. The smaller one, *Antennarius hispidus* (Tam. *Thoppaimin*), is common at Madras.

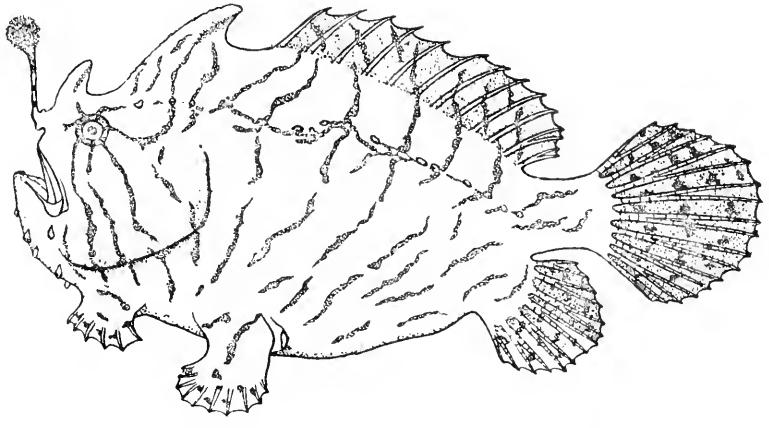

FIG. 15.—The Yellow Angler (*Antennarius hispidus*). × ¼

Like its well-known relative in European waters (*Lophius*) it has the first dorsal fin-ray modified into a miniature fishing rod with a fluffy white tassel at the end to represent the bait. The angling habits of the two differ considerably; the big European fish buries his body in the mud, the bait and a length of the rod protruding, to tempt the curiosity of other fish, whereas the Madras fish is a lumpy little fellow who loves to hide his yellow body striped with brown among sea-weeds. There he remains motionless, camouflaged exactly in the same way as a tiger in a thicket of reeds or bamboos. All that ever moves is the rod and bait. The former is hinged near the base and the tassel bait is often flicked up and

down to attract the inquiring eyes of some little fish or prawn. Woe to those who give way to their curiosity! The little Angler may be inert as a stone while awaiting his prey but on these occasions his jaws and throat are galvanized into surprising activity—the prey is instantaneously sucked into the gaping mouth, the jaws shutting with a snap. If danger threaten the "bait"—it would be a misfortune to have it bitten off—the rod folds down and the tassel-like end snuggles into a little pit between the two strong fin spines immediately behind the fishing rod. As he lives almost entirely on the bottom, his breast or pectoral fins and in less degree the ventral ones also, are modified into hand-shaped claws, most useful to elbow him quietly over the sand and gravel.

They occasionally spawn in the tanks; the eggs, extremely numerous and tiny are embedded in a colourless gelatinous band-shaped sheet, relatively of enormous size compared with the parent. One such sheet deposited early in September 1919, measured 9½ feet in length, with a width of 6¼ inches.

A second species, *A. nummifer*, is also found at Madras, but is distinctly less common. In this the body is smooth and in colouring irregularly blotched.

The feeding of these anglers causes the attendant considerable anxiety; they are so accustomed to have their prey come to them and literally fall into their mouth, that when feeding-time arrives, their more active tank companions give them no chance to get any food. The attendant gets over this difficulty by transfixing a morsel of fish on the end of a long wire and dangling it above the face of the fish. The temptation does not always succeed; this fish takes so long to make up its mind that as often as not a scorpion-fish pounces on the morsel and the whole operation has to be gone through again—a situation that tries the patience of the attendant and often results in the angler having to go without his dinner.

TANK No. 8.

Of the numerous kinds of fishes in this tank, the most noteworthy are the **Globe** or **Puffer fishes**, distinguished for the curious property they possess of being able to blow themselves up with water or air when alarmed. Few are brightly coloured; among these is the one called *Tetrodon patoca* (Tam. *Pullipilachai*) which shows pretty shades of yellow and green on the sides and throat when distended. The fore part of the gullet in these fishes is enormously

developed as a great pouched sac passing backwards between the skin and abdominal organs. By admitting air or water into this it puffs out like a balloon, doubling at once the diameter of the body. At the same time the thorny spines that lie at rest in the skin, are erected to add emphasis to the horrific appearance of the creature—a marine counterpart of the fretful porcupine. To add to its defences, the flesh is esteemed to be poisonous; indeed it is the only fish with really unwholesome flesh in our waters, though under certain exceptional or seasonal conditions some other fishes may occasionally (rarely) induce symptoms of poisoning.

These Puffers are very common at times in the shore seines (*karai valai*). When drawn from the sea they instinctively inflate themselves and as it is now air with which they are filled, they float helpless, upside down, if thrown back into the sea. These animated footballs are, of course, the joy of every child that is lucky enough to find one on the beach. In Japan the skins are dried inflated with a filling of paddy husk, and later when emptied, are often made to play the part of Chinese lanterns, a candle being ingeniously introduced within.

The scientific name of the genus is *Tetrodon*, in allusion to the parrot-like jaws, each armed with two great white cutting teeth, sharply edged, capable of inflicting a nasty wound. Puffers are among the many enemies that young pearl-oysters have to contend with.

Amongst themselves there is continual strife, and the commonest species at Madras, *Tetrodon oblongus* (Tam. *Karum pilachai*), is particularly pugnacious when excited or hungry. They are apt to set upon any weak or sick fish in the same tank, crowding round it and while one gets hold of the tail, others tear at the pectoral and other fins and the rest bite pieces out anywhere they can get a grip with their great parrot-beak teeth. Whenever Puffers are kept together, they appear a ragged, crippled crowd; not one amongst them can boast an entire tail; the other fins are also often bitten down to mere stumps.

Several specimens of that handsome and useful food-fish, *Drepane punctata*, the **Spotted Dory**, find a home also in this tank. Known in Madras as *Pullithirattai*, in the Gulf of Mannar it is called *Painthai*. It usually moves about in shoals and is one of those bottom-haunting fish that should be caught in large quantities when steam-trawling shall begin to take adequate toll of the

inhabitants of the sea, which our inshore men with their inefficient gear are quite unequal to do.

TANK No. 9.

This tank is the usual home of Pomfrets, Grey Mullets, Cat-fishes, Soles and other Flat-fishes and of various species of the larger sea-perches for which room cannot be found elsewhere.

The **Pomfrets**, better known on the Bombay side than here, are represented by three species in these waters, the **White Pomfret** (*Stromateus sinensis*), the **Silver Pomfret** (*S. cinereus*) known as the Grey Pomfret when adult, and the **Black Pomfret**, which is really not a Pomfret (*Stromateus*) at all, being more nearly related to the Horse-mackerels (*Carangidæ*). All are deservedly among our most highly esteemed Indian food-fishes, taking the place on our tables of the sole and plaice of home waters. Unlike the latter fishes, they swim upright in the water, but as they are compressed greatly from side to side and are deep from back to belly, they have much the same appearance as the plaice when we see them in the cooked condition. Though common here they never reach the incredible shoals met with on the Bombay coast, where they share with Jew-fishes and Bombay-ducks the credit of being among the three most valuable classes of food-fishes of that coast.

Of extremely compressed form are the true **Flat fishes**, the *Pleuronectidæ* of science. Though not often seen in our markets, they are common enough, as for example the **Indian Sole**, *Plagusia marmorata*, known to Tamils as the *Nākkumin* or Tongue-fish, and the **Indian Turbot** (*Psettodes erumei*, Tam. *Erumei nākku*). All these fishes are much flattened and have the habit of habitually lying upon one side—the so-called "blind side." This side, besides being bereft of an eye, is normally white or colourless, whereas the upper surface is usually speckled and marbled to harmonize with the colour of the sea bottom. But the underside has not been always eyeless. The little flat-fishes when hatched from the egg are very much like other fishes, with a "round" or nearly cylindrical body, with both sides alike, and with an eye on each side of the head. For sometime the larva swims freely in the sea but as it grows older it heads towards the land; when it reaches shallow water it takes to the bottom and lies on one side, sometimes the right, sometimes the left. It is obvious that an eye on the under side in contact with the sand is useless and reduces materially the

eye-power of the owner. So, little by little, the still plastic bones of the orbit on the lower side twist round till they come to face upwards, taking the eyeball with them. Nothing of this kind takes place in the equally flattened Ray-fishes, for there the flattening is from above, causing the *sides* of the body to spread out like wings, whereas in the Flat-fishes proper, the compression is from side to side, and so if the fish has to lie prone on the bottom it must be lying on one side or the other. It seems immaterial which side shou'd be downwards; whichever it may be, usually it loses all pigment, while the upper one develops it of such tints as afford the fish almost perfect concealment.

The true **Mullets** (Tam. *Madavai kendai*) are handsome fish of great value to man, as they abound particularly in backwaters and estuaries. They are largely vegetarian in diet, browsing on green weed and conferva. They can live and thrive where other fishes would starve and hence fill a complementary rôle in the stocking of estuarine fish ponds. Several species are also tolerant of change to fresh-water and we are now utilizing these species for the stocking of tanks within reach of the backwaters and tidal rivers where their fry abound in myriads at certain seasons. They are pretty fishes in their quaker-grey tints. The scales are comparatively large and the snout is peculiarly broad and flattened, an adaptation to their browsing habits.

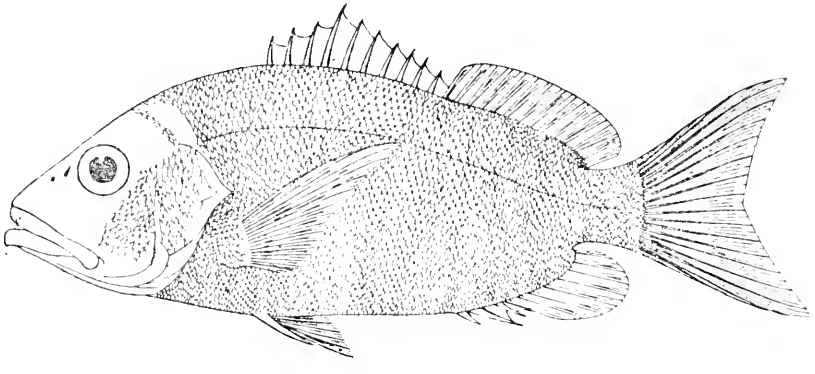

FIG. 16.—A common Schnapper (*Lutianus lunulatus*).

Several **Sea-perches** of the common genus *Lutianus* are also accommodated here, and, like their relatives in tanks Nos. 5, 6 and 8, show perhaps greater intelligence and observation in matters relating to the feeding arrangements than any other fishes in the

aquarium. They are ever on the watch for the attendant with his pail of fish. His coming is sensed long before he reaches their tank and this is sufficient to throw them into a state of wild excitement.

Other curious but by no means beautiful fishes in this tank are several kinds of **Cat-fishes** belonging usually to the genera *Plotosus* and *Arius* (Tam. *Kelethi*). They get their English name from the long whisker-like feelers arranged around the mouth. The family is a large one, with numerous representatives both in the sea and in rivers and tanks. The skin is smooth and scaleless. Cat-fishes have considerable value as food. Certain species, as *Arius*, are met with in the sea in great shoals and single captures may run into thousands. On the Malabar Coast cooked cat-fish heads, highly spiced and salted, are sometimes served free to customers by toddy-shopkeepers to create a greater thirst!

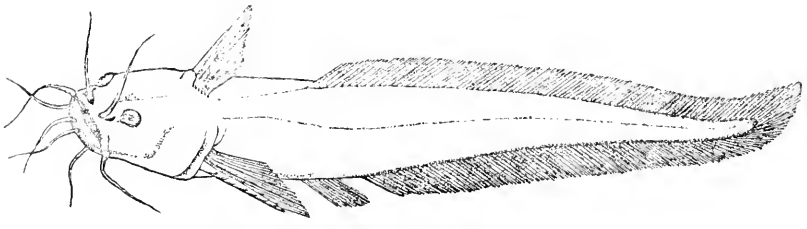

FIG. 17.—A common Cat-fish (*Plotosus canius*).

The dorsal and pectoral fins are often armed with formidable spines capable of inflicting severe wounds if trodden on or incautiously handled. In some cases a poisonous secretion is introduced into the wound and causes considerable inflammation. As with the tail spine of rays, so here the fishermen are accustomed to break off these spines before taking the fish to market.

The male of certain species of *Arius* has the curious habit of receiving the eggs, as extruded by the female, into his mouth where he retains them till the young hatch out. As the eggs are particularly large, about half an inch in diameter, the number that he can care for is limited. As the eggs completely fill his mouth, the poor father has to abstain from feeding till his family are born, and able to swim away. What part the unincumbered mother takes during this time is obscure; possibly she devotes her attention to piscine politics!

Many fishes change colour in sympathy with their environment or when excited. One of the best examples is the case of a

sea-perch, *Lutianus jahngarah* (Tam. *Musidimin*) inhabiting this tank. In the mornings it is very pale in colour, nearly white, except for the fins which are rosy; towards evening the colour of the body deepens till it is a distinct dull or smoky red. This deep red tint is also assumed during excitement or when disturbed or teased by its tank companions.

Both in tank No. 8 and in this one are usually specimens of a pretty blue serranid sea-perch, *Serranus flavocaeruleus* (Tam. *Utha Kalavai*). Those in tank No. 8 are the younger and the significance of its scientific name "the yellow and blue Serranus" will be understood if the blue fishes with yellow markings in tank No. 8 be studied in comparison with the entirely blue individual in this tank. It will be noticed that the shape and other characteristics of all are the same, except in regard to colour, and they are indeed one and the same species. The youngest show the fins bright yellow, with the upper jaw and the edge of the operculum also similarly coloured. The medium-sized show a great reduction in the parts coloured yellow, and in the fully adult the yellow is completely lost. It is seldom that colour changes are so strongly associated with different ages as in this fish and by having the three stages in adjoining tanks these changes are more readily observable than if the fishes were all together.

TANK No. 10.

A family of fat **Sea-perches** (Tam. *Kalavai*) of the genus *Serranus* occupy this tank. They are the oldest inhabitants of the

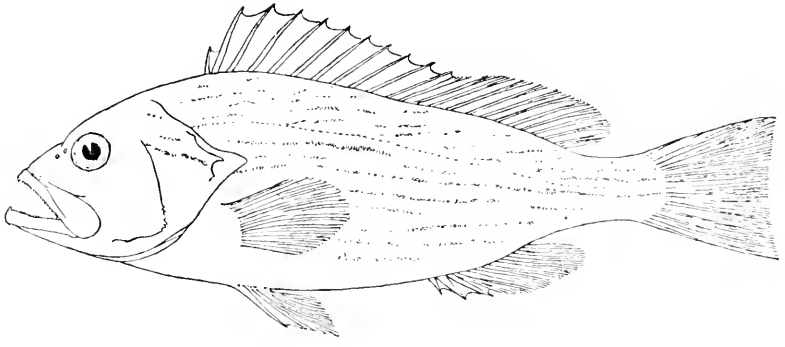

FIG. 18.—Indian Rock Cod (*Serranus undulosus*). × $\frac{1}{6}$.

aquarium; three have been here for 11 years and have become very tame. They have their regular hours for sleep, and at sunset

settle down on the bottom, resting lightly on their fins, just like any ordinary person as Brer Rabbit would say. Other fish in the aquarium do the same, particularly the heavily built ones; the Dog-fishes among others do so and they even close their eyelids. Others do not rest on the bottom, but remain merely motionless suspended in the water. Many again never seem to sleep, the sardines and their kin for example; these fish are particularly difficult to keep alive in a tank as they continue to swim about after dark and receive such injuries by butting against the walls that they invariably die within a few days or even hours. Only if a light be kept burning throughout the night can they be protected from injuring themselves.

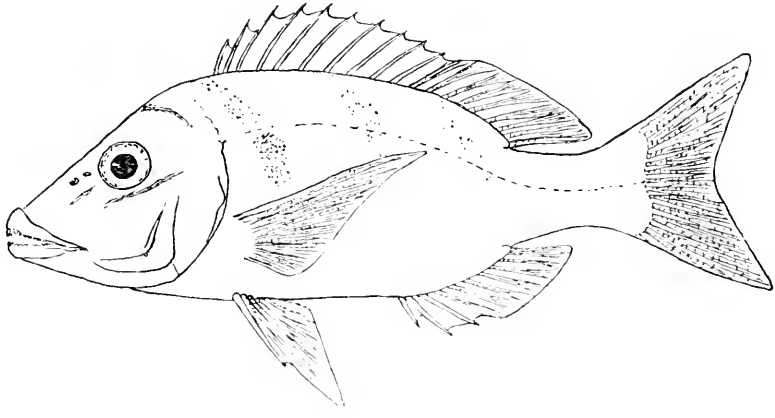

FIG. 19.—Velamin (*Lethrinus nebulosus*). × $\frac{1}{6}$.

The Serranid sea-perches are among our most abundant and valuable food-fishes. Many species are found in our seas, varying enormously in colour and size. The former characteristic renders their scientific identification peculiarly difficult.

One of the larger and most numerous of these sea-perches is the *Kalawa* of the Tinnevelly coast, a fish not unlike the cod in outline and not infrequently called the **Indian Rock Cod**. It abounds on the hard bottom that stretches from the southern extremity of India to the 100-fathom line, and with other sea-perches of the genera *Lutianus* and *Lethrinus* may one day be brought to market by the tens of thousands when steam-trawling is begun on the rich fishing grounds off Cape Comorin.

TABLE AQUARIA

The contents of these are variable; usually they contain some of the more interesting of the smaller creatures of the sea, which would perish incontinently were they put among the ravening inhabitants of the larger tanks. Among these are generally examples of the **Octopus**, various curious crabs and lobster-like Prawns, Sea-anemones, Starfishes and the like.

The little **Sea-horse** (*Hippocampus*, Tam. *Kadal Kuthirai*) is not uncommon and is more interesting because of the quaintness of his

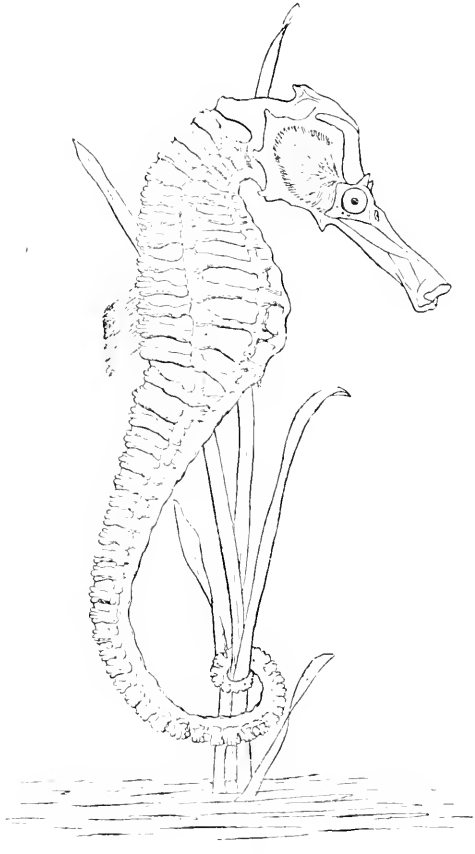

FIG. 20.—Common Sea-horse × 1.

shape than for anything curious in his habits as seen in a tank. Usually he rests quiet and apparently very observant if we may judge by the quick movements of the eyes; to anchor himself securely he twists the end of his thin tail round some weed or the twig of a sea-fan, with body erect and rampant. Near relatives,

the **Pipe fishes**, are also taken occasionally and put in the same tank.

The male in both groups has the peculiar habit of carrying the eggs his mate lays, within a long fold of the skin along each side of the body—a real incubatory pouch. There they remain till they hatch. One male sea-horse opened his incubatory pouch one day early in last December and set free over 200 tiny babies, miniatures of himself, but only 4 to 5 millimetres in length.

Segregated rigorously by themselves are the little **Coffer-fishes** (*Ostracion cornutus*) creatures so feeble-looking that one wonders how they manage to escape destruction at the jaws of larger fish. Put them with other fishes, even considerably larger than themselves, and the reason is soon evident. Wounds appear on the sides of the other fish, bleeding patches where the scales have been bitten through. This is the work of the Coffer-fishes; harmless though they look, their small teeth are powerful and exactly adapted for nipping holes in skin and scales. Their own body is protected against damage by being encased in a box-like covering of bony armour, with openings through which project tail, fins and eyes. In Tamil they are known as *Madumin* (Ox-fish) from the two horn-like projections on the upper part of the head. They never grow to any large size.

Baby Sharks are often exhibited in the table tanks. The embryos of Dog-fishes usually develop within horny purse-like cases anchored to weeds by strong filaments looking like catgut; the Rays also come forth from flattened purse-like egg capsules, but the majority of the sharks are viviparous and often a brood of young are thus obtained when a big shark is brought ashore by the fishermen.

Perhaps of all sea-animals the **Octopus** or **Devil-fish** is the most curious. Though common enough in Indian waters it never attains large dimensions; the largest I have seen here had a body smaller than a man's fist with arms not more than 20 inches long. Smaller ones with a body of the size of a walnut and arms 3 to 4 inches in length, are numerous, and in Palk Bay are fished for in an ingenious manner for use as bait in lining for fish; shells with the apex broken off are tied at intervals along a long line; these are sunk overnight, raised in the morning and the shells searched for any Devil-fishes that have ensconced themselves therein. The Japanese have a more refined method; instead of shells, they tie narrow-necked vases of earthenware to their lines.

The Octopus belongs to the great group of the Mollusca, and is closely akin to the **Pearly Nautilus** whose brown streaked chambered shells are not uncommonly washed ashore on our coasts after storms. But the octopus long ages ago discarded

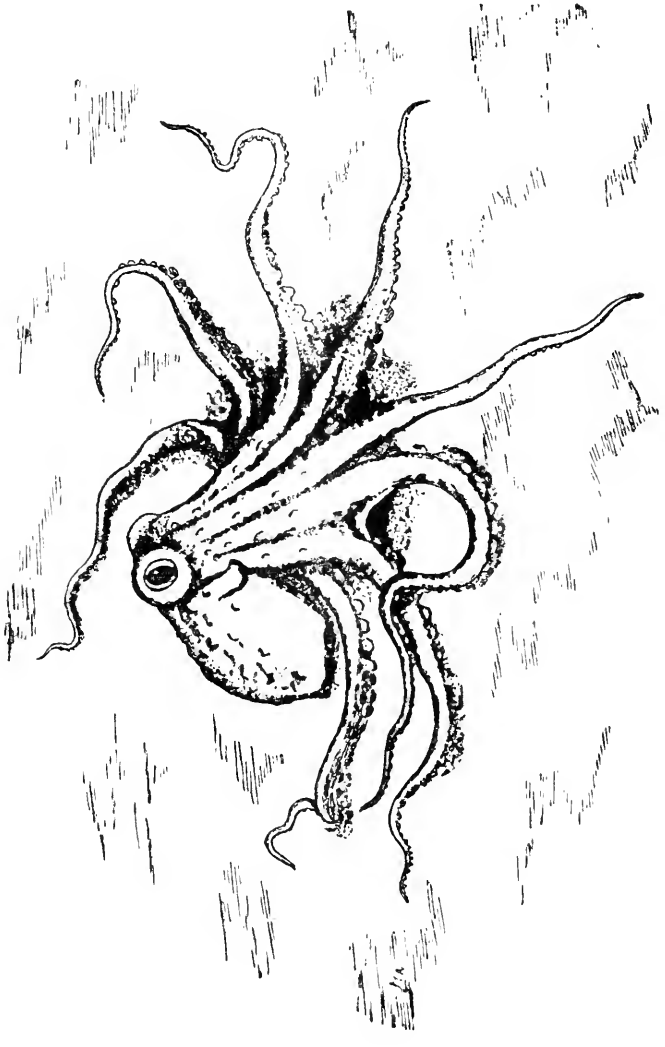

FIG. 21.—The common Indian Octopus.

the clumsy shell that set narrow limits to his restlessness, and since then trusts to the sharpness of his eyes and his wits to escape from his larger enemies to whom he is a luscious tit-bit. As H. G. Wells has cleverly shown, evolution might easily have given an octopus-like form to the dominant race on earth. And

certainly so far as my experience goes, the octopus is the most brainy creature in the seas apart from whales and seals. I have seen the larger European species play pranks on one another, tamper with the pipe fittings in their tank, make a regular toilet when the innumerable suckers on their arms wanted cleaning, and

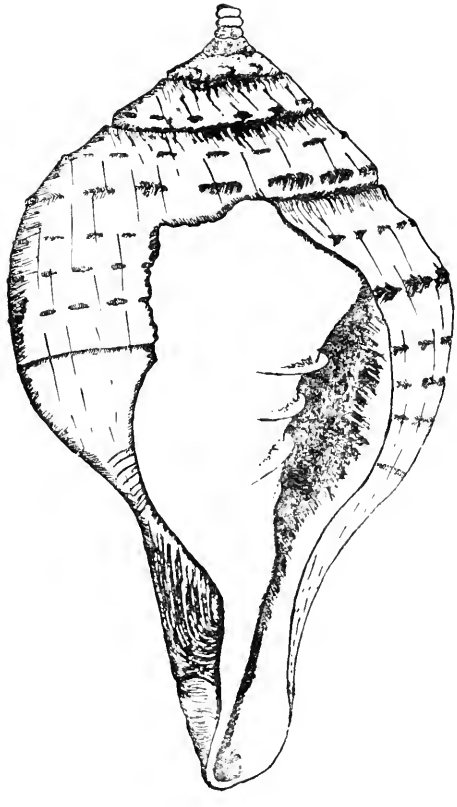

FIG. 22.—The Sacred Chank. (*Turbinella pirum*). × ¾.

FIG. 23.—Egg capsule of the Chank. × ⅔.

change colour according to their surroundings when crawling stealthily over the bottom; when cornered they employ the common cuttlefish device of discharging a cloud of ink from their body and under cover of this often make good their escape. They have eight slender arms, each beset with two rows of suckers; with

these they seize their prey—crabs chiefly—and drag it to their mouth which is furnished with a black horny beak not unlike that of a parrot.

Few shellfish are attractive enough to be worthy of exhibition in our tanks, but one, the Sacred Chank or Conch (*Turbinella pirum*) has such absorbing interest from the religious standpoint of the Hindus that an exception has to be made in its favour. This shell is common on the Madras coast and is indeed the object of a special fishery. It is sawn by the tens of thousands into bangles at Dacca in Bengal, and few valuable bullocks in the Tamil country are without a small chank tied upon the forehead.

The eggs are deposited in a curious capsule shaped like a twisted ram's horn (Fig. 23). An account of the varied roles played by the chank in Indian religion and life is contained in "The Sacred Chank of India" which forms Volume VII of the *Madras Fisheries Bulletin.*

Crabs and their allies do not live well in the tanks, due probably to iron contamination in the water circulation. From time to time there are present examples of some of the many handsome species of swimming crabs found off Madras. Of these, *Neptunus sanguinolentus*, marked by three livid spots on the shell covering the back (carapace), and *Neptunus pelagicus* are the most common. The sexes of the latter are distinguished by great colour divergence; the male is a big handsome fellow with his legs brightly tinted sky-blue; the female shows a network of greyish white lines on a ground of dull olive. A curious parasite called *Sacculina*, allied to the ship-barnacles and acorn-shells, often attacks these crabs, attaching itself under the little tail that is tucked away beneath the body proper. When this happens to a male, his gay blue tints fade and he assumes eventually the dull uninteresting colour scheme of the female. The parasite runs a mass of rootlike tubules throughout the body of its host and through these drains its life blood and arrests further growth.

Another common Madras crab is the little *Dorippe dorsipes*, particularly interesting because it exhibits wonderful sagacity in utilizing the defensive weapons of another animal for its own protection. When caught in nets this little crab is usually found to be using the last two pairs of its walking legs to hold in position on or rather over its back, a single valve of some small clam on which is seated a pale-coloured anemone. Now, all anemones

have the power of stinging exactly like their relatives, the jelly-fishes, and by carrying about this partner, the crab provides itself with a whole series of ready-made batteries of stinging cells, enough to frighten away any small fish looking round for a tasty *bonne-bouche* of crab. The anemone gains also by this association

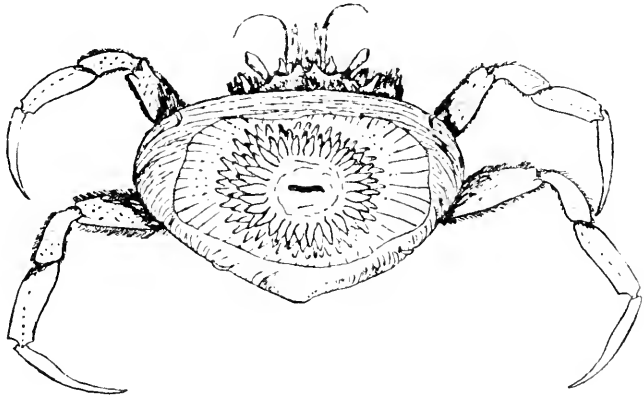

FIG. 24.—*Dorippe dorsipes*, carrying an anemone seated upon a shell.

for when the crab finds something to eat, in tearing it to pieces some shreds must float within reach of the anemone's tentacles and so provide it with food. Such partnerships for mutual benefit in the struggle for existence are said to be instances of **commensalism**—a subject of constant interest to the marine naturalist, so common and protean is the habit.

At the edge of the tide, the pretty yellow-legged *Matuta victrix* is often to be seen. Its carapace is remarkable for the great purple-tipped spine that stands out threateningly on either side. While the general tinge is yellow, a great amount of pretty purplish colouring, composed of innumerable tiny dots, is spread over the carapace and the legs.

Hermit or Soldier crabs (Tam. *Sangu nandu*) inhabiting any empty shells big enough for them to stow their soft tails inside, are often shown. In many cases a sea-anemone has settled on the shell, affording the hermit crab some protection, by reason of its sting-beset tentacles, against fish enemies, and at the same time profiting itself from scraps of food that float to it when the hermit is making a meal. This is another good instance of the habit of **commensalism.**

The **Squat Lobster** (*Scyllarus*) is quite common at Madras, taken in fishermen's nets. It owes its name to its broad short appearance, due largely to the way in which the appendages of the head are broadened and flattened. In the lobster proper these are the

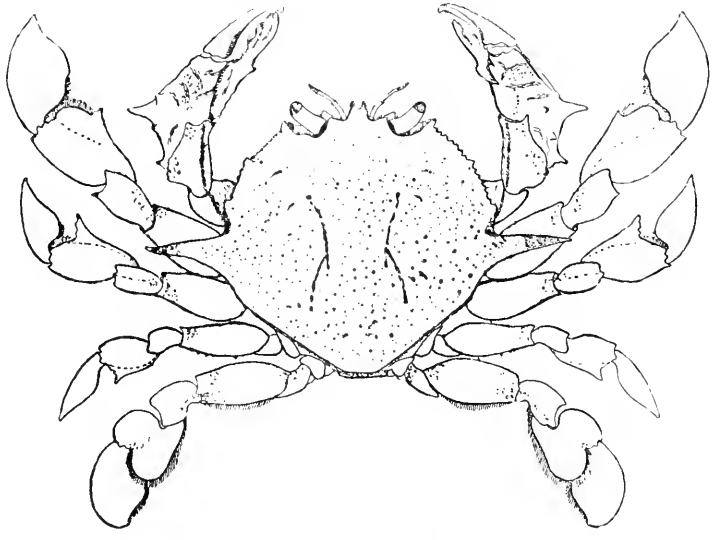

FIG. 25.—Tide-mark Crab, *Matuta victrix*.

characteristic long and slender antennae. The **Rock Crawfish** or **Spiny Lobster** (*Panulirus*) is common among the stones and concrete blocks that buttress the foot of the harbour walls; the true lobster is not found in Eastern waters.

Among the smaller inhabitants of the tanks are the **Sea-anemones**, less gorgeous generally in colour and form than European species. Some make up in size what they lack in colour; the giant *Discosoma*, quite common at Pāmban and Tuticorin and probably also at Madras, attains sometimes the almost incredible diameter across the disc of over three feet. The disc in this sea-anemone lies outspread above the sand like the blossom of some huge flower. In the centre is a slit-like opening, the mouth, leading to the bag-shaped stomach; around the mouth are rows of tentacles armed with stinging cells used to paralyze the fishes on which anemones prey. The tentacles in some are long cylindrical finger-like tubes; in others, as in the giant *Discosoma*, they are short and clubshaped, quite small but immensely numerous.

The small pond in the centre of the hall contains freshwater fishes and water-tortoises. The former comprise examples of the

Murrel (*Ophiocephalus*), a valuable food fish in India, and of the **Gourami** (*Osphromenus gourami*), a highly esteemed Javanese fish now in course of introduction into this country by the Madras Fisheries Department. Both are nest-building fishes, forming them among the stems of water plants. The parent Murrel (Tam. *Viral*) are particularly jealous of any prying into their domestic affairs when they are guarding their eggs in the nest; they have been known to jump out of the water and seize the nose or a finger of a too inquisitive short-sighted visitor; the flutter of a handkerchief will always rouse them to an attempt to seize it.

The **Climbing Perch** (*Anabas scandens*) is another fresh-water fish usually to be seen in one of the table aquaria. It has special mechanism for breathing in air as well as in water, as also has the Murrel; both are able on occasion to leave the water and travel over marshland or grass sward. It has been proved in Madras that the former are able to climb out of water up a sheet of cloth held tightly in a vertical position and there is no reason to doubt that individuals may occasionally climb some distance up the rough bark of a tree margining a pond or stream. Their Tamil name is suggestive in this connexion—*Panai eri kendai*, "the perch that climbs Palmyra palms."

In yet another table aquarium are shown specimens of the two tiny fishes *Haplochilus melanostigma* and *Panchax parvus* (Tam. *Mundakkanniparavai*), that have been found by experience to be the most effective of the kinds which habitually prey upon the larvæ of mosquitoes when they are present in the same pond or well. Many thousands of these are bred annually in the culture ponds of the Fisheries Department whence they are sent out in special carriers to Municipalities and others, for introduction into ponds and wells infested with mosquito larvæ. When properly introduced and cared for, the way in which the mosquitoes of the neighbourhood diminish in numbers is a most striking testimony to the efficacy of this simple method of combating one phase of the mosquito plague.

Other useful larvicidal fish for fresh water are various small species of *Barbus*, as *Barbus ticto*, together with *Polyacanthus cupanus*, while *Therapon jarbua* is excellent in backwaters and estuaries.

