REPORT

TO THE GOVERNMENT OF CEYLON

ON THE

PEARL OYSTER FISHERIES

OF THE

GULF OF MANAAR,

BY

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WITH SUPPLEMENTARY REPORTS

UPON THE

MARINE BIOLOGY OF CEYLON,

BY OTHER NATURALISTS.

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CONTENTS OF PART I.

PEARL OYSTER REPORT.

SUPPLEMENTARY REPORTS.

PREFACE.

THE plan of this work is as follows :—

AN INTRODUCTION explaining briefly the past history of the Pearl Banks in the Gulf of Manaar and the circumstances which led to my Ceylon Expedition, and the subsequent work to which it gave rise, is followed by a section, entitled NARRATIVE, which deals with the course of the investigations undertaken by Mr. HORNELL and myself, given in chronological order. The observing stations where the fauna was investigated around the Coast of Ceylon are described in detail in the Narrative; but those other investigations—such as the anatomy of the Pearl Oyster, a description of its parasitic worms, and an account of its pearl-formation—which will be dealt with separately in special articles later on, are not treated fully in this section. After the Narrative comes a Description of the physical condition of the pearl-oyster banks or "paars" of the Gulf of Manaar, followed by their classification from the fisheries point of view, and by a short discussion as to the causes of certain paars being unreliable, and of the serious mortality of the oysters. Then comes a section dealing with the Observations and Experiments made by Mr. HORNELL and myself on the life-history and habits of the pearl oyster, which form the basis of some of our recommendations as to the cultivation of the oyster banks.

This general part is then followed by the Supplementary or Special Reports, which various scientific friends have kindly undertaken to write upon their special groups or subjects. I feel that these articles by experts add very greatly to the completeness and value of this Report, which without them could only have given a very imperfect account of the fauna and flora of the Gulf of Manaar and of the other natural conditions of existence surrounding and influencing the pearl oyster on the various "paars."

Of these special Reports, seven are published in the present Part I. The first of these is on the Geology of the Sea-bottom, by Mr. JOSEPH LOMAS, F.G.S.; it deals with the very fundamental question of what the "paar" is, how the hard, cemented material usually known (and marked on the charts) as "rock," which by its presence enables the pearl oysters to live there, comes to be formed.

The next is by Mrs. GEPP on the Algæ collected, and this contains an account of the previously unknown fructification of a species of *Halimeda*, one of the commonest and most characteristic forms of sea-weed on the pearl banks.

The remaining Reports are Zoological. Mr. A. E. SHIPLEY'S on the Gephyrea, Mr. E. R. SYKES' on the Chitons, and Mr. J. PEARSON'S on the Holothurians, all contain descriptions of interesting new forms. Mr. W. M. TATTERSALL'S Report on the Cephalochorda adds no new species of Amphioxus, but performs the equally useful function of showing that some of those previously described are so closely linked by variations that they may safely be regarded as the same. It is interesting to find that out of the dozen well-established species of Amphioxus, no less than seven were found in two months work round the Coast of Ceylon.

The last Report in this present Part I.—that on the Copepoda, by Mr. ISAAC THOMPSON and Mr. ANDREW SCOTT—is by far the largest, and deals with a great number of species. It is certainly surprising that we should in such a short time, without being able to pay any special attention to the group, have come across no less than 283 species of Copepoda, of which 76 were new to science. Mr. THOMPSON has acknowledged handsomely the large share which his colleague, Mr. A. SCOTT, has taken in the more laborious parts of the preparation of the Report; but I also must draw attention to the combined industry and skill which Mr. SCOTT has exhibited in the beautiful drawings for the numerous accurate plates illustrating the new species of Copepoda.

The next Part will be ready early in 1904, and will contain Reports upon the Sponges, by Professor A. DENDY; the Hydroid Zoophytes, by Miss L. R. THORNELY; the Medusæ, by Mr. E. T. BROWNE; the Turbellaria, by Mr. F. F. LAIDLAW; the Polychæta, by Mr. HORNELL; the Cephalopoda, by Dr. W. E. HOYLE; the Cumacea, by Dr. W. T. CALMAN; the Fishes, by Mr. J. JOHNSTONE; and the Entozoa of the Pearl Oyster, by Mr. A. E. SHIPLEY and MR. HORNELL.

The remaining Parts, which it is hoped will be issued during the following year, will deal with the other groups of animals. The reports on the Amphipoda by Mr. A. O. WALKER, on the Caprellida by Dr. PAUL MAYER, on the Isopoda by the Rev. T. R. R. STEBBING, on the Ostracoda by Mr. ANDREW SCOTT, on Sarcophytum and its allies by Miss E. PRATT, on the Nudibranchiata by Mr. G. P. FARRAN, on the Nullipores by Mr. J. LOMAS, the Polyzoa by Miss L. R. THORNELY, the Crinoidea by Mr. H. C. CHADWICK, and the Alcyonaria by Professor J. ARTHUR THOMSON, are in progress, and some of them are far advanced. My wife is helping me with the identification of the remaining Echinodermata, and Professor JEFFREY BELL has kindly undertaken to examine and describe those that seem new. Mr. A. LEICESTER and Mr. W. J. HALLS are engaged in examining the Molluscan shells, and will draw up a list of all the species collected. A few other groups are still unexamined. The final Part will contain in addition the remainder of Mr. HORNELL'S and my own observations and conclusions, including the results of our experiments now in progress, and our final recommendations as to the future management of the pearl oyster banks.

It is pleasant to be able gratefully to acknowledge much help, both administrative and scientific. To many in Ceylon—to their Excellencies the Governor Sir WEST RIDGEWAY and the Lieutenant-Governor Mr. E. F. IM THURN and to others—I am indebted for much kindness and consideration which smoothed away difficulties, expedited my work, and rendered duty a pleasure. I desire also to record my thanks to Captain J. DONNAN, then Master Attendant at Colombo and Inspector of the Pearl Banks, and to his successor, Captain J. LEGGE, who, during the time which I spent with them on the inspection barque "Rangasameeporawee," spared no trouble in trying to let me examine as satisfactorily as possible the various banks and the other localities and conditions which I desired to investigate. I had also the advantage of spending some days on the pearl banks with Sir WILLIAM TWYNAM, who has had a long extended experience of the fisheries as Superintendent from 1862 to 1896, and as Government Agent of the Northern Province.

Several men of science in Ceylon were kindly in their welcome and practical in their help. I would specially mention Dr. A. J. CHALMERS, through whose good offices the Medical College at Colombo placed accommodation in one of their laboratories at the disposal of Mr. HORNELL and myself; Mr. J. C. WILLIS, Director of the Botanic Gardens at Peradeniya, and the late Mr. OLIVER COLLETT, of Roselle, who has himself written on the pearl-oyster fisheries. I was fortunate in accidentally meeting during my first few days in Ceylon Dr. PAUL and Dr. FRITZ SARASIN, who had made important biological investigations at Trincomalee; and also Professor ALEXANDER AGASSIZ, then returning from his expedition to the Maldives, who very kindly allowed me to ship from his steamer to mine, as they lay together in Colombo Harbour, a reel containing 600 fathoms of steel-wire dredging rope.

I desire to record my entire satisfaction with the work done by Mr. JAMES HORNELL, both while I was with him and also since. I was fortunate in having such a capable and willing assistant, and such a helpful and pleasant companion. It would have been quite impossible for me to have got through the work that had to be done in the very limited time at my disposal had it not been for Mr. HORNELL's skilled assistance.

I am much indebted to the Staff of the Colonial Office, and to Sir MICHAEL FOSTER, K.C.B., of the Royal Society, for their interest in this investigation, for their advice from time to time, and for the trouble they have taken in facilitating the arrangements by which this Report will be published by the Royal Society for the Government of Ceylon. And I need hardly say how gratefully I acknowledge the appreciation of my labours shown by the Royal Society in assisting, in the first instance, towards my being requested to carry out the investigation and subsequently in undertaking the publication of the Report.

W. A. HERDMAN.

THE UNIVERSITY, LIVERPOOL,
August, 1903.

REPORT ON THE PEARL OYSTER FISHERIES OF THE GULF OF MANAAR.

INTRODUCTION.

The celebrated "Pearl oysters" of Ceylon are found mainly on certain parts of the wide shallow plateau which occupies the upper end of the Gulf of Manaar, off the North-west Coast of the Island and South of Adam's Bridge. Pearl banks also exist on the opposite Coast of India, off Tuticorin. The animal (*Margaritifera vulgaris*, Schum., = *Avicula fucata*, Gould) is not a true oyster, but belongs to the family Aviculidæ, and is therefore more nearly related to the Mussels (*Mytilus*) than to the Oysters (*Ostrea*) of our British seas. One very notable character of great practical importance, in which it differs from *Ostrea*, is that the Pearl oyster, like our common Mussels, has a "byssus" or bundle of tough threads by which it can attach itself to rocks or other foreign objects.

The Pearl Fisheries of Ceylon, India, and the Persian Gulf, yielding the highly prized "Oriental" pearl, are of very great antiquity. They are probably the most ancient fisheries still in existence, and seem to be carried on at the present day under very much the same conditions as 2000 or perhaps even 3000 years ago. These fisheries are referred to by various classical writers, and Pliny, after saying how highly valued the pearls are at Rome, refers to Taprobane [Ceylon] as "the most productive of pearls of all parts of the world."* Pliny also describes the coral that abounds in the Gulf of Manaar, and mentions pearls and precious stones as the products of Ceylon. But the Singhalese records take us to still earlier times. According to the "Mahawanso," pearls figure in the list of native products sent as a present from King Vijáya of Ceylon to his Indian father-in-law in about 540–550 B.C.; and again when, in B.C. 306, King Devanampiyatissa sent an embassy to India the presents are said to include eight kinds of Ceylon pearls. The King's Hall in the Brazen Palace at Anuradhapura (B.C. 161) is said to have been decorated with native pearls. The mortar in the ruins of Polonaruwa shows the remains of the pearl-oyster shells which were used in its manufacture—no doubt the refuse of an

* 'Plin. Nat. Hist.,' Bk. IX., chap. 54, Lemaire's Edition. I am indebted to my colleague, Professor H. A. Strong, for kindly giving me these and other references. Athenæus and Ælian make similar statements. The anonymous "Periplus" of the Erythræan Sea describes a great pearl fishery at Colchi, near Comar, in Taprobane or Ceylon, which probably refers to some part of the Gulf of Manaar.

early fishery. Many other references could be given. In the eighth to eleventh centuries, trade in the East was in the hands of the Persians and Arabs, and we find Arab writers alluding to the pearls. We know also that they enriched the kings of Ceylon in the days of MARCO POLO (1291). One record, given by Friar JORDANUS, says that in 1330 about 8000 boats were engaged in the pearl fisheries of the Gulf of Manaar.

CÆSAR FREDERICK, a Venetian merchant (1563), crossed from India to Chilaw (about the middle of the West Coast of Ceylon) to be present at a pearl fishery, the methods of which were very much as they would be at the present day. We are told that the Tamil name "Salubham" (Sea-of-Gain) given to the Gulf of Manaar because of its pearl banks, was also applied to Chilaw, which in former times was the town nearest to the fishery. The centre of the pearl fishery is now much further north, but the oyster "paars" still exist off Chilaw, and were fished at least thrice during the nineteenth century, in 1803, 1815, and 1884. And so we continue to have glimpses,* through the centuries, of this ancient and highly prized industry being carried on with little or no change, first under the Singhalese kings of Kandy and the Tamil kings of Jaffna, and subsequently under the successive European rulers. At the time when RIBEYRO† wrote (1685), Aripu was, as it has been since, the centre of the northern fisheries, and from the description given, it is evident that the method of fishing in these Portuguese times was as we see it now, even to the manning of the divers' boats and the cessation of diving at noon. As would be expected, we have much more definite records of the details of the fisheries during the Dutch and British occupations than in previous times. We have a vivid description, by MARTIN, of a fishery which took place off Tuticorin in 1700. PERCIVAL (1803) and CORDINER (1807) both give excellent accounts of the early British fisheries. The last Dutch fishery took place in 1768, and the first under English control in 1796—and for this fishery the arrangements were made before the surrender of Colombo.

* Here is another glimpse of the early native fisheries which I have just (August 18th, 1903) received from Sir WILLIAM TWYNAM of Jaffna. He says: "It is an extract from the translation of an old Tamil work called the 'Kalveddu,' given to me some time ago by a Mr. TILLEANOBELAM, employed in the Jaffna Kachcheri"—"VIDANARAYANEN CHEDDI and the Puravu men who fished pearls by paying tribute to ALLIYARASANI, daughter of PANDIYA, king of Madura, who went on a voyage, experienced bad weather in the sea, and were driven to the shores of Lanka, where they founded Karainerkai (Karativo) and Kutiraimalai (Kodramallai). VIDANARAYANEN CHEDDI had the treasures of his ship stored there by the Puravus, and established pearl fisheries at Kadalihilapam (Chilavaturai) and Kallachihilapam (Chilaw), and introduced the trees which change iron into gold," &c., &c.

Sir W. TWYNAM adds: "The Puravu divers referred to were afterwards converted to Roman Catholicism by St. FRANCIS XAVIER, and their descendants are, I believe, the Roman Catholic Puravu divers who now come to our fisheries from Tuticorin and other ports in Southern India;" and "some large mounds of old oyster shells were pointed out to me in the neighbourhood of Marichchukaddi as having been the accumulations of Queen ALLIYARASANI'S fisheries."

† My copy is LE GRAND'S translation, "Histoire de l'Isle de Ceylan," Amsterdam, 1701; I believe it is doubtful whether the original Portuguese of Captain RIBEYRO was ever published.

A notable feature of these fisheries, under all administrations, has been their uncertainty and intermittent character. The Dutch records show that there were no fisheries between 1732 and 1746, and again between 1768 and 1796. During our own time the supply failed—to mention only the longer intervals—in 1820 to 1828, in 1837 to 1854, in 1864 to 1873, and finally after five very successful fisheries in 1887 and the succeeding years, culminating in the record fishery of 1891 (when the Government proceeds reached close upon a million of rupees), there has been no return for the last decade. In addition to the longer intervals given above, there were many unproductive single years or groups of two and three; in fact there were, in all, only 36 fisheries during the nineteenth century. It will be of interest to give here the complete list in the following table (p. 4), compiled by Mr. Hornell at the Government Record Office in Colombo. Besides showing the marked intervals, and the general irregularity in results, it brings out the very considerable value of the fisheries, and is a useful indication of the relative productiveness of the principal paars.

The intermittent character of the fisheries has been recognised by various writers both before and since 1740, when Baron von Imhoff, then Governor, wrote in a memorandum for his successor:—"It is now several years since the pearl banks have fallen into a very bad state both at Manaar and Tuticorin; this is mere chance, and experience has shown that, on former occasions, the banks have been unproductive even for a longer period than has yet occurred at present." What was formerly put down to "chance" has in most lines of inquiry proved susceptible of scientific analysis and explanation, and it is reasonable to expect that, in the case of the pearl fisheries, investigation will lead to a better understanding of the phenomena, and a rational treatment based on such knowledge to a greater regularity in the results.

Writing in 1697, for the instruction of the Political Council of Jaffnapatam, the then Commandant of that town justly remarked that "the pearl fishery is an extraordinary source of revenue on which no reliance can be placed, as it depends on various contingencies which may ruin the banks or spoil the oysters." The above is quoted by both Thurston and Collett in their recent papers. Mr. Thurston's comment is: "And this remark holds good after the lapse of two centuries." The late Mr. Oliver Collett adds: "This statement holds good after a lapse of more than two centuries—indeed, the periodical disappearance of oysters from certain of the banks, sometimes for many years at a time, may be said to form one of the peculiar characteristics of the Ceylon fishery. Nevertheless, since the British occupation of the island, a sum equal to more than one million sterling has been derived from the fishery; and the matter is therefore one of immense importance to the Government of the Colony."*

* "Pearl Oysters and Pearl Fisheries," by O. Collett, F.R.M.S., 'Journ. R. Asiat. Soc.,' Ceylon Branch, vol. XVI., No. 51, 1900.

PARTICULARS of the Pearl Fisheries held during the Nineteenth Century.

(Compiled from the Government Records.)

Year of fishery.	Total number of oysters fished.	Gross Government proceeds in rupees.	Name and region of bank fished. [*The notes within square brackets are added by Mr. Hornell.*]
1801	[Particulars not available as to number of oysters fished.]	150,227	Kondatchi Paar.
1803		163,154	Chilaw Paar.
1804		770,202	Aripu [Cheval and Modragam paars (*fide* VANE'S "Report" to Governor, Sir H. WARD, February, 1863).]
1806		412,842	,,
1808		842,577	,,
1809		272,463	,,
1814		1,051,876	,,
1815		5,842	Chilaw Paar.
1816		9,266	Aripu [Cheval and Modragam paars (*fide* VANE).]
1820		30,410	,,
1828		305,234	South-East Modragam Paar.
1829		382,737	North-West Cheval Paar.*
1830		222,564	South-East ,, ,,
1831		293,366	North-West ,, ,,
1832		45,810	Off Karativu (near the Isle of Cardieu).
1833		320,896	Periya Paar Kerrai.
1835	16,058,880	403,460	,, ,, ,,
1836	6,181,537	58,624	Modragam Paar.
	737,105	10,524	Cheval Paar [Central].
	2,974,236	40,158	Periya Paar Kerrai.
	6,117,750	145,629	Koddai Paar [South Cheval].
1837	2,538,307	106,312	North Cheval Paar.*
1855	6,743,762	109,220	South-West Cheval Paar.
1857	32,453,053	203,633	North-West ,, ,,
1858	16,484,861	241,200	,, ,, ,,
1859	3,143,402	194,481	,, ,, ,,
	6,391,549	287,678	North Modragam Paar.
1860	791,226	87,269	,, ,, ,,
	2,813,271	279,547	South-East Modragam.
1863	11,695,794	510,178	South-East Cheval Paar.
1874	1,699,669	101,199	North-West Cheval Paar.
1877	6,685,001	184,591	South-East and East Cheval Paar.
	164,719	4,420	North Modragam Paar.
1879	7,645,901	95,694	Kottapakku Paar (3 miles West of Cheval Paar) [Periya Paar].
1880	35,238,972	200,152	North-West Cheval Paar.
1881	27,338,596	599,533	,, ,, ,,
1884	636,000	17,153	Off Chilaw.
1887	8,834,330	103,664	North Modragam Paar.
	22,513,575	292,430	North-East Cheval Paar.
1888	22,052,769	804,247	Cheval Paar (whole) and both Modragams (North and South).
1889	38,995,447	498,377	Muttuvaratu Paar. [Included in these figures are the proceeds of 1 day's fishing each year on Karativu Paar (200,243 oysters in 1891).]
1890	33,677,892	313,177	
1891	44,311,441	963,748	

* [We cannot attach much importance to the topography of the Cheval Paar in these early records. The nomenclature of the regions has varied much in the past. For example, DONNAN'S North-East Cheval is not that of STEUART.]

Many reasons, some fanciful, others with more or less basis of truth, have been given from time to time for the recurring failures of the fishery; and several investigations, such as that of Dr. KELAART (who unfortunately died before his work was completed) in 1857 to 1859, and that of Mr. HOLDSWORTH in 1865 to 1869, have been undertaken without much practical result so far.

In September, 1900, after a continued failure of the fishery for ten years, I was asked by the Colonial Office (acting on the advice of the Council of the Royal Society and of Professor RAY LANKESTER) to examine the records and report upon the matter, and in the following spring I was invited by the Government to go to Ceylon at the end of the year, with a scientific assistant, and undertake such investigation into the condition of the pearl banks as might appear necessary. I arrived at Colombo in January, 1902, and, as soon as a steamer could be obtained, proceeded to the Gulf of Manaar.

In April it was necessary to return to my University duties in Liverpool, but I was fortunate in having taken out with me as my assistant Mr. JAMES HORNELL, who, it was arranged, would remain in Ceylon for at least a year longer in order to continue the observations and experiments we had started and complete our work. This programme has been carried out, and Mr. HORNELL has kept me supplied with almost weekly reports, and with specimens requiring detailed examination.

The s.s. "Lady Havelock" was placed by the Ceylon Government at my disposal for the work of examining into the biological conditions surrounding the pearl-oyster banks; and this enabled me on two successive cruises of three or four weeks each to examine all the principal banks, and run lines of dredging and trawling and other observations across, around, and between them, in order to ascertain the conditions that determine an oyster "paar." Towards the end of my stay I took part in the annual inspection of the pearl banks, by means of divers, along with the retiring Inspector, Captain J. DONNAN, C.M.G., and his successor, Captain LEGGE. During that period we lived and worked on the native barque "Rangasameeporawee," and had daily opportunity of studying the methods of the native divers and the results they obtained.

It is evident that there are two distinct questions that may be raised—the first as to the abundance of the adult "oysters," and the second as to the number of pearls in the oysters, and it was the first of these rather than the frequency of the pearls that seemed to call for investigation, since the complaint has not been as to the number of pearls per adult oyster, but as to the complete disappearance of the shell-fish.