Till the larger aquarium which is planned be built, there is no opportunity to show any of the myriads of smaller and equally

interesting creatures that abound in our seas ; we cannot at present accommodate any of the many magnificently coloured sea-urchins, starfishes and sea-cucumbers ; we cannot show specimens of the lovely corals that flourish on the reefs at Pamban and Tuticorin ; none of the sea-fans, sea-pens, and corallines can find accommodation in the tanks, to say nothing of the jelly-fishes and strange pelagic flotsam and jetsam met with along the shore during stormy weather.

The life of the local seas shown in the present aquarium must be taken merely as a foretaste of the splendours that shall be when a more commodious building be built, if funds, now lacking, ever become available for such purpose.

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THE COMMON MOLLUSCS OF SOUTH INDIA

BY

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INTRODUCTION.

Till a few years ago the study of zoology in Indian colleges was greatly handicapped by difficulties attendant upon the supply of specimens of representative types of the various groups comprised in the fauna of our seas. To a large extent students relied upon a study of text-book figures and had no familiarity whatever with the animals themselves. In the rare cases where more thorough work was done, either attention was concentrated upon land and fresh-water types as more readily procurable, or limited supplies of material were obtained at a heavy cost of money and time, from European Biological Stations. The fact that zoological study was hopelessly fettered for want of supplies that lay abundant to hand, in our waters and on our shores and among the coral reefs of the Gulf of Mannar, so impressed me at an early date in my fishery work in the Madras Presidency that I decided to make an effort to diminish the disability, and so to render zoological study more attractive and profitable to students with a bent in that direction. It happened at that time that my fishery duties involved extensive dredging over faunistically rich bottom in the Gulf of Mannar and Palk Bay ; the riches of extensive coral reefs were also available. Day after day far more material was brought aboard the inspection vessel by the dredge and my divers than was required for my own work and the rest had to be dumped overboard and wasted. In 1915, I sought and obtained the permission of the Government of Madras, to begin the supply of zoological specimens to educational institutions throughout India, at rates calculated just to cover the cost of preparation. Appreciation of this work was immediate and far beyond my expectations. The work has now developed so largely that a special staff is

employed exclusively upon this branch of the department's activities. A clear idea of the utility of this work is obtained by an examination of the value of the specimens supplied during the six years since its inception, namely :—

	RS.		RS.
1915–16	360	1918–19 ...	1,258
1916–17	576	1919 20	1,608
1917 18	736	1920 21	3,131

The unbroken rise in the annual value of the supplies bespeaks not only increasing appreciation by the educational world of India, but also a greatly widened and more solid foundation of the zoological training now current in our colleges.

The improvement of school museums is also amongst our aims. In very few instances are existing collections of any practical value ; especially is this true of the natural history exhibits. If the school be in a coast town, a jumble of unnamed shells with od ls and ends of the flotsam and jetsam of the sea, offends the eye of the zoologist, by reason of its utter uselessness. What possible educational value can lie in a collection of shells gathered haphazard and exhibited without order or explanation ?

To afford a remedy in part for this unsatisfactory state of affairs in secondary schools, I arranged some time ago for the preparation of compact glazed wall-cases containing collections illustrative of the common types of the molluscs and crustaceans characteristic of Indian seas. The Director of Public Instruction welcomed the idea, but before ordering a large supply of these collections, desired that descriptive hand-books should be prepared ; this is obviously the only proper way of promoting a true interest in branches of zoology represented by these collections and I agreed willingly.

The notes which follow are the first outcome of this arrangement, but the scope has been widened somewhat to make them of use to that large body of people who take interest in the things they find on the shore and desire to know some of the more interesting and outstanding facts in their life-histories.

With the exception of a few figures borrowed from various sources and duly acknowledged, the illustrations are all original and have been sketched specially for this paper by my assistants Mr. M. Ramaswami Nayudu, B.A., and Mr. K. R. Samuel, to whom

I am under great obligation for the care they have exercised in carrying out my ideas, and for the skill shown in the actual drawings. The exigencies of printing have, I fear, obscured in too many cases the excellence of their work.

GENERAL.

The commonest objects on the sea-beach are the shells of those soft-bodied animals called by zoologists *mollusca* and popularly known as *shellfish*. These names appear at first sight to be contradictory, for the scientific term signifies that the animals are soft-bodied, while the popular name implies that they are encased in hard protective coverings or shells. Combining the two we get a fairly clear idea of their characteristics—they are soft-bodied animals protected by an outer casing usually hard, composed of some form of limy or calcareous material, and without any internal skeleton except in very exceptional instances.

The shells of molluscs are extremely diversified in shape and colouring. Each may consist of two parts or *valves* as in the oyster and the mussel (*Bivalves, Lamellibranchia* or *Pelecypoda*), of a series of plates as in Chiton, the coat-of-mail shell (*Amphineura*), or of a single piece, in most cases spirally twisted (*Gastropoda*); finally come the highest of the group, the *Cephalopoda*, comprising the most active and intelligent of all the mollusca, the octopus, cuttlefishes, and squids, together with the nautilus and the whole host of fossil ammonites. A division (*Scaphopoda*) has to be made to receive the elephant-tusk shells, a small number of peculiar forms with long tapered tubular shells well described by their vulgar name.

Except in bivalves the body of molluscs can be made out usually to consist of three regions—an anterior part marked out as a distinct head, bearing the mouth, tentacles and the chief organs of sense; behind this is a swollen dorsal mass, the visceral sac, containing the intestine, liver, and reproductive organs. The integument of this mass is the mantle and this is generally disposed in a fold reflected over the back of the animal. The outer surface of the mantle secretes the shell; in bivalves the mantle is double, formed a free fold or flap on either side of the body, hence originating the two valves or half shells characteristic of these molluscs. On the ventral side of the body below the visceral mass is a large muscular organ, the foot, flattened and

adapted for crawling in the gastropods and chitons ; hatchet shaped in bivalves; in cephalopods it is split up into a number of mobile arms beset with suckers.

The mollusca are a difficult subject for the evolutionist ; they appear in groups as generally distinct and fully differentiated in the lower Palæozoic strata as at the present day ; gastropods and lamellibranchs are found in the Cambrian and the remaining classes in the Ordovician or Lower Silurian. There is no geological sequence to help us to a decision ; the larval history of some species gives a hint, for a characteristic larval form of many molluscs is a tiny globular body furnished with a circlet of cilia round the middle ; the lashing of the cilia causes it to spin through the water. This larva is termed a trochosphere and is practically identical with the larvae of many of the bristle worms (polychaeta). Excepting the lamellibranchs, all other classes (with the usual qualification of "exception" that meets us at every turn in the study of zoology) possess a ribbon-shaped tongue, or *radula*, set with rows of teeth ; these molluscs generally possess a definite head, bearing eyes and other sensory organs. If the larval history of molluscs points to an ancestry among those marine worms that are typically furnished with a well-marked head and in several families with a gullet armed with a series of horny teeth, we may conclude that those molluscs with a head region and a radula are more akin to the ancestral form than the lamellibranchs, which have diverged in order to fit themselves for a sedentary life. This change has led to the loss of a definite head region and of the tooth-set radula. In specializing, they have become degenerate in several ways.

CLASS I.—AMPHINEURA.

The CHITONS or Coat-of-mail shells are the only members of this class that need concern us. Like the gastropods proper the foot is well developed as a crawling organ, flattened and extending the whole length of the elliptical body. The species most common in Indian waters grow to a length of 1½ to 2 inches. They live among rocks, generally between tide-marks and often may be seen adhering to the sides of rock pools at Cannanore and on the shore reef at Rāmēswaram. Another favourite haunt is the eastern reef-flat of Krusadai Island (Pāmban) where they are often found clinging to the under side of boulders poised on others.

They are easily recognized by the jointed shell protecting the back. It is made up of eight distinct plates fitted to overlap one another like a row of roof tiles. When detached from their foothold, chitons roll up into a ball like the short millipede or like the armadillo and the hedgehog. All our Indian chitons are sluggish creatures feeding on the smaller seaweeds clothing the adjacent rock surfaces. One outstanding interest they possess is the fact that some species have developed very minute eyes, complete with lens, retina and pigment, upon the surface of the shell plates. They are often thousands in number in the one individual, always most numerous on the anterior plate. Chitons have no economic importance in India.

Unlike the gastropods proper, the body and organs of chitons are bilaterally symmetric, that is, the right side of the body is exactly like the left. The head is at the front end, and the gullet, stomach, and intestine form a straight tube through the body, ending in the anus at the hinder end. The breathing organs are a series of plate-like gills, arranged on each side between the muscular foot and the edge of the thick leathery mantle in which are sunk the eight plates that form the shell. Like the alimentary canal, the heart is straight and tubular as in the ancestors of the bristle worms from which the mollusca may have been derived. These points are of much importance to remember, for we shall find in the gastropoda striking divergences from these simple and probably ancestral characters.

CLASS II.—GASTROPODA.

SUB-CLASS I.—STREPTONEURA. ORDER I.—DIOTOCARDIA.

The most primitive and simplest of these show distinct kinship with the chitons and serve to bridge the gap between the latter and the spirally coiled shells that characterize the great majority of the gastropods. Of such simpler forms are the LIMPETS (*Patellidae*). In these

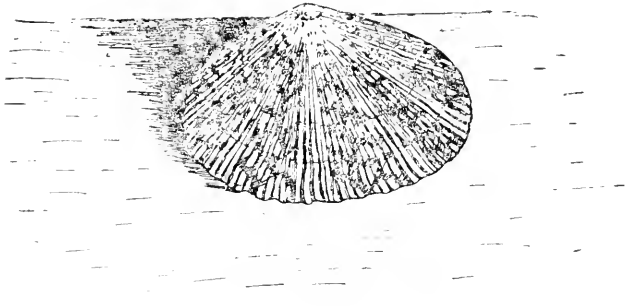

FIG. 1. A Limpet (*Patella rudis*).

molluscs the shell is conical and forms a stony cap under which the animal lives secure. The limpets have a broad sole-like foot as in the chitons. This assists them greatly in clinging to the rocks on which they have their home; the broad muscular foot-disc acts like a boy's leather sucker and by the total exclusion of air beneath it, atmospheric pressure comes into play and has to be overcome before the limpet can be pulled away from its foothold. Atmospheric pressure amounts to 15 lb. to the square inch, and the conical shape of the shell gives no grip to the fingers; it is well nigh hopeless to detach a limpet from a rock unless we can take it unawares when the edges of the shell are raised slightly off the rock, and slip a knife under, dislodging the animal by a sudden wrench.

Limpets live between tide-marks on rocky coasts. They are not very abundant in India and are usually small. At Covelong, Pāmban, Mandapam and Cannanore, they may usually be found, often so near to high tide level that the sea leaves them high and dry for several hours twice a day. They feed upon the smaller seaweeds and their habits are well worth watching. On coasts where they abound I have often heard a continuous low rasping hum rising from the rocks around. It was meal-time with the limpets; a multitude were browsing on the tiny weeds growing on the rocks, the noise arising from the file-like action of myriads of minute teeth. The radula or dental ribbon of the limpet is longer than the whole animal's body. In the common British limpet the tongue has nearly 2,000 teeth set in about 160 rows of 12 teeth in each. The hinder part lies coiled up like a watch spring. New teeth are formed at the hinder end and the ribbon unrolls a little as equired to make good the waste that goes on at the front end from the wearing down of the teeth in use. Limpets have a well-marked homing instinct and though they may crawl several feet away from their home, they return there regularly after their foraging expeditions. In soft rocks they make quite a deep pit at the place they choose as their home; on hard rocks this spot is marked out by its smoothness, and may even be a little lower than the surrounding surface.

In Europe the poorer classes in several countries (France, Italy, Ireland, etc.) value the limpet as a cheap delicacy; very large quantities are eaten. At Covelong where they are more numerous than I have seen anywhere else on the Madras coast, some of the poorer

people are accustomed to collect them for food. They are known there as *Unai* in Tamil.

The common Indian species are *Patella variabilis* and *P. rudis*.

The KEYHOLE LIMPETS and the SLIT LIMPETS (*Fissurellidae*) in the shape of their shell resemble closely the true limpets, but have either a perforation at the apex or a tiny slit in the front margin of the shell. The use of these apertures is to ensure the removal of foul matter. Pure water is admitted to the gills through the space between the edge of the shell and the rock surface beneath and then is passed out by a tubular fold of the mantle through the hole at the apex or the notch in the front edge, washing out at the same time any excreta that require removal. The Indian species are all small and consist of a few species of the keyhole limpet (*Fissurella*) and of the still rarer and smaller *Emarginula*, one of the split limpets. These live below low tide line and are not found except by dredging. Dead and worn shells are occasionally cast up on the Rāmnād and Tinnevelly coast.

Closely allied to the preceding are the EAR-SHELLS or *Haliotidae*. A common species is *Haliotis varia*, found living under boulders at extreme low tide at Pāmban and Krusadai Island and the other coral reefs that skirt the south-east coast. This species is quite a small one, seldom exceeding 1½ inch in length—a poor representative of the family. In other lands, in France, Japan, New Zealand and California, the ear-shells attain a length of 4 to 6 inches, and vie with the rainbow in the gorgeous colouration of the mother-of-pearl lining of the shell. As a consequence it is extensively used for pearl inlay work. Pearls are not uncommon in the mantle, but their value is not great as coloured pearls are little in demand. Wherever it is found, the ear-shell is highly valued as food, its great muscular foot being a delicious morsel when properly prepared and cooked. The Chinese especially value it and great quantities are prepared in Japan and California for export to China. It may either be cured dry or put up in tins—the *abalone* of Californian markets. In shape it is a flattened limpet with a row of holes piercing the shell along the left margin. The function of these holes is more specialized than in the keyhole limpet, for here it is only the most posterior one which is used as an anal funnel to get rid of impure water and debris, whereas the others, of which there are several, are used apparently to *admit* water to the gills.

In the Ear-shells, although the general shape is flattened, the essentially spiral form is clearly apparent at the hinder end where a distinct short spire is seen. In the vast majority of gastropods this spire is greatly emphasized and in the next family to be described, the Top-shells, this form is fully established. Such molluscs are said to be highly asymmetrical, but this lack of symmetry is confined almost wholly to the visceral mass—the part containing the viscera—the stomach, intestine and so-called liver; the mantle, the shell and the gills are also affected by this twisting. The foot and the head usually remain as symmetrical as in the Chitons. In other words the "back" of these animals has been twisted and coiled into a spire, and the shell takes on the same shape, as it is formed by shell-forming secretions poured out by the fold of integument that covers the viscera.

The TOP-SHELLS (*Trochidæ*) and the TURBAN-SHELLS (*Turbinidae*) may conveniently be taken together. They are much alike in appearance, both comprising some of the commonest of our littoral shells. In shape they are conical and are beautifully pearly within. The larger kinds are commercially valuable, for the widely spread "Trocas" shell of trade (*Trochus niloticus*) and the even more valuable "Green snail" (*Turbo marmoratus*) of eastern seas are

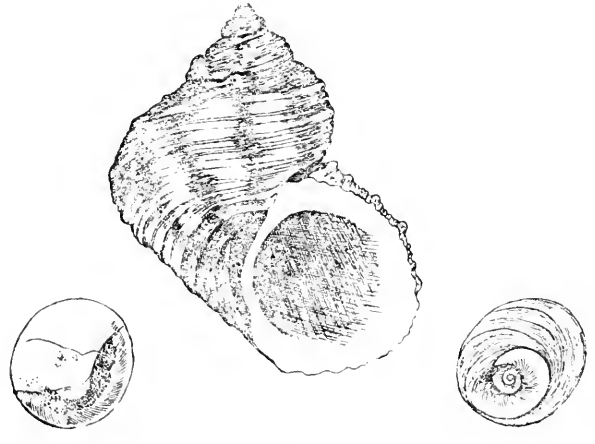

FIG. 2. The Common Turban shell (*T. argyrostoma*) with inner and outer views of the operculum × 1.

in great demand for pearl button manufacture. The two families are easily distinguished by the nature of the *operculum*, a flattened hard structure found upon the upper surface of the tail end of the

foot in many gastropods. When the animal retires into its shell, when alarmed or attacked, the operculum serves as a door to close the opening and to keep the intruder out. In the Top-shells it is horny and marked with a closely set spiral; in the Turban shells, it is stony and very massive, and there are species so large that the operculum is heavy enough to be used as a paper weight—two inches in diameter. The operculum of one species found in New Zealand, very brightly mottled with green and brown, is highly valued by the Maoris as a personal ornament set in gold; they also used it to form the eyes of their idols in former times. Even in India the operculum of Turbo has value. It finds its place, with all sorts of local shells and marine curiosities, in numerous booths within the main entrance to Rāmēswaram temple, for sale to the pilgrims and devotees who flock there in thousands from all parts of India. The best ones are retailed at 8 annas per hundred, sea worn ones at considerably less. The Valayan women who collect shells on the Pāmban reefs get about 8 annas per measure for these opercula and 2 annas for the same quantity of any Top-shells they can collect—another object of sale to pilgrims. The Tamil name for Turbo opercula is *ambilimau*, meaning "the disc of the moon." The flesh of Turbo (*nathai*, Tamil) is eaten by the island people (Valayans) but that of Trochus (*thalappaikatti*, Tamil) is not esteemed owing to its small size and the difficulty of extracting the body from the coils of the shell.

All our species of Turbo and Trochus are small except in the Laccadive Islands where a commercial "Trocas" (*Trochus pyramis*) is sometimes found and some fairly large Turbos *T.* (*argyrostoma*). Sometimes on overturning a large boulder among the scrub near the beach in one of these islands, a score or more of big Hermit-crabs have scurried away in all directions, the majority hiding their soft tail in a big Turbo shell.

A rather pretty Top-shell (*Clanculus clanguloides*) is not uncommon in the Pāmban neighbourhood. Like the other Top-shells, the sides of the body are fringed and provided with a number of long and slender tentacle-like filaments.

Most common of all the Trochidae is the beautifully variegated and polished shell of *Umbonium* (*Rotella*) *vestiarium*, a little species that occurs at the mouths of some of the East Coast backwaters in enormous numbers. It is one of the most dainty little shells I know.

Usually about a quarter of an inch across, its low depressed spiral shell is stippled and marbled in dozens of variations and in a range of colour from pink to brown. Some are nearly white, so few and pale are the markings, while others are deep chestnut, so closely set are the spots. Millions must be exported to Europe, for this shell is one of the chief of those used in the ornamentation of shell-boxes sold at every watering place in England.

Grouped with the Turbos are the PHEASANT SHELLS (*Phasienella* spp.), prettily patterned tiny shells that occupy to the Turbos much the same relation as the handsome Umbonium does to the true Top-shells. Their little polished shells are to be found on rocky shores at the edge of pools and in sheltered crevices. They are gregarious and like Umbonium, the patterns of their colouring vary enormously.

The NERITES show unusual adaptability to varying conditions. *Nerita* lives in the sea ; one picks it up just below high water mark at Pāmban and the Rāmnād reefs ; the closely allied *Neritina* is the fresh-water form, though it may also be found in brackish water. A third genus, *Septaria* (=*Navicella*) is still further removed from the ancestral marine form, for it has actually acquired the habit of living in places on the banks of streams where it is only kept damp by spray or the lapping of the water on the rock or tree root or stem to which it adheres. The series of transition forms seen here is an excellent illustration of how fresh-water faunas have arisen and how from these land molluscs may in turn be evolved.

Considering their size—barely three-quarters of an inch in length—the shells of the Neritas are extremely massive. They live at the edge of the sea and are often tumbled off their lodgment on the rocks by the waves ; were they less strongly built their shells would be broken and destroyed.

The shell externally shows distinct spiral markings at one side—the apex ; internally in adults the whole cavity is simple and rounded. Study of the life history of Nerita from the very young stages, shows that it begins life with a well-marked spire wound round a central column, the *columella*. As it grows the columella and whorl partitions are gradually absorbed. It would seem that the animal has to be so busy in strengthening the external wall of its house, that it can spare no limy material for interior decoration.

The shell is often prettily marked—it varies very greatly—and in old ones the surface is much corroded and pitted (mollusc shells are normally protected against damage by a horny skin, the *periostracum*, or else by folds of the mantle wrapped over them. If the periostracum be worn away, the limy shell beneath is liable to corrosion, especially in shells often exposed by the receding tide).

As in the Turbos, the operculum in the whole family of the Nerites is stony. Usually, it is roughly semi-lunar in shape; at one end is a finger-like projection that hitches behind the columellar lip and forms a locking device, giving additional security. A peculiar little hermit crab (*Coenobita rugosus*) that frequents the beach and lives almost entirely out of water, finds the empty shells of Nerita just suited to his wants; indeed he has adapted the shape of his big claw so precisely to the form of the mouth of the shell that when he shuts himself up inside, the big claw closes the aperture as perfectly as did the operculum of the living shell.

In the fresh-water Neritina the shell is thinner and the spire still less evident; finally in Septaria the spire is so completely lost that the shell may easily be mistaken for that of a small narrow limpet. Internally the columellar lip persists as a thin ledge and there still remains a little operculum, too small to fit the aperture and more or less embedded in the foot.

Order 2.—Monotocardia.

In these gastropods the heart has a single auricle only, and the gill is single, with a single row of plates (monopectinate). The body is greatly twisted and this results in the shell being frequently drawn out into a long spire. There is practically no vestige of the bilateral symmetry that can be traced in some organs in the Diotocardia even when their shells are spirally coiled, as in the Top-shells. The group is an exceedingly large and varied one and includes some 76 families. Many are extremely specialized for life under abnormal conditions; some have adapted a life on the high seas—pelagic—swimming or floating; others have migrated to the land and to fresh-water pools; a number have become parasites or live as messmates (commensals); they may be carnivorous and even possess poison glands, or they may be vegetarian in their diet; some move with considerable rapidity, others attach their shells to rocks and simulate the appearance of certain tube-building worms.

Owing to this high specialization it is difficult to arrange their relationship in any comprehensible sequence; one can form groups easily seen to have mutual affinities, but these groups stand apart from others, and it is practically impossible to arrange them in any satisfactory order that will show the line of descent or of specialization. They represent the terminal twigs of a great branch, and while they acknowledge a common ancestry, they stand to each other as cousins of varying degree.

If we follow the classification of Pelseneer, perhaps the greatest of living authorities upon the mollusca, we take first two families living in fresh-water, the *Viviparidae* and the *Ampullaridae*. The former is represented in India by the common fresh-water snail, *Vivipara*, so called because it is viviparous—the young develop within the parent and are born as tiny miniatures of the adult and ready at once to begin life independently. The shells are thin and comparatively fragile, covered with a thick olive-green periostracum; the shape is like a Turbo—hence this form of shell is said to be turbinate, coiled like a turban. It lives in tanks and streams and is occasionally eaten by low-caste people in the Southern Tamil districts where it is known as *umachchi*.

Even more common is the larger APPLE-SNAIL, *Pachylabra carinata*, formerly known as *Ampullaria globosa* (*naththai*, Tamil). It grows to a comparatively great size, and may even exceed one and a half inch in diameter. The shell is nearly globular with a small spire and a very large mouth opening. In appearance it is like a big globular Vivipara; the two are often found together in ponds and paddy fields, but Pachylabra appears to be the more hardy, for it has the advantage over Vivipara of having an air-breathing organ or rudimentary lung, in addition to a gill for use under water. This enables it to live in comfort for some time even out of water and so to withstand successfully the vicissitudes of a tropical country. It can also lie hidden in soft mud and still obtain air by

FIG. 3. Apple-Snail (*Pachylabra carinata*).

pushing upwards to the surface of the mud the end of a long muscular tube. Through this air is passed down to the "lung cavity." Pachylabra is also prepared for the complete drying up of the mud during the dry season; it withdraws its whole body into the shell, closes the opening behind it with its strong calcareous operculum and remains dormant till the rains come, when the caked mud enveloping it softens and becomes liquid once more. The eggs are large and attached together in masses. In the Tanjore and Tinnevelly districts it is regularly collected after the paddy has been harvested, by poor people who use it to eke out their ordinary meals. It is also used medicinally as an application for sore eyes. In the Philippine Islands it is a regular market commodity.

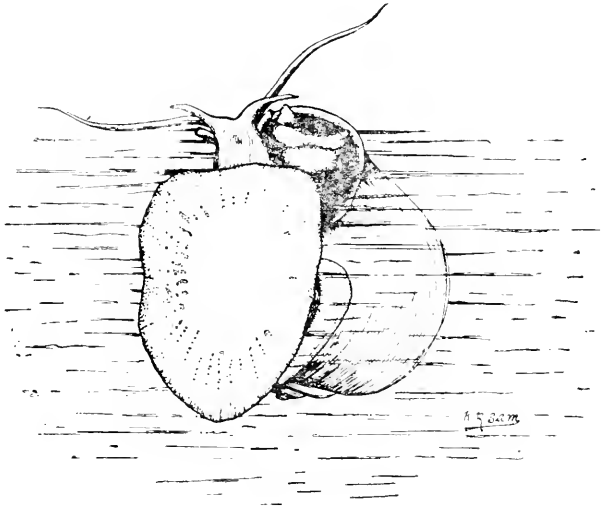

FIG. 4. Life appearance of *Pachylabra carinata*. It has climbed to the surface of the water up the glass front of an aquarium and is inhaling air. Note the large expanse of foot and the wide inhalent siphon.

The PERIWINKLES (*Littorinidae*) are found on rocky shores in all parts of the world. They are small turbo-like shells, but differing therefrom in having no pearly lining; the operculum is horny. They appear closely related to the fresh-water snails (Vivipara and Pachylabra), for they can live a long time out of water especially on coasts where the rise and fall of the tide is great. In some species this sub-aerial habit is so highly developed, that individuals may be found living so high on the littoral as to be reached

only by the sea-spray at high tide. In these the internal surface of the mantle is undergoing modification on the lines seen in the lung chamber of Pachylabra ; another demonstration is afforded us here of how land gastropods have evolved in the past. It is significant also that the operculated land snails and pond snails (*Viviparidae*) agree with the periwinkle in the arrangement of the teeth on the radula—in each row a broad median tooth flanked by three somewhat similar ones on each side. In the periwinkles the radula is peculiarly long, the hinder end being coiled up like a spare rope, in a pocket at one side of the gullet.

In Europe great quantities are used as food, but in India they are put to no useful purpose. They are common at Cannanore and at Pāmban and the neighbourhood. An allied Indian genus *Cremnoconchus* has entirely abandoned life in the sea and has taken permanently to the land.

The next family, that of the HORN-SHELLS or *Cerithiidae*, is another with a tendency to migrate from the sea to the land. All have the apex of the shell drawn out into a long spire, simulating the appearance of the true Turret shell, yet to be described, but differing in having the mouth aperture widely channelled and with the lip thickened and everted ; the whorls are usually ornamented with small tubercles or with varicose ridges marking the position of the lip at different dates during growth.

The marine species are mostly littoral ; *Cerithium obeliscus*, is one of the biggest of several that are common in sheltered bays and saline backwaters. At Ennur and Tuticorin a small species, *Potamides cingulatus* (Fig. 5), is often found in multitudes on mud-flats and at the edge of the tide, playing the part of humble scavengers ; lime-kiln women collect them at Tuticorin to be burnt into the best quality of lime for whitewashing, in specially small kilns used for this purpose. Two large species, the HORN-SHELLS proper, belonging also to the genus *Potamides*, and undoubtedly derived from the marine Cerithium, are found in abundance crawling in the mud in the mangrove swamps of the Kistna and Gōdāvari deltas, more often out of water than in it. These shells are also used for lime burning. One species, *Potamides palustris*, is easily recognized ; it is obviously a gigantic *Cerithium* ; the other, often called *Telescopium fuscum*, has a smooth shell without tubercles or ridges. It may grow to 4 inches in length and village boys in the Gōdāvari hamlets use it as a spinning top, a feat requiring great skill to

accomplish. In the Philippine Islands the flesh of the Horn-shells is esteemed as food; the shells are thrown on wood fires and when sufficiently cooked, the apex of the spire is broken off and the animal sucked out through the broken end. Even the small species of Cerithium are used in these islands as food. A third but smaller species of Potamides (*P. fluviatilis*) is common in brackish water

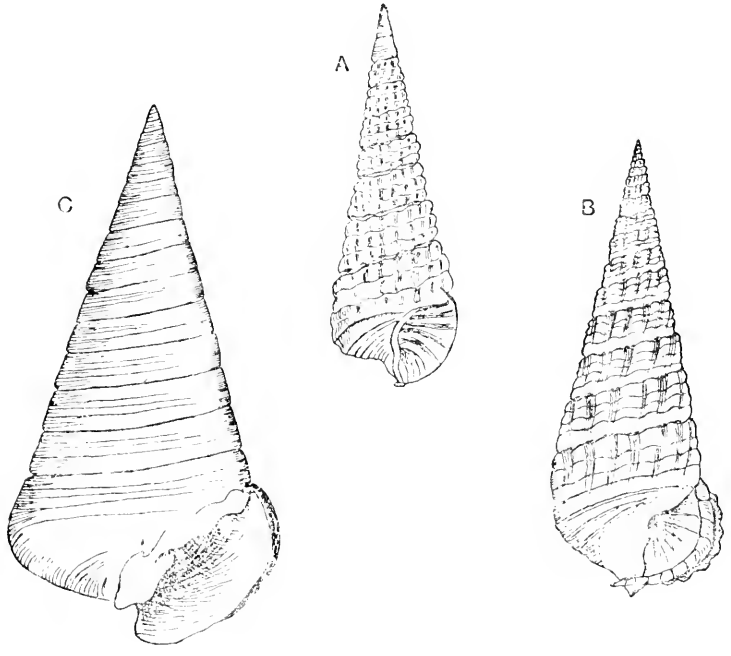

FIG. 5. Horn-shells. A. *Potamides cingulatus.* × 1½
B. *Potamides palustris.* × ⅔
C. *Potamides fuscum.* × $\frac{7}{10}$

it closely resembles Cerithium in the ornamentation of the shell. In India, under purely fresh-water conditions, the Horn-shells are replaced by the little *Melania*, a tuberculated shell much like Cerithium, but without the deeply channelled aperture characteristic of the latter.

Peculiarly aberrant in habit are the WORM-SHELLS (*Vermetidae*), for in adult life they are found always attached to rocks or embedded in sponges. In early life they are free and their shells are regularly spiral, but after they settle down, the spiral as it grows becomes lax and distorted, and may readily be mistaken by the tyro for that of *Serpula*, one of the marine tube-building worms. Under

these circumstances a foot for crawling is no longer needed; it has been reduced to a vestige and serves merely as a support for the strong horny operculum. Two genera are common in Indian seas, *Vermetus* and *Siliquaria;* the former has an entire tube; the latter has a narrow slit or else a series of perforations running along one side for the whole length of the gill chamber. Their respective habitats further distinguish them; Vermetus cements its tube to rock boulders, Siliquaria lives commensal with sponges, its coils sunk within the mass of the sponge to which it gives rigidity; possibly the presence of these hard tubes protects the sponge against enemies which otherwise might browse upon it. As Vermetus increases in size, it vacates the hindmost portion of the shell, cutting off the disused portion by means of a transverse partition. This is repeated frequently and so produces a series of partitioned chambers at the inner end of the shell cavity.

The reefs at extreme low water in the Gulf of Kutch are so covered with the tubes of the common Worm-shell, Vermetus, that barefoot walking becomes dangerous; it is also found fairly abundant on rocky ground in the Gulf of Mannar, where also Siliquaria is common.

The SCREW-SHELLS (*Turritellidae*) have elegantly tapered shells of the general appearance of a very elongate and slender Horn-shell. They grow sometimes to a length of 4 inches. The mouth aperture is simple and thin, without any suggestion of the thickened or everted lip seen in the Horn-shells. Like Vermetus, the Screw-shells find the first whorls of their shell too narrow to accommodate the apex of the body as they grow larger, and have adopted the same habit of partitioning off the narrow disused portions. They live in moderately deep water in muddy sand. Their shells are often cast upon the beach on all our coasts and are quite common at Madras. The only ornamentation consists of spiral ridges; there is never any trace of tubercles or varices. *T. duplicata* is a common species.

The WING-SHELLS (*Strombidae*) include some of the largest of the gastropods and many most interesting species. The family is an extensive one with a great range in outward appearance. Three genera are common in Indian seas; *Strombus, Pteroceras,* and *Rostellaria.* The first two have short conical spires, and the outer lip

is dilated into a stout wing-like expansion, which in *Pteroceras* is armed with enormously stout finger-like spines.

The common Strombus of South India is *S. canarium* (*viranjan*, Tamil), a small massive species with a prominent thickened "wing," abundant in the shallows of Palk Bay and the Gulf of Mannar. The poorer coast people collect them when gathering other shells for food and sometimes cook them along with more esteemed shell-fish. The shells have value independently of this; very large numbers are used annually at Kilakarai by shell-ring cutters in their trade. These men, who belong to the *Sangu vettian* Muhammadan community, pursue the most primitive of methods, such as doubtless pre-historic men employed for the same purpose. The two ends of the shell are first broken down by means of hammer blows, and then the resultant middle portion is ground down laboriously upon a stone. Except a hammer, a chisel, and a file to smooth the edges, no other tool is employed. These rings, known as *Sangu modiram*, are extensively used as finger rings throughout the Tamil country as a specific for skin disease In the Malabar and South Kanara districts, certain classes of the poor population—Pulayas, Holayas and some Mukkuvans use these rings in the making of necklaces for their women and children.

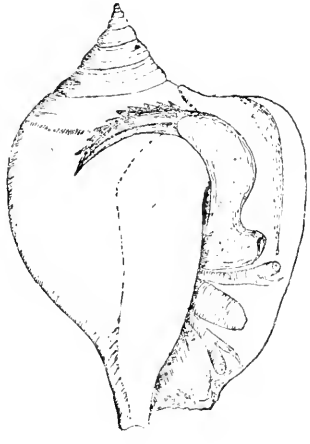

FIG. 6. Common Strombus (*S. canarium*).

The stromb is a remarkably active gastropod; its foot is narrow and arched, the hinder part elongated and armed with a peculiarly long claw-shaped operculum strongly serrate along one side. They progress by a sort of leaping movement; they are reputed to be carrion feeders and whatever may be their powers of smell, their sight is remarkably smart. Holding one in the hand the watchful alert look in the prominent eyes when at bay, is so different from the impression of sluggishness given by most other molluscs that one has no difficulty in giving the strombs credit for comparatively high intelligence. Cautious handling is necessary, for they have a habit of lying quiescent for a few moments, watching an opportunity,

and of suddenly wrenching themselves clear with a quick jerk and a vicious lash of the opercular claw; a nasty wound can be made by this weapon in the case of the larger species.