Most of the pearl-oyster banks or "paars" (meaning rock or any form of hard bottom, in distinction to "manul," which indicates loose or soft sand) are in depths of from 5 to 10 fathoms, and occupy the wide shallow area of nearly 50 miles in length, and extending opposite Aripu to 20 miles in breadth, which lies to the south of Adam's Bridge. On the western edge of this area there is a steep declivity, the sea deepening within a few miles from under 10 to over 100 fathoms; while out in the centre of the southern part of the Gulf of Manaar, to the west of the Chilaw pearl banks, depths of between 1000 and 2000 fathoms are reached. On our two cruises in the "Lady Havelock" we made a careful examination of the ground in several places outside the banks, to the westward, on the chance of finding beds of adult oysters from which possibly the spat deposited on the inshore banks might be derived. No such beds, outside the known "paars," were found; nor are they likely to exist. The bottom deposits in the ocean abysses to the west of Ceylon are "globigerina ooze" and "green mud," which are entirely different in nature and origin from the coarse terrigenous sand, often cemented into masses, and the various calcareous neritic deposits, such as Corals and Nullipores, found in the shallow water on the banks. The steepest part of the slope, from 10 or 20 fathoms down to about 100 fathoms or more all along the western coast, seems in most places to have a hard bottom covered with Alcyonaria, Sponges, deep-sea Corals, and other large encrusting and dendritic organisms. Neither on this slope, nor in the deep water beyond the cliff, did we find any ground suitable for the pearl oyster to live upon.

It soon became clear to us that different paars were placed under very different physical and biological conditions, and that the sudden disappearance, or the continued absence, of pearl oysters in different localities and at different times might be and probably was due to very different causes. The Periya Paar, about 20 miles from land and close to the top of the steep slope (see p. 78), is very differently situated from the East Cheval or the Modragam paars relatively near the shore, protected to some extent from the ocean and with shallow water all around. The pearl oyster is the same animal all over the district, and facts of anatomy and physiology once ascertained will hold good; but the paars are different, each presents its own problems, and all must be studied. In reading the reports of former superintendents and inspectors of the pearl banks, it is possible, after acquiring some knowledge of the physical and biological conditions of the various paars, to account for some of the apparently mysterious disappearances of oysters and catastrophic changes in the fauna. It is unnecessary to go over all the cases that have been recorded, but the recent history of the Periya Paar, and the more noteworthy disasters on the Cheval and other important paars, will be found discussed below. For a knowledge of the past history of the pearl banks we are indebted mainly to the official reports of the Ceylon Government. I would mention especially as amongst the most important contributions to our knowledge of the subject: the reports of Dr. E. F. KELAART in 1857 to 1859; the "Account of the Pearl Fisheries of Ceylon," by Captain JAMES STEUART, Ceylon, 1843; H. SULLIVAN THOMAS' "Report on the Pearl Banks and Fisheries of Tuticorin"; "The Pearl and Chank Fisheries of the Gulf of Manaar," by E. THURSTON (Bulletin of the Madras Museum, No. 1, 1894); Mr. E. W. H. HOLDSWORTH'S "Report on the Pearl Oyster Banks," 1867; Captain J. DONNAN'S successive Reports on Inspections and Fisheries; and finally the comprehensive and most interesting "Report on the Ceylon Pearl Fisheries," drawn up in 1899 by Sir WILLIAM C. TWYNAM, K.C.M.G. (Colombo, 1900).

There is much that we agree with in all of these previous reports. There are some points in each on which we differ from the author. We account for the occurrence in another way, or draw a different conclusion from the observed facts. Several of these writers, although not strictly speaking scientific men, were accurate observers and acute investigators who have left valuable records. Others better equipped in scientific training have been prevented from doing more by unfavourable circumstances. Dr. KELAART'S short reports show that he was tackling the problems in a scientific manner, and his researches were incomplete at the time of his sudden death.* Mr. HOLDSWORTH'S visit to Ceylon (1865–69) was apparently made at an unfortunate time. Mr. OLIVER COLLETT states ('Journ. R. Asiat. Soc.,' Ceylon, Br., 1900) that Mr. HOLDSWORTH never had an opportunity of seeing a fishery, and according to Sir W. TWYNAM, he "did not witness an inspection of a bank with a bed of oysters on it, young or old." Mr. HORNELL and I were more fortunate, as during our cruises in the Gulf of Manaar we found pearl oysters in all stages of growth, from the microscopic free-swimming larvæ and newly-deposited "spat" to the pearl-bearing adults, and we have also two consecutive inspections of banks well covered with oysters, and the successful fishery of 1903, from which to draw conclusions. Mr. THURSTON, of Madras, has also had experience of fisheries and inspections with Captain DONNAN, and has written a most interesting and valuable record containing a great deal of incidental information as to the fauna of the Gulf of Manaar, but had apparently not the opportunity and the implements for a more detailed survey, nor the time for a more thorough investigation of the oyster problems.

To all our predecessors, however, we are indebted for information and for suggestions which have been of value to us in our work. That work has led us into various different lines of inquiry. Outside the larger influences, cosmic in origin, uncontrollable, and wide-spread in effect, such as oceanic currents, monsoon storms, depth of water, configuration of bottom, and shifting sands which may devastate a bank and cause the sudden disappearance of many millions of oysters, there are, in addition, various minor causes of failure of the fisheries, some of which we were able to investigate. The pearl oyster has many enemies, such as Star-fishes, boring Sponges which destroy the shell, boring Molluscs which suck out the animal, internal Protozoan and Vermean parasites, and carnivorous Fishes, all of which cause some destruction, and may on occasions conspire to ruin a bed and change the prospects of a fishery. But, in connection with such animate foes, it is necessary to bear in mind that, from the fisheries' point of view, their influence is not wholly evil, as some of them are closely associated with pearl production in the oyster. One enemy (a Plectognathid fish), which doubtless devours many of the oysters, at the same time

* Soon after the fishery of 1859, during which Dr. KELAART worked with the Swiss Naturalist, HUMBERT, at Chilavaturai, he was sent to England in medical charge of General LOCKYER, who was very ill and died in the Red Sea. Dr. KELAART, who was in constant attendance on the General, died suddenly a day or two later.

receives and passes on the parasite which leads to the production of pearls in others. The loss of some individuals is in that case a toll that we very willingly pay, and no one would advocate the extermination of that particular enemy.

In fact, while wholly at the mercy of its inanimate surroundings, such as storms and sand, the pearl oyster can probably cope under most circumstances with its animate environment on the paars, if not too recklessly decimated at the fisheries, and if not exposed to some exceptional combination of adverse influences. Man has thus afforded to him the opportunity of intervening. Although he cannot control the monsoon or build a sea-wall around the "paar," yet without any violent attempt to disturb the balance of Nature, or remove wholly the influence of any particular enemy, he can compensate to some extent for the damage he himself does, and he can help the oyster population to withstand the attacks of normal enemies and prevent complete destruction under abnormal combinations. This he can do by giving some attention to the breeding stock, by having a more intimate knowledge of the exact distribution of the oysters at all ages on the ground, by attending to the dissemination and location of "spat," by thinning out in parts where there is overcrowding, or where young are mixed with old, and by transplanting, when required, the growing young from unsuitable ground, where from experience it is known they cannot arrive at maturity, to more sheltered and reliable "paars."

It is clear that, in considering the conditions of existence of the oyster and the vicissitudes of the pearl banks, we have to deal with great natural influences which cannot be wholly removed, though they may to some extent be avoided and compensated for; and that, consequently, it is necessary to introduce large measures of regulation and cultivation in order to increase the adult population on the ground, have the more reliable "paars" provided more fully with successive broods of young oysters by transplantation, and so give greater constancy to the supply and remove the disappointing fluctuations in the fishery.

We have shown conclusively in our work the ease with which young pearl oysters can be dredged up in quantity and transported to considerable distances, and we can also demonstrate by our figures the advantages derived by transplantation from overcrowded and unhealthy localities to better conditions. The young are present in abundance, and they are probably sacrificed in millions every year. When we examined the Periya Paar in March, 1902, we estimated the number of young pearl oysters on the ground at not less than a hundred thousand millions; when Mr. Hornell returned in November they were all gone. With such numbers the inshore paars could be kept continuously supplied with young oysters transplanted from their precarious position on the more exposed grounds out at sea.

There is no reason for any despondency in regard to the future of the pearl fisheries, if they are treated scientifically. The adult oysters are plentiful on some of the paars and seem for the most part healthy and vigorous; while young oysters in their first year, and masses of minute spat just deposited, are very abundant in many places. The material exists, ready for man's operations.

To the biologist two dangers are, however, evident, and, paradoxical as it may seem, these are *overcrowding* and *overfishing*. But the superabundance and the risk of depletion are at the opposite ends of the life-cycle, and therefore both are possible at once on the same ground—and either is sufficient to cause locally and temporarily a failure of the pearl-oyster fishery. What is required to obviate these two dangers ahead and ensure more constancy in the fisheries is careful supervision of the banks by someone who has had sufficient biological training to understand the life-problems of the animal, and who will therefore know when to carry out simple measures of farming, such as thinning and transplanting, and when to advise as to the regulation of the fisheries.

In connection with cultivation and transplantation there are various points as to structure, reproduction, life-history, growth and habits of the oyster which we had to deal with, some of which we were able to determine on the banks, while others have been the subject of Mr. HORNELL's work since, in the little marine laboratory we established at Galle, in the south of Ceylon.

Although Galle is at the opposite end of the island from the pearl banks of Manaar, it is clearly the best locality in Ceylon for a marine laboratory—both for general zoology and also for working at pearl-oyster problems. Little can be done on the sandy exposed shores of Manaar Island or the bight of Kondatchi—the coasts opposite the pearl banks. The fisheries take place far out at sea, from 10 to 20 miles off shore, and it is clear that any Natural History work on the pearl banks must be done not from the shore, but, as we did, at sea from a ship during the inspections, and cannot be done at all during the monsoons because of the heavy sea and useless exposed shore. At such times, the necessary laboratory work supplementing the previous observations at sea can be carried out much more satisfactorily at Galle than anywhere in the Gulf of Manaar.

Turning now from the health of the oyster population on the "paars" to the subject of pearl-formation, which is evidently an unhealthy and abnormal process, we find that in the Ceylon oyster there are several distinct causes that lead to the production of pearls. Some pearls or pearly excrescences on the interior of the shell are due to the irritation caused by boring sponges and burrowing worms. Minute grains of sand and other foreign particles gaining access to the body inside the shell, which are popularly supposed to form the nuclei of pearls, only do so, in our experience, under exceptional circumstances. Out of the many pearls I have decalcified, only one contained in its centre what was undoubtedly a grain of sand; and from Mr. HORNELL's notes taken since I left Ceylon, I quote the following passage showing that he has had a similar experience:—"February 16th, 1903. '*Ear-pearls*,' of two decalcified, one from the anterior ear (No. 148) proved to have a minute quartz grain (micro-preparation 25) as nucleus." Since then he has found one more.