The SCORPION-SHELL or FIVE-FINGERED CHANK (*aiveral sangu*, Tamil), *Pterocera lambis*, is the most common species of this

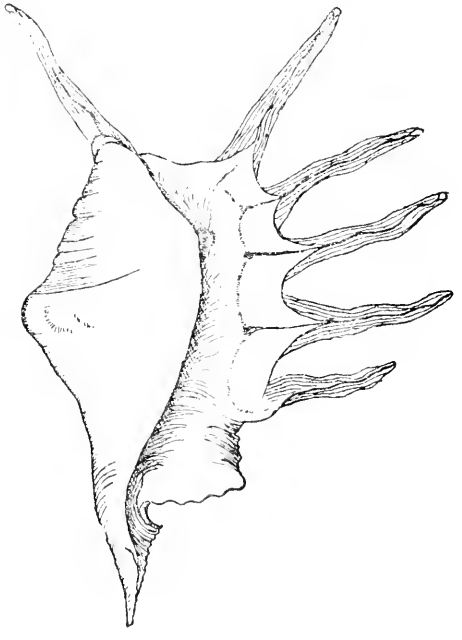

FIG 7. The Five-fingered Chank (*P. lambis L.*).

genus in our waters. It is extremely abundant in the faunistically rich weedy shallows of the south-western angle of Palk Bay. The size when adult is considerable; a length of seven inches is quite common, and the width, if we include the long fingers, is fully half this measure. In the immature condition the shell looks like an ordinary stromb, and only when it attains full size does it form the great "fingers" which are its characteristics. These are channelled on the lower side, processes of the mantle passing along the channels, until they attain full size, when the channels close and the "fingers" become solid.

From low water to two fathoms, this shell is often numerous, particularly along the coast between Pāmban and Tondi. Some are collected by the shore people wading in the sea at low tide, but

the great majority are taken either by the Kadayan and Muhammadan beche-de-mer divers, or accidentally in nets set for crabs, whereof many miles length are shot daily during the season. The shells serve a variety of purposes; as food they are broken open and the flesh extracted, and used for curries; as net sinkers they have the "fingers" broken off, the shell perforated and then are tied at intervals along the ground rope of nets; by burning, white-wash lime is made; lastly they are used as octopus traps. To fit them for the last named use, the apex of each shell is broken off together with the fingers, and each is tied at the end of a short line

FIG. 8. Growth changes in the shell of *Pterocera chiragra* from the Laccadive Islands. In the youngest stage no fingers are present. They appear at first as wide channelled projections.

which in turn is tied to the main rope. The branch lines are attached at intervals of 5 or 6 feet along the main rope. As many as 30 shells may be attached to one rope. A number of ropes are tied end to end and then laid in shallow water overnight; when raised next morning a number of small octopus are found sheltering in the cavities of the shells. These are used as bait when lining for such fish as seer, parai, dogfish and rays. Hundreds of these shell-trap lines are in use on the Rāmnād coast from Devipatam northwards. In Japan and in Italy a device on the same principle is used for a similar purpose; in place of Pterocera shells, the Japanese and the Italians use narrow necked vase-shaped earthware pots, tied by the neck to the main line.

Several other species are found in our seas, but none is nearly so abundant as *P. lambis*.

The third Indian genus of the Strombs is *Rostellaria*, a beautiful finely tapered, spiral brown shell, not unlike a smooth Screw-shell except that the walls are thick and the mouth whorl expanded into

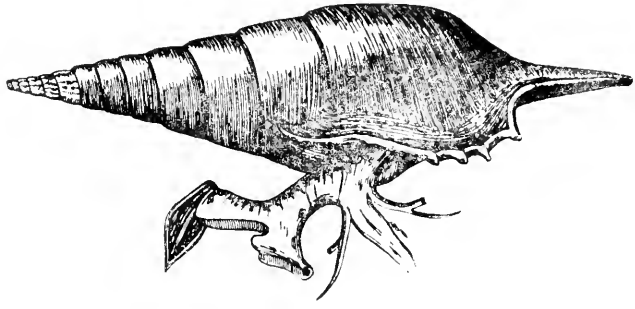

FIG. 9. Living appearance of *Rostellaria curta*. (25 fms. off Malabar). × $\frac{2}{3}$

a wide wing armed with several stout spines at the side, and the front end prolonged into a long semi-tubular pointed "canal." (fig. 9). Rostellaria is rare in the Gulf of Mannar but off the Malabar coast it is fairly abundant in places; numerous specimens of *R. curta* were dredged in 10 to 30 fathoms during the cruise of the *Margarita* in 1908.

Closely related, but very different in outward form, is *Xenophora*, a shell not uncommon in deep water in company with Rostellaria. The shape is trochiform ("like a Trochus") but more

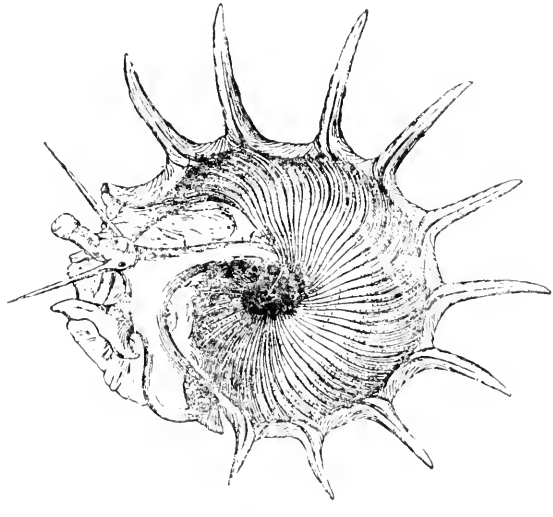

FIG. 10. Living appearance of the Stellate *Xenophora*. (Malabar, 20 fms.).

depressed and wider in proportion, and rather fragile. The animal is very like a stromb but with the foot even more conspicuously divided into two parts and equally obviously intended for scrambling over the ground at a rapid pace. The operculum is fan-shaped and sculptured. The remarkable characteristic of these shells is the way they disguise themselves by cementing numerous small dead shells to the upper whorls of the spire—the last whorl in adult shells is usually without this decoration. This masking device is intended to deceive possible enemies; the trick must be effective for the shell of Xenophora unlike those of its relatives, the true strombs, is usually thin and easily crushed. Fig. 10 is of a specimen dredged off Malabar. In this particular species the margin of the whorls is beautifully stellate; in others it is thin and foliaceous. On account of this singular habit of collecting shells to conceal their habitations, the Xenophoridae have sometimes been named "Conchologists," those that use fragments of stone being termed "Mineralogists." They are usually found on level muddy bottom where the surface is strewn with dead and broken shells.

Of habit wholly different are the two families of FALSE-LIMPETS, *Capulidae* and *Calyptraeidae*. The former includes the BONNET LIMPETS (*Capulus* and *Amathina*). *Capulus* has a conical shell not unlike a cap of Liberty, the apex slightly recurved. In our Indian waters, the common species is *Amathina tricostata*, a small shell with the apex towards the hinder end and without any trace of the recurved point seen in *Capulus*. Three stout ribs pass from the apex to the anterior margin, rendering identification easy. It seldom grows more than an inch in length, and is generally found attached to the valves of pearl-oysters in 5 to 6 fathoms in Palk Bay.

Another interesting Indian Capulid is the little *Thyca ectoconcha*, parasitic on the under side of the long arms of the star fish *Linckia*. A muscular plate grips the surface of the starfish and through a hole in this, the pharynx of the parasite works its way into its host.

The *Calyptraeidae* include the CUP-AND-SAUCER LIMPETS (*Calyptraea*) and the SLIPPER LIMPETS (*Crepidula*). The former are small and conical, the latter, as their English name implies, oval and much flattened. In both an internal plate occurs, the remains of the original spire of the shell. In Calyptraea this plate

has a half-cup shape whence has come the popular name. These small shells are not uncommon in fairly shallow water; on hard bottom they usually adhere to stones, where it is muddy to any shells that manage to exist there, particularly to the Window-pane oyster (*Placuna*). The exterior of the shell is rough and irregular and always white, in marked contrast to the pale-yellow tint of the body within.

The form of the SLIPPER LIMPETS (*Crepidula*) is well expressed by the name—a long oval, much flattened, and with a shelf-like projection within, across the posterior half, exactly like the toe-end of a slipper. They show a remarkable resemblance in the shape of the shell to *Navicella*, the fresh water Nerite; the internal ledge is however not the remains of the lip of the columella, but a purchase for the attachment of the adductor muscles. Under favourable conditions slipper-limpets may increase so prodigiously as to become a danger to the prosperity of the oyster industry. An example of this is the damage done within the last few years to valuable oyster beds on the east coast of England by the American Slipper-limpet (*Crepidula fornicata*), imported inadvertantly with a consignment of oysters from the United States. The intruder found conditions so favourable that now a dredge sometimes brings up as many slipper-limpets as oysters, and their consumption of the available food is so great that the oysters, which live on the same organisms as the limpets, have insufficient food and do not fatten and thrive as they should. During the war, the plague of slipper-limpets became so alarming that the Fisheries Department in England, after investigation, arranged for the oyster fishermen to be paid for all slipper-limpets collected, and these were then turned into meal and shell-grit for use on poultry farms.

The *Naticidae* are active sand-burrowing animals. In Natica proper the shell is strong and handsome and highly polished, usually almost globular, but in some cases with the mouth whorl so expanded as to appear roughly ear-shaped The whorls are few, the spire small and obtuse. The columella is often much thickened. They are predaceous in habit, and exceedingly voracious. The foot is enormously enlarged and has developed a system of water canals that enables it to burrow with remarkable celerity—a most ingenious device. Lobes of the foot rise over the shell before and

behind and completely enfold the shell, protecting it from abrasion. The burrowing habit renders sight valueless, so we find eyes in the Naticas either absent or buried in the integument.

Natica melanostoma and the snowy-white *N. mamilla* are two Indian species abundant on sandy shores, where they live upon the burrowing bivalves that abound there. Having found a shell, Natica seizes it and settles down to bore a hole through one of the valves. This it performs neatly and much more quickly than one would think possible. When completed, the long retractile

FIG. 11. Life appearance of Natica, the shell sunk in lobes of the foot. × $\frac{2}{3}$.

proboscis is inserted through the aperture and the flesh of the victim eaten out. They must be very numerous along the Madras coast for their peculiar egg mass, in the form of a broad spiral ribbon (fig. 12), is quite common at times on sand flats and in shallows at the mouths of our rivers (Ennur, the Adyar, Pāmban and Tuticorin, for example). The eggs are minute and so mixed and agglutinated together with sand grains that few even suspect these sandy ribbons that look like rolls of coarse sandpaper, to enclose thousands of eggs of a little gastropod.

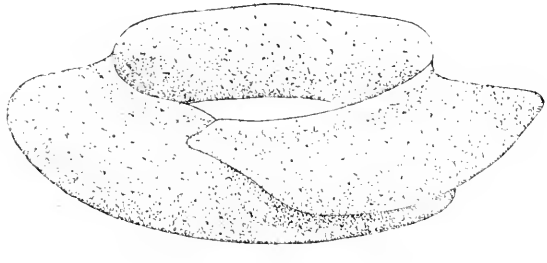

FIG. 12. Egg ribbon of Natica. (Tuticorin.) × 1.

A less common Indian genus is *Sigaretus*. Here the foot is even more greatly developed than in Natica, particularly at the front

where it assumes the form and function of a plough to push the sand away on both sides as it burrows. In these animals the shell is ear-shaped with a very wide aperture; the operculum is minute and of no protective value to its owner.

The lovely VIOLET SNAILS (*Ianthinidae*) are purely pelagic; they are found floating at the mercy of the currents in all warm seas; particularly common in the Indian Ocean, their beautiful violet tinted papery shells are common objects along the shore after long continued onshore winds. Often they are cast ashore alive and if we put them in a bowl of water we see how cleverly they have overcome the difficulty of keeping afloat. Under natural conditions, they float head up with the spire of the shell downwards. The foot is small and attached to it is a long frothy-looking raft, composed of bubbles entangled in a transparent secretion of the foot that dries into a delicate tough membrane. They are gregarious and float about in shoals, feeding upon oceanic jellyfishes

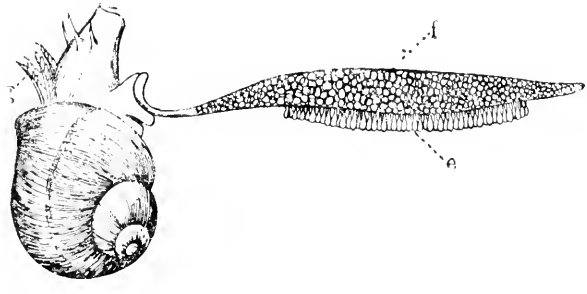

FIG. 13. Life appearance of Ianthina, showing the float and the egg-capsules attached beneath. (After Owen; modified.)

(Siphonophores), usually tinted violet like Ianthina itself. Some species attach their egg capsules to the under side of the float; others bring forth their young alive.

Strangely enough in animals that are free-swimming, the eyes are absent. Neither have they any operculum. Several species are found in Indian seas.

The COWRIES (*Cypraeidae*) are amongst the best known of Indian shells; the beauty and variety of their splendidly polished shells render them conspicuous and valued. The adult shell differs in form from any other; to understand its structure one must examine the stages by which it changes from the immature condition to the

perfect shell. The young shell is elongated, with a prominent conical spire, and a long wide mouth aperture bounded by a thin sharp outer lip. A delicate epidermis covers the surface. As it approaches maturity, the mantle flaps on either side expand and become reflected over the back of the shell, the edges meeting a little to one side. The epidermis becomes absorbed and in its place the inner surface of the mantle lobes deposits a highly polished enamel of variegated colouring upon the shell; this deposit extends over the spire as well and ends by obliterating and concealing its coils. A line, usually of paler colour, down the back indicates where the mantle lobes meet. Coincident with this, the outer lip turns inwards, thickens and assumes the furrowed appearance so characteristic of the lip in adult cowries; the edge of the columella or inner lip also thickens and assumes a similarly furrowed appearance. In the end the aperture becomes quite narrow, with a well-marked short canal at each end. The mantle and foot are even more vividly coloured than the shell and few objects are more beautiful than a large cowry crawling in a coral reef pool, the mantle bright with scarlet and yellow and beset with gracefully branched filaments. The foot is without an operculum; though large it can be retracted, together with the great mantle lobes, wholly within the shell. The cowries live on rocky ground particularly in and about coral reefs. They are often found hiding under boulders at low tide and appear limited to shallow water.

The little yellow Money Cowry (*C. moneta*) is abundant on the reefs near Pamban, where it attains a larger size than those brought from the Maldive islands; the Indian variety is distinctly intenser in colouring, being a dark yellow. Even yet it is employed as small change in bazaars in India and enormous quantities are in circulation in West Africa. In India it is esteemed also as an ornament and as an amulet; the lore of the money cowry in India alone, would fill a bulky volume.

Another small species common on coral reefs is the Eyed Cowry (*C. ocellata*), the back dotted with tiny greenish spots ringed round with yellow—ocelli. Larger species comprise the Tiger Cowry (*C. tigris*) covered with large bordered spots, the Black Cowry (*C. mauritiana*), a most handsome and elegant form, the Mole Cowry (*C. talpa*), the Serpent's head Cowry (*C. caput-serpentis*), the Arabian Cowry (*C. arabica*) and several others less well known.

In the Ovulidæ, only the outer lip is furrowed (crenulated), the columella remaining smooth and rounded. The best known is the

big Egg Cowry (*Ovum ovum*) used in New Guinea and the islands to the east as a personal ornament and as a decoration of everything the natives value and more especially their boats. It is snow white in colour and is a striking ornament when a number are worn as a fillet round the forehead or hung like bells from the prows of canoes. Smaller forms are common in Indian seas as commensals upon the sea-fans (Gorgonids). Gorgonids are usually brown or yellow or red and the little Ovula shells (*Ovula formosa*) always agree in colour with their host's hue; a yellow Ovula is never found on a red gorgonid, or a red Ovula on a yellow gorgonid. The colour of the mollusc resides in the mantle only; the shell is not coloured. Even more beautiful is a species of cowry living upon the cauliflower-like *Spongodes*—one of the soft corals. In this case the host is either pink or orange in general colour, but this colour is confined mainly to the terminal parts of the branches bearing polyps; the main stem and the branches are generally white. Hence the little cowry that lives here has the mantle blotched yellow or red as the case may be; this obviously harmonizes with the general colour of the host much better than if the mollusc were self-coloured. The foot is narrow and admirably adapted for climbing along the round stems of its host. In size these little commensal cowries seldom exceed an inch in length. They are active in habits and get along nearly as quickly as the red (or yellow) spotted commensal crabs that have the same protective colouring and live the same life among the branches of Spongodes.

Of the TRITON-SHELLS none of the large species used as shell trumpets in Polynesia and in the Mediterranean is seen in Indian waters except in the Laccadives; its place appears to be taken by the chank or sankha (*Turbinella pirum*). Small forms belonging to the genus *Ranella* are, however, common. These shells, known in Europe as FROG-SHELLS, are short and stout, with a strong ridge or varix continuous along the whole length of each side of the shell. The intervening space is tuberculated; the lip corrugated. They live in shallow water on rough bottom, and well deserve their common name for they have an absurd likeness to a tiny tree-frog squatting, head up, ready for a leap. *Ranella foliata* and *R. granifera* are common species.

The larger HELMET-SHELLS (*Cassididae*) are represented in India by two species, the Great Helmet-shell, *Cassis cornuta*, and the Red Helmet, *Cassis rufa*. The former is the heaviest and

largest Indian gastropod, its shell weighing several pounds. In shape it is not unlike a gigantic knobbed strombus but with the outer lip thickened and the inner one spread horizontally over the body whorl to form a flat polished surface in the fully adult condition. These shells are rare and are found usually in 8 to 10 fathoms on the pearl banks of the Gulf of Mannar. A smaller species, *Cassis rufa*, growing to about six inches in length is found in the Laccadive Islands. It is of a reddish tint, and the prominent spines of *C. cornuta* are here reduced to low blunt knobs. *C. canaliculata* is a common shore species of small size.

The shell substance of the large Helmet-shells consists of differently coloured layers, and this peculiarity is taken advantage of by the cameo-workers of Naples and Torre del Greco, who employ *Cassis rufa* for cameos requiring a dark red ground. Other species give a purplish blue ground, the carved figure appearing in white relief.

The *Doliidae* are familiar objects on the Madras beach. The shells have a widely expanded (*ventricose*) body whorl with a short spire. Two genera are common, *Dolium*, the TUN-SHELL, and *Pirula*, the FIG-SHELL. Dolium is remarkable for its globose form,

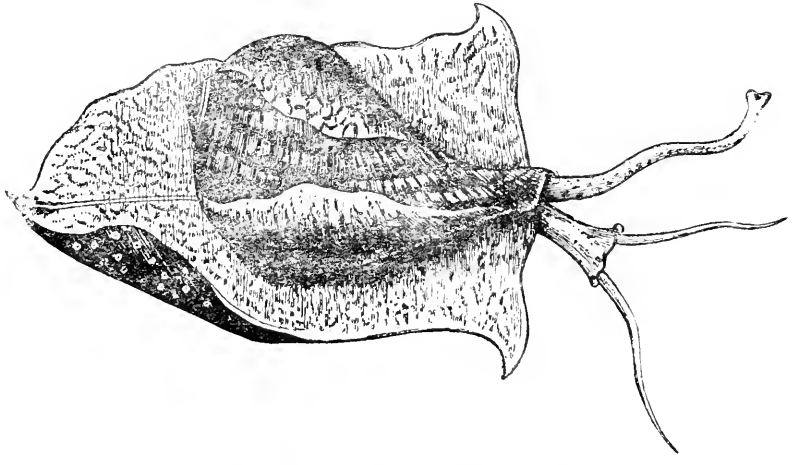

FIG. 14. Pirula seen crawling. Note the large flattened foot and the mantle folds enwrapping the shell. (After Owen.)

and the many narrow ribs that revolve round the shell from mouth to apex. The tun is fragile but so light is it and so round that the

dead shells seldom get damaged when they are washed ashore. The two Madras species are *Dolium maculatum* and *D. olearium*.

The Fig-shells (*Pirula*) are so named because of their shape. Their habits are the same as those of the Tun-shells—they live on sandy bottom not far below low-tide mark; to enable them to crawl rapidly and comfortably over soft unstable sand, the foot in both is very wide, forming a broad flat sole (fig. 14). In Pirula this is particularly wide and both the upper surface of this foot and the mantle folds that more or less enwrap the back of the shell, as in the cowries, are beautifully veined. (These dorsal folds are not present in the case of Dolium.)

Dead examples of the STAIRCASE-SHELL, *Solarium*, are fairly common on sandy beaches around our coasts after storms. The shell has a handsome low spiral not unlike Xenophora in general form, but orbicular in outline when viewed from above, the last whorl angular at the outer edge; a deep pit or umbilicus passes down the centre of the columella on the under side of the shell. The projecting edges of the whorls seen on the sides of this umbilicus have been fancifully compared to the windings of a spiral staircase.

RAÇHIGLOSSA.

The family Turbinellidæ is of special interest in India, for the type genus is *Turbinella*, the Sankha or Chank, a shell around which has gathered more legend and folk-lore than around any other in the world. Other important genera are *Cynodonta* and *Melongena*.

The CHANK (*Turbinella pirum*) is a peculiarly Indian species. It occurs nowhere in Asia outside of India and the Andaman Islands, its nearest relatives living on the Brazilian coast. Its finest or central variety is distinctly fusiform or spindle-shaped, with a handsome, well-balanced spire, but this may be depressed so greatly in some varieties as to give a distinctly piriform or pear-shaped appearance. The mouth is wide and prolonged anteriorly into a long deep canal lodging the great siphon used apparently in sensing the presence of the worms which form its principal food. The columella bears three and sometimes four strong ridges to which the very strong columellar retractor muscles are attached. Individuals living in shallow water, where

they are exposed to the influence of strong currents during the monsoon, have these ridges particularly strong and prominent giving increased purchase to the muscles connecting the foot with the shell. The exterior is covered with a thick velvety coating of golden brown periostracum, completely hiding the snowy white porcellanous shell beneath.

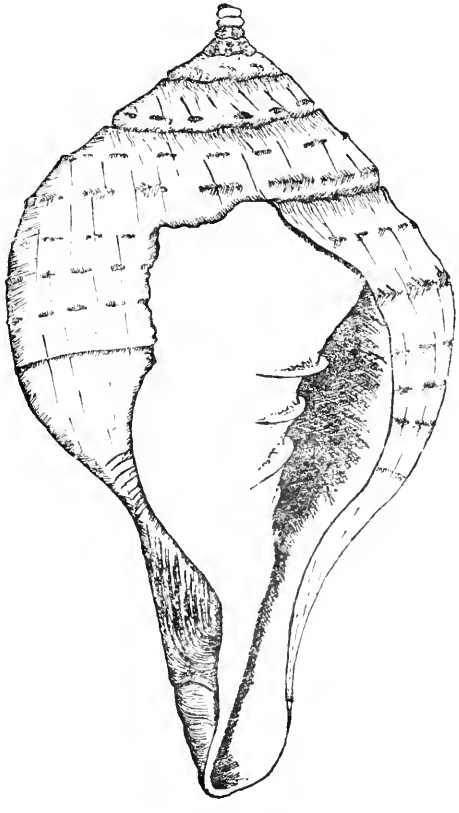

FIG. 15 The Sacred Chank (*Turbinella pirum*, L.). × ¾.

The chank is gregarious and its haunts form distinct "beds." It prefers a sandy bottom where tube worms abound; these constitute its chief food. These sandy beds are most prolific in depths from 8 to 10½ fathoms off the Tinnevelly coast; in Palk Bay the beds are at a lesser depth and where there is much mud mixed with the sand, this appears to affect the growth of the chanks adversely. Other beds occur along the Tanjore and South Arcot coast and extend to some distance north of Pulicat lake. Chanks are found also off South Travancore and in Okhamandal in Kathiawar. In the Andamans a distinct variety (? species) occurs with elongated mouth and distinct remains of knobs along the shoulder of the whorls, a type more akin to the ancestral form than the smooth-surfaced shells from the east coast of India.

The larval development of the chank is typical of that of many of the larger Gastropods and is almost identical with that of the

European whelk (*Buccinum*). The ova are deposited in a many-chambered stiff parchment-like egg-capsule of striking and peculiar appearance. In general form it is an elongated, loosely spiral, annullated cylinder, divided transversely by partitions into a number of chambers, each representing one capsule unit; the whole looks like a minature ram's horn, corrugated and twisted, set point downwards in the sand. When newly formed it is pale opaque yellow in colour; with age it darkens, and becomes covered with low growths of algæ. It stands upright on the sea-bottom, the lower and first formed end rooted in the sand by means of a broad, flange-shaped, anchoring disc. The lower end is narrow and neck-like, the chambers there small; these gradually increase in size, till at a point about one-third of the length from the base they attain a maximum size, which is maintained thence to the abruptly truncate summit. The total height of the capsule is from 7 to 10 inches.

FIG. 16. Egg capsule of the Sacred Chank. × $\frac{3}{5}$.

In reality the case is a compound capsule, consisting of a number, 25 to 30 or more, of discoidal capsules attached at one point on the edge to a broad basement band that runs along one side of the case from base to summit (fig. 16). Without this knowledge it would be difficult to understand the complicated structure. The various capsules are closely set, the "roof" of one practically touching the "floor" of the one above. In the floor of each capsule is a crescentic slit parallel with the front edge, hence when the case sways to the current, the partition walls of the individual capsules gape slightly and so allow a circulation of

sea-water to provide the aëration needed by the larvæ. The horizontal partitions or walls are much thinner than the outer or circular wall of the capsule.

In each chamber or capsule a considerable number of fertilized ova are deposited, embedded in a transparent, colourless, albuminous nutritive jelly which entirely fills the chamber. In this matrix the embryos go quickly through the trochosphere stage and then assume a modified veliger form characterized by the possession of a spiral larval shell. This is quite different from that of the adult and is distinguished by the term *protoconch*. In its full development it reaches a length of about a quarter of an inch; the whorls are all nearly the same diameter, so that it appears when fully formed as a cylindrical coil of about 2½ to 3 turns. During the earlier larval period fratricidal war occurs among the brood, ending in the disappearance of the weaker among them, till only some half dozen (5 to 7 usually) remain alive to complete their development within the capsule. The change to the miniature semblance of the adult takes place suddenly; there is no gradation from the cylindrical form of the protoconch into that of the young adult form marked by the expansion of the mouth whorl, an expansion that widens continuously to keep pace with the rapid increase in size of the young chank. Differences of colour and surface also take place; from the white smooth surface of the protoconch, the newer part of the shell becomes brown-flecked, with a distinctly angular shoulder, bearing low knobs.

By the time the young chanks attain a length of rather over half an inch, all the nutritive contents of the capsule have been exhausted, and being no longer able to devour one another because of the stoutness of their shell, the ravenous young find it necessary to leave home in search of food. Their first step is to eat through the partitions dividing the separate chambers, a proceeding which results in the bringing together of the whole surviving family, numbering usually from 200 to 250 in all. The stronger next either eat a way through the outer wall or force their way out between the capsules. The whole brood follow, to scatter over the adjacent sea-bottom to lead independent lives. It is noteworthy that in the chank, the protoconch persists through life, accidents excepted, at the apex of the adult shell.

The breeding season, when the capsules are fashioned and rooted in the sand, extends throughout January, February, and the first half of March. Some divers assert that new capsules are also to be found in June and July, but I have had no opportunity to test this statement. The sexes being separate the divers have several stories to tell anent the breeding habits. Among others they assert that the females are the larger and are attended each by a number of smaller males, who assist in the making of the capsules!

The chank is an excellent instance of the acquisition by an animal of characters which appear, for all practical purposes, absolutely perfect to enable it to hold its own with ease in its struggle for existence. Against every one of its known enemies it has evolved suitable means of defence. The massive strength of its shell protects it from the attacks of all ordinary fishes; the density and thickness of its periostracum give during youth and maturity adequate protection against the insidious attacks of the boring sponge *Cliona* and its shell-burrowing congeners; the strong capsule it constructs for its young gives them protection till they reach a self-supporting stage endowed even at this early period with a fairly strong and resistent shell—one cannot crack it between one's finger and thumb. Its semi-burrowing habits give it defence against those fishes which have the habit of snapping off the protruded feet of gastropods. Finally the pale yellowish-brown periostracum assimilates closely in colouring to the sand and should be a further protection against its discovery by enemies; to this form of protection I am, however, not inclined to assign great value, for chank divers can distinguish the presence of a chank even when half buried in the sand, and if they can, I feel assured that predatory fish are equally clever.

As chanks grow old, their resisting powers diminish, the protecting periostracum receives damage and the burrowing sponge *Cliona*, obtains a lodgment in the shell. Once there it runs its branching tunnels everywhere in the substance of the shell, converting it into a honeycombed mass. I greatly doubt if this contributes except indirectly to the death of the chank. This probably occurs usually from senile decay on beds that are not fished commercially. It is noteworthy that beds which have not been fished for some years, contain great numbers of Cliona-burrowed shells, whereas on beds that are fished regularly, the

proportion of wormed shells is so low as to be practically non-existent.

Among the chanks fished each year are usually a few left-handed (sinistral) examples, in which the coil of the shell instead of twisting clockwise from left to right if the shell be held with its mouth (anterior end) pointing forwards, is reversed and twists from left to right. It is noteworthy however that the terms used are also reversed in Tamil, a sinistral or left-handed shell being called *valampuri* or "right-hand shell"—the converse of the European way of looking at it!

These abnormal shells on account of their great rarity are accounted by Hindus and Buddhists of great religious value. A valampuri chank is one of the emblems of Vishnu, and such shells are amongst the most important of the treasures of the great Hindu temples of the present day. Similarly in Tibet a few of the Buddhist monasteries treasure similar objects. The Emperors of China considered a sinistral chank the most valuable gift they could present to one of their Viceroys.

At one time the value of these shells is said to have been assessed at their weight in gold. Good shells are still assessed according to weight, the price per tola weight increasing greatly as the shell becomes heavier. A shell under 30 tolas weight is valued at from Rs. 5 to Rs. 20 per tola according to quality; from 30 to 100 tolas weight Rs. 30 to Rs. 40 per tola, while if above this, the price will be not less than Rs. 50 per tola. A shell of 110 tolas weight at this rate would be worth Rs. 5,500, by no means an extravagant price if the shell be nearly perfect, and without "worm-holes."

In one season, 1900–01, twelve valampuri shells were obtained from the beds in the south-west corner of Palk Bay, but nearly all were small and badly "wormed"; at auction they brought the comparatively small sum of Rs. 601 for the lot.

Among the ignorant in South India the belief is prevalent that a valampuri chank blows of its own accord during the night, and in China, the Viceroy of Fukhien, in the days when Formosa was included in his jurisdiction, carried one in his State junk on the occasion of his inspection of the island, as the blowing of a sinistral chank is believed to have the effect of stilling the waves in stormy weather.

The chank fisheries of India and Ceylon produce not less than 2,000,000 shells per annum. In some years the number may rise to 2¼ millions but of this number only 6 to 8 lakhs are "live" shells, the remainder being sub-fossil shells dug out of the mud of the Jaffna lagoons where they have lain for hundreds and perhaps thousands of years.

The bulk of the shells fished in all localities are exported to Bengal where the great majority are sawn and carved into bangles, used universally in that province by Hindu women of all castes. In the Tamil districts of Madras, great quantities of small ones are used as amulets against the evil eye, especially in respect of draught bullocks and cows in milk. Another large lot are fashioned into babies' feeding spouts, while the larger ones are used as shell trumpets during religious ceremonies.

As an article of food the flesh of the chank has come into local prominence only since the Great Famine of 1877 when the families of Parawa chank divers of Tuticorin first made systematic use of it. On the run home from the fishing grounds, the divers extract the foot and head region from the shell, using a strong iron skewer for the purpose. The whole of the glandular tissue in the "tail" of the mollusc is left within the shell. The part extracted is chiefly muscular tissue and carries the large horny operculum. This meat, called *sangu sathai*, is collected in little palmyra-leaf baskets and taken home as soon as the shells have been handed over to the Government officers. In preparing it, the flesh is boiled, cooled and then, after pulling off the opercula, cut into thin transverse slices which are sundried. In this condition they keep indefinitely—hard and horny slices looking like very thin chipped potatoes. In cooking, the slices are fried in ghi or in gingelly oil. The bulk of the flesh is consumed by the divers' own families. Its value is 12 annas to one rupee per measure.

The operculum (Tamil, *nagamam* or *navanam*) of the chank has a considerable value, being in demand for use as a glue in the composition of incense sticks. An exhaustive monograph upon the chank fisheries and industries, and of the innumerable superstitions centring around the shell, is contained in Volume VII of the Madras Fisheries Bulletin.

A close relative of the sacred chank is the DOG CHANK, *Cynodonta cornigera*, a strong murex-like shell covered with stout

knobs; like the true chank strong ridges are present on the columella. It is found on rocky ground, rarely in the Gulf of Mannar, more frequently in the Laccadive Islands.

Melongena vespertilio is common at the mouths of backwaters on the East Coast; it may often be found crawling in the shallows near the bar at Ennur. It has a distinct resemblance to the Andaman variety of the chank, having a well marked shoulder from which short conical knobs project at regular intervals. The spire is short and the canal long. The surface is covered with a velvety yellowish-brown periostracum. There are no plicae on the columella.

The *Fasciolariidae* often grow to a great size, particularly so in the case of *Fasciolaria gigantea* which may reach a length of two feet and *Fusus colossus* and *F. proboscidalis*. In Indian waters the largest species is the KNOBBED CHANK, *Fasciolaria trapezium*, a chank-like shell, often 4 inches long, with a short spire, armed with stout knobs. The columella lip anteriorly is ridged with several oblique folds. A thick brown periostracum protects the shell. It lives on the same ground as the true chank, but in comparison is few in numbers; the chank divers of Tuticorin bring it ashore when they find it and eat the flesh. The eggs are laid in capsules where the young undergo their development. A smaller species is the dark brown *F. filamentosa*, with sculpturing reduced to faint spiral ribbing and the merest vestiges of knobbing on the shoulder.