It seems probable that it is only when the shell is injured, as, for example, by the breaking off or crushing of the projecting "ears," thereby enabling some fine sand to gain access to the interior, that such inorganic particles supply the irritation which gives rise to pearl formation.

Pearls of another class are found in the muscular tissue of the animal, usually in the levators of the foot, and in the palpar region, but also frequently in the pallial insertions, rarely at the insertions of the retractor and adductor muscles. These muscle-pearls have no organic nuclei. They seem to start as minute calcareous concretions ("calcospherules") in the tissue, and the centre is sometimes crystalline. They may be extraordinarily abundant. At the insertion of one levator muscle, 23 small pearls were counted with the eye, while under the microscope 170 additional tiny spherules were found to be present.

The best pearls, however, the "cyst" or "orient" pearls, lie in the thin muscular margin of the mantle, or in the thick white lateral part over the stomach and liver, or even, secondarily, free in a cavity of the body.

Consequently, as we shall show in the section of the Report dealing with pearl-formation, we can classify these pearls from the biological point of view into three sets:—(*a.*) "Ampullar-pearls" which are not formed within closed epithelial sacs like the others, but lie in pockets or ampullæ of the epidermis. The nuclei may be sand-grains or any other foreign particles introduced through breaking or perforation of the shell. (*b.*) "Muscle-pearls" formed around calcospherules at or near the insertions of the muscles. (*c.*) "Cyst-pearls" where concentric layers of nacre are deposited on cysts containing parasitic worms in the connective-tissue of the mantle.

The majority of the fine pearls found in the soft tissues of the body of the Ceylon oyster contain, in our experience, the more or less easily recognisable remains of Platyhelminthian parasites (especially the young larva of the Cestode *Tetrarhynchus*), so that the stimulation which causes eventually the formation of an "orient" pearl is, as has been suggested by various writers in the past, due to infection by a minute worm, which becomes encased and dies, thus justifying, in a sense, DUBOIS' statement that:—"La plus belle perle n'est donc, en définitive, que le brillant sarcophage d'un ver" (Comptes Rendus Acad. Sci. Paris, 14th Oct., 1901).

To Dr. KELAART (1857–59) belongs the honour of having first connected the formation of pearls in the Ceylon oyster with the presence of vermean parasites. It is true that FILIPPI, seven years before, in 1852, showed that the Trematode *Distomum duplicatum* was the cause of pearl formation in the fresh-water Mussel *Anodonta*, and KÜCHENMEISTER (1856), MÖBIUS (1857), and others extended the discovery to other pearl-producing oysters, and to other parasites; but it is possible that KELAART knew nothing of these papers, and that he made his discovery in regard to the Ceylon oyster quite independently. He (and the Swiss Zoologist, HUMBERT, who was with him at a pearl fishery) found "in addition to the Filaria and Circaria, three other parasitical worms infesting the viscera and other parts of the pearl oyster. We both agree that these worms play an important part in the formation of pearls; and it may yet be found possible to infect oysters in other beds with these worms, and thus increase the quantity of these gems." Thus we have KELAART, in 1859, definitely stating the possibility, in the case of the Ceylon pearl oyster, of infecting other beds with the larvæ of the pearl-producing Platyhelminthian parasites in order to increase the quantity of pearls.

THURSTON, in 1894, confirmed KELAART'S observation, finding in the tissues and also in the alimentary canal of the Ceylon oyster, "larvæ of some platyhelminthian (flat worm)." He figures ('Madras Mus. Bull.,' I., Plate II., fig. 1) a section showing two of the parasites encysted between the alimentary canal and generative tubes. Here the matter rested so far as the Ceylon pearl oyster was concerned.

Long before, however, GARNER, in 1871, had associated the production of pearls in our common English Mussel (*Mytilus edulis*) with the presence of Distomid parasites; GIARD (1897) and other French writers have made similar observations in the case of *Donax* and other Lamellibranchs; and DUBOIS (1901) has more recently ascribed the production of pearls in Mussels on the French coast to the presence of the larva of *Distomum margaritarum*. H. L. JAMESON (1902), then followed with a more detailed account of the relations between the pearls in *Mytilus* and the Distomid larvæ, which he identifies as belonging to *Distomum* (*Brachycœlium*) *somateriæ* (LEVINSEN). JAMESON'S observations were made on Mussels obtained partly at Billiers (Morbihan), a locality at which DUBOIS had also worked, and partly at the Lancashire Sea-Fisheries Marine Laboratory at Piel, in the Barrow Channel. Finally, DUBOIS has just published a further note (Comptes Rendus Acad. Sci. Paris, 19th Jan., 1903) in which, referring to the causation of pearls in *Mytilus*, he says (p. 178):—"En somme ce que ce dernier [GARNER] avait vu en Angleterre en 1871, je l'ai retrouvé en Bretagne en 1901. Quelques jours après mon départ de Billiers, M. LYSTER JAMESON, de Londres, est venu dans la même localité et a confirmé le fait observé par GARNER et par moi." But JAMESON has done rather more than that. He has shown that it is probable (his own words are "there is hardly any doubt") that the parasite causing the pearl-formation in our common Mussel (not in the Ceylon pearl oyster) is the larva of *Distomum somateriæ*, from the eider duck and the scoter. He also believes that the larva inhabits *Tapes* or the cockle as a first host before getting into the mussel.

We have found, as KELAART did, that in the Ceylon pearl oyster there are several different kinds of worms commonly occurring as parasites, and we shall, I think, be able to show in a later section of this report that Cestodes, Trematodes, and Nematodes may all be concerned in pearl-formation. Unlike the case of the European mussels, however, we find that in Ceylon the most important cause is a larval Cestode of the Tetrarhynchus form. We first found this larva in pearl-like cysts outside the liver of pearl oysters on the Cheval Paar during the second cruise of the "Lady Havelock" in February and March, 1902. Since then Mr. HORNELL has traced a considerable part of the life-history of this parasite, from an early free-swimming stage to a late larval condition in the File-fishes (*Balistes mitis* and *B. stellatus*) which frequent the pearl banks and prey upon the oysters. We have not yet succeeded in finding the adult worm, but it will probably prove to infest the Rays or other large Elasmobranchs which may devour *Balistes*.

We have also found the pearl-provoking Cestode larva in *Pinna*—where pearls are sometimes found—but we have no reason to suppose that *Pinna* finds a place in the same life-cycle with the pearl oyster. Nor do we think that any other Mollusc or Invertebrate is implicated. The stages in the life-cycle, as regards environment, are probably as follows :—

1. Free embryos in the sea ;
2. Encapsuled in the pearl oyster ;
3. Later larval stage in the File-fishes ;
4. Adult in large Elasmobranchs.

We suppose, then, that the adult Worm from the body of the Shark or Ray sets free its numerous young embryos into the sea ; and there we pick up the history, for amongst our Vermean embryos in the tow-net we have some caught on the Muttuvaratu Paar, in November, 1902, which we consider to be the younger stage of our *Tetrarhynchus* larva. Such free-swimming embryos on an oyster bank will readily gain access to the body of the oysters. They will be carried in with the current of water, and may either pass into the alimentary canal with the microscopic food particles or get lodged in the gills. We have found these in the gills, and have also found very young stages in the mantle ; while later stages of larger size are common in the liver and in the connective-tissue of the body-wall generally. In some samples of oysters examined scarcely any individuals are free from the encysted parasites, and in one 45 cysts were counted. In the case of oysters so infested which are eaten by the File-fishes—and from the frequency with which we, and others, have found the broken-up shells in the stomach there can be no doubt that these fishes do eat the oysters—the Cestode larvæ are transferred to the body of the new host ; and Mr. HORNELL has found them in quantity in the alimentary canal and peritoneum of specimens belonging to the two common species *Balistes mitis* and *B. stellatus*, from several localities. The Cestodes are now in a later stage, and are clearly recognisable as *Tetrarhynchus ;* but are not yet adult and have no reproductive organs. Whether they become mature in time in the body of the File-fish or, as we think more probable, in a larger animal which feeds upon that fish, such as one of the large Elasmobranchs common in these seas, we cannot yet say ; but possibly that point may be settled before the Report is finished.

In those oysters, on the other hand, which do not become the prey of the File-fish the larval Cestodes have no opportunity of fulfilling their destiny as parasites, but die and become encapsuled in the layers of pearly nacre deposited by the living tissues of the oyster upon the source of irritation. What proportion of the parasites become the nuclei of pearls we are not able to say, but many, we feel sure, neither complete their life-history nor yet remain long enough encapsuled in the bodies of adult oysters to become pearls of value. There are many potential and incipient pearls in young oysters which, even if transferred to the body of a fish, contain only dead larvæ, and so are lost from the parasite population; while the death of their host prevents them from causing pearl-formation. It is not sufficient for the oyster to be infected by the *Tetrarhynchus*, it must also live, retaining its parasite, until such time as it can produce sufficient deposit of the calcareous secretion to form a true pearl. In the case of the Ceylon pearl oyster very little increase in size of the shell by additions to the ventral margin takes place after an age of three and a half or at most four years has been reached. But the shell after this period thickens greatly by the deposit of nacreous material in its interior and especially in the neighbourhood of the hinge at the dorsal edge. This is the time of rapid pearl-formation. The oyster's tissues are then in the condition which leads to the secretion and deposition of limy material either externally by additions to the thickness of the shell, or internally as successive coats deposited upon any particle—such as a dead parasite or, it may be, a sand-grain, a Diatom frustule, a fragment of nacre, ova, or excreta—which has given rise to the necessary stimulation.

There is general agreement amongst those who have seen most of the Ceylon oyster on its native banks that the animal does not, as a rule, live beyond six or seven years. Captain DONNAN's opinion is that "the oysters may be profitably fished at the age of four years, and that they are in their prime at five years, and may be kept till that age if circumstances will permit of it; but if they are kept till the sixth year they are almost certain to be found dead." From the figures he gives in his reports it seems that the age of the oysters at fisheries where we have reliable data has been nearly always under five years. The pearl oyster should be fished when it measures $3\frac{1}{2}$ inches in diameter at right angles to the hinge line, has no soft growing edge to the shell, and shows a deep V-shaped groove between the valves at the hinge.

Although it is not correct to say that there are no pearls in young oysters, for we have found some of moderate size in quite small oysters, still there is no doubt that rapid and widespread pearl-formation begins only when the animal is about three and a half years old and has ceased to grow a thin spreading ventral margin to the shell. During the year or eighteen months following this is the time when it is most profitable to fish the oysters up and open them for the sake of their pearls. Although some oysters contain more pearls than others, and some paars have on occasions been characterized by richness in pearl-production, the Cestode parasites are apparently very widely spread and generally distributed. All oyster communities of the proper age contain pearls, and it would probably be impossible to transplant young oysters to any ground in the Gulf of Manaar where they would not become to some extent infected by the pearl Cestode. The frequent thinning out of young oysters, and the transporting as required from one ground to another, which we shall recommend at the conclusion of this Report, will, however, have the effect of causing a more even distribution of the parasites, since some oysters will be taken from more highly infected ground to less, carrying with them the larvæ, either free or encapsuled, and others, again, which may have escaped infection will go to areas where they run a greater chance of encountering the parasite. It is important to note also, in view of experiments in other parts of the Colony, that the *Tetrarhynchus* parasites are not only widely distributed over the banks in the Gulf of Manaar, but also at other places on the coast of Ceylon.

Mr. HORNELL* has found *Balistes* with its Cestode parasite both at Trincomalee and at Galle, and the sharks and rays also occur all round the island; so that, in short, there can be no doubt as to the probable infection of pearl oysters grown at these or any other suitable localities.

The details and illustrations of the parasitic life-history outlined above, and the figures upon which our statements in regard to the oysters are based, will be given in the special articles further on in this Report. But even when we have figured all our specimens, have described all that we have seen, and have shown what conclusions may safely be drawn, we feel sure that gaps will be left, and possibly doubts remain, which can only be filled up and finally settled by patient work extending over years, carried on by a competent observer resident in Ceylon, and having at his disposal a laboratory and experimental tanks. A marine biologist working at the Galle Biological Station can scarcely fail to add further details affecting the life-history of the oyster and the prosperity of the pearl fisheries.

During the two cruises of the "Lady Havelock," in our work on the parasites, commensals, enemies, food, and other organisms associated with the pearl oyster, we were brought in contact with many forms requiring identification, and some apparently new to science. It was clearly our duty to collect all such and have them worked up with the view of elucidating the fauna of the Gulf of Manaar and also of making any necessary comparisons with other parts of the coast. Consequently, I am now able to supplement this Report by a series of papers, written by specialists upon the various groups of animals, which not only adds to the completeness of the pearl-oyster work, but will also, I hope, be recognised as a welcome contribution to the marine biology of Ceylon.

The land fauna of Ceylon is very much better known than the marine. Dr. E. F. KELAART published in 1852 his important work, the 'Prodromus Faunæ Zeylanicæ,' dealing with the mammalia, birds and reptiles. Mr. E. L. LAYARD has worked at the ornithology and conchology, and we have his papers in the 'Annals and Magazine of Natural History.' HARVEY visited Ceylon in 1852 to collect the Cœlenterates and Crustacea. SCHMARDA, a few years later, wrote on the worms. In EMERSON

* It is only due to my excellent assistant, Mr. JAMES HORNELL, to state that our observations on pearl-formation are mainly due to him. During the comparatively limited time (under three months) that I had on the banks, I was mainly occupied with what seemed the more important question of the life-conditions of the oyster, in view of the frequent depletion of particular grounds.

TENNENT'S 'Ceylon' (1859) there is a good summary of the fauna as known up to that time, with lists which were supplied, or supplemented, or revised by HUXLEY, GRAY, HANLEY, KELAART, and others. Further papers on new animals in various groups (many of them collected by Dr. W. C. ONDAATJE) have been published from time to time by BOWERBANK, ALLMAN, RIDLEY, DENDY, BELL, CARTER, NEVILL, and the SARASINS. But the most notable contribution to our knowledge of the marine fauna is THURSTON'S 'Notes on the Pearl and Chank Fisheries and Marine Fauna of the Gulf of Manaar,' published from the Government Central Museum, Madras, in 1890. In this interesting little work Mr. E. THURSTON, with the help of Professor DENDY, Professor JEFFREY BELL, Professor HENDERSON, and Mr. E. A. SMITH, gives considerable lists of the Porifera, Cœlenterata, Echinodermata, Crustacea, Mollusca and Pisces which he had collected during visits to Tuticorin, Rameswaram, and some parts of the Ceylon pearl banks.

Taking a somewhat wider area—the northern part of the Indian Ocean—there are three recent series of faunistic explorations which have some bearing on our work, viz., the reports upon Dr. ANDERSON'S collections made in the Mergui Archipelago ('Journal Linnean Soc., Zool.,' vols. XXI. and XXII.), the great series of Memoirs, Reports, and 'Illustrations' issued by Major ALCOCK, of the Calcutta Museum, as a result of the explorations of the surveying vessel "Investigator," and lastly, Mr. STANLEY GARDINER'S series dealing with 'The Fauna and Geography of the Maldive and Laccadive Archipelagoes' (Cambridge Press). The Ceylon marine fauna resembles that of Mergui in some respects, but differs in detail; Dr. ALCOCK'S "Investigator" work has been mainly—though not wholly—in the abyssal waters of the Indian seas; while the Maldives are an Oceanic group, in contrast to Ceylon which is faunistically as well as geologically a part of India. Our dredgings were nearly all within the 100-fathom line, and were mainly in the zone of 5 to 20 fathoms. This account of a shallow-water Continental coast fauna may fill a gap and be of use for comparison with these other recent investigations in the Indian Ocean.

The faunistic reports which will appear along with this INTRODUCTION in Part I. will tell their own story, but it may be well to give briefly what information I can in regard to a few of the other groups, the reports upon which may not be ready for some months.

Professor DENDY has sent me a preliminary report upon the Sponges as follows:—

"This collection of sponges appears to be by far the most extensive that has ever been made in Ceylon waters, and contains many species of great interest. Amongst the siliceous sponges, the Tetractinellida are represented by at least a dozen species, including a new *Stelletta*, a new *Plakinastrella*, and a form which will be described as the type of a new genus under the name *Dercitopsis cingalensis*. There are also a massive Lithistid, a *Placospongia*, and a curious Suberites-like species which is anchored by silky tufts of spicules in soft mud. Amongst the Monaxonids, the Chalinidæ, Ectyoninæ, and Axinellidæ are the most conspicuous groups; while of special interest from the point of view of the pearl fishery is a Clionid which burrows in the shells of the pearl oyster. Many of the Monaxonids are characterised by a strong development of horny fibre, and from these we pass by a natural transition to the true horny sponges, represented by the genera *Euspongia*, *Phyllospongia*, *Hircinia*, *Dysidea*, *Spongionella* and *Aplysina*. The *Euspongia* is a fairly good, compact, resilient bath sponge . . . . . and the possibility of establishing a sponge fishery is worth consideration." Professor DENDY then gives a list of his identifications, amounting to about 60 species.

Mr. HORNELL, who is reporting upon the Polychæte worms, has sent in a preliminary list of over 60 species, at least four of which are new to science and will (Mr. HORNELL states) be described under the names—"*Hermione ridgewayi*, *Thalenassa imthurni*, *Phyllodoce foliosopapillata* and *Spiochætopterus herdmani*."

Mr. ISAAC THOMPSON and Mr. ANDREW SCOTT, who are working up the Copepoda, state that "The collection of Copepoda is the richest and most varied series of this group that has ever been brought from tropical seas by any expedition. The group is represented by over 200 known species and nearly 80 new species, now being described. Of these new species only a small number are true pelagic forms, the remainder being littoral and semi-parasitic species, mostly associated with the pearl oysters on the paars. Some of the pearl-oyster washings were extremely rich in minute Crustaceans, mainly Amphipods and Copepods. The washings from the Muttuvaratu oysters yielded 43 species belonging to the Harpacticidæ alone, besides several species of Lichomolgidæ and Ascomyzontidæ, many of which are new to science."

Mr. A. O. WALKER, who is reporting upon the Amphipoda, writes to me that it is "The most important collection of Amphipods which has yet been made known from the tropics . . . . . It contains over 70 species, and the report will describe a large number of new species, some of which will require new genera . . . . . Many of the forms are closely allied to British and Mediterranean species, while others again have been described from the Australasian seas . . . . . The size of the individuals is small; compared with those from the Arctic and Antarctic areas they are pygmies."

Mr. JAMES JOHNSTONE, who is writing on the fishes, reports:—"The collection consists of 116 species belonging to 73 genera. It is very representative and contains species belonging to 37 families. About 6 forms are still undetermined, and most of these are probably new to science. A number of the species obtained are apparently new to the fauna of India and Ceylon."

In other groups also, Hydroids, Polyzoa, Turbellaria, Alcyonaria, Cumacea and Cephalopoda novelties are turning up, but the examination of these is not yet far enough advanced to warrant more detailed announcement. In the concluding article of the Report I hope to submit such discussion as may seem necessary of the general characteristics and affinities of the marine fauna of Ceylon.

NARRATIVE,

WITH

AN OUTLINE OF THE INVESTIGATION,

AND

DETAILS OF THE STATIONS WHERE OBSERVATIONS WERE MADE.

THE greater part of our observations at sea (as distinguished from the laboratory work which came later), both on the Pearl Oysters and on the animals that are associated with them and the conditions that surround them on the banks in the Gulf of Manaar, can be given most conveniently in the form of a narrative of our cruises in the s.s. "Lady Havelock" and with Captain DONNAN in the inspection boats. This narrative is written out with as little change as possible from the diary and other note-books in which each day's work was recorded at the time. Consequently the names in the lists of species* although, with the help of my friends who are kindly working up the groups, they have been corrected up to the time of writing, will naturally in some few cases require alteration, and therefore it will be understood that, in the event of any difference in nomenclature, the "Supplementary Reports" that follow must supersede the lists in this "Narrative." On the other hand, this section contains the authoritative statement as to the dates, localities, depths, and other particulars of the observing stations, and therefore forms a necessary introduction to the Special Reports. A station, in the later sections of the work, may be referred to briefly by its roman numeral, and the details, both as to the locality and conditions and also as to the other organisms obtained, may be found here.

I may add, in conclusion, that my view in regard to these present lists is that although by no means *complete*, they are substantially *correct* as far as they go, and will serve a useful purpose in giving a general impression of the most abundant and conspicuous, or in other ways noteworthy, organisms at each observing station. They will also enable conclusions to be drawn as to the fauna of the "paars," and as to the enemies and other competing organisms which may affect the life and prosperity of the pearl oyster.

* As all these species will be treated more fully in the Special or Supplementary Reports, I have not considered it necessary to give in these provisional lists the authorities and references. To have done so would have added greatly to the length of the lists, with little or no compensating advantage.