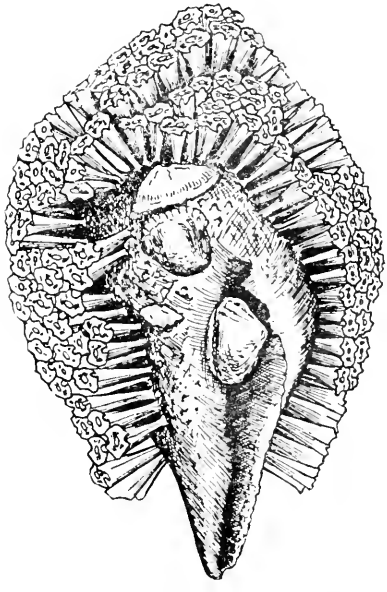

FIG. 17. Egg cases of a large Gastropod, probably *Fasciolaria trapezium*, upon a dead chank shell.

Much more elegant is our common SPINDLE-SHELL, *Fusus colus*. No shell could be more truly named for it is typically fusiform or spindle-shaped, the spire drawn out very long and the canal extremely elongated and narrow. The body whorl is comparatively small; the well-defined angular shoulder to the whorls

is beset with wide rounded ridges. *Fusus antiquus* is an extremely abundant species in Western Europe; apart from its considerable economic value as food, a point of great interest is that a separate race or variety arose in Pliocene times distinguished for its reversed or sinistral twist. In the chank, this abnormal form is extremely rare, but even here the bulk of them occur in one particular locality, indicating that there is in that place a family (in the popular sense) distinguished by this peculiarity, just as there are occasionally families among men distinguished by six fingers in place of five on each hand. In Pliocene days such a family evidently competed successfully with their normally shaped relatives and formed a race that became dominant; to-day this sinistral form still exists in the Mediterranean and on the coast of Spain, but on the British coasts the normal (dextral) form has ousted completely the abnormal sinistral variety.

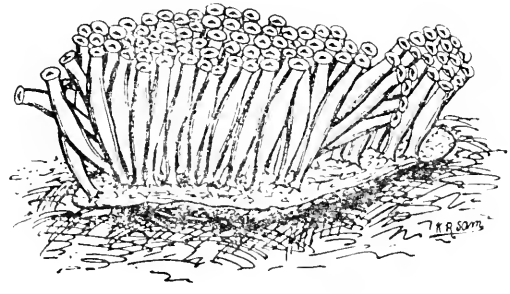

FIG. 18. Egg cases of a large Gastropod, probably a Murex, common off Tuticorin.

The MITRE-SHELLS (*Mitridae*) are handsome, brightly coloured shells, much sought after by collectors. Unfortunately the finer species are rare in Indian waters; the BISHOP'S MITRE (*Mitra episcopalis*) found in the Gulf of Mannar, is particularly beautiful, its shape elongated into a stout spindle and the surface decorated with spiral rows of blotches and spots. The mouth is rather narrow and like that of the chank is distinguished by the presence of several pleats or folds on the columella. The mitres are almost exclusively confined to the warm regions of the earth, from the Mediterranean, where they are small and few, to the East Indies and thence to Panama. They are most abundant and diverse in the Philippine region.

The next family, the WHELKS or *Buccinidae*, conversely are characteristically northern in their habitat, in regard to their most typical genera. The only conspicuous Indian genus is *Eburna* (= *Latrunculus*). These are stout whelk-like shells, solid, smooth and white, usually brightly spotted or blotched with red, obscured during life by a thin dirty brownish periostracum; the foot is similarly spotted. A characteristic feature is the rectangular form

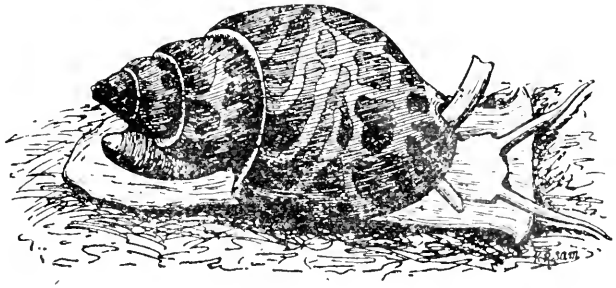

FIG. 19. *Eburna spirata* crawling over sand.

of the suture dividing the whorls. In the young an umbilicus is present; with age the inner lip becomes thickened and eventually spreads over the umbilical opening. The common Indian species are *Eburna spirata* and *E. zeylanica*.

The NASSAS (*Nassidae*) are all small and often tiny shells of the outline of a chank, usually covered completely with many rows of tiny tubercles; the aperture is usually small, the outer lip thickened and strong and often armed with peculiar and prominent "teeth," as may also be the inner lip formed by a strong callus deposited upon the end of the columella. The foot is long and broad and the siphon elongated. The Nassas are in the main scavengers living upon carrion; their sense of smell is extremely acute and they may be trapped in numbers by laying down a dead crab or a piece of decaying meat in shallows or rock pools and watching the effect. If Nassas abound it is not long before they are seen trooping from all sides, each with its siphon extended in front and waving inquiringly from side to side, to locate the source of the odour they have smelled. They cluster round and over a dead mollusc or a dead crab exactly as ants do over a dead insect they have found, but instead of dragging it away to their nest the Nassas devour

their find there and then. Common Indian species are *Arcularia australis*, and *A. thersites*, both found in the shallows of Palk Bay and the Gulf of Mannar.

The family of the *Muricidae* has a world-wide distribution; tropical species are numerous and include many very handsome and peculiar forms, ornamented not infrequently with prominent varices fantastically armed with thickly set spines. The basal form of the shell is fusiform; the aperture is rounded; in many species the anterior canal is very long and narrow, with sides so incurved as to become almost closed and tubular; a posterior canal absent. The foot is abruptly cut off in front. The proboscis is long and retractile, armed with strong teeth on the radula capable of boring circular holes in other shells in a manner similar to Natica. The Murices are all carnivorous; living free on the bottom they fill towards the non-burrowing bivalves a role similar to that of Natica in the case of those that live buried in the sand; they are capable of great damage and some of the smaller species, *Urosalpinx* sp. and others, together with the Purpurid *Sistrum*, cause havoc on the pearl banks when the pearl oysters are young and thin-shelled.

From some of the murices the Phœnicians obtained their famous Tyrian purple dye; the animal was extracted whole from large shells, small ones being broken in a mortar. Vestiges of this industry still exist on the eastern coasts of the Mediterranean in heaps of broken murex shells and in caldron-shaped holes in the rocks.

The handsome, long-spined *Murex tenuispina* is often brought ashore in considerable numbers by Madras fishermen, entangled by its spines in their nets; the same species and the closely allied *M. ternispina* are common on the West Coast in moderately deep water. Both these have extremely long beaks beset with spines; the WOODCOCK-SHELL, *M. haustellum*, has an equally long beak but no spines; it bears a fantastic resemblance to the head of a woodcock, whence the popular name. It is common on muddy sand on both coasts.

Of short-beaked small forms, *M. palmiferus* is peculiarly handsome, the spines being stout and branched. It occurs in the Gulf of Mannar,

Largest of all the Indian murices is *M. ramosus*. This shell is found associated with the rather larger Horned Helmet-shells (*Cassis cornuta*) in deep water (10 fathoms) on the pearl banks off the Tinnevelly coast. The fishermen call it the ELEPHANT-CHANK (*Ani sangu*, Tamil). The shell is short and massive, the beak quite short and wide and the whole surface beset with powerful spines slightly curved. Closely related is *Murex anguliferus*, a small edition of the elephant chank. So much alike are they that the smaller one has been supposed by some to be the young of the larger. The spines in the young are less developed than in the mature, and in this condition the angular form is well seen. It is common on the East Coast and at the temple at Tirukkalikkunram this shell appears sometimes to take the place of a real chank in the miracle enacted periodically at this place, which lies between Chingleput and Mahabalipuram. Here at intervals of several years, a chank shell rises to the surface of the temple tank and among the shells thus miraculously produced and treasured at the temple, I have seen two of *Murex anguliferus*.*

The PURPLES (*Purpuridae*) are littoral shells of small size found on all rocky coasts. The largest Indian species, *Purpura bufo* and *P. rudolphi* (*par attai*, Tamil) are barely 2 inches in length, thick

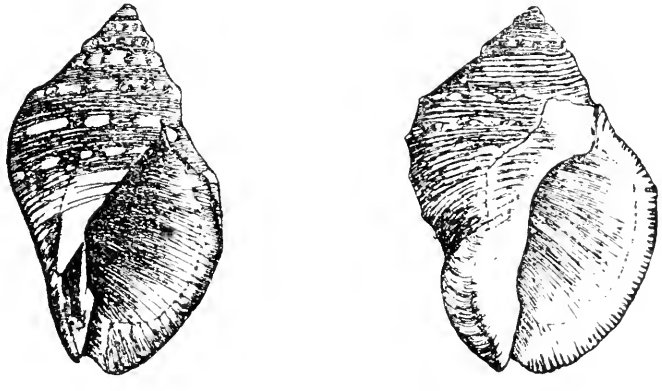

FIG. 20. Purples. *Purpura rudolphi* and *Purpura bufo*. × 1.

and stoutly built, with a short spire and a fairly large body-whorl and large aperture. They live on rocks between tide marks at

* "The Sacred Chank of India," p. 184. *Madras Fisheries Bulletin*, No. 7 Madras, 1914.

Covelong and along with Turbo on the stone-strewn shoals of the islands and mainland of the Rāmnād and Tinnevelley districts where they are occasionally eaten by the shore people.

In habits the Purples closely resemble the Murices; they prey on other molluscs, obtaining access to the soft bodies of their unfortunate victims by the same expedient of boring holes through their shells; they also secrete a dull crimson fluid that was used by the ancients for dyeing. *Rapana bulbosa* is another common Indian species and a spiny little *Sistrum* is a companion of *Urosalpinx* in its depredations on pearl-oyster brood.

The closely allied family of *Coralliophilidae* comprises a curious group of sedentary gastropods that live in coral reefs, intimately associated with the corals. *Magilus*, an Indian form, is like a thin-shelled Purpura when it settles down upon a coral; as the latter grows, the shell becomes ever the more deeply immersed, until, to prevent itself being entombed, it changes the growth of its shell from the spiral to the straight, lengthening it as the coral increases in thickness. As the straight section lengthens, Magilus fills the hinder cavity of its tube with solid material. An operculum is retained.

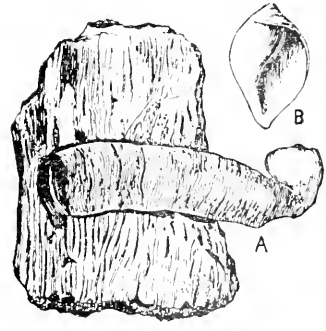

FIG. 21. *Magilus* showing the larval form of shell (B) and the abnormal straight form assumed in adult life (A) (after Cooke).

The VOLUTES (*Volutidae*) have great interest in India, for besides the pretty and typical *Voluta interpuncta* of our seas, the family includes the great MELON-SHELL (*Melo indica*). In its youth, this shell has a well-developed spire as in ordinary volutes; with growth, the body of the animal increases so fast that the whorl becomes so inflated and overgrown that the spire is eventually hidden. Strong folds are present on the columella. The adult form is almost globular, and the mouth whorl so roomy that in New Guinea it is commonly used by fishermen as a bailer. Our Indian species grows to a length of about eight inches. It is fairly numerous in 5 and 6 fathoms in Palk Bay, less numerous on the Coromandel Coast and in the Gulf of Mannar. The shell is pale reddish brown blotched with a darker shade. The

animal—foot, mantle, and head—is striped like a tiger with yellow and black. When crawling it presents a remarkable appearance, the shell all but lost to sight in the enwrapping lobes of the mantle and foot.

The eggs are deposited in a wonderful egg mass—the strangest of any produced in these seas. It stands nearly a foot high, a great honeycombed glassy cylinder made up of some hundreds of clustered capsules each nearly an inch in length. In form and sculpturing it resembles a tall cylindrical pineapple, the capsules representing the bracts. A narrow cavity perforates the centre of the cylinder. The walls of the different cells are tough, colourless and hyaline. As in Turbinella, a number of ova are deposited in each capsule, but with growth all disappear eventually but one,

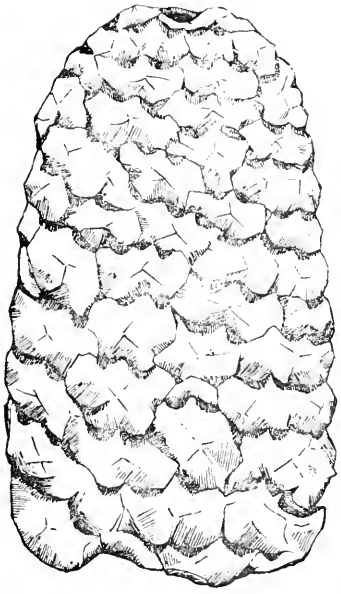

FIG. 22. Egg-mass of the Melon shell (Palk Bay). × ⅓.

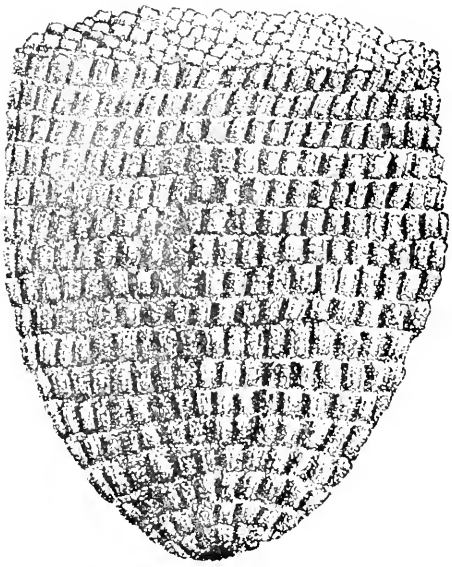

FIG. 23. Another gastropod egg-mass, parentage doubtful (Tuticorin). × 1.

and this, when it frees itself by eating through the capsule wall, is nearly an inch in length. Long before they come out, the young can be seen clearly through the transparent walls. The spire at this period is distinctly conical, and the whole shell extremely like the land-snails Bulimus and Achatina. This giant egg-mass

is not planted in the sand as in the case of the chank ; the parent carries it about till the young become free.

The family of the OLIVES (*Olividae*) contains some of the commonest shells found on the East Coast; they are rarely seen in Malabar. They are notable for their high polish and the beauty of their marbled colouring. Among themselves there is less difference in form than usual, the shape being roughly cylindrical, with a very short spire and a long narrow aperture. The suture is channelled and is in connexion with the hinder end of the mouth aperture by a narrow slit in the lip. The columella is overlaid with deposit and is striated obliquely ; no operculum is present.

As in Natica, where the habit of life is similar, the shell is partly immersed in the swollen foot; the mantle lobes are also large and meet over the back and so maintain the high polish of the shell. A slender tactile filament is given off behind from the mantle to pass through the posterior slit and lie when at rest in the suture furrow.

The Olives are very active; they burrow rapidly in wet sand in quest of the bivalves on which they live, and it is said that they may even be taken on a line baited with a fragment of flesh.

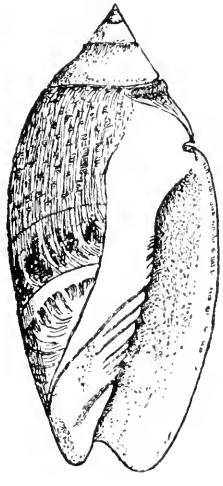

FIG. 24. Common Olive (*Oliva gibbosa*). × 1.

The common species is *Oliva gibbosa* (Tamil, *koranji* in Palk Bay and Madras, *sangu* at Pulicat). *Oliva ispidula* and *Ancillaria cinnamonea* are other less common forms. On the Coromandel coast the Olives are extensively used as food by the Pattanavar or sea-fishermen caste. On the Rāmnād coast they have less importance as a minor food item; while being utilized, chiefly by Valayans, in the same way as other shellfish whenever found, they are in some cases sought for separately on account of the price the shells fetch when sold to the shell-dealers in Ramēswaram temple, who give an anna per hundred for the shells. The chief collecting season is at the times of spring tides during the fine weather period from February to April. Towards the end of the ebb tide

Pattanavar women and lads then engage in the search, from about extreme low water to a depth of a couple of feet. They find the shells by turning the sand over with the feet or in the case of those in the uncovered sand by marking the trail made as the Olive travels about. The Pattanavars boil their catch in fresh-water, extract the flesh and then either use it in their curry or fry it in oil.

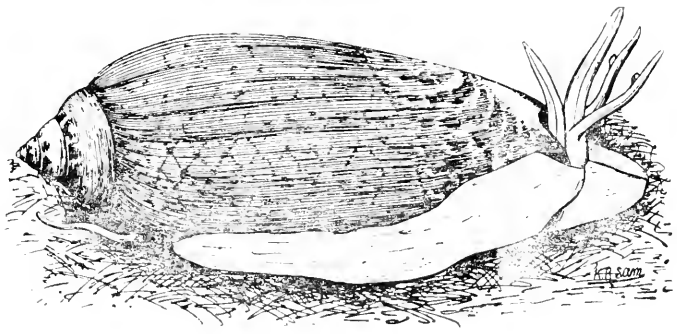

FIG. 25. *Oliva gibbosa* crawling. × 1¼.

The size of these olives (*O. gibbosa*) runs from 50 to 60 millimetres in length. In the sea-fishing hamlets or kuppams in the neighbourhood of Pulicat Lake, their shells, with those of Donax, contribute no inconsiderable bulk to the kuppam kitchen middens there accumulating.

The *Margineliidae* are small shells akin in appearance and anatomy to the olives; *Marginella augustata* is sometimes mistaken for a young olive. A distinguishing character is that the outer lip is thickened.

The last family of the Rachiglossa is that of the HARP-SHELLS (*Harpidae*), a small group of very beautifully coloured shells, the polished surface decorated with prominent longitudinal ribs, suggesting the strings of a harp. The body whorl is greatly inflated as in Dolium (ventricose), the spire short, and the columella callous. The foot is very large with a semilunar fore part, separated by a transverse groove; no operculum. As is usual in highly polished shells, the mantle is reflected over the back. The only living specimens I have found, were in coral reef pools in the Gulf of Mannar and in the Laccadives. When irritated *Harpa ventricosa*, our local species, commits self-mutilation by severing and throwing off the hinder part of its foot.

The next three families, the *Pleurotomatidae*, *Terebridae*, and *Conidae* possess a large " poison gland " in the gullet, communicating by a duct with barbed teeth on the radula ; they constitute the tribe of " Poison-teeth " or TOXOGLASSA. As may be inferred from this, they are carnivorous in habit.

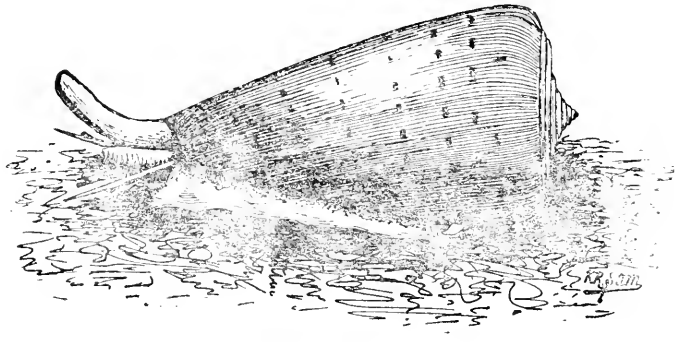

FIG. 26. Life-appearance of Conus.

The CONES (*Conidae*), as their name implies, are more or less conical in shape. The spire is usually short and may even be telescoped so greatly as to give the apical end a truncated appearance. The aperture is long and narrow, the outer lip thin ; a claw-shaped small operculum. Internally the partitions are partly absorbed. The family is very large, mainly tropical in character ; it includes many most brilliantly coloured shells, some so rare and beautiful that collectors have paid as much as Rs. 750 for a single shell. Some species are dangerous to handle on account of the poisonous nature of their bite, but none of the Indian species have ever attempted to bite me when handling them and none of our fishermen appear to fear them ; the South Sea Islanders on the contrary have a most lively dread of them, and allege that their bite is often fatal.

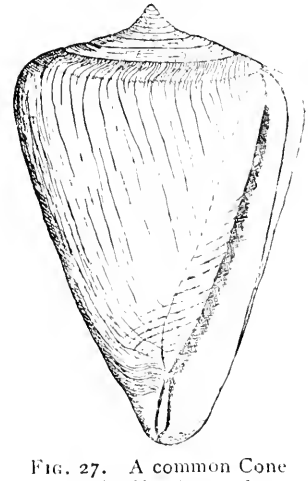

FIG. 27. A common Cone (*C. figulinus*). × 1.

Our common species chiefly haunt coral reefs. They include *Conus hebraeus* (the markings resembling Hebrew letters),

C. litteratus and *C. ceylonensis*, the last with a characteristic spiral white band in the middle of the mouth whorl. *C. textile* is a magnificent shell, large and beautifully marked.

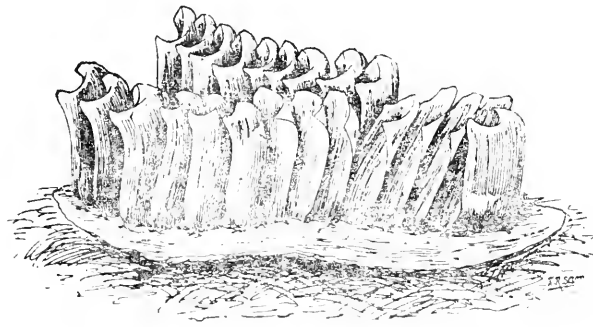

FIG. 28. Egg capsules of a large Conus on a broken valve of Placuna (Tuticorin). × ¾.

The SLIT-LIPS (*Pleurotomatidae*) are even more numerous in species than the cones and unlike them are world-wide in distribution. They are fusiform in shape, with a tapered spire and elongated body whorl ending in a long canal. A deep slit or notch in the thin lip is their characteristic feature. Our common species are *P. marmorata* and *P. tigrina*.

Lastly we have the AUGER-SHELLS (*Terebridae*), very long tapered shells of many whorls, resembling in general form the Turret-shells (*Turritella*) but usually are smooth surfaced, and brightly ornamented with coloured spots. *Terebra duplicata* is not uncommon in moderate depths on sandy bottom.

SUB-CLASS 2.—EUTHYNEURA.

The gastropods belonging to this section have the visceral nerve straight and not twisted as in the Streptoneura with which we have just dealt. Another characteristic is the excessive development of the sides of the foot into lateral folds or epipoda. These tend to envelop the shell and in degree as this is more complete and permanent, so the spiral form of the shell is reduced and its substance lessened in thickness, till it eventually disappears. In the most specialized in this direction, the torsion or twisting of the body tends to disappear and the animals acquire a *secondary* external symmetry. The section is divided into the orders Opisthobranchiata and Pulmonata, the former marine, with breathing arrangements suitable for life in water, the latter without gills and normally air-breathers.

ORDER 1.—OPISTHOBRANCHIATA.

This order includes the Bubble-shells (*Bullidae*), the Sea-Hares (*Aplysiidae*), the Umbrella-shells (*Umbrellidae*), one section of the Pteropods and the large and interesting shell-less group of the Nudibranchs.

The BUBBLE-SHELLS (*Bullidae*) are abundant on sandy bottom in shallow water. The swollen oval shells of *Bulla ampulla*, seemingly all "mouth," mottled with pale transparent brownish-red are often thrown ashore at Madras. In life none of the shell is seen, the fleshy lobes of the foot being reflected over the shell both at the sides and behind. In front, the foot, like many other burrowing molluscs, Natica and Oliva for example, forms a stout head-shield—the equivalent in its economy of a plough-share.

A closely allied species is the little *Cylichna*, belonging to the family *Scaphandridae*. The shell is cylindrical, with a long narrow aperture; it is not unlike a young Oliva.

An extremely beautiful animal is the Striped Bubble-shell *Hydatina*, belonging to the *Aplustridae*. The shell has the form of Bulla but is thin and fragile and ornamented with broad spiral black bands on a pale ground. The foot is very broad; the head

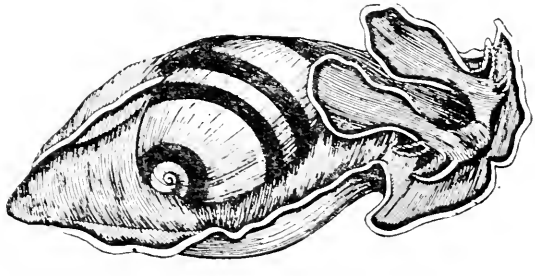

FIG. 29. Striped Bubble-shell (*Hydatina circulata*), life appearance showing the broad foot and head and ear-like tentacles. (After Adams.)

disc extremely large. The true tentacles (there are four small labial ones) are wide and ear-shaped and of enormous size, partially covering the shell. The colouring of the foot and the tentacles partakes of the colour scheme of the shell; it is a wonderful sight to see this creature when crawling in a pool, the shell partly uncovered, the great head with its elephant-ear tentacles stretched forwards and the wide side-folds partly reflected, undulating gracefully over roughnesses of the ground. Hydatina is found but only rarely, on the Rāmnād and Tinnevelly coasts.

In the *Philinidae* the form of the body is fully specialized for burrowing. The shell has become thin and small, the spire almost lost and the aperture wide and ear-shaped; it is embedded entirely and there is therefore no longer a clumsy projecting mass on the back as in Natica and Oliva, to hinder progress through the sand; the lobes of the body are fleshy and smooth, without any projections, the whole an animated plough-share perfect for its purpose of burrowing rapidly. Like Bulla and Cylichna it has a powerful gizzard armed with a crushing apparatus composed of three shelly plates. The common species is shapeless in appearance, a mere mass of white fleshy lobes. It is not uncommon in soft wet sand.

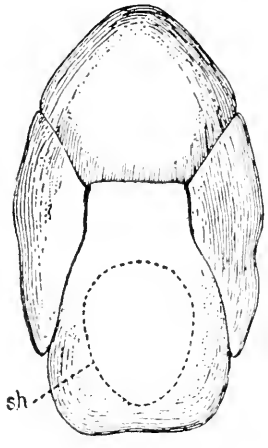

FIG. 30. Life appearance of *Philine*. Sh., outline of shell embedded in mantle.

Very different is the beautiful little LOBIGER (*Lophocercidae*). This form is often seen in great abundance in quiet sheltered bays where sea-grass prairies are found, as at Tuticorin. At first sight one is inclined to take it for one of the naked forms known as nudibranchs, till the rounded shell is observed. The body is

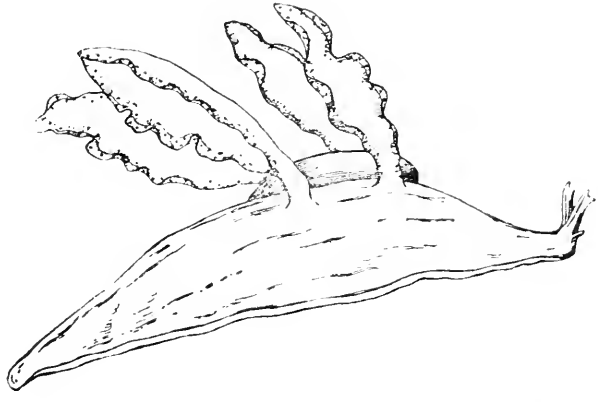

FIG. 31. *Lobiger viridis* showing the oval shell between the two pairs of 'fins' (Tuticorin). × 2.

slender and sluglike, tapering off behind into a long narrow tail. The head bears two flattened tentacles, while on each side of the body proper rise upwards two pairs of great leaf-like lobes or fins,

whereof the anterior pair is the smaller. Each fin is a thin wide lobe with frilled edges, attached to the body by a muscular stalk. When alarmed or disturbed, the animal seeks to escape by throwing off its fins; when cast off, these exhibit slight movement for some time afterwards. With the help of the mobile "tail" and these paired "fins," Lobiger is enabled to swim with ease. The oval shell, slightly convoluted, is transparent and very delicate; its convex surface is freely exposed on the middle of the back between the fins; there is no need as in Bulla and Philine to protect it from sand attrition, for Lobiger pursues a free life in the water, never attempting to burrow. The colour of our Indian species is normally a brilliant green, harmonizing with the colour of the sea-grass of the shallows where it abounds. Sometimes minute dark specks are scattered through the green. The ground colour of the fins is green likewise, bordered with a band of coral red speckled with black dots. Lobiger appears to have some power of colour adaptation, for when placed in a white vessel it becomes yellow, the bright red border to the fins disappearing. In Great Britain the place of Lobiger is taken by the little nudibranch *Elysia viridis*. This though belonging to a group altogether different has almost identical habits and a related scheme of colouring.

Here are now placed the shell-bearing PTEROPODS, "Butterflies of the sea" as they are often called. They spend their whole life in the open sea, often occurring in such vast swarms as to discolour the water for miles; they form the principal food of the Baleen Whale. Their shells are either tubular (*Creseis*) or broad and pocket shaped (*Cavolina*); the former (*Creseis*) are common in the minute floating life of our waters (*plankton*) but so small, pellucid, and needle-like that only under the microscope can it be recognized; the shell of *Cavolina* is sufficiently stout to be recognized when thrown ashore after storms, usually in company with Ianthina and violet-coloured siphonophore jellyfishes.

The Pteropods differ from other molluscs in the transformation of the foot into a pair of great wing-like swimming fins, arranged one on either side of the mouth, the head as a distinct organ having virtually disappeared.

The SEA-HARES (*Aplysiidae*), so named from a fancied resemblance to a crouching hare, are heavily built grotesque creatures,

lumpy and very soft to the touch, with a thin and much reduced transparent ear-shaped brown shell all but covered by the mantle and further protected by two fleshy side lobes of the foot. The stumpy head is armed with two pairs of tentacles, the hinder the larger. The middle region of the body rises high with a humpy back; behind, the broad flat foot passes into a distinct tail. In colour *Aplysia* is mottled and spotted a dirty purplish brown with points of white scattered throughout.

They are common in most parts of the world and the Indian species is almost indistinguishable from the British, and equally abundant in weedy shallows in bays and the seaward ends of backwaters. They vary greatly in abundance from year to year; sometimes they appear along the margin of the sea in multitudes; in other seasons scarcely one is to be found. When handled these animals discharge a large quantity of purple fluid from under the mantle. This secretion is quite harmless but is undoubtedly protective, for it discolours the water for a considerable distance around, alarming to any fish that may seize one of these animals. The odour too is unpleasant, and to some people distinctly nauseous. Aplysia deposits its ova in long greatly tangled cords, of considerable total bulk, the colour pale brownish pink (fig. 33). In India the spawning time (Ennur and Tuticorin) is February and March. It is at this time that the animals are particularly gregarious. A

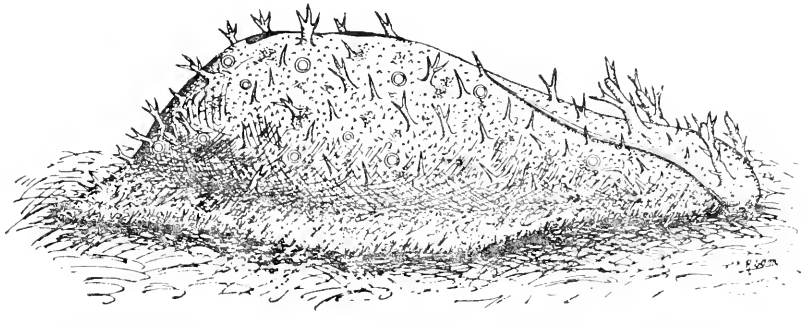

FIG. 32. Life appearance of the Plumed Sea-hare (*Notarchus*) from Ennur. Natural size.

member of another genus extremely closely related in form, size and colour is *Notarchus*, marked off distinctly from Aplysia by the presence of long filaments, the larger dendritic, scattered thickly over the whole upper surface of the body. Whether this is in any

way protective I do not know. The lateral flaps in this genus are united behind and not open as in Aplysia, leaving only a small aperture on the summit of the back. No shell is present, a stage further, the final one, in the process of the elimination of what had become a useless structure. Large and beautiful eye-spots are scattered over the body, the centre peacock green, ringed round with pale orange; each is at least 3 millimetres in diameter.

The gelatinous cords filled with opaque dirty reddish ova are similar to those of Aplysia. Its spawning time is the same and so is its habitat, all along the East Coast wherever quiet weedy shallows are to be found; it is very common in some years at Ennur in March.

The UMBRELLA-SHELL (*Umbrellidae*) is another clumsy creature not uncommon in moderate depths on the East Coast and easily recognized by the flattened shell that covers the back of its fleshy tuberculated body, very solid and muscular. The shell is quite

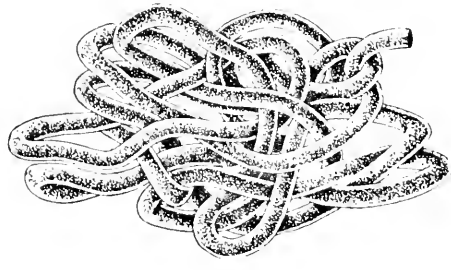

FIG 33. Egg cord of *Notarchus*. Natural size.

uncovered, and hides the large plumed gill disposed in front and to the right side. The head is small, and retractile like that of the tortoise into a deep notch in the front of the massive foot.

Finally as representative of the *Pleurobranchidae*, we have the dull unsightly *Pleurobranchus*, coarsely slug-like in shape, greenish drab in colour, and rough surfaced. It is common in dirty muddy pools between tide-marks at Rameswaram. The head bears two pairs of fleshy tentacles and like Umbrella the foot gives off no lobes at the sides as does Aplysia. As if its appearance were not already sufficiently repulsive, spicules are formed in the mantle.

The shell is altogether hidden; it is a long oblong flexible plate, slightly convex.

The important group of Naked-gilled Molluscs or NUDIBRANCHS is not well represented on the Madras littoral as their especial habitat is among weed-grown rocks; there are certainly many and beautiful forms but they are either small and inconspicuous or else comparatively rare. They are slug-like animals without shell of any sort, and true gills are absent, their place being taken by outgrowths from the back, protean in the variety of their form, and often exceedingly elegant and brightly coloured. In some these form rosettes, in others richly arborescent filaments, in other club-shaped knobs, or even simple folds not unlike those of Lobiger.