Mr. HORNELL and I arrived in Ceylon on January 20th, 1902, so as to leave some weeks free before the end of February, when we proposed to join Captain DONNAN in his annual inspection of the pearl banks. This interval I had thought essential in order that we might perfect and test our apparatus, find out the necessary methods of investigation, and make ourselves acquainted with the biological conditions in the Gulf of Manaar, and with any special features in which that region differs from the other seas around Ceylon. For the purpose of this preliminary biological survey the Government of Ceylon placed the s.s. "Lady Havelock"* at my disposal, in the first instance for a period not to exceed three weeks. This first cruise lasted for twenty days (January 30th to February 19th), and was followed, for reasons given below, by a second cruise of about four weeks in the same vessel. After that we joined Captain DONNAN on his inspection barque.

In the first cruise of the "Lady Havelock" my objects were :—

(1.) To investigate the general biology of the seas around Ceylon, and especially of those places where pearl oysters were said to exist.

(2.) To examine more carefully any localities that seemed to be likely spots for uncharted pearl oyster banks.

(3.) To investigate the fauna, the bottom deposits, and the characters of the water in the Gulf of Manaar for comparison with the conditions at Trincomalee, Galle, and other parts of the coast.

(4.) To make experimental hauls of the fish- and the shrimp-trawls round the coast, so as to obtain information as to the prospects of fish-trawling as an industry in Ceylon waters.

(5.) To look into any other departments of marine biology which might be prosecuted as useful industries.

We joined the s.s. "Lady Havelock" on the evening of Thursday, January 30th, 1902; and started from Colombo harbour early the following morning. The course during this cruise is shown by the strong dotted line on the map (p. 19), and the observing stations are marked by a cross within a circle (see also more detailed map on p. 82). After steaming northwards for some hours the dredge was put overboard for the first haul about 11 A.M., at 5 miles S.W. of Negombo in $12\frac{1}{2}$ fathoms of water. The rest of the day was occupied in dredging and trawling along an area about 5 miles in length extending opposite Negombo Lake from Pamunogan at the south to Negombo, keeping from $4\frac{1}{2}$ to $5\frac{1}{2}$ miles off shore, in from 12 to 20 fathoms. A little further out the sea deepens very rapidly, 50 fathoms being reached 10 miles from land, 70 fathoms a mile further out, over 700 fathoms at about 18 miles west of Colombo and 1000 fathoms at about 20 miles from land. My object in working along

* I ought to state that on the whole the "Lady Havelock" proved a very suitable vessel for the purpose, and I desire to record also my sincere thanks to Captain CAMPBELL and the officers and others on board for the pains they took to carry out my wishes. The steamer is shown on p. 54.

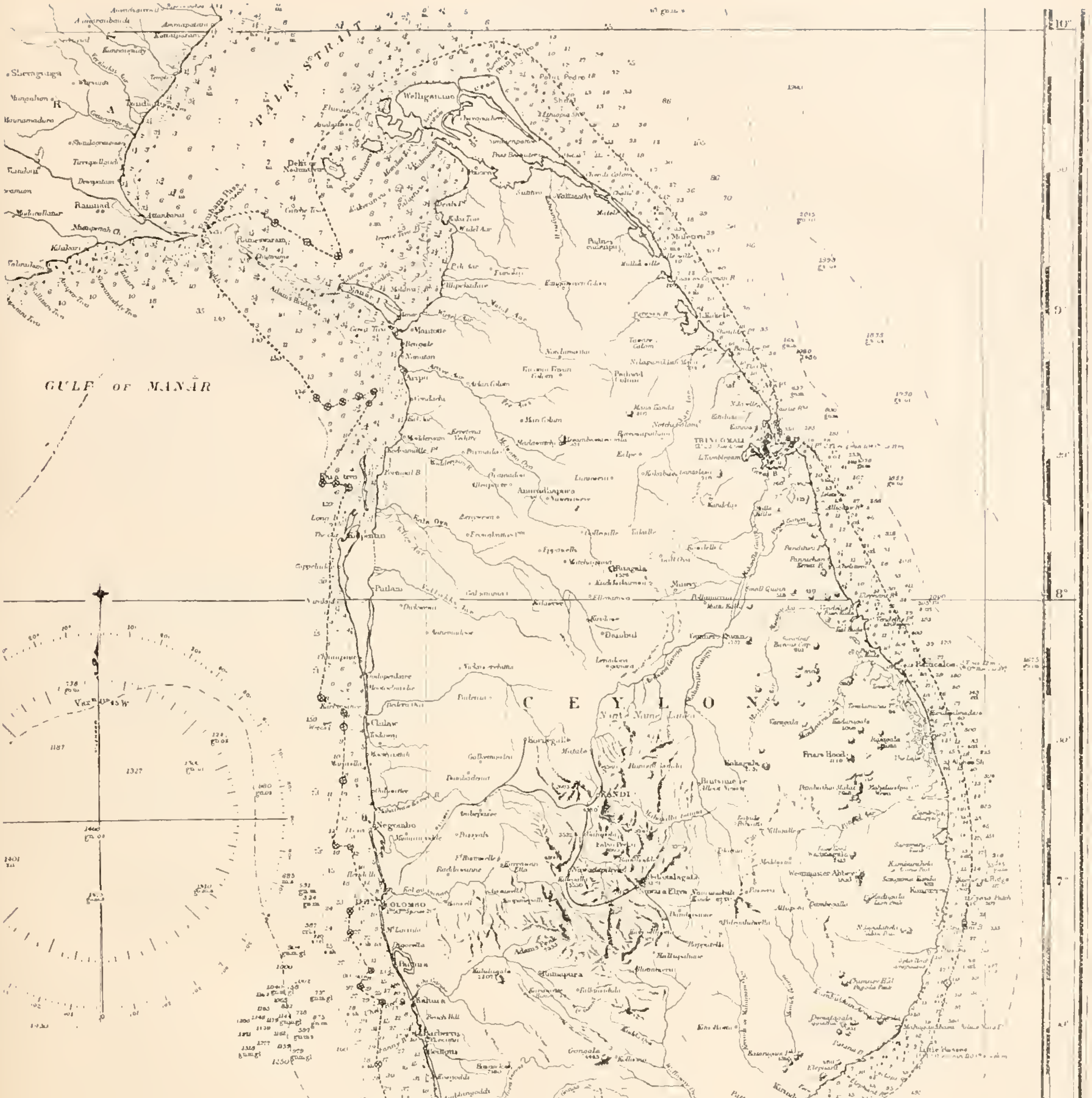


Fig. 1. Sketch-plan of route in first cruise of "Lady Havelock," January–February, 1902.

the shelf within the 20-fathom line off Negombo was (1) to get a fair sample of the conditions and the fauna for comparison with the pearl bank region off Aripu further north and (2) to explore the ground and the water, as we did wherever possible, for any stages young or old of the pearl oyster.

There is a record of an old pearl oyster bed, the "Muttu-Parawuttu Paar" lying about 4 miles W. of Negombo in 9 fathoms. No oysters have, however, been found there I believe for many years. We did not find any trace of this paar, but may have been just outside it; next day however we came upon large quantities of young pearl oysters about 7 miles further to the north. Half-a-dozen hauls of the dredge, two hauls of the 25-foot beam-trawl, with a 7-inch fish-net, and four surface gatherings with the silk tow-net were taken on this first day, off Negombo; and these, although recorded separately at the time, may now be united as one locality:—

STATION I.—Five miles west and south-west of Negombo; 12 to 20 fathoms; bottom coarse yellow sand with a few dead shells; temperature of sea, 77·5° F.; dredged and trawled. Amongst the animals were:—

Various sponges;

Diphasia mutulata, *Lytocarpus* (? n. sp.), *Campanularia juncea*, and some Plumularian Zoophytes, *Caryophyllia* sp. and *Heteropsammia michelini* (with commensal Gephyrea), Gorgonacea (*Spongodes*, &c.);

Leptoplana sp. and another Turbellarian, and *Aspidosiphon corallicola*, *Filograna* sp., *Hyalinœcia* sp., *Terebella* sp., *Acholoe* sp. (commensal with *Astropecten*), *Hesione* sp., *Ophelia* sp. and other Annelids;

Crisia sp. and other Polyzoa;

Echinus and Temnopleurids (sev. spp.), *Salmacis bicolor* and *S. sulcata*, *Lovenia elongata*, *Clypeaster humilis*, *Echinodiscus auritus*;

Thyone sacellus, *Holothuria atra*, *H. tenuissima* and allied species of "trepang" (up to 16 inches long), *Pectinura intermedia* and other Ophiuroids, *Astropecten hemprichii*, *Luidia maculata*, *Antedon* sp.;

Lepas sp., *Hippolyte* sp. (with Bopyrid) and other Macrura, *Neptunus* sp., *Calappa* sp., *Ebalia* sp., and other Brachyura;

Acanthochites penicillatus, *Styliola acicula*, *Teredo* sp. (in wood), *Arca* (sev. spp.), *Venus lamarcki*, *Cardium rugosum*, *Pinna bicolor*, *Pectunculus* sp., *Dentalium octagonum*, *Murex tenuispina* and *M. haustellum*, *Oliva candida*, *Turbo margaritaceus*, *Conus marmoratus*, *Natica* sp., *Harpa conoidalis*, *Umbrella* sp., *Pleurophyllidia* sp., *Melibe fimbriata* and *Sepia* sp.

Molgula sp., and some colonies of a snowy white *Leptoclinum* which grows over the coarse quartz sand and cements the grains together.

The Tow-net gatherings contained:—

Trichodesmium erythræum (in quantity), Diatoms, *Ceratium tripos* and some Foraminifera; *Sagitta* sp., *Salpa democratica-mucronata*, and *Oikopleura* sp.;

Copepoda—many, including a conspicuous blue form *Centropages violaceus*, and also *Oithona similis*, *Euterpe gracilis*, *Ectinosoma atlanticum*, *Temora discaudata* and *T. stylifera*, *Eucalanus subtenuis*, *Calanus vulgaris*, *Calanopia elliptica*, *Corycæus speciosus* and *C. venustus*.

[Note.—In coming across the Indian Ocean to Ceylon we used silk tow-nets day and night to strain the organisms from the sea-water running from the tap in one of the bath rooms. In two of these gatherings I obtained the pelagic Amphioxus (*Branchiostoma pelagicum*, Günther). One specimen was taken in a coarse net on January 16th, to the south-east of Sokotra, about halfway between Perim and the Maldives; and five others were found in a finer net on January 20th, after passing Minikoi Atoll, and therefore between the Maldives (where this species was found by Stanley Gardiner) and Ceylon.

Amongst other interesting or novel forms found on the way to Ceylon were:—a new species of *Centropages* (rather widely distributed), *Miracia minor* (taken near Sokotra, previously known from Gulf of Guinea), *Mecynocera clausi* (common), *Scolecithrix chelifer* (Red Sea, the only known locality), *Pseudodiaptomus salinus* (Suez Canal and Red Sea, males found for the first time), *Anymone spherica* (in Suez Canal), *Acartia dubia* (Suez Canal, only known previously from Gulf of Guinea), *Pseudocyclops obtusatus* and *Canuella perplexa* (both European forms, now found in Suez Canal). These will be discussed fully by Mr. Isaac Thompson and Mr. Andrew Scott in their Report on the Copepoda—see below, p. 227.]

On Saturday, February 1st, we dredged and trawled at various localities between Negombo and Chilaw, covering an extent of about 23 miles. The distance was generally from 4 to 5 miles off land, and the depth varied from 8 to 14 fathoms.

This day's hauls can be grouped into two localities; the first (Station II.) from opposite Ooluwitti to off Mararilla, half-way from Negombo to Chilaw, and the second (Station III.) off Chilaw; we dredged and trawled at both, as follows:—

STATION II.—From 7 to 14 miles north of Negombo, 5 miles off shore; 8 to 9 fathoms; bottom coarse yellow sand, shells, stones, and small coral; temperature of sea, 77·5° F., specific gravity, 1·023. Two hauls of fish-trawl and several of dredge.

Pachychalina sp., *Acanthella carteri*, *Hircinia* sp., and *Siphonochalina* sp. (pale lilac, with large oscula occupied by small colourless *Alpheus*);

Masses of living corals (up to 20 × 14 × 6 inches), many solitary corals, mainly *Stephanoseris rousseaui* and *Heteropsammia michelini*, small scarlet Actinians;

Lineus sp., *Aspidosiphon corallicola* (in the solitary corals), Lumbrinereids, *Hesione* sp., *Axiothea* tubes (in masses), *Serpula actinoceros*, *S. quadricornis*, *Sabellaria bicornis*, and many Polyzoa;

Antedon variipinna and another species (many), *Luidea maculata*, *Clypeaster humilis*, *Laganum depressum* and *Echinodiscus auritus*, *Salmacis dussumieri*, scarlet Ophiuroids, and *Phyllophorus cebuensis*;

Leucothoe spiniearpa and other small Amphipods and Isopods not yet determined, some Macrura, *Galathea* sp. (black and white), and *Pilumnus vespertilio*;

Young pearl oysters (in quantity), *Avicula vexillum*, *Conus marmoreus* and a few other common shells, *Philine* sp., *Aplysia* sp.;

Pseudorhombus arsius, and some sea-snakes (see p. 65).

On the second haul, which was 5 miles off Ooluwitti, at a depth of $8\frac{1}{2}$ fathoms, the trawl came up with the beam broken, but contained some large masses of coral and great quantities of young pearl oysters, measuring from $\frac{1}{4}$ to $1\frac{1}{2}$ (mostly 1) inch across. There is evidently at this point some hard bottom with coral growing on it, and with many broken lumps of coral and rounded masses of nullipore, from the size of a walnut to that of an orange—constituting in fact a "paar" upon which young pearl oysters are living. The oysters we got are in their first season, and probably ranged from one to three months in age. On the sand outside this hard patch we brought up quantities of the filamentous green weed (*Hypnea*, *Cladophora*, and *Gracilaria* spp.), which we found afterwards on the south part of the Cheval Paar, covered with the newly deposited "spat" of the pearl oyster.

STATION III.—Off Chilaw, $2\frac{1}{2}$ to 4 miles off shore; 9 to 14 fathoms; bottom coarse sand and small corals; temperature of sea, 77·75° F.; specific gravity, 1·023; one haul of fish-trawl and several of dredge.

Large numbers of *Heteropsammia michelini* (with Gephyreans).
Antedon sp., *Pentaceros lincki* and *P. nodosus*, *Echinanthus rosaceus*;
Aspidosiphon corallicola, Pagurids and other crabs, *Neptunus pelagicus*;
Mitra militaris, *Turbinella rapa* (the sacred chank), *Philine* sp.;
Leptoclinum (2 species).

We were now in the region of the Chilaw Paars, which consist of (1) one large bank running north and south for about 9 miles, at a distance of from 7 to 8 miles from shore, with a depth of 8 to 10 fathoms; (2) a group of two small paars lying north-east of the large Chilaw Paar, at from 5 to 6 miles off-shore; and (3) four small paars nearer the shore opposite Karkopani, about 4 miles north of Chilaw. These small paars are little hard patches, so-called "rock," on the general sandy expanse. The rough bottom varies greatly in depth, the extremes on these inner paars off Karkopani being 6 to 16 fathoms. Outside the outer large Chilaw Paar the depth increases rapidly, and at one place, in less than a mile, we pass from 10 to over 100 fathoms, at about 10 miles off shore.

On February 2nd we first had several hauls of the dredge (the trawl could not be used because of the very irregular hard bottom) amongst the inner paars off Karkopani, then trawled in the more even sandy ground (9 to 11 fathoms) between the inner and the outer paars, and finally had a couple of hauls of the dredge along the outer edge of the outer paar at depths of from 10 fathoms outwards to about 30 (the dredge dropped off the bottom finally on the steep slope about the 100-fathom line). I have placed the dredging off Karkopani as Station IV., and have united the trawling and dredging further out as Station V.; but Stations III., IV., and V., explored on the two days spent off Chilaw, do not differ much and may be regarded as one region. (Also Station LXIX., see chart of route and stations on p. 82.)

STATION IV.—Opposite Karkopani, from 1 to 3 miles off-shore; depth 6 to 9 fathoms; bottom coarse yellow sand with dead shells, nullipores and corals; temperature of sea (7 A.M.), 77·8° F.; specific gravity, 1·023. Several hauls of dredge.

Orbitolites complanata and *Heterostegina depressa* (forming a good deal of the sand);

Axinella donnani, *Acanthella carteri*, and a black leathery sponge;

Solenocaulon sp., *Sarcophytum ehrenbergi*, *Goniastræa* sp. (green), *Turbinaria cinerascens*, *Heteropsammia michelini* (with Gephyreans);

Luidea maculata, *Asterina cepheus*, *Astropecten hemprichii*, *Echinus* sp. (small, flat), *Echinolampas oviformis*, *Maretia planulata*, *Clypeaster humilis*, *Lovenia elongata*, *Thyone fusus*, var. *papuensis* (two), *Holothuria atra*;

Gephyreans (yellowish, burrowing in pearl oyster shell), Cirratulids (deep red), *Sabellaria bicornis*, Serpulids (on pearl oysters), *Trophonia* sp. (?), and Polyzoa;

Caprellids, Pagurids, Portunids, *Calappa* sp. and other crabs;

Acanthochites penicillatus, and, in addition to pearl oysters, molluscs belonging to the following genera:—*Avicula*, *Solen*, *Pecten*, *Mactra*, *Cardium*, *Arca*, *Pectunculus*, *Strombus* (*S. succinctus*), *Cypræa*, *Conus*, *Terebra*;

Branchiostoma belcheri, *Asymmetron cingalense*, and a Solenette (*Cynoglossus* sp. ?).

STATION V.—On both edges of upper end of Chilaw Paar, from 5 to 10 miles off shore; depth, 9 to 11 fathoms and upwards; bottom coarse yellow sand, with many *Orbitolites* and *Heterostegina* inside the paar, outside broken coral, *Halimeda* and Nullipores; temperature of sea (2 P.M.), 79° F.; specific gravity 1·023. One haul of trawl and several of dredge.

Tetractinellid sponges, *Siphonochalina* sp., *Acanthella carteri*, *Dictyocylindrus* (scarlet, massive), *Pachychalina multiformis* var. *manaarensis*, *Madrepora* (two species), *Pocillopora* sp., *Turbinaria cinerascens*, *Plexaura indica*;

Pentaceros lincki and a white Spatangoid;

Pectinaria sp., *Euphrosyne* sp., *Polynoe* (spiny); Polyzoa (various);

Melita obtusata, *Elasmopus subcarinatus*, *Leucothoe spinicarpa* and another (? n. sp.), some interesting new Caprellids, *Galathea elegans* and some other Decapods;

Pectunculus sp., *Pinna bicolor*, and many young pearl oysters; *Leptoclinum* sp.

The Tow-net gatherings during the day (February 2) contained *Sagitta*, *Appendicularia*, Nauplei, Plutei, Larval Polychætes, the veliger stage of Mollusca, eighteen species of Copepoda and the conspicuous blue *Centropages violaceus*.

Having now obtained what we considered fair samples of the bottom, and of the animals associated with the pearl oysters, on the paars off Chilaw, and of the ground between the paars, we steamed for some distance north along the shores of Kalpentyn Island, and anchored for the night about 1 mile off "St. Anna's Church," near the Etaly ferry across Putlam Lake (one of the succession of great inland seas, "gobbs" or lagoons, that extend up this coast of Ceylon) to Putlam Fort. The tow-net was left out all night, and on being hauled at 5 A.M. was found to contain many large Stomatopod larvæ in various Erichthus stages, and some Lucifers, various other larvæ as on the previous day and a few Copepods (*Labidocera acuta*, *L. kroyeri*, and *Calanus vulgaris*). Another haul taken at the same spot from 8 to 9.30 A.M. contained a mass of minute plant-life, *Navicula* and other diatoms, *Pediastrum*, and many small larvæ of worms and Copepod nauplei; also small adult Copepods (*Ectinosoma rosea* and *E. atlanticum* and *Oithona similis*).

A third haul at 11.30 A.M. had swarms of crab zoea and some Foraminifera (*Planorbulina*), also the blue Copepoda (*Centropages violaceus*), *Pontella securifer*, several species of *Labidocera*, including a large new species, also a greenish-blue larval Squilla. This last haul was taken further north, over Muttuvaratu Paar, but the difference in these successive gatherings is probably due to some extent to the time of day and to tidal currents carrying streams of plankton past the ship.

My intention was now to examine the neighbourhood of the celebrated Muttuvaratu Paar lying off the middle of Karativo Island, and perhaps one of the most important of the pearl oyster grounds after the Cheval and Modragam paars. It afforded profitable fisheries in 1889, 1890, and 1891.

We commenced dredging at 11.30 A.M. and spent the rest of the day in making a traverse from east to west across the paar and into the deep water lying outside it. The first five hauls were all in the neighbourhood of the paar and may be considered as one locality (Station VI.), and several hauls were then taken at two spots (Stations VII. and VIII.) further out, the first at 45 to 50 fathoms and the second at 90 to 100 fathoms. This was one of the localities where we examined the ground outside the known paars, down to the 100-fathom line, with the view of ascertaining whether there was any evidence in support of the statement which had sometimes been made in the past, that there were probably unknown beds of pearl oysters further out and in deeper water from which spat was produced for the supply of the inshore paars. No evidence was found.