In certain cases the brilliant hues are assumed as warning colouration- possible enemies are told to beware of the spicules present in the skin or of the stinging cells which in some species (*Aeolis* for example) are developed in the dorsal processes; in another class the colouring is protective and mimetic, harmonizing with that of the sea-weeds and animals amid which they live.

The rough yellowish SEA-LEMON, *Doris*, lives largely on sponges, while the little *Doto*, with club-shaped appendages, feeds on zoophytes. A very peculiar form is the soft gelatinous *Melibe*, not uncommon on the pearl-banks, which has six pairs of large semi-transparent lobes upon the back, mottled olive green and brown; these drop off at a touch and when taken in a net, separate from the animal, are very puzzling to one who is not acquainted with Melibe. Some of the colouring within the skin is dûe to lowly algæ living in virtual partnership—symbiotic as this habit is termed.

Study of our Indian Nudibranchs is much wanted, and offers a wide field for original research; we know almost nothing of the life appearance of many species and still less of their habits.

The origin of the group is clearly shown by the larvæ which possess minute nautiloid shells, furnished with an operculum, both of which are cast off before the adult form is assumed.

ORDER 2.—PULMONATA.

With the exception of certain fresh-water forms which have re-acquired gill-like breathing organs, the Pulmonata are air-breathers in which the walls of the mantle cavity are traversed by a net-work of fine blood-vessels, constituting a true lung. Their

most familiar representatives are the land-snails and slugs, the former with a typical spiral shell; the latter have none externally but most of them possess a small internal plate or a few calcareous particles hidden beneath the skin of the back—a vestige of the ancestral shell.

In Madras Presidency two distinct land-snail areas exist, the one, the dry zone with a pulmonate fauna related to the Central and Northern regions of India; the other, the wet zone, comprising the whole of the West Coast with the Anamalai, Nilgiri and Palni Hills, has much more intimate connexion with Ceylon; it is indeed classed as part of the Sinhalese province by faunistic writers.

There is, however, much overlapping of these two regions and much intermingling of species. For example we are told that the Sinhalese province is characterized by the dominance and abundance of the genus *Helix* while *Ariophanta*—which differs from Helix in having a mucous pore at the end of the tail—takes its

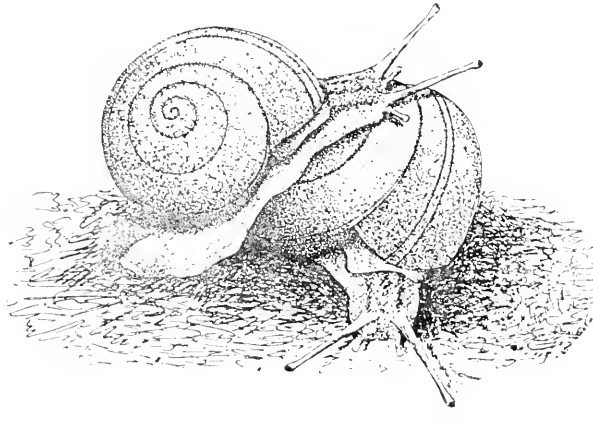

FIG. 34. A common Madras snail (*Ariophanta bistrialis*). × 1.

place very largely in the Indian province. As a matter of fact the Ariophantas are particularly abundant on the hills named and include the Imperial snail, *Ariophanta basilcus*, a magnificient form growing to $2\frac{1}{2}$ inches in diameter, characteristic of the Cochin teak forests (where it is occasionally eaten by the semi-wild tribes who live on forest produce) and found also in the Anamalai and Nelliampathi Hills. Two smaller species are abundant in Madras gardens; one is the single-banded *Ariophanta ligulata*, the other the two-banded *Ariophanta bistrialis*. Conversely a small dark-banded

white Helix (*Helix* [*Planispira*] *vittata*), coloured red brown within the mouth cavity, is seen everywhere in the Tinnevelly and Rāmnād districts on babul thorns and other dry-district bushes. They are reputed to have a bitter taste and this probably accounts for their immunity from attack by birds; their white shells are extremely conspicuous on the dark leafless thorns in the hot weather when bird food is scarce. During this period our Indian land snails lie dormant, closing the aperture of the shell by mucous secretion that dries hard and prevents evaporation from within. As this resting stage occurs in hot countries during summer it is termed aestivation; it parallels the winter rest or hibernation of animals in temperate and cold countries.

In Ceylon a huge snail, *Achatina fulica*, whose home is Africa, was introduced some years ago and is now a recognized pest, causing considerable loss owing to its depredations in vegetable gardens in the low-country region. It is an ovoid shell with well developed conical spire, and grows to a length of five inches. Its eggs are bright yellow and about one-tenth of an inch in diameter. Hitherto it has not obtained a footing in Madras and as it is important to be able to recognize it, a figure is given here (fig. 35). Any occurrence in Madras should be immediately reported and specimens forwarded to the Agricultural Department in order that its complete destruction may be effected before it makes good its footing. In Bengal it has been established for over 60 years and is common in Calcutta gardens.

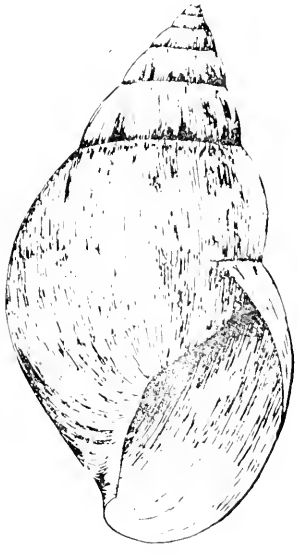

FIG. 35. Shell of *Achatina fulica*. Natural size. (Ceylon.) × 1.

Of very different appearance are the little EAR-SHELLS, *Auriculidae*; one species is very common among the roots of mangroves in tidal back-waters, and others in moist spots near the sea. The shells are oblong or oval with a well developed spire; the outer and inner lips are thickened and expanded; in one common

species both are conspicuously toothed. Some have a superficial likeness to the little Nassid *Arcularia*; the form of the mouth is however quite different.

Of fresh-water snails belonging to this division, *Limnaea* and *Planorbis* are typical, the one elegantly spiral, and the other discoidal, coiled in a flat *sinistral* manner. The shell of Limnaea is thin and fragile, with a large body-whorl; the colour brown. In

FIG. 36. Planorbis crawling on water weeds (*Vallisneria*). × 1.

Planorbis, usually a much smaller snail, and nearly black, the shell is stouter. It is specially remarkable because a lobe of the mantle just outside the pulmonary cavity has been metamorphosed into a functional gill; this genus therefore, derived from an air-breathing land pulmonate, which in turn originated in a water-breathing gilled marine gastropod, has returned to a wholly aquatic life, and has re-adapted its breathing apparatus a second time. It

is noteworthy that the original form of branchiae has not re-appeared, a wholly different part of the body being specialized anew for the purpose, a fact, which, Pelseneer remarks, illustrates the irreversibility of evolution.

Both Limnaea and Planorbis have the habit of crawling upside down beneath the surface of the water, the foot gliding along exactly as if it were moving along a sheet of glass; the well known phenomenon of the surface tension of fluids is the explanation of this miracle. Their spawn is deposited in colourless gelatinous masses on stones and water weeds. In hot weather when tanks and streams dry up, they aestivate in the mud in the same way as Pachylabra and Vivipara.

CLASS III.—SCAPHOPODA.

Standing apart from all other Gastropods is the little group of the Scaphopods, in many ways so specialized as to appear degenerate for there are neither eyes, nor tentacles nor any distinct head present; neither is there any gill nor any true "heart." The only well-known species are the TUSK-SHELLS (*Dentaliidae*). In these the edges of the mantle lobes unite to form a complete tube, and as a consequence the shell is tubular. At one end, the posterior, it is narrow, widening gradually to the other end, through which protrudes the short beak-shaped foot and a number of long filaments. The tusk-shells belonging to the genus *Dentalium* are often very common in sandy ground in depths of a few fathoms around our coasts; their empty shells are often cast up ashore. The most abundant species in Indian waters (*Dentalium octogonum*) has a very pretty curved shell, snowy white, with eight grooves running down the entire length, giving an octagonal outline in transverse section. It grows to a length of an inch and a half. Another species, very rare, grows to a length exceeding three inches and is stout in proportion. This species which I have seen on only a few occasions, has a shell mottled with shades of dark red, a very handsome shell. All live buried obliquely in the sand, pointed end upwards. In this there is a small perforation and it is through this that the water required for breathing passes in. The food of the tusk-shells consists of foraminifera and minute bivalves.

It is interesting to learn that the scaphopods were for long mistaken by naturalists for tube-forming annelids, so close is the superficial resemblance both of their tubes and of their head filaments with those of certain of these marine worms.

CLASS IV.—LAMELLIBRANCHIA (PELECYPODA).

The most conspicuous characteristic of this class is that the shell is in two parts or *valves*, hence the convenient semi-popular term of bivalves often applied to them. The mantle consists of two lobes, a right and a left, corresponding to the two valves and enveloping the body between them. A head is virtually absent, and no radula or teeth are present, whereas the foot, frequently developed into a narrow axe-shaped organ, is often of considerable size and of great mobility and strength in sand-burrowing species. The breathing organs are developed into plate-shaped gills, varying greatly in structure; these differences are now made use of in the classification of the group. The majority of bivalves pass their lives in burrows in sand or mud; others anchor themselves by a cable of fine threads, the byssus; in some one valve is cemented to rocks; a few bore into wood and stone and others are so exceptionally active that they swim through the water by alternately opening and shutting their valves.

Their food consists of minute organisms, animal and vegetable, swept within the cavity enclosed by the mantle lobes by the rythmic lashing of microscopic threads or *cilia* lining the interior. These particles are intercepted by the filter-like structure of the gills and wafted to the mouth by other cilia.

Before describing some of the common Indian bivalves, an explanation of certain technical terms is necessary for the ready understanding of the subject. If an ordinary bivalve such as a clam (*matti*, Tamil) or a mussel (*kallikai* or *pachchiali*, Tamil) be taken in the hand and held in such position that the hinge is uppermost and the end at which the mouth is situated is directed forwards, we are holding the shell with its *dorsal* side uppermost, its ventral side down, the *anterior* end turned forwards and the *posterior* end towards the person holding the shell; in this position the valve on the right is the right valve, the other the left one. The elastic pad joining the two valves at the hinge is the *ligament* and the fine skin on the surface of the shell is the *periostracum*.

Usually the *hinge* is formed by small interlocking projections, the hinge teeth. The valves are kept shut by the contraction of large *adductor muscles*, usually two in number, one towards each end of the shell. These pass from one valve to the other; when they relax slightly, the margins of the shell open, the normal condition; after death these muscles relax completely and the shell gapes widely, owing to the elasticity of the ligament which acts precisely as though a small pad of indiarubber were inserted in the hinge. In burrowing forms, where the shells lie mouth downwards in the sand, the two mantle folds join posteriorly to form two apertures—the inhalent and the exhalent. In bivalves that bury themselves deeply these apertures are extended into a pair of long tubes or *siphons*. Through the inhalent or branchial siphon water laden with microscopic food is drawn within the mantle cavity, where it filters through the gills and then passes out through the exhalent siphon.

The two chief orders of the Lamellibranchs are the *Filibranchia* and the *Eulamellibranchia*. In the former the thread-like gill filaments lie parallel to one another and are bent upon themselves (reflected upwards) at about half their length. In the latter the filaments instead of being free are united at regular intervals by cross bars containing blood vessels, and thus form a more efficient breathing and food-collecting apparatus—a very perfect form of filter.

ORDER I.—FILIBRANCHIA.

The Indian *Anomiidae* include the FALSE-OYSTER (*Anomia achaeus*) and the Window-pane oyster, *Placuna placenta*. Anomia is a small shell usually about 1½ inch diameter, frequently found adherent to edible oysters in the backwaters on the East Coast. It has a beautiful pearly shell often golden in colour, very like a young edible oyster in shape. It rests with its right or flat valve downwards; the left valve is convex. Through a hole in the lower valve, a shelly plug passes; by this it attaches itself to fixed objects. This plug is a modification of the byssus which in most other bivalves consists of numerous elastic horny filaments.

The WINDOW-PANE OYSTER grows to a much larger size, often 5 and even 6 inches in diameter. It is orbicular in outline when adult, very much compressed, and is remarkable for a very strong Λ-shaped tooth to which the ligament is attached.

It forms no byssus, lying more or less prone on the muddy bottom of estuarine creeks and landlocked bays (Palk Bay, Tuticorin Harbour, and the Buckingham canal) and in the sheltered bays along the Bombay coast from Goa to Sind.

The foot is long and trumpet-shaped; it is employed largely in freeing the interior from mud that finds its way in and would otherwise quickly choke up the fine network of the gills. The shell is peculiarly soft; both in appearance and softness it resembles mica, particularly whilst immature. Small shells are usually colourless, clear, and translucent; the Chinese ages ago noted this, and with their usual ingenuity put it to the useful purpose of glazing windows and verandah roofs. For this purpose the young shells are cut into squares about 2½ inches across, and then secured between narrow vertical strips of wood. The Portuguese borrowed the idea and introduced it into their Indian possessions in the 16th century. To-day the windows of the older houses in Goa and Diu are still glazed in this manner—the Governor's old palace at Marmugoa has fine examples of such windows.

In some localities—not all—the window-pane oyster produces a large abundance of seed pearls, soft, often misshapen but still valuable for use in indigenous medicine in India and China, and also for the production of an expensive lime for use in betel-chewing. Four such places in the Indian region are Chittagong, Tamblegam Bay in Ceylon, the Gulf of Kutch and the creeks of the Indus. In all these localities Placuna forms beds of great extent—they are numbered by the million—and the revenue derived from their fishery is often of considerable importance. Usually these fisheries belong to the State—a royal prerogative of ancient standing.

The anatomy and habits of this mollusc are dealt with in detail in volume II of the "Marine Zoology of Okhamandal." *

The ARK-SHELLS (*Arcidae*) are a large family including many Indian species, varying widely in appearance and habit. All agree however in having the hinge set with a large number of tiny plate-shaped teeth disposed perpendicular to the edge. The shells are often angular and the edge of the mantle set with minute composite eyes. The mantle is open and no siphons are present.

* Hornell, J., London (Williams and Norgate), 1916.

The best known Indian species are *Arca granosa*, *Arca tortuosa*, *Barbatia barbata*, *Pectunculus taylori* and some small species that live in crevices in corals.

The RIBBED ARK-SHELL, *Arca granosa* (*vari matti*, Tamil), is a fine shell found widely but sparingly distributed on the East Coast in backwaters and estuaries. Nowhere is it common. In appearance it looks like a very rugose cockle; the flesh is distinctively coloured red, due to the blood being of this hue, an exceptional condition among molluscs where the blood is generally colourless or tinted pale bluish-green. The flesh is tough, but because, presumably, of its red colour, some shore dwellers have the idea that it has specially nutritious and strengthening qualities; on this account it is often given to women during pregnancy. In size it seldom exceeds 53 mm. in length by a thickness of 43 mm.

It is noteworthy that this species is the subject of very profitable cultivation in Japan, where from a culture area of 830 acres between 75,000 and 100,000 bushels have been obtained annually. The method employed is simple; it depends for success upon the fact that the fry of Arca, after quitting the free-swimming stage, tend to settle in definite areas in great quantities. Once these are discovered the young ark shells can be raked up in thousands, usually when they are about 3 mm. long, and transplanted to culture grounds where they are strewn and left to burrow into the bottom. As they grow larger, from time to time they are redistributed in order that overcrowding and food shortage may be avoided. They are said to attain a marketable size in their third year. The bulk of the produce is exported to China.

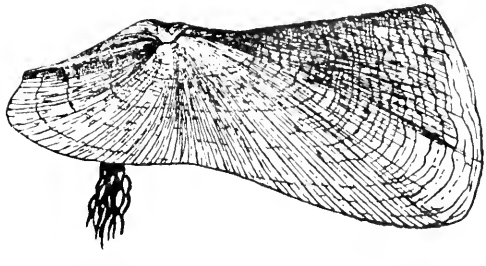

FIG. 37. The Twisted Ark-shell. × 1.

In the open sea, particularly in Palk Bay, the estuarine *Arca granosa* is replaced by the Hairy Ark-shell (*Barbatia barbata*) and the Twisted Ark-shell, *Arca* (*Parallelopipedum*) *tortuosa*. The former is ribbed and cockle-shaped, covered with a dense black periostracum thickly beset with short black bristle-like

hairs. The second species was well named *Parallelopidum tortum* by some authors, for whilst the opposite sides are parallel none of the angles are right angles and the shell appears as if it had been twisted out of shape when in a plastic condition. Both of these are fairly numerous in certain parts of Palk Bay and were shell-fish more widely appreciated by Indians, they would find a place in market supplies. The habitat of both is between the 4½ and 6 fathom lines on a bottom of dirty muddy sand. They do not form continuous beds but occur scattered singly over large areas. Their shells often give foothold to pearl oysters on the banks north-east of Tondi.

A small, elongated and very typical Ark-shell not unlike the Twisted Ark-shell is found in crannies among massive corals, and sometimes in the empty burrows of boring molluscs, especially of the Date-shell. The foot is large and secretes a short and massive horny byssus made up of thin plates of a characteristic deep green colour.

Belonging to the same family but very different in appearance is the equivalve *Pectunculus*, a common shell in depths of a few fathoms on the East Coast. In shape it is orbicular, somewhat compressed and smooth, with central umbones. The hinge is curved and so the line of the comb-like hinge teeth is somewhat arched instead of being straight as in Arca. The animal lives free and unattached and so powerful is its crescent-shaped foot that some species are able to leap to a height of several feet when disturbed. *P. taylori* is a common species.

The well-known MUSSELS (*Mytilidae*) form a large family. The three common genera of these seas are *Mytilus, Modiola* and *Lithodomus*. All have elongated shells with the hinge close to the anterior end and without hinge teeth. In Mytilus, the umbones are right at the anterior end; in Modiola they are some little distance away. Both these live attached by byssal cables; Lithodomus is not attached by a byssus, but is equally sedentary as it bores into limestones and corals, and does not leave its burrow once it has formed it.

Two species only of true Mussels grow to a considerable size in the waters of this Presidency. One of these is the very handsome Green Mussel (*Mytilus viridis*), readily recognized because

of the handsome green colouration of the horny membrane or periostracum investing the exterior surface of its valves; the other is an even larger species, less elegant in contour, coated with a coarse brown periostracum that looks commonplace when contrasted with the vivid tint of the green. The green species is distributed widely upon the Madras coasts, extending as it does almost continuously from South Kanara on the West Coast to the borders of Orissa on the East. The brown form, on the other hand, is confined so far as I am aware, to the extreme south of Travancore and of the Tinnevelly district.

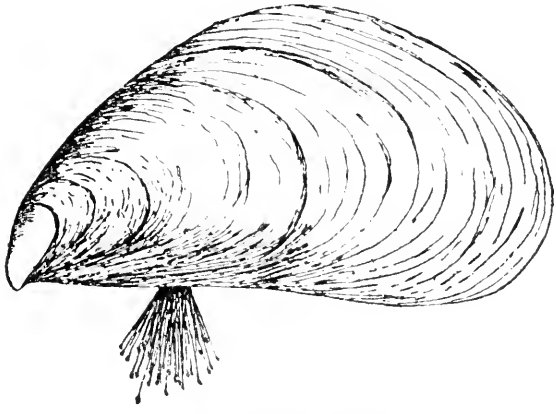

FIG. 38. The Green Mussel (*Mytilus viridis*). × ⅔.

No representatives of the closely related genus *Modiola* are eaten, although several species are found, particularly in Palk Bay, where the sea-bottom is frequently carpeted over hundreds of acres with vast multitudes of *Modiola barbata*, *Modiola japonica* and allied forms. These seldom grow more than an inch in length and live generally at a depth of 3 to 5 fathoms, hence their non-utilization as food. Could they be cheaply collected in quantity, they would form both an excellent food and, when dried and pulverized, a first-class manure.

Throughout South Malabar the green mussel is usually termed *kaduka* which appears to be a corruption of *kadalkai* (sea-fruit) by which name it is known amongst better educated people; in Cochin this same shell-fish is known as *nilakakka*, the "long kakka" in contradistinction to the ordinary *kakka* which is the common backwater clam (*Meretrix casta ovum*). In Kanarese it is *pacile*, in Tulu, *ageer*, and in Tamil *kallikai* in the south, *pachchai-ali* at Pulicat.

Mytilus viridis, although so widely distributed, is found in large quantity only on the West Coast from South Kanara to the

northern part of Travancore. Within these boundaries, wherever rocks are found inside of the three-fathom line, the Green Mussel usually finds conditions favourable and covers the walls of all crannies and protected sheltered surfaces with its closely set multitudes. Wherever it is found, it is accompanied by edible-oysters—chiefly *Ostrea virginiana ;* we can clearly distinguish an *O. virginiana—M. viridis* formation in such situations on both the East and West Coasts. The rocky coast of South Kanara from Gangoli to Kap, and that stretch of the Malabar Coast from Eli Mala to Kadalundi, are the two localities where conditions are most favourable for its growth ; these localities produce the great bulk of the mussels consumed in these two districts. The south section of Malabar is too sandy and rockless to give foothold and few mussels are fished there.

The collection of mussels is a minor marine industry of some importance at several places, especially in the neighbourhood of Cannanore, Tellicherry, Mahē and Calicut and also in Travancore. The flesh is highly esteemed and is eaten by Muhammadans and Christians and by all Hindu castes inferior to the Nayars ; in Malabar, I understand, however, that even the last named consider mussels as a delicacy, although those of Travancore will not partake of them. Kitchen-middens composed largely of these shells are often to be seen near huts as the train passes along the coast line between Calicut and Cannanore.

As the higher range of these mussels extends just above the low-water level of spring tides, the greater quantity are got by collection from rocks exposed or awash at spring tides ; a considerable number are, however, obtained from deeper water by divers. Both at Cannanore and at Tellicherry there are a few Mappillas who prosecute this industry for a few months in the year. The diver carries with him a coir bag and a bamboo stick sharpened at each end. With the latter he separates the mussels from the rocks and brings them to the surface in the bag. They are fished only during the dry months from December to May by which time they have attained edible dimensions. During the south-west monsoon it is impossible to gather any owing to the violence of the sea and for a few months thereafter they are too small in size to be worth taking.

Cannanore, Tellicherry and Mahē are the only towns in Malabar where mussels are exposed for sale in the public markets. About

half a dozen basketsful may be sold per day during the season. The demand is particularly active when fish are scarce and dear. In Calicut, Beypore, Badagara and some other large towns they are occasionally hawked through the streets. In other places there is no regular trade ; the fisherfolk and other coast people living in the neighbourhood of mussel rocks, gather supplies at low tide for their own use and sometimes sell any surplus they have.

On the East Coast, the Green Mussel is comparatively rare ; nowhere is it found in thickly stocked beds as in Malabar and Kanara. Yet almost everywhere along the coast occasional stragglers are found and in several estuarine backwaters where beds of the edible oyster (*O. virginiana*) occur, they become comparatively numerous.

In the Sonapur backwater in Ganjām district this mussel is fairly abundant, considerably more so than at Pulicat. As in the latter locality, its habitat is the oyster patches in the deeper parts of the backwater. Particularly numerous is it in the deep main channel near the fish-curing yard at Revu-Sonapur village. Here occurs a deposit of large oysters living in great clustered clumps ; in the angles and crevices of these masses the Green Mussels find suitable lodgment. They vary from single individuals to groups of three or four ; seldom do they exceed this number ; they never form a massive deposit nor do they ever cover their habitat with a living carpet as they do in Malabar. At Sonapur they have economic value but not as food. Owing to certain characteristics of this backwater these mussels are largely infected with the larvæ of parasitic worms, and, induced by the irritation thus produced, pearl formation is frequent. For many years past this peculiarity of the Sonapur oysters has persisted, and those of the local fishermen who can dive, devote considerable attention to the mussel fishery at times when the water in the channel is low. The pearls found are moderate in size and of poor colour, usually pinkish, but as the mussels yield them fairly abundantly, the beds are well exploited.

From the observations made (which I hope to amplify shortly), these pearls have a related origin to the pearls sometimes produced in quantity by the common mussel (*Mytilus edulis*) of France and England. The Sonapur backwater is the haunt of myriads of seagulls and waterfowl and it is from the adult parasites contained

in the alimentary canals of these birds that the flatworm larvæ found in the adult mussels are derived. Under certain circumstances occasional larvæ induce the formation of pearls in the mantle of the mussel, the dead body of the parasite persisting as the nucleus of the pearl. The life-history of the Sonapur pearl-inducing parasite has yet to be worked out.

The Brown Mussel (*Mytilus* sp.) is the largest and stoutest species found in South India, attaining commonly a length of 4 inches. It is distinctly larger than the Green Mussel, but unlike the latter its distribution is limited to a comparatively short length of coast in South Travancore, where it displaces the green species. The coast here is exposed to exceptionally heavy seas during the monsoon, but in spite of this it thrives in great abundance on rocks from low-tide level to a depth of about 2½ or 3 fathoms. Annually large quantities are taken from the rocks by divers. They form an important food item among fishermen and coast Muhammadans.

Several medium-sized species of the WEAVING MUSSELS (*Modiola* spp.) exist in our seas ; in Palk Bay and the pearl bank region in the Gulf of Mannar one species, the Bearded Weaving Mussel (*Modiola barbata* ; *suran*, Tamil) is so abundant that I have seen several square miles of sea bottom covered continuously with a carpet of these shells, felted together in a tangle of byssal threads. The presence of suran in such myriads is one of the adverse influences militating against the prosperity of our pearl banks ; the rapidity of their growth and their habit of enveloping everything about them in a dense network of felting fibres, contributes largely to the destruction of the more delicate pearl-oyster spat. The two molluscs have identical feeding habits and the competition of hungry myriads of suran has the same blighting effect on pearl oysters as that of the American slipper limpet upon the edible-oyster on the East Coast of England. The larger species, the Tulip Mussel (*Modiola tulipa*), is common in Palk Bay where it forms extensive beds. The average size is not too small for food purposes, and were there any demand, tons of them could easily be dredged in Palk Bay. The larger species is excellent eating, while the smaller would make, if dried and pulverized, poultry meal and fertilizer. A very small species, *Modiola variabilis*, characterized by the fine ribbing of the shell, lives associated with the edible oyster in backwaters,

The DATE-SHELLS (*Lithodomus* spp.) are long cylindrical mussels, growing to a length of 3½ inches, which tunnel into limestone rocks and corals, and sometimes into massive gastropod shells such as the chank and the helmet-shell. Two of our common Indian species are *Lithodomus antillarum* and *L. straminicus*. Date-shells bore only into shells, corals, and calcareous rock, the reason being that the boring is effected by means of an acid secretion poured out by glands in the mantle. The secretion decalcifying the surface little by little enables the animal to scrape off and remove the resultant debris and so permit of a fresh surface being attacked.

Of the *Pernidae* only one conspicuous species is found in our waters. This grows to a size of quite 5 inches in diameter; it is usually mistaken for a large pearl-oyster. In outline it is nearly the same and the interior is lined with mother-of-pearl of good quality. The hinge is distinctive. Instead of a single oblong mass as in the true pearl-oyster, the ligament is subdivided into numerous short sections, each sunk in a separate little pit or fossette. The long row of these fossettes renders Perna easily identified. It is rare and I have seen only a few brought up from a depth of several fathoms from rocky ground in the Gulf of Mannar.

The large family of the *Aviculidae* is of great interest to Indian students for in the waters of the Indian Ocean are found some of the best known representatives; they include the Pearl-oyster (*Margaritifera*), the Wing-shells (Aviculids proper), the Hammer-oyster (*Malleus*) and the curious *Vulsella*.

The Indian and Ceylon PEARL-OYSTER (*Margaritifera vulgaris*), the *muththu chippi* of Tamil pearl fishers, is amongst the smallest of its kind; it seldom exceeds 3½ inches in height (length from hinge to ventral edge) and compares unfavourably in size with the huge Gold-lip Pearl-oyster from Mergui and the South seas, a species with shell large enough for a dinner plate. Our local species makes up in abundance what it lacks in size; at the Ceylon pearl-fishery of 1905, over 80,000,000 of these shells were fished within six weeks. The pearls produced are correspondingly small, but in lustre, "skin" and colour, they far excel the larger ones from the big species. The shell figured here shows the normal form and size when grown under favourable conditions. The shell is nearly straight along the hinge line, and is produced at each end

into a short " ear," a modification of the wing-like projection that gives the Aviculids proper their name of " wing shells." Ventrally the shell is deep and rounded with a series of finger-like projections at the ends of radial lines made up of older fingers now outgrown, worn, and disused. These pearl-oysters reach their limit of size in about 3½ years ; if they live longer the shells become worn, the fingers disappear and the over-all length and depth sometimes actually decrease ; the thickness increases until death and this then is our best criterion in determining the age of pearl-oysters.

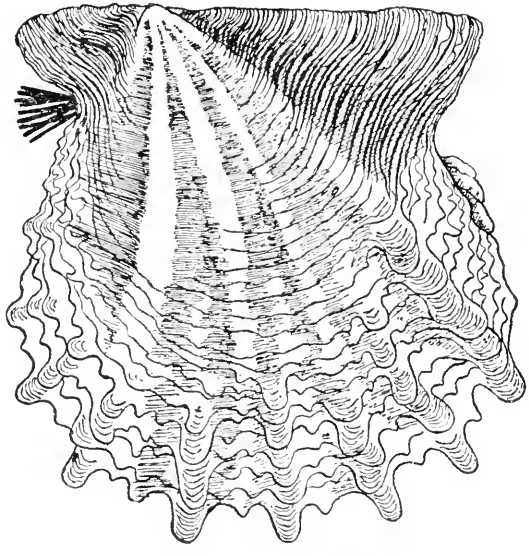

FIG. 39 The Indian Pearl-oyster (*Margaritifera vulgaris*). Natural size.

Pearl-oysters in life-history and habits are akin to the mussels. A strong cable of byssal threads attaches them to rocks, stones and other shells ; they possess the power of cutting their cable or rather of casting it off, at will ; they are capable of crawling short distances and this power to shift their foothold sometimes enables them to avoid entombment and death through an overwash of sand. When quite young they are restless and inclined to shift their position frequently. I have often seen them do so six or seven times within a few hours, each place of attachment marked by a tiny tuft of golden byssal threads. The formation of one of the threads forming the byssus takes only a few seconds ; the thread is formed

from a glue-like secretion poured into a fine groove on the underside of the tongue-shaped foot. On contact with water it hardens into a strong, slightly elastic substance, golden yellow in young oysters, dark bronze green in adults.

The sexes are separate, and fertilization of the tiny ova, of which several millions are produced by one individual, takes place in the water. Development is rapid, a trochosphere stage first and then a veliger. In the former stage, the larva is a little sphere with a ring of rhythmically waving tiny threads (*cilia*) around the equator, and a tuft of long filaments from the "North Pole" of the little creature. The lashing of this ring of cilia carries the larva through the water rotating on its axis. In the veliger a tiny shell with triangular valves has been formed, but still for some days yet the little creature continues its free-swimming existence near the surface of the sea, a ring of cilia, the *velum*, in front of the mouth, forming the swimming organ. At the end of about a week or even earlier if conditions be favourable, the larva settles down to the bottom and makes its first attachment. In this condition it is called "spat," the earliest stage of the settled period of its life. It is obvious that a satisfactory "spat-fall" on the pearl-banks is dependent upon a favourable run of currents at the time the oysters spawn; experience shows this to be the exception rather than the rule; there are many years when no extensive spat-fall occurs and hence pearl-fisheries in the Gulf of Mannar, both on the Indian and the Ceylon sides, are irregular. Blank years are more frequent than prolific years, especially on the Indian side. Worst of all, science is powerless; no human agency can control ocean currents and it is their influence and interaction more than any other factor that determine the conditions favourable or otherwise for an extensive spat-fall.

Pearl-oysters occur sporadically all the way along the East Coast from Cape Comorin to Madras. I have even found a young living individual in Pulicat backwater. But the only places where they occur in fishable quantities are the Gulf of Mannar and Palk Bay. The "banks" off Tuticorin have been worked from time immemorial, certainly for over 2,000 years. Those in Palk Bay are a recent discovery, for they were found as recently as 1913 during an inspection carried out by the writer. In the Gulf of Mannar pearl-oysters occur on banks where there is a good deal of stony

bottom, rocks, stones and shells, in depths from 5 to 11 fathoms. In Palk Bay they occur on muddy bottom or rather just where the purely muddy bottom merges into muddy sand at a very uniform depth of 5½ fathoms. On this bottom there are no stones, only occasional dead shells, the valves of *Arca*, *Modiola* and *Placuna* chiefly. To this precarious foothold the pearl-oysters attach. In 1914 they were found in sufficient numbers to justify an experimental fishery. Though the result showed only a small profit, the fishery was of great benefit to the villages in the neighbourhood, bringing a considerable amount of money into circulation.

It is probable that the permanent habitat of the pearl-oyster in South Indian waters is in Palk Bay and that the beds which were recently discovered there give rise to the spat that repopulate from time to time the banks in the Gulf of Mannar.*

In the Gulf of Kutch a pearl-fishery is carried on by His Highness the Maharaja of Nawanagar. The oysters there do not form banks; they occur scattered along the low-water edges of the rocky reefs that abound on the Nawanagar coast. They are collected by men wading in the shallows at low water of spring tides.

The shell of the common Indian pearl-oyster is too thin for manufacture into any but the most inferior quality of small pearl buttons. Pearls are the sole object of the fishery; the shells are of such little value that they have usually been left derelict by their owners at the end of a fishery.

The origin of pearls has long been the subject of speculation, but it was not till 1912 that the subject as concerning the Ceylon and Indian pearl-oyster was systematically investigated. In that year Professor Herdman and the writer went to Ceylon by request of the Government to investigate this and related questions. The result was to show that pearls belong to two main classes, orient and muscle pearls. The best of the former usually owe their origin to the irritation set up by the presence of a parasitic worm larva in the mantle. To get rid of the trouble the oyster covers the intrusive body with layer after layer of nacre, thus forming a

* The anatomy of the Pearl-oyster is described by Herdman and Hornell in Volume II of the *Ceylon Pearl Fisheries Reports*, Royal Society, London, 1904, while the *Madras Fisheries Bulletin*, Reports IV and II of Vol. VIII, should be consulted respectively for information regarding the pearl beds in Palk Bay and the factors governing the irregularly cyclic occurrence of Indian pearl fisheries.

pearl of the finest quality and normally spherical in shape. Very rarely a grain of sand may be similarly entombed. "Muscle-pearls" contain no worm nor other intrusive body; they originate from some particle of the shell substance dislodged usually by some strain; this passes into the mantle and is covered up eventually by layers of nacre. They are found usually close to the insertion of certain muscles on the shells; they constitute the bulk of the little pearls called seed-pearls and are usually irregular in shape.

Solitary individuals of the larger Black-lip oyster (*M. margaritifera*) are found with the common species. It is a handsome stoutly built shell, with a shade of green in the very dark ground colour which is decorated with several radial lines of white spots passing outwards from the umbo. The "ears" disappear in the adult and the outline becomes sub-orbicular. The nacre of this species is thick enough to be of value in button making; but its dark smoky colour greatly impairs its market price. It is fairly numerous in the Persian Gulf.

The Aviculids proper, the true WING-SHELLS, have usually an oval shell with enormously developed "ears" at each end of the hinge. Several species may be termed common on rocky ground, such as the rough bottom off Negapatam and in the Gulf of Mannar and Palk Bay, but they never form beds or banks. Usually they are semi-commensal, living associated with particular kinds of sea-fans and hydroid zoophytes. Two characteristic forms with this habit are the brown *Avicula radiata* and the brown and white striped *A. zebra*. The former is a typical wing-shell, the hinder "ear" prolonged into a huge backwardly directed spine. It is found clustering upon the branches of stout sea-fans (Gorgonids) usually characterized by a brownish orange colour. (Fig. 40.) When young the aviculid has the identical rich orange brown colouration of the sea-fan; its concealment is further aided by the elongated shape of the "ears"—these simulate branches of the host; shape and colour are so similar that the young shells readily escape observation on casual examination. With growth, these resemblances become obscured, the Wingshells becoming much darker in colour and too stout to escape detection. By such time the shell has thickened sufficiently to become unpalatable to most of the smaller fishes that are its chief enemies when young.

The Zebra Wing-shells (*A. zebra*) are still more adept at mimicry; they live chiefly upon a tall handsome zoophyte (*Halicornaria insignis*). The host has stoutly built pinnate branches of a deep brown colour. Upon these the little zebra wing-shells often congregate in numbers, their shells striped brown and white

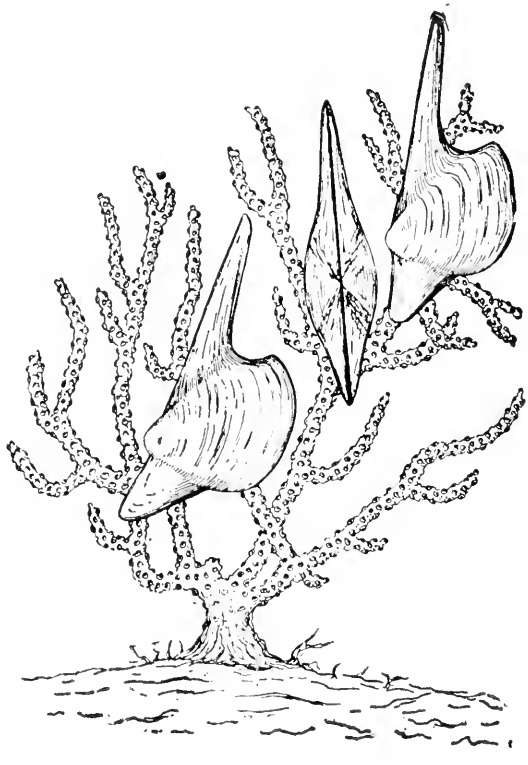

FIG. 40. *Avicula radiata* commensal upon a Sea-fan. (Gulf of Mannar.) × ½.

exactly simulating the brown pinnules and the colourless spaces between—precisely the same idea is exploited as is seen in the colouration of the tiger and the zebra; against their usual background, they are indistinguishable at a distance.

The smallest of our wing-shells is *Avicula vexillum*, known in old pearl-oyster reports as 'false spat,' as it has been mistaken times out of number for the spat of pearl oysters, thereby raising unfounded hopes of great pearl-fisheries in the immediate future. It is a tiny shell, seldom more than one-third of an inch long. It

occurs frequently in immense numbers in the neighbourhood of the pearl banks, clustering in myriads on seaweeds and zoophytes. While quite young it is very difficult to distinguish from real pearl-oyster spat; only as growth proceeds do points of difference emerge.

One species of wing-shell is occasionally found on rough bottom, of a size exceeding the common pearl-oyster. It is particularly common off the South Travancore coast. Its shell is brittle and the nacre thin, so is of no commercial value. It may grow to a length (height) of 7 inches.

Closely related to the wing-shells is the HAMMER-OYSTER (*Malleus vulgaris*), a black misshapen corrugated shell, shaped like the letter **T**. The cross bar at the top represents the two enormously developed ears, the upright, the high narrow body. When young it has the general form and habits of an aviculid. With increasing age it changes gradually into the monstrous form of the adult, twisted, rough, and corrugated, and usually overgrown with crusting growths of sponges, hydroids, polyzoa and ascidians. Like all aviculids a portion of the inner lining of the valves is nacreous; but here is much less extensive than usual.

Last of the family is the curious *Vulsella rugosa*, a deep oblong shell without ears. It lives imbedded in sponges, not singly but in numbers, so much so that an association appears to have sprung up between the two, in the same way and for the same reason that the gastropod Siliquaria forms a similar association with another sponge. Vulsella is particularly common both north and south of Rameswaram Island in depths of 3 to 5 fathoms. The shell is roughened on the exterior and covered with a coarse yellowish periostracum. No typical byssus is formed; some authorities consider its differences from the true Aviculids sufficient to entitle it to be put in a special family by itself—the *Vulsellidae*.

The SCALLOPS (*Pectinidae*) are not well represented in Indian waters and are all small and insignificant unless we include the magnificant smooth-shelled *Amussium*, which by some is put in a separate family, the *Amussidae*.

The true scallops, such as the common *Pecten senatorius*, have a deeply ribbed shell, usually round or oval in outline, with two well developed and conspicuous "ears." In the young condition some attach themselves to rocks and stones by means of a byssus;

when adult they usually desert this habit and lie free, resting upon the right or convex valve. They have uncommonly active habits for Lamellibranchs, especially when quite young, when some species dart through the water by the alternate and rapid opening and shutting of their valves. But even the adults have considerable power of shifting their position in this way. Probably correlated with this unusual activity, is the presence of highly developed "eyes" upon the mantle edge. They are placed at the end of short tentacles at irregular intervals among the long tentacular filaments margining the "gape" of the shell. They are always more numerous on the left or superior lobe ; these eyes are brilliant iridescent green in colour, very conspicuous and arresting when the animal is watched alive. In structure they are as complicated and perfect in optical design as the human eye, with a cornea, crystalline lens and retina of complex structure together with a well-developed optical nerve. There can be no question as to the functional value of such eyes; they are made to see with and are valuable in warning their owner of the approach of danger independently of touch.

The colours of scallop shells are usually bright with red and brown and even canary yellow, but these are believed to have no special significance. In the days of the Crusades a scallop shell was the badge of pilgrims returning from Palestine.

Very much finer than the small pectens met with in shallow water, is the lovely porcellanous *Amussium pleuronectes*, met with in deeper water in the Bay of Bengal off the Ganjām and Orissa coast. Unlike the pectens, this shell is smooth externally, highly polished and handsomely decorated with reddish brown. The dredge is necessary to procure it.

The THORNY-OYSTERS (*Spondylidae*) resemble the scallops in anatomy, even to the presence of eyes bordering the mantle, but they have abandoned a free life completely. The valves are both ornamented with long spines and those of the lower (right) valve become cemented more or less extensively to a rock or boulder. Spondylus is a fairly common shell on rocky ground and among coral reefs, where its brilliant red or yellow valves, decorated with radial ribbing of long spines are conspicuous. It relies upon quickness of sight and upon the strength and spinous defences of its shell to defy enemies. That its valves may not be wrenched

apart by main force, the locking arrangement of the hinge is cunningly devised. The ligament is a stout pad lodged centrally in a deep triangular pit in the hinge area, with two very stout interlocking teeth in each valve, guarding the ligament. The adductor muscle is also specially strong.

ORDER 2.—EULAMELLIBRANCHIA.

In these the gill filaments are united at regular intervals by cross branches. Except in the oysters and a few others, two adductor muscles are present. Many have the edges of the mantle lobes united in one or two places posteriorly and these are often prolonged into tubes or siphons, sometimes quite short, sometimes extremely elongate.

The true OYSTERS (*Ostraeidae*) are among the least typical of the order and have much in common with some of the preceding order, particularly with the Scallops and Spondyles. They all live a sedentary life after the early free-swimming stage is past—the description of the larval life of the pearl-oyster is practically identical with that of all our South Indian oysters. Once they settle to the bottom they turn over on to the *left* side (the converse of the Spondyles and the Scallops) and cement the left valve to whatever is handy—preferably a stone or another oyster, for they are gregarious and form regular "beds." Sometimes they may even attach to the roots of mangroves in backwaters. Their value to mankind as food is greater than that of any other mollusc ; they are susceptible to great improvement under cultivation, and the value of their tonic qualities and easy digestibility when eaten raw is difficult to over-estimate, particularly in the case of the old, and those convalescent from illness. Three species are common in South India, but one of these is local in habitat and does not form beds, so that the number of our edible oysters is reduced to two, the Backwater-oyster (*Ostrea virginiana*) and the Rock-oyster (*O. cucullata*). The former is the one specially valued and the one which lends itself readily to cultivation ; the second, while well flavoured, is rather tougher as well as smaller than the other and is seldom eaten except at one or two places on the Kanarese coast where it is specially abundant.

The Madras backwater oyster is extremely variable in form, and passes under many names, scientific as well as local. Among

the more recent of the former under which it has been described are *Ostrea gryphoides* var. *cuttackensis* in the Records of the Geological Survey, and *O. madrascusis* by Preston.* It has, however, no outstanding differences from the common American species and I agree with Vredenburg in believing it to be in no wise separable from this widely distributed form. In Tamil it is known as *ali* at Madras and Pulicat, *patti* at Tuticorin; in Malayalam it is *muringa* in Travancore and Cochin, *murru* in Calicut.

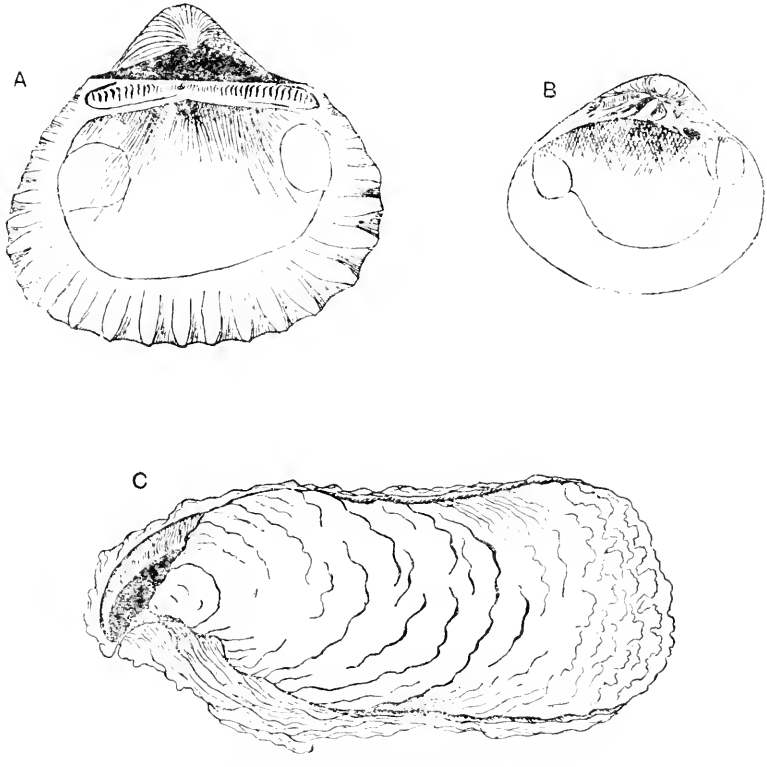

FIG. 41. A. Ribbed Ark-shell (*Arca granosa*). × 1.
B. Common Backwater clam (*Meretrix casta*). × $\frac{3}{4}$.
C. Backwater Oyster (*Ostrea virginiana*). × $\frac{1}{2}$.

It is very hardy and can sustain considerable fluctuations in the salinity of the water it lives in. Hence it thrives in nearly every estuary and backwater on both the coasts of the Presidency; only

* Preston, H. B. "Report on a collection of Mollusca from the Cochin and Ennur backwaters." *Records of the Indian Museum*, Vol. XII, pt. 1, Calcutta, 1916.

exceptionally, as on some rocks situated near estuaries on the Malabar Coast, does it form considerable deposits in the open sea, although odd individuals are often met with wherever rocks occur upon the littoral. Young oysters of this species are also often found on shells in water up to 8 fathoms in depth, but these do not thrive and seldom reach maturity.

Backwater oysters have considerable value to the poorer populations living in the vicinity; the chief centres on the West Coast are the backwaters at Tellicherry and Beypore in Malabar, Cochin and Azhikode in Cochin State and Vembanad backwater in Travancore. On the East Coast the backwaters at Cuddalore Covelong, Ennur and Pulicat are famed for the abundance of their oyster beds, while further north there are extensive beds in the deltas of the Kistna and Gōdāvari and in the backwaters of Vizagapatam and Ganjām. The oyster beds of Sonapur backwater in Ganjām are the most extensive of these latter.

Unfortunately the better classes of Indians do not appreciate oysters and none will make use of this excellent food supply. Among Hindus, only the lower classes of shore dwellers eat oysters, together with some Muhammadans and Indian Christians. The only good class trade in oysters is that supplying the requirements of Europeans and Anglo-Indians in a few of the larger coast towns, as Madras, Calicut, Cochin and Mangalore. Many of the sources of supply are however under grave suspicion of possible sewage contamination. Because of this and in order to provide a supply of good quality oysters free from any danger of being disease carriers, Government in 1910 permitted the Fisheries Department to form a model oyster park in Pulicat Lake where oysters are cultivated under hygienic conditions and thence distributed throughout the length and breadth of the Presidency.

The most extensive oyster beds in South India are those in Cochin Harbour and in Vembanad backwater in Travancore. In both localities oysters are exceedingly numerous, the flesh finding a ready sale among the lower classes. In the Vembanad villages the flesh, called *moringa iracha*, is said to be regularly exposed for sale in the fish markets. In Cochin it is not seen in the markets, being hawked about the streets in small-mouthed chatties. The beds in Cochin harbour chiefly lie within Cochin State limits and the right to fish oysters is let annually by the Darbar for an

amount seldom exceeding Rs. 100 per annum. In practice, the lessee sublets the right to individual divers, who pay him a small sum for each day's fishing. The divers are usually Roman Catholic Christians. As the water over the beds varies from one to three fathoms the men require to dive for them; when the current is strong the assistance of a pole thrust into the bottom is used, the diver using this to prevent himself being carried away. As the oyster clumps are collected they are piled into a small attendant dug-out canoe and as soon as this is full, a matter of some three hours' work, the spoil is taken to the shore where women purchase it at the rate of from ten annas to one rupee per lot—a quantity usually averaging about 800, or a rate of 1½ to 2 annas per hundred. The buyers proceed to open them, putting the flesh into an earthen pot containing a little water. This flesh they hawk through the town at from 2 to 4 annas the hundred. Surplus oysters are sometimes kept alive in the canals till wanted.

Oyster flesh is never eaten uncooked by Indians; the common method of preparation on this coast is to fry the flesh in ghee after flavouring with salt and condiments. The trade is of considerable volume in Cochin in spite of the fact that many of the largest beds are subject to sewage contamination. The fact that the flesh is never eaten except after cooking appears to be an effective safeguard. The discarded oyster shells, in the absence of any local rock, are put to extensive use in reclaiming swamp land and as foundations for buildings.

In the Beypore, Elattur and Tellicherry backwaters, oysters abound wherever rocks occur and good quantities are taken annually by the womenfolk of the local Hindu fishing communities, who collect oyster flesh at low tide, breaking open the shells with short iron knives as they occur *in situ* and transferring the flesh to small chatties which they take with them.

On the East Coast, in the backwaters in the neighbourhood of Madras, a certain amount of oyster flesh is collected and eaten by the local pariah population. Sometimes Muhammadans will have some, but this appears to be done in imitation of the European custom. In these places the bulk of the oysters consumed, as already mentioned, is by the Europeans and Anglo-Indians of the large towns. Further north, in Ganjām district, certain sections of the fishing population make a limited use of the local oysters,

particularly those in the Sonapur backwater, where the Bairavi men are accustomed to visit the beds at low water, break open the shells and carry away the flesh in chatties to use in their own curries.

Seasons and spawning.—The season when oysters are in marketable condition depends upon the time of spawning and this in turn is controlled by rainfall and sunshine. Heavy rains causing flood water to enter backwaters in such amount as to greatly lower the salinity of the water over the beds invariably entails wide-spread and immediate emission of the reproductive products in all oysters where the gonads are well filled. Hence as the rainy season differs on the two main coasts of India, there is a corresponding divergence in the spawning maxima and in the marketable season in these two localities.

On the Malabar Coast the chief spawning maximum occurs about midsummer or even earlier, at the onset of the south-west monsoon and the oysters are not again in condition till October or November. From this time onwards they improve in quality till about the end of March; thenceforward till the final and complete spatting at the end of May or early in June, there is a good deal of irregular spatting induced by the hot weather then prevailing, emphasized by the exposure and semi-drying of many of the oyster covered rocks during the low-water of the major spring tides. Between March and June a considerable percentage of spent oysters are always found in any number examined; the gonads of those that spawned early in March will be partly full again when the floods arrive in June and these, after enduring the lowered salinity of the water for a while, will at last emit their spawn though perhaps only half mature. Long continued floods cause very extensive mortality on the beds, and few survive except the small number living on the bottom of deep channels. In these places saline conditions appear to last much longer than on the surface, the lighter specific gravity of flood water causing it to pass over the deeps without clearing out completely the saline water which was there before the onset of the floods. Spawning in the case of these few surviving oysters appears to be deferred till about August when the floods have partly subsided and tidal conditions are re-established. Much variation exists however in this cycle of events, for under normal conditions the common Indian oyster is a most irregular spawner; except when the floods

are on, some individuals with ripe gonads can always be found; hence there is no definite and universal spawning season as in the case of English oyster (*O. edulis*). The mortality of the oysters during the rains is confined to those living well within the backwaters; those close to the mouth suffer less and many survive, except in exceptional years when the floods are very long continued. Much, too, depends on the physical conformation of the backwaters. In such an one as that at Cochin, the oysters on the beds in the harbour usually survive, the considerable (relative) depth of water over the beds constituting a protection.

On the Coromandel Coast, as the floods take place generally from the end of August until November, the season runs from January to the middle of August, with a partial break about April when a large proportion of oysters spawn. August and September constitute a spawning maximum, induced in part by the hot weather prevailing then and in part by the lowering of the salinity due to flood water: in a wet season the latter is the main factor; in exceptionally dry ones or when the rains are long deferred, the former in the effective factor. A second maximal spawning sometimes takes place in March and April, and between this time and August, spawning individuals can always be found.

The reproductive habits of this oyster are similar to those of the Indian pearl oyster (*Margaritifera vulgaris*) and closely akin to those of the Portuguese oyster (*Ostrea angulata*). In all these species the sexes are separate; the ripe ova and spermatozoa are poured forth free into the surrounding water when a sufficient stimulus is experienced. Fertilization takes place in the water outside the parents' bodies, trochosphere and veliger forms being in turn assumed during the growth of the fertilized ova. The free-swimming stages last for several days and in this time they may be carried by currents for considerable distances, thus ensuring wide dispersion throughout the neighbouring coasts. The free-swimming spat when ready to attach is easily obtained in any suitable estuary or backwater by the employment of spat collectors; experience shows that ordinary country roofing tiles, arranged in low piles of several rows, are the most suitable form to use. During our first experiments at Pulicat, we arranged these collectors with a view to catch the spat produced during the September spawning season; experience shows that it is preferable to aim at obtaining the necessary spat during spring (April-May) as the parent

oysters are in much better health then; the results obtained are altogether better, for operations can then be carried out with greater facility, the water level in the parks being lower than it is in September and the salinity normal and not unduly reduced.

The ROCK-OYSTER (*Ostrea cucullata*) differs greatly from the backwater oyster. Its main distinguishing characters are as follows:—

Outline roughly oval; the left valve extensively attached, deep and cupshaped, with a sacciform extension into the hollow beak region of the hinge, which is moderately elongate in freely grown individuals; the edges of this valve have a distinct tendency to grow upwards. Externally the left valve is folded into deep ridges passing radially outwards from the hinge and ending in a

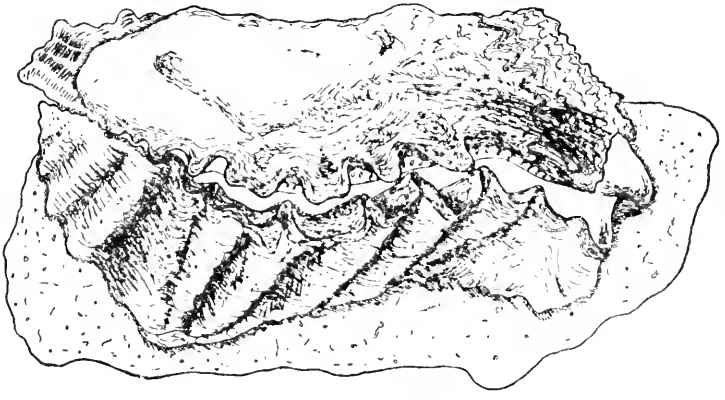

FIG. 42. The Rock-oyster (*Ostrea cucullata*). Natural size.

dentately lobate edge which tightly interlocks with the margin of the upper or right valve. The latter is flattened and opercular in form. The muscle scar of both is usually dark purplish-black in tint, rarely white. Very characteristic is a row of closely set elongated denticulations seen a short distance inwards from the margin on the inner surface of the upper valve; these fit into a corresponding series of furrows in the lower valve. Externally the shell is tinted an opaque pinkish purple. Internally it is white, margined with purple or black. The size is generally smaller than that of the ordinary backwater or mud-oyster and seldom exceeds 3 inches in length.

The habitat of rock-oysters is in a narrow band between tide marks; during ordinary spring tides, these oysters are entirely

uncovered at low-tide. They are purely a marine species, never forming beds in backwaters or estuaries, though an occasional individual is sometimes seen among backwater oysters.

Under favourable conditions they form densely crowded colonies upon rocks between tide marks; the finest example of such beds which I know, is on the rocky shores of St. Mary's Isles, off Malpe, in South Kanara. They are of excellent flavour, but on account of their small size, both natural and often further reduced by overcrowding, as well as the difficulty experienced in opening them by reason of their interlocking edges, they are not of economic importance.

The third species of South Indian oyster is the COCKSCOMB-OYSTER (*O. cristagalli*), a massive form occurring singly on stones and shells on the East Coast—Tanjore Coast, Palk Bay and the Gulf of Mannar. The edges of the valves are deeply pleated and these pleats are marked on the surface of the valves as angular ridges and furrows extending radially from the hinge. In the rock oyster similar pleats occur but they are more numerous and much shallower than in the coarsely pleated cockscomb species.

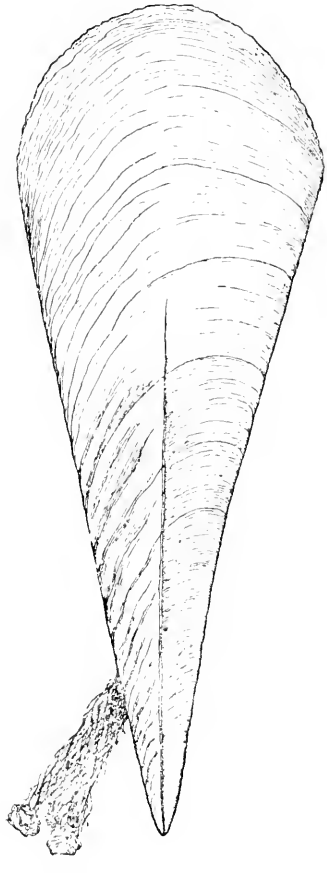

FIG. 43. Common Pinna showing byssus. × $\frac{1}{3}$.

Several species of PINNA (*Pinnidae*) occur in Madras waters. The most common one in the Gulf of Mannar is *Pinna bicolor*, a big wedge-shaped shell often a full foot in length that occurs commonly on sandy bottom on the East Coast. It lives in depths from just below low-tide to about 6 fathoms. The umbones are at the apex of the wedge, the hinge-line along the length of one of the two long sides. It lies buried to half its length or even more, point downwards in the sand, the posterior edges gaping. It is quite common

in the beds of sea grass along the south side of Palk Bay, and bathers there must beware of the knife-like edges of its posterior margin standing erect out of the sand a couple of inches or more. Pearl oysters sometimes settle in numbers on these projecting edges; in the 1905 Ceylon fishery when some millions were fished from such foothold, the divers complained bitterly of the injuries they received in pulling the Pinnas out of the sand; as many as a dozen oysters sometimes clung to one Pinna—the reason being that this area was almost all sand and the projecting shells of Pinna were the only stable objects to which the oysters could cling.

Pinna has a tongue-shaped foot and spins a strong byssus of very fine silky green fibres, wholly unlike the coarse strands of the byssus of the pearl oyster. Occasionally thread has been spun from these fibres and silky gloves and stockings woven therewith, but these are mere curiosities and have no commercial importance.

A second species, shorter and stouter, the SMOKY PINNA (*Pinna fumata*) is common in 5 fathoms in Palk Bay.

No one eats Pinna on the Indian Coasts but in China it is in great demand; in Japan great numbers of the large adductor muscle, circular discs of white flesh measuring 1½ to 1¾ inch in diameter are cut out and dried for export to China, in similar way to the treatment of the foot of the Ear-shell (*Haliotis*).

The FALSE COCKLES (*Carditidae*) are often uncommonly like the ordinary English cockle, thick and heart-shaped and deeply ribbed with radiating ridges. Typical of this form is *Cardita bicolor*, a coarsely ribbed species unevenly spotted with dark red on a ground rendered yellowish by thick periostracum. It is common on coarse sandy or even gravelly bottom. Like the cockle the foot is sickle-shaped, and highly muscular; by its aid these molluscs are able to hop along the bottom.

A circular outline and a pure white shell are features very general in the *Lucinidae*. The form of the anterior muscle scar is still more characteristic; it is of unusual length and for the most part lies separate a little distance within the pallial line. *Lucina cummingi* is typical, with a long vermiform foot longer than the length of the body, specially useful in burrowing in the loose sand where it is found on both our coasts. More conspicuous is the fine BLADDER-SHELL, *Cryptodon vesicula*, a thin fragile white shell almost globular in form. Unlike *Lucina*, which has a toothed hinge, in the

Bladder-shell it is weak and toothless. The foot is short. The hemispherical valves, papery and delicate, occasionally nearly two inches in diameter, are very common along the shore at Tuticorin.

The *Galeommidae* are all tiny creatures, remarkable for the way the mantle folds are reflected outwards over the edges of the valves, nearly concealing them. The foot is long and flattened on the underside after the gastropod fashion and for the same purpose—crawling. To this family I refer a beautiful little creature I found once at Pamban. As is shown in fig. 44, drawn whilst alive, the

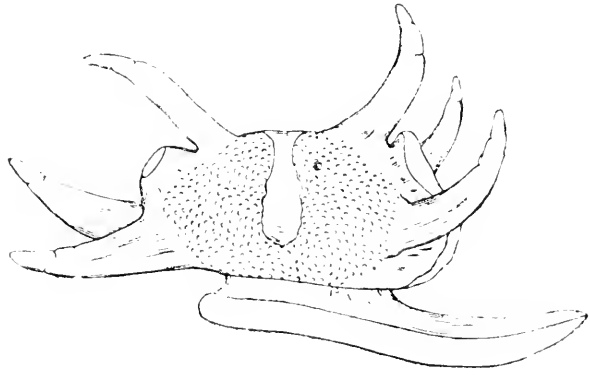

FIG 44. A Galeommid (*Scintilla hanleyi*) from Pamban showing the flattened crawling foot and the mantle reflected almost entirely over the valves. × 4.

inner edge of the mantle is furnished with six long cylindrical tentacles, tapered towards the free end. These are coloured brown madder, shading from the tip to the base, where they shade into the pale buff of the mantle. The edge of the mantle has a line of madder running along it while the surface is covered with many minute madder brown tubercles. The upper surface of the fore-part of the foot is also madder-tinted, the base white.

The BLACK CLAM (*Velorita cochinensis*) called in Malayalam *Kar crunthu*, is our most conspicuous member of the family *Cyrenidae*. It is a small thick-shelled clam found only in the West Coast estuarine backwaters, where it is associated with the common clam (*Meretrix ovum*). Its shell is ribbed concentrically and covered by a coarse thick blackish-olive periostracum frequently worn away by corrosion at the umbo, showing the whitish shell beneath. The interior is characteristically pale pink in tint. This clam can survive the prevalence of fresh-water conditions longer than the common clam ; it was originally as other Cyrenids still are, a purely

fresh-water species, and its presence in quantity in estuarine backwaters, subject during a considerable portion of the year to brackish water conditions, indicates a marked change in its habits and a re-acquired tolerance for saline conditions. It is used by the same people who eat the common clam and its valves are also employed in lime-burning in Malabar. It is not nearly so abundant as *Meretrix ovum*; its habitat is usually further distant from the sea than that of the latter species.

The shell seldom exceeds 30 mm. in length.

The FRESH-WATER MUSSEL (*Lamellidens marginalis*). Although this common Indian species, closely allied to the text-book types so well known to biological students under the names of Anodonta and Unio, is very widely distributed throughout the Presidency, it finds little favour as food. Only in Ganjām have I found it eaten, and then only by the lower castes, being both flavourless and tough.

Both in Ganjām and Vizagapatam districts, the valves are used extensively as instruments for peeling mangoes. To prepare one a hole is made in the convex umbonar region by rubbing this part of a valve—usually a right one—upon a stone till a hole of the right size is formed; to use the peeler thus formed, it is grasped in the hand with the hollow side towards the palm, and then one edge of the hole is used to peel off strips of skin. The advantage claimed for this implement over a knife is that the mango does not become stained and its flavour impaired from contract with steel.

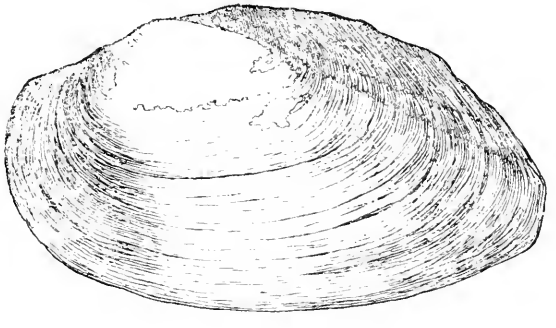

FIG. 45. The Fresh-water Mussel (*Lamellidens marginalis*). × $\frac{2}{3}$.

It seems probable that the valve of a fresh-water mussel, having a large hole in the centre, figured in Bruce Foote's "Catalogue of Prehistoric and Protohistoric Antiquities," Madras, 1915, under the number 234-129, from Narsipur-Sangam, Mysore, is a mango scraper of this kind, and not part of a shell necklace as surmised by the author.

This species, although its shell is usually too thin to be of any use in pearl-button manufacture, sometimes produces pearls in considerable quantity of fair value. Occasionally they are offered in the Surada Bazaar (Ganjām); these are obtained from a great irrigation reservoir in the neighbourhood wherein these mussels flourish, growing to a length of about three inches. The pearls have a reddish tint and less lustre than those from the marine pearl oyster. Another species in Bengal is extensively employed in making buttons. An allied genus, *Parreysia*, has coarser hinge-teeth and generally a stouter shell.

The species of TELLINA (*Tellinidae*) most common on all our sandy shores is small and pink-shelled, about ¾ of an inch long, compressed from side to side. The fore end of each valve is rounded, the hinder end shorter and slightly angular; the ligament is external, showing as a prominent black hinge behind the beak or umbo. The markings on the inside of the valves are distinctive; the pallial sinus, which marks the position of the "siphons" when withdrawn into the shell, is extremely deep, extending from the hinder margin nearly to the anterior adductor. Without seeing

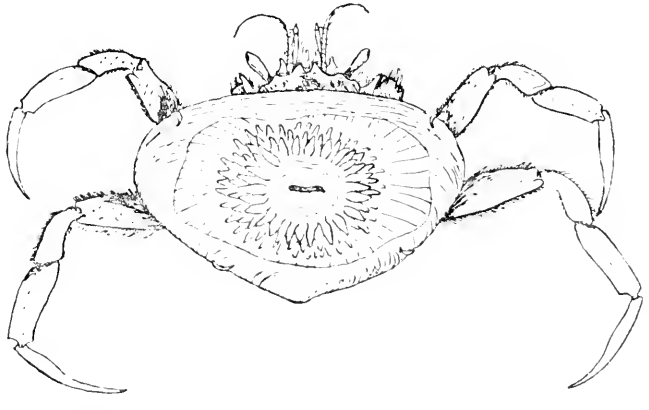

FIG. 46. A Masking Crab (*Dorippe dorsipes*) carrying a Tellina shell on which is an anemone, for the purpose of concealment and defence.

the live animal a zoologist can tell from this that the Tellinas have long siphons. These in fact exceed twice the length of the shell; they are formed by the tubular outgrowth of the mantle edge at the posterior end of the body; the evolution of the siphonal tubes in bivalves is particularly interesting, for among

our common shells we can find a full gradation of transition stages, beginning with instances where the siphonal openings, one incurrent (to the gills) and one excurrent or anal, are formed by the *temporary* coming together of the mantle edges of opposite sides at one or two definite points, thus forming *temporary* openings. The next stage is for these temporary junctions to become permanent and then for the edges of the openings to lengthen out gradually into tubes of varying length. The Tellinas and their near relatives *Donax*, *Mesodesma* and *Psammobia* are noteworthy for the extreme length attained by their siphons. The shells are usually small and as their habitat is in shallow water on sandy coasts, seafowl and other birds search the sands for them at low-water, to say nothing of predaceous fish that take up the hunt whenever the depth of water permits. Hunted continually, these molluscs lie in deep burrows with just the tips of their siphons level with the surface—as inconspicuous as may be. If discovered they withdraw the siphons into the shells lying below at a depth of may be a couple of inches and begin with lightning speed to burrow still lower by the help of their wedge-shaped muscular foot. The longer the siphon, the greater the protection; it is significant that the four genera named as having peculiarly long siphons are the commonest bivalves along our sandy shores—infinitely more numerous than those with short siphons.

Two species of the WEDGE-SHELLS (*Donacidae*) known on the Madras Coast are the small *Donax cuneatus* or MURAL (Tamil) and the much larger *Donax scortum*. In outline the former is a small much compressed bivalve roughly wedge-shaped; the posterior part of the shell obliquely truncate. It is abundant between tide-marks and for some short distance below low-water level. It never enters backwaters and is essentially a marine form. In size it seldom exceeds 40 mm. in length. On the East Coast, the mural is particularly plentiful on surf beaten sand-flats; on the Rāmnād Coast the name *mural* gives place to *vazhimatti*. Along the Malabar shore it is less plentiful and is usually smaller. In Tamil districts, especially on the Coromandel Coast, the mural is

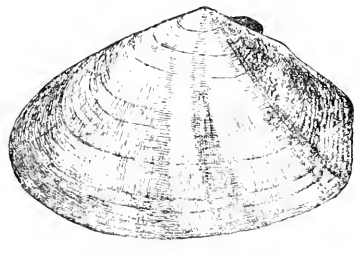

FIG. 47. The Mural (*Donax cuneatus*).

valued as food by the fisherfolk (Pattanavars, etc.) whose lads are accustomed to collect it when rough weather cuts off the usual supplies of sea fish. The mural serves largely to meet such an emergency. It is seldom collected for sale. It lives buried an inch or two below the surface layer of the sand; the boys who collect it turn over the wet sand with their feet as each roller spends its force and slips back into the sea.

The larger and more handsome *Donax scortum* is much less common but its strong boldly sculptured purple tinted valves are often to be picked upon sandy beaches. The sculpturing takes the form of coarse concentric ridges upon valves roughly triangular in shape. The beak is angular and prominent, the fore end and ventral margin rounded, with the hinder end folded and produced

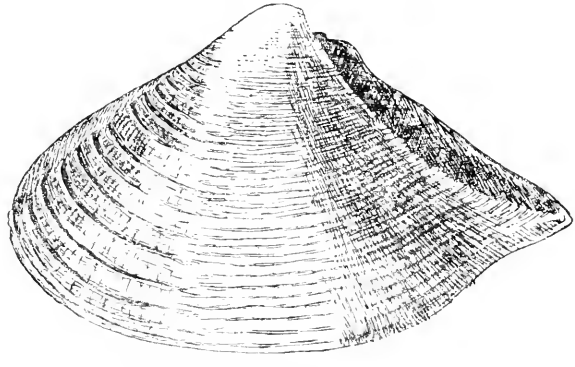

FIG. 48. Donax scortum. × 1.

sharply to a bold point. They run to 2¼ inches in length, and are among the most easily identified of our local bivalves.

The *Mesodesmidae* are represented by the little KAKKAMATTI (*Mesodesma* [*Paphia*] *glabratum*) common in the sands of the island beaches near Pāmban. It grows to a length of 1¼ inch. The shell,

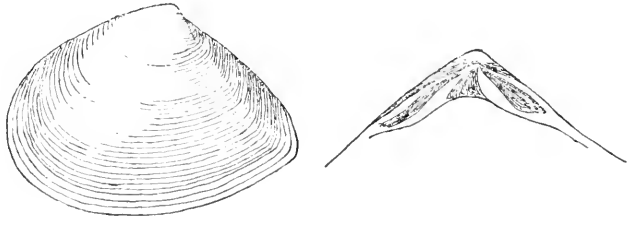

FIG. 49. Kakkamatti (*Mesodesma glabratum*). Shell and hinge plate.

strong and massive, is sculptured with bold concentric ridges; the colour is white, but this is obscured by a skin of dirty yellow except near the umbo, where this covering is usually worn away. The ligament is internal as in Mactra.

The MACTRAS (*Mactridae*) are widely distributed on sandy shores and become plentiful when conditions are favourable. They are generally thin shelled and smooth surfaced, more or less triangular in outline, with deep roomy valves, whence the name *mactra* (Latin), a kneading trough. The ligament, in the form of a triangular pad is lodged in a deep hollow or pit within the hinge and immediately under the umbo. Several typically thin-shelled species are common on both the East and the West Coast. Some attain quite a considerable size and may exceed two inches in length (*M. tumida*). Numbers of a large species affected by the peculiar poisonous water that occasionally devastates shore life in certain places in Malabar were seen washed ashore at Cannanore in a moribund condition in 1916. The best known species is the pretty little Sevalamatti (*Mactra corbiculoides*), tinted a deep violet

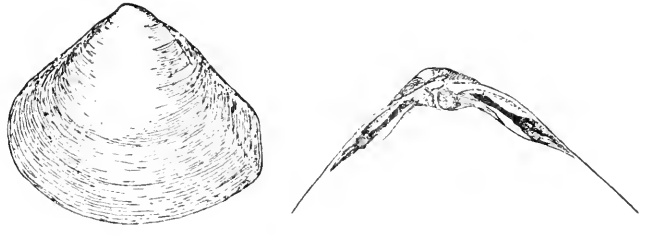

FIG. 50. Seva'amatti (*Mactra corbiculoides*). Shell and hinge plate.

colour within, common at Pamban and the neighbourhood; its shell is distinctly trigonal in outline, usually about 30 mm. in length, and with deeply concave valves which are thus able to give accommodation to a body relatively much larger than is contained within the shallower valves of the Kakkamatti. Its colour is most distinctive, externally bluish grey with pink or purplish blue colouring showing through at the umbo and usually another distinctly similar colour band within the margin; internally the whole surface is characteristically tinted violet. When partially bleached, the colour fades to a warm pink, whence the local name of *Sevalamatti* (red matti).

Many of our most familiar and beautiful Madras shells are included in the *Veneridae*, small clams characterized by the handsome colouring and great strength of the valves. They vary greatly in shape, ranging from greatly flattened discoidal forms (*Circe scripta*) to swollen forms like *Circe gibba* and oblong ones such as *Tapes* and *Sunetta*. The beaks are usually prominent and situated above the mid-length of a strong hinge-plate bearing (usually) three prominent, strong cardinal teeth, flanked by long laterals.

The genus *Venus* is purely marine; its shells are ovate with deep crescent-shaped ventral margin and a strongly beaked umbo. Widely distributed on sandy shores on both our coasts it never forms beds. *Venus reticulata* and *V. plicata* are two common forms. The sea-worn fragments of the Money Venus, *Venus mercenaria*, when perforated and strung on leather thongs were the *wampum* of North American Indians, used as a rude form of coinage in their business transactions. A wonderfully lovely Cytherea (*Crista crycina*) is to be found in the shallows westward of Kundagal point at Pamban. It is a thick ovate shell nearly 3 inches long, boldly ribbed concentrically, splashed and marbled in rich red brown. So handsome is it, that the shell dealers in Rāmēswaram temple offer good prices for it; they know its colouring will tempt the pilgrims who come from far away inland homes, to whom everything from the sea in this holy place is invested with virtue and interest.

Much more abundant in South India are the BACKWATER CLAMS belonging to the genus *Meretrix*, distinguished by the fine striation of the elongated posterior lateral tooth in each valve. At least three species are of value as food in this Presidency, namely *Meretrix meretrix*, *M. casta* and *M. ovum*. The first is comparatively rare, but is found on both our coasts, the second is localized to the East Coast, while the third, which appears to be a sub-species of the second or vice versa, is found only on the West Coast.

The two latter are known in Tamil as *matti* (மட்டி); in Malayalam as *crunthu* at Calicut and *kakka* at Cochin; everywhere along the coast from South Kanara in the west round to Ganjām in the east, either one or other of these little clams is found abundantly in muddy sand in estuaries and connected backwaters wherever the water remains saline throughout the greater part of the year.

Suitable conditions prevail over more extensive areas on the West Coast, and it is there, *par excellence*, that these clams attain their greatest importance.

Meretrix ovum.—The valves of this species are smooth, grey in general tint and either with or without two imperfect brown rays; in shape the shell varies from a swollen cordate form to one compressed and almost almond shaped. It lives in great abundance in West Coast backwaters, with a size average from 35 to 40 mm. in length by 25 to 28 mm. in depth; when overfished as in the Beypore river, the average size becomes considerably reduced, as few individuals have an opportunity to reach maturity. Two dark rays, faint and easily overlooked, are very characteristic of the species; only occasionally can these rays be traced back to the umbo; they are usually best marked towards the ventral margin where they usually terminate in two small reddish brown colour patches on the extreme edge. The periostracum is well developed and persistent; it varies from a distinct pale cream to a rufous yellow or even brown, the darker tints being largely of stain origin.

This clam is probably the most important food mollusc of the Presidency. Its flesh is of good flavour, tender and nutritious. To the poorer classes of shore dwellers, wherever it is obtainable in quantity, it often takes the place of fish in their curries when this is dear or scarce and is esteemed both for its cheapness and tastiness. On the Malabar Coast these clams are largely collected by low caste people who hawk canoe-loads along the backwaters and canals. The usual retail rate varies from one to two pies per seer, indeed a pie's worth is considered in Malabar sufficient to make a curry for a whole household. The Malabar clam fishers usually use very small dug-out canoes, which are anchored when the fishing ground is reached. Men, women and lads all engage in the fishing; the feet are used to locate and dislodge the clams when these occur in shallow water. In deep channels diving has to be resorted to.

One of the commonest sights in Malabar is the heaps of discarded shells forming miniature kitchen middens in the neighbourhood of many huts; these are sold eventually to lime-burners, as the shell of this clam being exceptionally massive, is valued as a source of high-class lime, particularly suitable for white-washing purposes.

On the East Coast, the place of *M. ovum* is taken by *Meretrix casta*, a rather larger and stouter species of the same habits, known

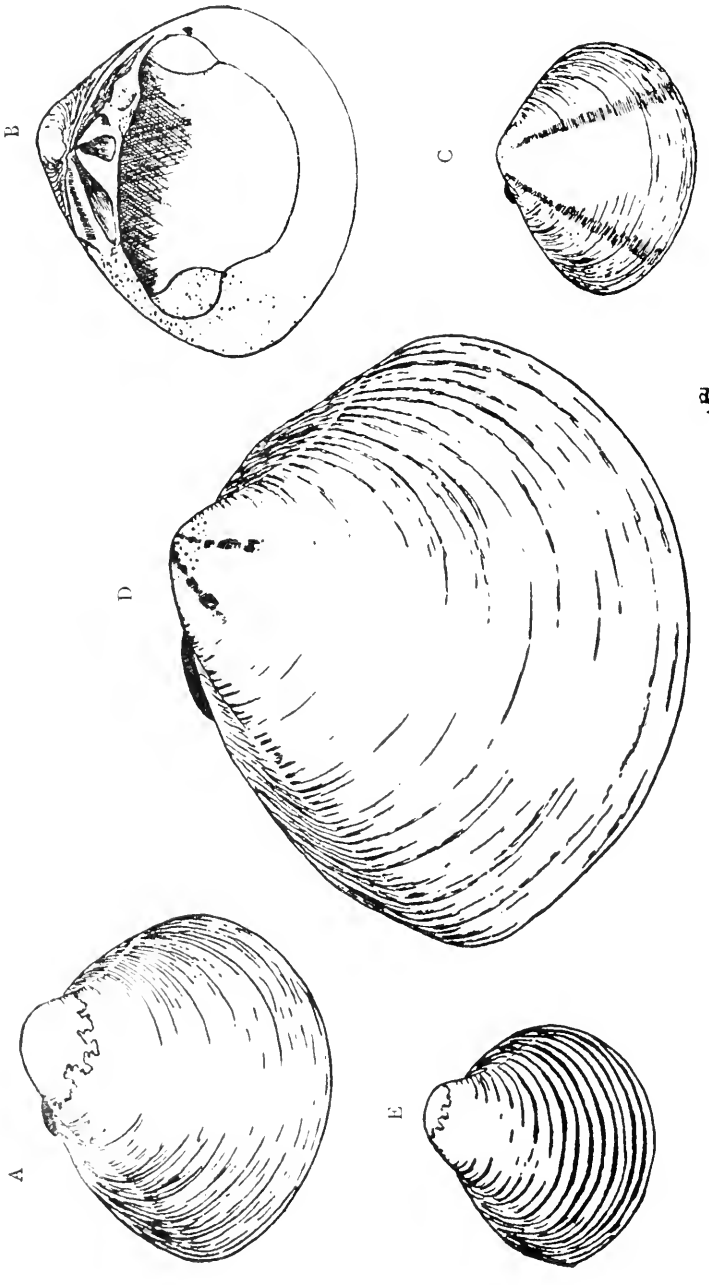

FIG. 51. Backwater Clams.

A & B, *Meretrix casta*, outer and inner view of a valve; C, *Meretrix ovum*; D, *Meretrix meretrix*; E, *Velorita cochinensis*. All natural size except E, which is $\times \frac{2}{3}$.

generally as *matti* in Tamil districts. Its valves are thick and massive, the exterior covered with a strongly adherent brownish periostracum, dull in appearance, that varies much in tint even in one locality. A purplish black band margins the posterior edges of the shell to a depth of about a quarter of an inch, extending from the hinge to the posterior angle of the shell; unlike the yellow colouring of the rest of the shell, this dark pigment permeates the substance of the valves and shows equally upon both the inner and the outer surface. None of the radial banding of *M. ovum* is shown, nor any of the diverse colour schemes of spots and chevrons so often found on the umbos of *M. meretrix*.

Although often very abundant it is generally less common than the corresponding species on the West Coast and is held in less esteem by the people. It is, however, eagerly sought for wherever it abounds. At Pulicat, for instance, as many as 30 women may often be seen collecting this shell-fish in the shallows opposite to the town. Unlike the Malabar custom, men here seldom engage in this work; Pariah women and girls alone carry it on. They work for preference during low tide when the depth of water is reduced over the beds. From time to time as they gather the clams, they pile them in heaps on an adjacent sand-bank. When they judge it time to drop fishing, they adjourn to the sand-bank, and there proceed to smash the clams one by one by striking them against a heavy stone. As each is broken open they deftly extract the meat with a push of the thumb, dropping it into a small earthen pot containing a little water. In this way in a short time each woman has emptied the whole of her catch, amounting to several hundreds. The broken shells are left behind for the lessee who has bought the right to the shells for lime-making, and who permits these women to collect them on this condition.

Women's wages at Pulicat averaged 2½ to 3 annas per day in 1914 and the value of the catch of clams made in a day by one woman working hard, was usually valued at this amount. The bulk of the clam meat obtained is however generally used to supply the needs of the woman's own family; if any surplus is left, it is often exchanged for paddy, bulk for bulk, I am informed. At times when specially large quantities are obtainable, the surplus flesh is sun-dried to serve as stock for use during the rainy season when the collection of clams is interrupted owing to increase in the depth of water over the beds.

Pariahs and Pallans and some of the Muhammadans and Christians of coast hamlets are the only people who eat these clams in Tamil districts.

On the East Coast, spawning appears to take place twice in each year, the first during April and May, the second about September. The busiest fishing season at Pulicat and the neighbourhood is the hot dry season from June to August when the level of the backwaters and canals becomes much reduced, facilitating greatly the work of collection. At this season the condition of these clams is at its best, the bodies fat and swollen with reproductive products.

At Pulicat, Sonapur (in Ganjām) and Tuticorin great beds of subfossil shells occur in silted up portions of the local backwaters and the bulk of the shells forming these beds are of this species. At Tuticorin and Sonapur a curious variety is also common, distinguished by an extreme thickening of the hinge plate and umbonar region. This causes each umbo to become unusually prominent and distinctly hooded. The general form of the shell is affected, becoming so trigonal that it has been described as a distinct species. But all gradations between this form and the typical *M. casta* can be traced; so it is at most a variety.

The GREAT CLAM, *Meretrix meretrix*, called in Tamil *panjamatti* (பஞ்சமட்டி) at Tuticorin, is a nearly related species to the common matti *(M. casta)*. It is distinguished by its greater size and by the smoothness and delicacy of the periostracum covering the valves. Its average dimensions when adult range between 74 × 60 mm. and 75 × 62·5 mm. with a weight (empty) of about 3½ ounces. The valves are perfectly smooth and so long as the periostracum is intact have a beautifully polished appearance due to the smoothness of this membrane, which is thin, delicate, and of a pale straw colour in tint. When this is removed the shell is dead white in colour except along the postero-dorsal margin where there is a deep band of greyish blue in some and bluish brown in others; this colouring occupies precisely the same region as in the common clam (*M. casta*). It is a very beautiful shell and the pity is that it is not more abundant. I have found it in the Silavathurai fish farm at Tuticorin, in the seaward part of Pulicat Lake, and in a subfossil condition at Surla in Ganjām district. It lives also in Chilka Lake, and is known also from Tellicherry and Bombay on the West Coast. There is little doubt that it lives at the mouths of the

majority of estuaries and backwaters in India, south of the Ganges and Indus. At Tuticorin it is fairly abundant, as a woman can easily collect from 30 to 40 in a tide. They are esteemed as food by the Valaiyans and Pallans who collect them and who use the empty shells for lime-burning. The flesh is considered less delicate than that of the common clam; it also seems less hardy; as a consequence its distribution is more local and restricted—it

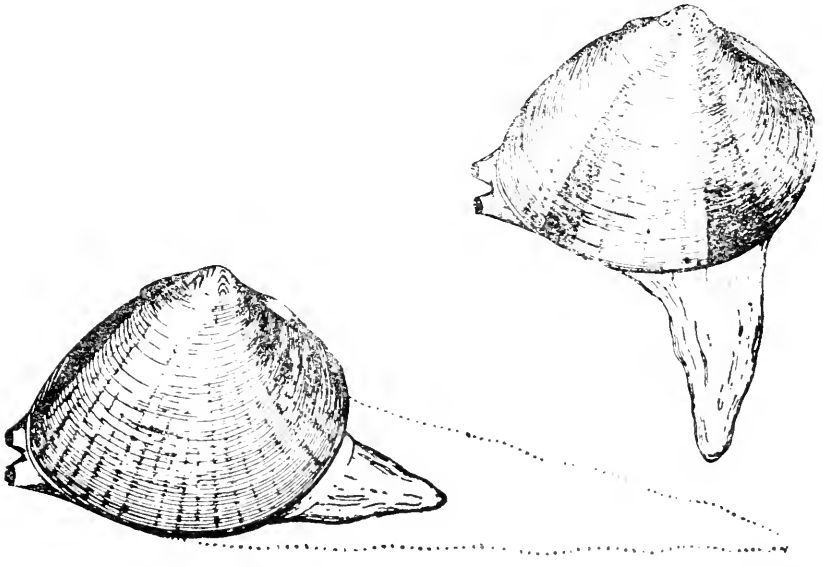

FIG. 52. The Great Clam (*Meretrix meretrix*). Two-colour varieties. Note the short siphons and the great extensibility of the foot; in the lower figure the dotted outline indicates the extreme extension possible. (Tuticorin.) × ⅔.

appears to require a cleaner habitat than *M. casta* and a strong tidal current over the bed where it lives. Hence they are usually found near the entrance to lagoons, where the tidal flow is great. They spawn about the beginning of September at Tuticorin, probably also about May.

The shell exhibits considerable variation in colouring, and at least five well-defined colour varieties are known; apart from the umbonar region which is very frequently rayed, the shell usually exhibits no banding, but in two varieties there are very broad ill-defined radiating bands of a somewhat livid or purplish colour extending from the ventral margin to half way to the umbo. The umbo nearly always shows considerable colour, but this is extremely variable and no two shells are exactly alike in this respect. Most

frequently a minute brownish speckling can be made out, either alone or associated with a more conspicuous and extensive zoning in a livid tint; in others this speckling resolves itself into a more distinct pattern of chevron-shaped chestnut markings, which may coalesce either into short rays or into concentric zones, never spreading far beyond the umbo. In one variety, the colouring is a uniform chestnut.

Circe is another genus of the Veneridæ of considerable economic value in the Madras Presidency, for the little COCKLE-CLAM (*Circe gibba*) known as *varimatti* in Tamil, is particularly plentiful in Palk Bay and the Gulf of Mannar where, especially in the former area, its collection is important to the Kadayans, Valaiyans and allied coast castes. It is a strongly ribbed white shell with a superficial resemblance to the European cockle (*Cardium edule*)—the ridges running radially from the umbo to the margin—and of about the same average size. Its dimensions average when fully grown 45 mm. × 37 mm. with a thickness of about 33 mm. It spawns about the beginning of September at Tuticorin. It frequents muddy sands near low-tide level along the open coast. The flavour is good and the flesh tender.

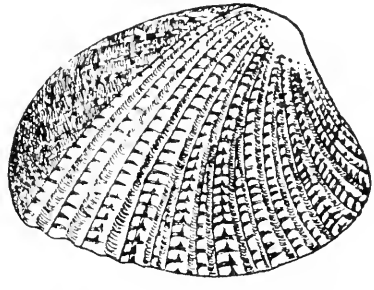

FIG. 53 *Circe gibba*, Lamarck. ×1.

Collection takes place at low water during spring tides, when the poorer women of the coast villages devote themselves to this work for two or three hours daily. In this time each can gather between 300 and 400 shells.

The muddy flats between Pāmban and Kundagal Point are rich collecting grounds and many women may be often seen there engaged in the search at spring tide. Very frequently a couple of shells are kept in one hand and rubbed or struck against one another to produce a clicking sound. When questioned the women say that this has the effect of attracting the clams to the surface; they watch for a slight movement wherever they see clam burrows and scoop up the sand where this occurs, generally getting one or two clams. I am inclined to think that in reality the clicking sound has an opposite effect to that believed by the clammers; it really

alarms the clam and causes it suddenly to retract its siphons and close its valves. In so doing a slight movement of the mud at the entrance of its burrow is necessarily caused and it is this that reveals its presence. Alphaeids—the so-called "clicking prawns"—are common on these flats and possibly the noise made by striking two shells together is mistaken by the clams for the clicking of Alphaeids.

The flesh is used either to form a curry, a soup, or a savoury, this considerable variety betokening the high esteem in which it is held. In all cases the preparatory operation is to steam the shells open and extract the flesh. This may then be made forthwith into a curry with the usual condiments, or it may be ground fine with coconut and spices, and boiled to form a highly tasty and nutritious soup, or, lastly, it may be ground to a paste, and fried in ghee or in sesamum oil and eaten with other food. The last mode of preparation is a strong favourite with those who habitually utilize this food. Probably no other bivalve is so universally valued on the shores of Palk Bay as is this cockle-clam; everybody seems fond of it with the exception of the higher caste Hindus.

The empty shells are used for lime-burning on the shores of Palk Bay, where it is the most abundant littoral mollusc. Along the Coromandel Coast, *Circe gibba* is scarce and does not seem to be used there as food. It is not found or at least is very scarce on the Malabar Coast.

More characteristic in shape of the true Circes are *C. scripta* and *C. personata*. These are greatly compressed nearly circular shells found sparingly in the neighbourhood of Pāmban and along the Tinnevelly coast. The colouring of the former, which is the more common, is yellowish, with a broken chevron pattern on the outer half of the valves that suggests the idea of writing. Closely set concentric ribbing covers the whole surface.

The TAPESTRY-SHELLS (*Tapes*), so called from the close ribbing and handsome markings that recall the texture and the patterns of tapestry, are generally characteristically oblong in shape with perfectly smooth ventral margins. A superb species is *Tapes adspersa*, found in the shallows south of Pāmban. It grows to a length of three inches and the handsome colouring and bold concentric ribbing make it one of the most striking of our commoner bivalves. *Tapes textrix* is another typical form, in this case with smooth valves marked with closely set dark

chevrons on a yellow ground. Other smaller species as *T. pinguis* are fairly common on both our coasts, but with the exception of *Tapes ceylonensis*, they are seldom to be found alive unless very diligent search be made, or a shell dredge used. *T. ceylonensis* departs greatly from the typical compressed Tapes form. It is a handsome inflated species, with a superficial resemblance to the Backwater Clam (*Meretrix casta*), being about the same size, shape and colour; it differs, however, in having radiating bands of a reddish brown tint running from the umbo to the margin. The pallial sinus is much better marked, and is deep and angular. Average length 1¾ inch. In the neighbourhood of Pāmban, where it is called *Vazhukkumatti*, it is found and fished with the *Sevala matti* (*Mactra corbiculoides*). It is also found on the West Coast, at Cannanore, Tellicherry, and elsewhere. Flatter and more like a true Tapes is *Paphia malabarica*, strongly ribbed, but in its colour closely related to *T. ceylonensis*.

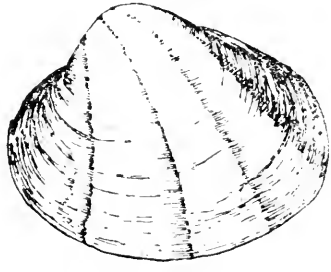

FIG 54. Vazhukkumatti (*Tapes ceylonensis*). × 1.

Closely allied to Tapes, are the pretty SUNETTA shells. Detached valves are common on our sandy beaches, and may be recognized by their coarse concentric ribbing and the attractive colour design, usually some arrangement of bold reddish brown chevrons; a fine milling occurs just inside the ventral edges of the valves. They are small shells seldom exceeding 1¾ inch in length. *S. meroe* and *S. effossa* are two common species.

The true COCKLES (*Cardiidae*) are represented in Indian seas by several large and handsome species, notably the Asiatic cockle (*Cardium asiaticum*) found on all our sandy coasts. This species is thin-shelled and highly inflated, with the exterior sculptured with fine ribbing. In size it runs to two inches in depth, the length being appreciably less. The foot is very large, bent in the middle nearly at a right angle; it is used for leaping and some species can jump a foot or more from off the bottom. Unlike the thick-shelled and smaller common cockle of European seas, none of the Indian cockles has any appreciable economic value, as they do not appear ever to occur in thickly-populated beds.

The HOLY-WATER CLAMS (*Tridacnidae*) are so called because of the use to which their huge ribbed valves are put in Roman Catholic churches in Europe. They grow to a larger size than any other bivalve, the shell attaining in exceptional cases a weight of over 500 lb. The substance of the shell is white and porcellanous and very thick and strong. A single adductor of enormous power controls the opening and closing of the valves. The smaller species usually bore into dead coral with the help of a great mushroom-shaped foot, forming roomy burrows ; others, often of great size, are non-boring in habit and either lie loose among coral blocks or cling to the rock by means of the foot. Stories are told of the great power of their grip and pearl divers in the South Seas dread as one of the greatest dangers of their calling, the possibility of setting a foot within the gape of a Tridacna shell. The valves are deeply corrugated with a number of very bold ridges. They live associated with corals and are most numerous and of greatest size in the South Seas, the eastern section of the Malay Archipelago and on the Great Barrier Reef of Australia. In our Indian seas, we find them among the coral reefs of Pāmban and the Gulf of Mannar ; they are especially abundant at the Laccadives. To see the gorgeous colouring of the mantle frilling as these molluscs lie with their shells agape in a clear pool is one of the many wonders of a coral reef ; the glory of Joseph's coat was as naught compared with the sparkling loveliness of the iridescent blues and purples and oranges of the mantle filaments protruding from between the open valves.

The next family, the *Chamidae*, has several essential morphological features common with the cockles and tridacnas ; but unlike them its members live their adult life with one valve, the left, cemented to stones, corals and shells. The CHAMAS are all small and may be taken for the Thorny Cockles (*Spondylidae*) if the form of the hinge be not noticed. In Chama, the ligament is external and not in a pit within, and there are fewer hinge teeth, two in one valve and one only in the other. The brilliant florid colouring of the spondyles is also absent, Chama being a pale insignificant little shell.

Of the *Psammobiidae*, the lovely *Solctellina diphos* is the best known representative on our coasts. It is a long, oval, purple coloured shell, rounded in front and narrowed behind to a somewhat pointed form ; in life the colour is masked by a smooth dark

yellow periostracum. In length it grows to five inches; this large size and the unusual colour of the shell render it conspicuous when thrown up on the beach. It must be fairly common on the Coromandel Coast, so often are its valves seen, particularly in the vicinity of the bars of the backwaters in the vicinity of Madras, Cuddalore and Negapatam. Like most of the other members of the family, this mauve Psammobia has extremely long siphons, each separate from the other. It lives buried deeply in the sand, keeping open communication with the water above by means of its siphons which open level with the surface. When retracted these long siphons occupy much space within the valves; this space is indicated by the deep bay marked upon the hinder part of each valve and known as the pallial sinus; in this family the sinus is unusually well developed. Several other species, chiefly of the genus *Psammobia*, are found in India; they are all much smaller than *Soletellina diphos* and instead of a pointed posterior end the shape is usually blunt or sub-truncate.

The RAZOR-SHELLS (*Solenidae*) are long scabbard-shaped shells living in deep burrows in sandy bays. The foot is enormously developed, cylindrical in form, mobile and protean in action, capable of swelling out with lightning rapidity or of thinning to a point capable of easy penetration into loose sand. At low tide the slot-like openings of their burrows are often exposed and as one walks near the edge of the sea, little jets of water shot up here and there bespeak the retreat to the bottom of their burrows of razor-fish that have felt the vibration of feet upon the sand. It is difficult to dig them out, so far and fast do they burrow; even if one does manage to seize one by the uppermost or posterior end it is hard to pull a large individual out, for the foot can be expanded at the lower end to form a living bulbous anchor after the fashion of the well-known mushroom anchor used for mooring buoys. Sometimes they hold on so tightly that the swollen end is broken off and left behind.

Most Indian species are small in size (*Solen corneus*, etc.). They are found on all sandy shores wherever the water is shallow and protected against surf.

A very pretty relative of the Solens is the Indian SUNSET-SHELL (*Cultellus radiatus*). The shell is smooth and oblong and marked by broad wedge-shaped bands of mauve radiating from the umbo. It is found on sandy shores in company with the more

deeply tinted Soletellina; the occurrence of this peculiar colour in molluscs that live completely buried in the sand is evidence that colour may be often of no significance in the economy of an animal save as the visual evidence of the presence of some waste excretion. A curious oblique ridge or rib extends on the inner surface of each valve from the beak across the shell to the ventral margin. In no other family is any similar structure seen.

The habitat and shell structure of the BORERS (*Pholadidae*) exhibit peculiar features of great interest. In countries where the coast rocks are comparatively soft, these molluscs excavate burrows in the same style as the Date-shells do in coral. In India, the Borers are seldom found in rock—our gneiss and schist are too hard for them; instead they affect stiff peaty and clayey deposits where boring is comparatively easy. The finest instance of this is on the north coast of Palk Straits, to the west of Point Calimere. Here a stiff clayey deposit is found; the conditions must be ideal for burrowing and food must be plentiful, for here a truly magnificent shell, the Oriental Borer (*Dactylina orientalis*), is found in large numbers and of a larger size than any European species. A length of 4 to 4½ inches is common. The shell is beautifully proportioned; long and tapered behind, snowy white in colour, papery in appearance, brittle but exceedingly hard. The surface is covered with prickly sculpture, rasp-like in arrangement. There is no true hinge, and the ligament has given place to an accessory shell plate. More peculiar still, the dorsal edges of the valves have grown *outwards* in such manner as to become reflected over the umbones protecting them from damage. These *umbonal plates* are further strengthened by supporting pillars and plates, dividing the space under these strange outgrowths into a number of chambers. Within the shell a short stout rod projects inwards from the edge of the umbonar cavity. The Pholads appear to excavate their burrows largely if not entirely by patiently rasping down the walls by the semi-rotation of their shell, first to one side and then to the other. The foot takes some part also in the operation.

The valves gape at each end. From the hinder one project the siphons, here united externally into a single organ, tubular in form. The extremity, slightly bifid, projects beyond the mouth of the burrow when the animal is feeding. The long narrow gills extend into the inhalent siphon.

A smaller species is found at Tuticorin, its valves washed ashore in great quantity after storms. This also appears to live in stiff peaty deposits, such as are formed by the consolidation of old sea-grass beds. It is also common at Calicut.

In floating timber, other Borers of this famiiy are found; a common Indian species is *Pholas* (*Martesia*) *striata*.

The SHIP-WORMS (*Teredinidae*) are still more specialized for boring, but they confine their attention entirely to wood. The body is long and worm-like, the siphonal tube being of extraordinary length, united through the greater part of its course. The shell is small and globular, covering only the thick anterior end, where the visceral organs are situated. The tiny valves show resemblance in essential features with those of the Pholads, especially in the presence of a calcareous "spur" in each umbonar cavity; Teredo has evidently descended from a Pholas-like ancestor, suffering extreme modification in its successful attempt to perfect its form to a burrowing habit. The body of some of the common species may reach a length of a couple of feet or more with a diameter of about a quarter of an inch. As it starts making its burrow when quite tiny and never quits it, the aperture to the exterior is minute. The burrow is lined by a calcareous tube, not connected in any way with the body of the Teredo, but deposited from a secretion poured out by certain glands. Ship-worms are extremely destructive to timber, especially in the tropics; unless protected by sheathing, woodwork under water becomes riddled with the multitude of their burrows within a few months. The hardest wood is not immune. I have seen ironwood piles completely destroyed, reduced to a mere shell of honeycombing, at Tuticorin. Dealwood perishes within a few weeks. Their ravages cause constant anxiety to the owners of small coasting craft and fishing canoes; the old Indian method of combating the ship-worm is to haul the boat ashore or else to careen her, and after drying as thoroughly as possible to daub the under-water parts with a mixture of chunam, dammar and oil. Canoes being easier to handle are frequently hauled ashore, dried, and the bottom smeared with rancid fish-oil, of an odour warranted strong enough to disgust any ship-worm that comes near.

A short length of the siphon tubes is free at the hinder end and at the point of junction of these free ends with the long united siphonal region, are situated a pair of tiny palette-like limy plates

supposed to be of use in protecting their owner against the intrusion of any unwelcome visitor. These pallets may be likened in function to the operculum of a gastropod.

Last of all and more degenerate and quite unlike the typical bivalve are the WATERING-POT SHELLS (*Clavagellidae*). They are common on our shores, washed up after storms; they may also be found at very low tides embedded upright in the sand. In form their shells are short, stout brittle cylinders about three inches long with several delicate upstanding frills round the open or upper end. The lower extremity is closed, slightly convex, perforated with holes and fringed with a number of short open-ended tubes—the whole suggestive of the rose of a watering-pot, whence the name. When seen first, the impression is that the short open cylinders fringing the "rose" are the broken bases of root-like tubes; this is not the case. That the creature is a bivalve is seen not only by a study of the soft parts of the body, but by the presence of a tiny but perfect bivalve shell embedded in the surface of the main tube just above the "rose." The larger structure, the frilled cylinder, is a secretion of the siphons.

A common Indian species is *Brechites dichotomus* or *Aspergillum dichotomum* as it was formerly called.

CLASS V.—CEPHALOPODA.

The Cephalopods are so called because the foot, here divided into a number of tentacle-like arms, is attached apparently to the head. The body is a muscular sac containing the viscera and gills. In many forms an internal "bone" or "pen" stiffens the body in a manner comparable with the backbone of the higher animals. The head, joined to the body by a narrow neck, is furnished with a pair of large eyes, perfectly constructed optically but evolved by quite a different line of development to the vertebrate eye. The arms, eight to ten in number, arise in a circle at the fore-end of the head. Except in the case of the Pearly Nautilus, these are armed with a large number of suckers, enabling the animal to cling tenaciously to any object. Each sucker is a round disc with a little bulbous cavity at the centre that enables the creature to work the sucker apparatus like an air-pump; the vacuum created causes the sucker to adhere by atmospheric pressure and this continues so long as the central intelligence

controls the muscles working the sucker's piston, in a state of tension. The mouth, situated in the centre of the circlet of arms, is armed with a horny parrot-like beak, in large species so powerful as to be capable of rending its prey.

The class is divided into two sections according as the number of gills is two or four. Those characterized by the latter number were predominant in former geological times, but to-day the Pearly Nautilus is the only existing form with four gills. The two-gilled section is in turn classed, according as the arms are eight or ten, into the Octopoda and the Decapoda. The common Octopus and the Paper Nautilus (*Argonauta*) are types of the former; the cuttle-fishes, squids (or calamaries), and the curious little Spirula, are the best known representatives of the other.

The Octopoda have neither internal nor external shell, with the partial exception of the Paper Nautilus where the female forms an extremely fragile and delicate transparent shell in which she brings forth and shelters her eggs. Some attain a large size and mythological stories tell of huge individuals that have seized men from boats. In our Indian seas the largest I have seen, Herdman's Octopus (*Polypus herdmani*), had a body less than the size of the fist, with arms about $2\frac{1}{2}$ feet long when fully extended. The Octopus is by far the most intelligent of the mollusca, indeed it seems an absurdity to class it with snails, chanks, oysters and clams; in one sense the name of Devilfish sometimes given to it in England, seems justified. If several Octopus be watched in captivity and if they are at home in their surroundings, the cleverness of the creatures in stalking their prey and their cruel rapacity in tearing the victim into pieces when caught, are uncanny and devilish. I have watched an Octopus on the prowl sliding stealthily over the bottom with all the skill of a high intelligence; every bit of cover is made use of and even the colour of the bottom is imitated for concealment. Passing over yellowish sand the dark body tints of the Octopus fade away and there is nothing but a slight movement to betray its presence. Anon it crawls over a mass of brown weed—dark tints come back in a flash and once more the animal is indistinguishable from its background. This ability to make lightning changes in its colour disguises is due to the colouring matter in its skin being in little sacs controlled by muscles. If the muscles contract the pigment spots grow and expand, giving dark tints to the body; if they relax, the spots close to pin points

and a greyish yellow pallor suffuses the body. Crabs are the favourite food of the Octopus, but they will also open bivalves, and fishes are occasionally caught by the cruel snake-like, sucker-beset arms.

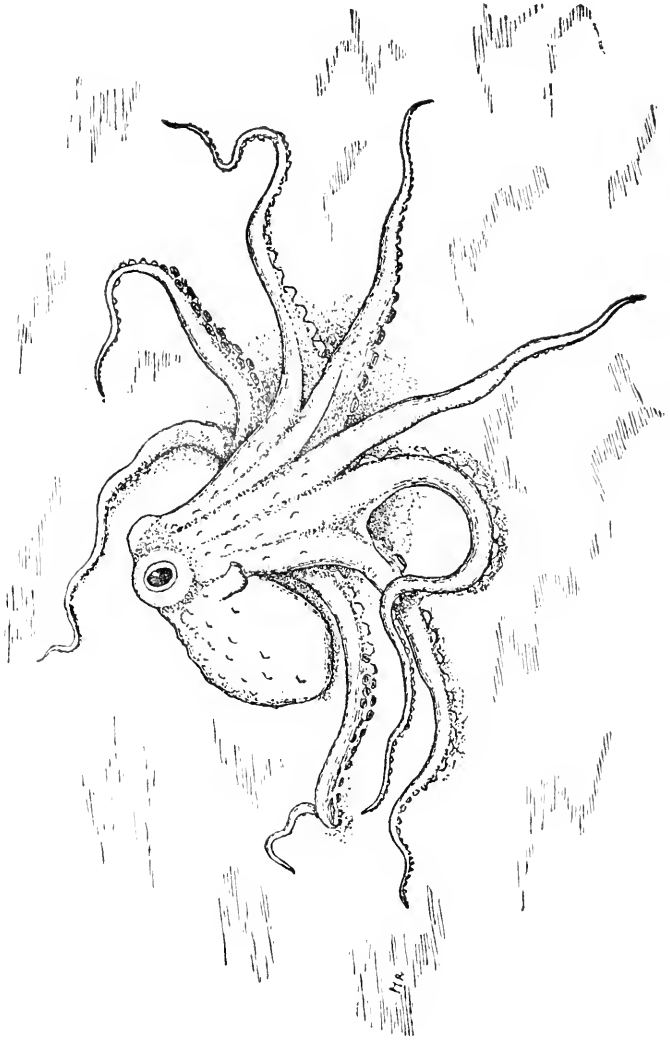

FIG. 55. A small Indian Octopus crawling over the bottom. Natural size.

Everywhere along the East Coast several species of small Octopus are abundant. They abound in the weedy shallows of Palk Bay where they are known to the fishermen under the names of *Sa kanavai*, *Pey kanavai* and *Sangu kanavai*. They are in keen demand by line fishermen as they make the best bait known to

them, the flesh firm and not easily pulled from a hook, and the odour tempting beyond measure to the fish sought after.

To capture them long lines are prepared having some hundreds of short branch lines tied on at intervals of from five to six feet. To each of these branch lines a large Pterocera shell (*P. lambis*) is attached, the apex and "fingers" being first broken off. These lines are sunk on the bottom in places which these Octopus frequent, and when lifted next morning many of the shells are tenanted by Octopods that have sought concealment therein.

Every village on the Rāmnād mainland fronting Palk Bay possesses these Octopus lines, and the number of Octopus thus caught is very great indeed; the industry is an important one both in itself and because of the dependence thereon of the line fishermen, who find it difficult to get other suitable bait if squid be wanting. This bait fishery is said to have existed at Rāmēswaram a decade ago, being given up when line fishermen abandoned this occupation, because, according to some, their boats being too small and unseaworthy, fishing on the offshore banks was found to be too dangerous for these timid and unenterprising souls.

The number of shell-traps used on a Devilfish long line usually runs to upwards of 800. The crew of a line-fishing boat on the Tirupalagudi coast consists usually of five men, and each of them when he joins, brings 5 or 6 lines, each armed with from 25 to 30 shells, say a total of 150 to 180 per man, or a grand total of 25 to 30 lines carrying 700 to 900 shells in all. The lines tied end to end are laid out in a depth of 2½ to 3 fathoms of water, one end being buoyed with a large wooden float. Each morning the fishermen haul the line and the attached shell-traps; so common are these small Devilfish that a considerable number of the shells are tenanted by them. Enough for the day's requirement of bait are removed, the line and its traps are relaid, and the fishermen proceed to bait their fish hooks with the captured Octopus.

Every third week or thereabouts the lines are brought ashore and dried for a day to prevent rotting and then relaid for a further active period. At the beginning of the rainy season lines are brought ashore, dried, and stored till the rains are over.

The most frequent name used for this creature is *Pey kanavai*—literally "Devil Squid"—the exact equivalent indeed of "Devilfish," the popular English name of the Octopus. The fishermen say they

call it so, because of the devilish restlessness which it exhibits when taken from the water and the impression of concentrated malignity which its appearance and habits make upon them. Often on the pearl banks I have come across small ones hiding in empty pearl oyster shells; they certainly do appear uncanny in their activity when attempting to escape; they dash hither and thither like some great fleshy spider of the sea, their arms writhe and twist with a speed the eye cannot follow; small as these are, the play of the little suckers closely set over the arms is unpleasant on the skin and to restrain them is as difficult as to hold a globule of quicksilver. Their eyes, huge for their size, are too human to be pleasant, and it is no wonder the fishermen think they have a devil's malevolence and ingenuity. They credit them too with a great deal of sagacity; amongst other clever tricks attributed to them, is that when they enter an empty shell, they are careful to close the entrance with a shell or piece of stone, as a screen against their enemies, the crabs. I cannot vouch for the truth of this story, but I think it quite probably true. They are also said to sham death when they realize that they are finally cornered. Another favourite trick is to eject a cloud of inky fluid from a special sac within the body. This diffuses at once and forms a dense dark cloud. Under cover of this the Octopus frequently escapes.

Another species of small Octopus called *Visha kanavai* (literally " poisonous kanavai ") is occasionally caught in shell traps in the relative proportion of one or two per hundred to the numbers of the *Pey kanavai*. The fishermen make no use of it as they say no fish will take it as bait. I have not seen it alive, but from dead specimens it is seen to be a slender-armed Octopus, looking very much like an immature example of the larger Octopod called *Kundal kanavai* at Tirupalagudi.

The common belief is strong that it is endowed with marked poisonous qualities; when caught it is usually thrown overboard at once. The fishermen say that it is equally active as the *Pey kanavai* and if it has the chance will fasten on a man's leg or foot and bite through the skin. The sensation is likened to the sting of a scorpion and if a remedy is not quickly applied, the limb will swell and a feeling of giddiness will be experienced. The accepted remedy is a curious one; betel juice is spat upon the place or chunam (slaked lime) smeared over the wound as soon as possible. Then when shore is reached, jaggery (palm sugar) is rubbed over

the place bitten and a dog being brought, is induced to lick the jaggery off ; in so doing it is believed that the poison will also be removed. In spite of this curious and complicated treatment, after effects of the poison are said sometimes to be experienced for several months afterwards, the usual complaint being that of a continued swelling of the leg bitten.

Although the bite of the Visha kanavai is esteemed so poisonous, the flesh is considered innocuous and when accidentally brought ashore with other species, it is cooked and eaten together with them.

Small Octopods are common on the pearl banks during a fishery and it is not uncommon to find their tiny colourless eggs attached to the inside of an empty pearl-oyster shell. As these fisheries occur in March and April, this then is one of their spawning seasons; possibly like many other tropic sea-creatures a second may occur in September.

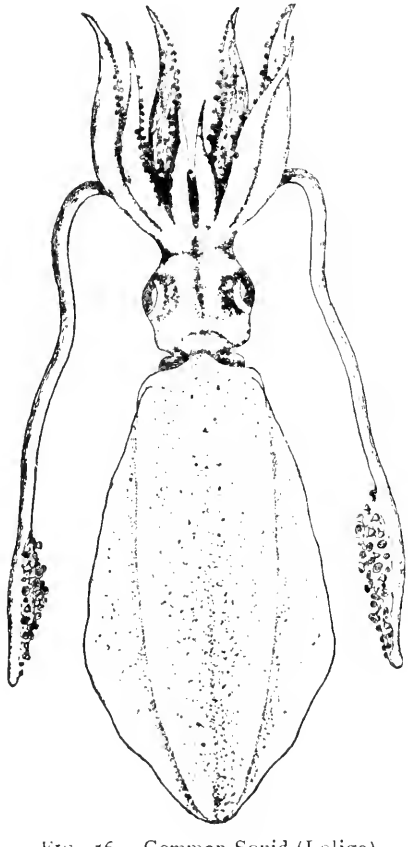

Fig. 56. Common Squid (Loligo).

Large species such as *P. herdmani* are scarce. They are found on rocky bottom in the Gulf of Mannar.

Of the ten-armed Cephalopods, the Squids or Calamaries (*Loligo*) and the Cuttlefishes (*Sepia*), several species are common on our Indian coasts. The Octopus has solitary habits, and frequents rough bottom where he can ambush his prey ; not so the Decapods. They have far less intelligence and instead of quartering the bottom in quest of prey, swim swiftly through the water in shoals, often of immense numbers. The SQUIDS (*Loligo*) are the more active, their body long and torpedo shaped and armed with a powerful triangular fin at each side of the body. The

Octopus on occasion is able to dart swiftly backwards by expelling the water in the gill chamber through a siphon on the under side of the body. The Squids also have this power, but they have so greatly developed their caudal fins that swimming is their ordinary method of locomotion. A shoal of these elegant creatures in flight through the water is an entrancing sight, never to be forgotton.

Unlike the arms of the Octopus, those of Loligo are short and stumpy with the exception of the extra two—the tentacular arms; these latter are very long and instead of the suckers being distributed throughout the entire length, they are restricted to a broad pad-like swollen region at the far end. Each of these long arms is rectractile into a pouch on either side of the head; they are used to seize their prey when at a distance. An internal support, the pen or *gladius*, is present in the dorsal region. It is a thin, light, nearly transparent horny structure, with a stiffening rib down the centre on one side.

Alike with the Octopus and the Cuttlefish, the Squid has an ink sac for defence. In the presence of danger the contents are discharged as an inky cloud; under cover of this the animal frequently evades its pursuer. It is a favourite morsel with most large fish.

Squid are very common in Palk Bay where they are known as *Kundal kanavai* at Rāmēswaram, and as *Ecki kanavai* on the western shore of the Bay. The species represented under these vernacular names is the only large Squid found in abundance in Palk Bay. Shoals appear in shallow water off Rāmēswaram Island about the month of April and during the height of the S.W. monsoon—June and July—the shoals reach their maximum, and then consist of immense assemblages of individuals sheltering under the lea of the land from the violence of the monsoon, to feed upon the smaller fry that seek similar shelter and to deposit their egg capsules among the weeds common in the places favoured.

Two methods of fishing are employed, the one a wholesale netting in which thousands are caught at a haul; the other where the skill of the fishermen is exercised in catching the Squid singly by means of a jigger.

The first method is largely practised in Rāmēswaram Bay during the south-west monsoon; a seine is used having a large close-meshed bag in the centre, with long wing-ropes closely set with strips of palm leaf (*ōlai*) to serve as scare-lines, and so to herd

the Squid into the bunt of the net. In the season there are usually four sets of these squid seines—called *ōlai valai* locally—in daily use at Rāmēswaram. When the shoals are about, catches may occasionally range up to 5,000 a haul. The bulk of the Squid caught are sold to fish runners who come from Pāmban and Rāmēswaram, at rates varying from Rs. 1-12-0 to Rs. 2-8-0 per 100; the balance is consumed locally. When demand is weak and little is sold for consumption fresh, the Squids are sun-dried and sold eventually at Rāmnād and other inland markets at about Rs. 3 per 100.

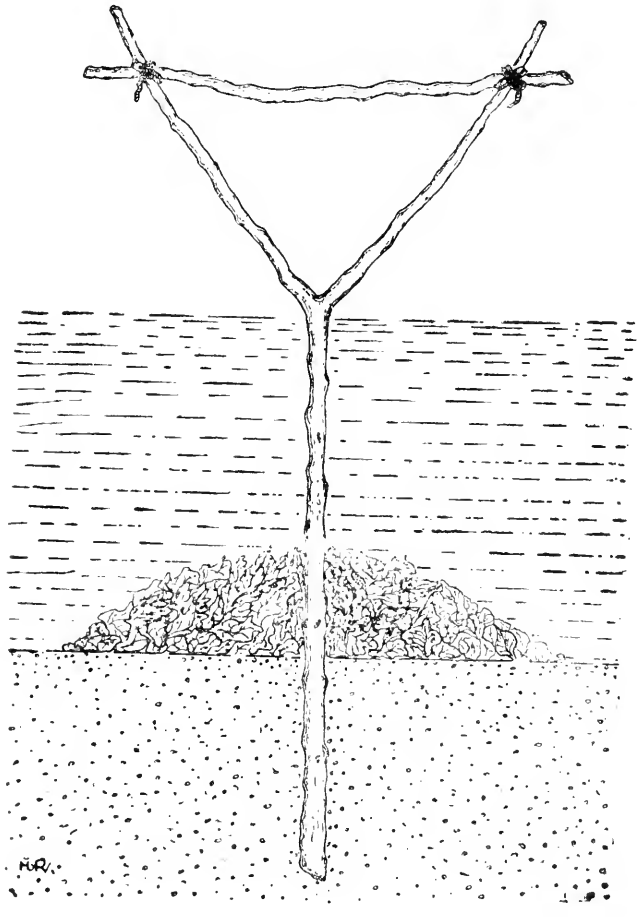

FIG. 57. Jigging platform used for spearing Squid at Rāmēswaram.

Jigging for Squid is practised chiefly for home requirements by individual fishermen, who sun-dry any surplus they may have.

This method is largely employed along the northern coast of Rāmēswaram Island, especially at the village of Aryakundu, near Tangachimadam, during the squid season. To carry it on the fisherman erects a small outlook in shallow water—a form of machan (fig. 57). The main portion of the structure consists of a stout bifurcated tree branch of Y shape, the main stem embedded firmly in the sea-bottom; across the ends of the two arms, which project upwards several feet above the surface of the water, a strong pole is fixed horizontally to serve as a rest for the fishermen. The height of this seat above the sea-bottom is generally about 6 feet; 8 feet at the utmost. A pile of leaves is tied or anchored at the foot of the staging to attract the Squid; the fisherman when ready, takes his stand on his outlook armed with a slender pole 12 to 15 feet long, furnished at one end with five or six stout hooks set grapnel-fashion, thus:—

FIG. 58. Squid jigger used at Rāmēswaram.

Watching the bottom intently, the fisherman waits till he sees a Squid approach to investigate the heap of leaves. As soon it comes within range he cautiously moves his jigger into a favourable position and with a deft jerk imbeds the jigger hooks in its flesh and lifts it from the water. The reason why the Squid seek shelter amid the leaves set as a lure, seems, on the part of the female, to be for the purpose of laying her eggs therein, as she requires such objects whereto to attach the great gelatinous candle-like capsules in which the ova develop (fig. 59). The male is said to follow the female at this time, so that sometimes both fall a prey to the fisherman's jigger. What is not used or sold immediately is split open, washed and sun-dried; it makes a very clean and attractive looking product.

This method of fishing is generally carried on in the morning, the fisherman occupying his outlook for four or five hours at a stretch. The branched post employed is cut generally from a babul, the one tree that manages to thrive well on this sun-scorched sandy coast. At Ariyakundu there are nearly one hundred of these squid machans.

CUTTLEFISHES (*Sepia* spp.), called *Ottu kanavai* in Palk Bay where they abound more than anywhere else on our coasts, have a large fleshy flattened body, bordered with a narrow frill-like fin on either side, a head furnished with two great goggle eyes, and beset with tentacles of the same general character as in Loligo, but instead of the long horny "pen" seen in the latter, the cuttlefish has a broad stoutly built "bone" composed of fine calcareous laminæ enclosing air spaces. This cuttle bone has value for rubbing down paint in fine coachwork and a minor industry on the Rāmnād

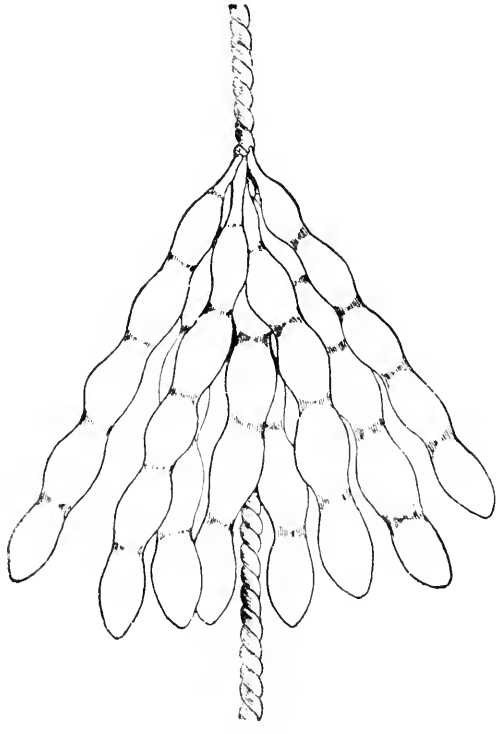

FIG. 59. Egg Clusters of Squid (Loligo) attached to a rope.

coast is the collection of these bones during the monsoon when they drift ashore in numbers. The brown pigment called 'sepia' is another minor commercial product obtained from the cuttle and its relatives; the brown pigment, when genuine, represents the dried and pulverized contents of the ink-sac.

Cuttlefish are far less abundant than Squid in Palk Bay and are not the object of any special fishery, though some are occasionally

taken in the casting net (*vichchu valai*) and in drift nets and shore seines. Their bones are, however, thrown up in large quantities on the southern and south-western shores of Palk Bay during the north-east monsoon, and at this period of the year, numbers of Kadayan women scour the littoral in their search. After long continued northerly winds, the supply is often very abundant, particularly during February and March, and a woman can collect several hundreds in a day. These are eventually sold to agents of Kilakarai, Devakkōttai and Pāmban merchants, who tour the coast to buy up the stocks available. A gunnybag full of cuttle bone of all sizes fetches from As. 10 to Re. 1-4-0; sometimes they are

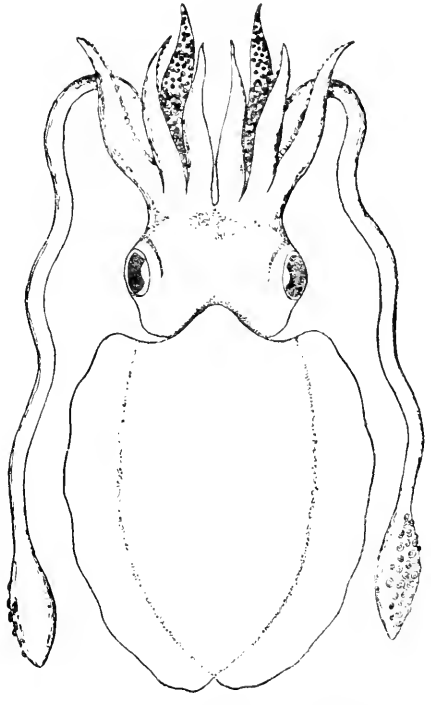

FIG. 60. Common Indian Cuttlefish (Sepia).

sold by number and size, the price varying from two to eight annas per 100; a common price is one pie (one-twelfth anna) for large bones and two or three per pie for small ones. A regular price cannot be said to exist; rates vary with the needs of the seller and of the purchaser.

On the south coast of Rāmēswaram and other islands near Pāmban cuttle bones come ashore during the south-west monsoon

but not nearly so plentifully—only about one-tenth the quantity—as they do on the north coast of Rāmēswaram Island during the north-east monsoon. In a single season the collection of cuttle bones from Rāmēswaram alone amounts to from 10 to 14 cwt., a quantity representing a very large number of bones. The total Indian export amounts to a considerably larger quantity. Several fishing villages on the mainland, such as Morepanai near Uppur, report an annual collection of 20 to 50 bags each per annum. A considerable quantity is also obtained from the Travancore and Malabar coasts; most of this is exported through Tuticorin. From Kilakarai 14½ cwt. were shipped to Colombo during 1914-15.

A considerable demand exists in Europe for cuttle bone, especically for large sizes.

Palk Bay fishermen cherish the belief that cuttlefish cast their bones annually in February and March, this being the season when the bones are thrown ashore in great quantity. Strangely enough no shoals of cuttlefish are ever caught in nets--only stray individuals; that large shoals do abound is evident, for it occasionally happens after a severe storm that very great numbers are thrown up on the beach, dead but quite fresh. The village women collect them, cure them in the sun and take to market, where they generally find a ready sale.

A small and very pretty form of Cephalopod is *Sepiola*, a stout form seldom exceeding an inch or an inch and a half in length. Its distinguishing feature is the presence of a rounded paddle-like fin on each side of the rotund body.

The last of the ten-armed forms is the mysterious SPIRULA of which only a single species, *Spirula peronii*, is known. It must live in great profusion in some locality in the tropics, for multitudes of its curious, loosely coiled "ram's horn" shell are to be found on every beach in the Pacific and Indian Oceans after a spell of long continued onshore winds. Only a very few specimens of the animal have ever been found and absolutely nothing definite is known of its habits. It has the appearance of a long-bodied Sepiola bereft of its fins, and measures about 2½ inches in length. It has the usual eight short arms and two long tentacular ones. Towards the end of the body on each side, the last whorl of the shell projects slightly, but still covered by a thin fold of the mantle; hence it is an internal shell like the "bone" of the cuttlefish. A terminal sucker or pore exists at the posterior extremity

of the body and it has been surmised that this enables it to anchor itself to rocks. The life-history and habits of this strange creature are still among the mysteries of life awaiting solution.

The shell is a loosely coiled cylinder, snowy white without, nacreous within. At frequent intervals throughout its length, it is divided into short chambers by thin concave partitions as in the shell of the Pearly Nautilus about to be described. As in the latter each partition is traversed by a tube or siphuncle. This tube passes close to the inner wall of the whorls, whereas in Nautilus it passes through their centre.

Last of the Indian Cephalopods, but represented solely by shells drifted ashore, is the four-gilled PEARLY NAUTILUS, the sole living representative of a great host of strange molluscs that flourished exceedingly in Palæozoic times. The Ammonites, though closely related in shell form, are not so nearly akin as the earlier straight-shelled *Orthoceras*. Though the shell of Nautilus like that of Spirula is one of the familiar objects of tropic beaches, nothing

FIG. 61. Pearly Nautilus in the attitude of crawling (after Willey).

was known of its habits until comparatively recently. Dr. Willey was one of the first to throw light on its life-history, and to watch it in captivity. The seas around the islands of the Western Pacific are its headquarters; there in moderate depths Willey was

able to capture numbers by the simple expedient of sinking traps to the bottom. He found Nautilus to be gregarious and nocturnal, crawling over the bottom in troops at night time in search of the crabs and molluscs on which it feeds. Figure 61 shows its ordinary attitude when crawling. It is also able to swim after the usual manner of Cephalopods. The earliest specimens captured were taken floating or swimming on the surface. In this position the numerous tentacles, 60 to 90 in number, which here take the place of the arms in other cephalopods, are arranged in a radial manner around the mouth and this accounts for the description given of it when seen on the surface as " a shell with something like a cauliflower sticking out of it." These tentacles are prehensile and are given off from lobes of the foot surrounding the mouth.

A dorsal lobe of the foot forms a thick and strong hood which protects the whole animal when withdrawn into the great terminal chamber of its shell. Unlike other cephalopods Nautilus has no ink sac.

The shell is a pretty object often thrown up on our shores during the monsoon. The size is considerable, often reaching 4 to 5 inches in diameter. It is a discoidal shell, coiled in one plane, and divided by concave septa into a large number of chambers increasing gradually in size as they approach the open terminal chamber. In this the whole body of the animal is lodged. The chambers are connected by a narrow siphuncle as is Spirula, and in life a narrow membranous tube passes from the animal backwards through the siphuncle. With increase in size, the Nautilus periodically finds the body chamber too small, so lengthens and widens it in front, while behind it shuts off the hinder portion of the chamber by a new transverse partition. The chambers are filled with a nitrogenous gas. This has value in lightening the shell and is useful in adjusting the weight of the body to the particular needs of the moment. It is what is known in physics as a hydrostatic apparatus.

The interior of the shell and all the septa are pearly, while the outer layer is porcellanous, barred irregularly with broad reddish-brown bands upon a whitish ground.

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APPENDIX.

MOLLUSCAN FAUNA OF THE LACCADIVE ISLANDS.

In Prof. J. Stanley Gardiner's *Fauna and Geography of the Maldive and Laccadive Archipelagos*, a long list of molluscs is given by the late Mr. E. A. Smith. Unfortunately it relates solely to collections made in Minicoy and the Maldives. So far as I know no list exists of shells collected exclusively from the sister archipelago of the Laccadives. It may therefore be useful if I append here the names of the shells brought back in 1920 by my assistant Mr. Ramaswami Ayyangar from a hurried visit to these islands. The short time allowed in each island did not permit of more being done than the collection of the commoner shells found on the beach and on the reefs; in many cases these were water-worn and broken; systematic work was impossible. The collection has, however, its own value, as it shows us exactly what are the shells most abundant and characteristic of these islands. The list will form a basis from which to work in any future investigation of their molluscan fauna. I am indebted to Dr. W. T. Elliott for his kindness in identifying the collection.

Haliotis ovina, *Chemn.*
Turbo argyrostoma, *L.*
Trochus maculatus, *L.*
Do. pyramis, *Born.*
Nerita plicata, *L.*
Do. undata, *L.*
Do. polita, *L.*
Do. albicilla, *L.* var. venusta *Phil.*
Cerithium articulatum, *Ad. and Reeve*, var.
Do. echinatum, *Lam.*
Do. morus, *Lam.*
Do. nodulosum, *Brug.*
Melania tuberculata, *Müller.*
Strombus gibberulus, *L.*
Do. lentiginosus, *L.*
Do. auris-dianæ, *L.*
Pterocera chiragra, *L.*
Do. lambis, *L.*
Modulus tectum, *Gml.* v. candida, *Petit.*
Mitrularia porosa, *Rve.*
Hipponyx australis, *Quoy.*
Vanicoro cancellata, *Lam.*
Natica melanostoma, *Lam.*
Ianthina fragilis, *Lam.*
Cypræa arabica v. histrio, *Meuschen.*
Cypræa caput-serpentis, *L.*
Do. carneola, *L.*
Do. caurica, *L* v. oblongata, *Melv.*
Do. erosa, *L.*
Do. errones, *L.*
Do. lynx, *L.*

Cypræa mauritiana, *L.*
Do. (Pustularia) nucleus, *L.*
Do. ocellata, *L.*
Do. poraria, *L.*
Do. tigris, *L.*
Do. vitellus, *L.*
Triton tuberosum, *Lam.*
Do. lotorium, *L.*
Do. (Persona) anus, *L.*
Ranella bufonia, *L.*
Do. rubela, *L.* = lampas auct.
Cassis rufa, *L.*
Dolium pomum, *L.*
Do. olearium, *Brug.*
Do. perdix, *L.* var.
Pyramidella sulcata, *A. Ad.*
Vasum (=Cynodonta) cornigera, *Lam.*
Latirus (Leucozonia) smaragdulus, *L.*
Latirus craticulatus, *L.*
Peristernia nassulata, *L.*
Engina mendicaria, *L.*
Cantharus undosa, *Lam.*
Nassa papillosa, *Lam.*
Do. monile, *Kiener.*
Iopas serta, *Brug.*
Ricinula hystrix, *L.*
Do. horrida, *Lam.*
Do. lobata, *Blainv.*
Do. tuberculata, *Blainv.*
Do. spectrum, *Reeve*, var.
Purpura pica, *Blainv.*
Coralliophila madreporarum, *Phil.*
Conus arenatus, *Hwass.*
Do. canonicus, *Brug.*
Do. coronatus, *Dillwyn.*
Do. eberneus, *Brug.*
Do. hebræus, *L.*
Do. do. var. vermiculatus, *Lam.*
Conus miles, *L.*
Do. monachus, *L.*
Do. nussatella, *L.*
Do. rattus, *Hwass.*
Do. tessallatus, *Brug.*
Do. tulipa, *L.*
Do. virgo, *L.*
Do. zonatus, *Brug.*
Terebra maculata, *Lam.*
Do. affinis, *Gray.*
Do. duplicata, *Reeve.*
Do. crenulata, *L*
Do. cingulifera, *Lam.*
Bulla vernicosa, *Gould.*
Atys naucum, *L.*
Melampus fasciatus, *Desh.*
Margaritifera vulgaris, *Schum.*
Pecten senatorius, *Gml.*
Spondylus violascens, *Lam.*
Ostrea cucullata, *Born.*
Pinna zebuensis, *Reeve* (probably ; much broken).
Cardita rufescens, *Lam.*
Cypricardia guiniaca, *Lam.*
Lucina (Codakia) bella, *Conr.*
Do. (do.) punctata, *L.*
Tellina elegans, *Gray.*
Do. scobinata, *L.*
Do. virgata, *L.*
Mesodesma glabratum, *Gml*
Mactra olorina, *Phil.*
Venus toreuma, *Gould.*
Do. reticulata, *L.*
Pitaria obliquata, *Hanley.*
Cardium australe, *Sowerby.*
Do. leucostoma, *Born.*
Do. fragum, *L.*
Tridacna elongata, *Lam.*
Asaphis deflorata, *L.*
Spirula peronii, *Lam.*

Notes.—Chank shells (*Turbinella pirum*) are used in certain of the islands as trumpets when the people are summoned for any work of importance to the community, as at the launching or beaching of boats and at their periodical rat hunts. Some of the fishermen aver that they occur alive in the islands. This statement requires early investigation; if true it would have a very important bearing upon the geological history of the archipelago. Large Triton shells (? *Triton tritonis* L.) are also employed largely as shell trumpets by the men, while boys often make use of *Cassis rufa* and some of the medium-sized Tritons; even the large frog-shell, *Ranella rubela*, is occasionally employed.

Pterocera chiragra.—This is very abundant and its flesh is eaten extensively. The little Capulid, *Hipponyx australis*, is often taken adhering to its shell.

Fresh-water molluscs are rare. The only one found in quantity was *Melania tuberculata*; this occurs in all the islands, its shell thin and fragile, and prettily marbled. It is noteworthy that corrosion of the apical portion which is so characteristic of Melanias of the mainland, is not shown by this species under insular conditions.

Pinna zebuensis.—This is the only species of mollusc that is looked upon by the islanders as a frequent pearl-producer. It grows to a great size, the valves broadly cuneate and massive. Before the introduction of the iron ramotti of European manufacture, the islanders state that single valves of this shell were used by their women when digging pits in the sand for the soaking of coconut husks.

Mesodesma glabratum is probably the most abundant sand-burrowing lamellibranch in the islands. It is collected extensively for food purposes. Extensive beds of a species of *Modiola* occur at Androth; tiny pearls are occasionally obtained from this source, but too few and inferior in quality to have any commercial value.

J.H.