STATION VI.—Across Muttuvaratu Paar, 4 to 6 miles west of the centre of Karativo Island; depth 6 to 9 fathoms; bottom sand with hard patches of "rock" at intervals; temperature of sea at noon 78° F., at 4 P.M. 79° F.; specific gravity 1·023. Five hauls of dredge.

Spongionella nigra, *Phyllospongia holdsworthi*, *Axinella donnani*;

Zoanthus sp. and lilac Actinians, *Madrepora cytharea*, *Montipora* sp., *Porites* sp., Astræids (two species), *Turbinaria cinerascens*, *Sarcophytum ehrenbergi*, *Plexaura indica* (with Cirripede galls), and other Alcyonaria;

Sabellaria bicornis and *Serpula* sp.;

Echinaster purpureus, *Ophiocnemis marmorata*, *Cucumaria turbinata*;

Pearl oysters, *Modiolaria* sp., *Modiola* sp., *Doris* sp.;

Botryllus sp. and *Leptoclinum* sp.;

Small olive-green Wrasse with white tail (*Pomacentrus bankanensis*).

STATION VII.—Further out, from 6 to 7 miles off shore; depth 45–50 fathoms; dredged.

Large masses of coral overgrown with *Chama foliata; Chromodoris* sp.;

Squilla (small—many—in cavities of the coral);

Sabella sp., *Eunice* sp., *Lepidonotus acantholepis* and *Harmothoe imbricata*, all evidently associated with the coral.

STATION VIII.—Still further out, $7\frac{1}{2}$ to $8\frac{1}{2}$ miles off shore; depth 90–100 fathoms; dredged.

Gorgonia miniacea, Juncella juncea, Antipathes sp. (black, fan-shaped), *Cyatho-helia* (?) and another allied form;

Galathea sp. (scarlet), *Lambrus* sp., *Arcania* sp. and other crabs;

Some species of *Nassa* and *Murex* and some small Octopods.

We now steamed further north to the region of the great Cheval paars, lying off the bight of Kondatchy, and started dredging at 8 A.M. on Tuesday, February 4th, along the southern edge of the West Cheval Paar. My object was, after seeing the condition of the ground on the Cheval Paar, to make a line of dredgings across the Cheval and the region outside it to the Periya Paar.

STATION IX.—On south-west corner of West Cheval Paar, about 12 miles from land; depth 7 fathoms; bottom fine quartz gravel, nullipore concretions, and many dead young pearl oyster shells; temperature of sea, 78° F., specific gravity, 1·023; dredged.

Axinella tubulata, Clathria indica (on oyster shells);

Sertularia distans and other Hydroids;

Actinometra parvicirra and another species, *Pentaceros lincki, Clypeaster humilis, Holothuria tenuissima;*

Physcosoma scolops (in *Axinella tubulata*, with commensal tubicolous Oligochætes), *Serpula actinoceros, Armandia* sp.;

Pearl oysters, along with "Suran" and "Oorie";

Branchiostoma belcheri (several).

In this haul young pearl oysters about $\frac{1}{2}$ inch to 1 inch in size were obtained in quantity, but the majority were dead; of 200 picked up at random only 20 were living. A large number of small boring Gastropods (belonging to the genera *Purpura, Nassa, Sistrum*, &c., and known collectively to the natives as "Oorie") were present. They ranged from $\frac{5}{8}$ inch to $\frac{7}{8}$ inch long and were very active, and no doubt contribute to the mortality of the oysters. There were also present considerable numbers of the small mussel, *Modiola barbata*, known to the natives as

"Suran," which form irregular nodular masses of gravel and oysters bound together by a network of byssal threads spun by the mussel. A number of the shells of the Suran as well as of the pearl oysters were perforated by the boring Gastropods.

The next eight hauls (Stations X. to XVII., some of them really representing more than one descent of the dredge) form a series taken from east to west from inside the Cheval to outside the Periya Paar.

STATION X.—One mile to east of East Cheval Paar; depth $5\frac{3}{4}$ fathoms; bottom quartz sand and dead shells; no oysters; dredged.

Sclerophytum polydactylum, *Suberogorgia suberosa*, and other Alcyonaria;
Luidea maculata, *Astropecten hemprichii*, *Pectinura gorgonia;*
Cirratulus sp., *Acholoe* sp. (on *Astropecten*), Lumbrinereids;
Caprellids (many), *Hyastenus* sp. (covered with Hydroids);
Eburna sp., *Turritella* sp., *Philine* sp.;
Styela sp. (with red apertures), *Molgula* (many), *Leptoclinum* sp.;
Dragonet (*Platycephalus punctatus*).

STATION XI.—On East Cheval Paar; depth 6 fathoms; bottom, sand; dredged.

Hircinia clathrata (with *Acasta spongitis*);
Campanularia juncea, *Plumularia setacea* (? n. sp.), *Idia pristina* and *Monostachys dichotoma;*
Centrosiphon herdmani, n. gen. and sp. (SHIPLEY), *Physcosoma asser;*
Clypeaster humilis and *Echinodiscus auritus*, *Lovenia elongata* and *Echinolampas oviformis*, *Synapta* sp. (?);
Lepidonotus carinulatus, *Harmothoe imbricata*, *Filograna* sp., *Retepora* sp.
Species of *Conus*, *Cypræa*, and *Oliva;*
Branchiostoma californiense, *Asymmetron* (*Heteropleuron*) *cultellum.*

STATION XII.—Between East and West Chevals; 6 fathoms; bottom fine sand and much green Algæ (*Hypnea*, *Cladophora*, *Gracilaria* spp.), no oysters; dredged.

Laganum depressum, *Clypeaster humilis*, and *Echinodiscus auritus;*
Sphæroma sp., *Mæra rubromaculata*, *Elasmopus subcarinatus*, Caprellids and other Amphipods; *Philine* sp.

STATION XIII.—On West Cheval Paar; depth 6 fathoms; bottom old worn coral fragments and dead shells.

The haul contained nothing conspicuous except a number of large pearl oysters and a few small ones. The larger ones measured $2\frac{3}{4}$ to $3\frac{1}{4}$ inches across. There were also a few dead oysters, four of which had the valves honeycombed by the boring sponge *Clione;* and some of the coral fragments contained the Gephyrean *Aspidosiphon steenstrupia.* The corals were mainly *Porites* and Astræids.

STATION XIV.—About 2 miles west of West Cheval Paar; depth 8 fathoms: bottom sand with many young and a few old pearl oysters; dredged.

Astropecten hemprichii, *Linckia lævigata*, *Echinaster purpureus*, *Clypeaster humilis*; *Chlœia ceylonica*, *Serpula actinoceros*, *S. quadricornis*, *Ophelia* sp.; *Margaritifera vulgaris* (in quantity) and *Natica* sp.

Leptoclinum sp. (green).

In this haul three dozen large and about 15,000 healthy young pearl oysters were taken. The young were placed in batches in our deck tanks and kept under observation.

STATION XV.—On Periya Paar, 18 miles off shore; depth 9 fathoms; bottom sand; many young oysters; dredged.

Petrosia testudinaria and other large sponges, *Reniera* sp. (green, with oysters attached), *Axinella tubulata* (with commensal worm) and *A. donnani*, *Phyllospongia holdsworthi*;

Favia sp. (large, green), *Adamsia* sp. (small, grey, proliferating);

Echinostrephus molare, *Ophiomaza caraotica*, *Pectinura intermedia*;

Eunice cirrobranchiata (?), *Armandia* sp., *Sabella phæotænia*, *Serpula quadricornis*, *Leucodora* sp., Pagurids (brilliant orange);

Pearl oysters, "Suran," "Oorie," *Murex anguliferus* (the elephant chank), and species of *Conus*.

The small oysters of this haul were many of them dead. They measured from $\frac{1}{2}$ to over $\frac{5}{8}$ inch in size, and quite a number of the dead valves were perforated by boring Gastropods. Out of a small handful taken at random, 17 oysters were living and 45 were dead, 7 of which were perforated, and along with them were 3 "Suran" and 2 "Oorie" ($\frac{5}{8}$ inch long).

STATION XVI.—On Periya Paar, about a mile further north; depth 9 fathoms; bottom sand, with nullipores, dead coral and shells, with great quantities of young living pearl oysters; dredged.

Orbitolites (very large), *Heterostegina depressa*, *Amphistegina lessonii*;

Isodictya sp. (green);

Paraplanocera aurora;

Pearl oysters and *Solarium* sp., *Turbo* sp., and young Octopods (a new species with branched processes on the body);

Antennarius nummifer.

The numerous pearl oysters in this haul were nearly all young ones, from $\frac{5}{8}$ inch to $\frac{15}{16}$ inch in size, and apparently in a healthy condition.

STATION XVII.—Outside western edge of Periya Paar; 11 fathoms; bottom same as last haul; small pearl oysters very abundant; dredged.

Ciocalypta sp., and other sponges;

Holothuria atra, *Ophiocnemis marmorata* ;

Phyllodoce foliosopapillata n. sp. (Hornell), *Lepidonotus trissochætus*, *L. carinulatus*, *Panthalis melanonotus* (in sandy gelatinous tubes) ;

"Suran," *Avicula* sp. ;

Asymmetron (*Heteropleuron*) *cingalense* (12 specimens).

Of the numerous small pearl oysters in this haul rather more than half (on the average 11 to 9) were dead, many of them entangled with "Suran."

Several hauls of the tow-net were made during the day (February 4), and amongst the most abundant organisms noticed were :—

Diatoms (vast quantities), Ceratium, Peridinium, and spherical gelatinous Algæ.

Mitraria, Nauplei, and other larvæ ;

Copepods (29 species), *Oithona similis*, *Calanus minor*, *Pseudodiaptomus aurivillii*, *Pontellopsis strenua* and *P. perspicax*, *Calanopia elliptica*, *Labidocera acuta*, *Tortanus forcipatus*, *Centropages* sp. (new to science) ;

Salpa democratica-mucronata.

The blue Copepods and Salpa were mainly in the later more westerly hauls (18 miles from shore), and the Diatoms and Algæ in the earlier hauls on the Cheval paars. A gathering taken during the night gave some large *Sagitta*, a few small Medusæ, some Amphipods and *Nebalia*.

Having now made a preliminary examination of the pearl-bank regions in the Gulf of Manaar and obtained some samples, I decided to visit various other localities round the island to which attention has been directed either by the literature of the subject or by information obtained since landing in Ceylon. We therefore made our way next through the Pamban Pass, between Rameswaram Island and the mainland of India, into Palk Bay, which lies north of Adam's Bridge (see map of route, p. 19).

On February 5th, while lying at the southern end of the passage, waiting for the pilot, the sea-temperature at 10.30 A.M. was 77·5° F., and the specific gravity was 1·0205. A tow-net gathering taken here contained a new species of *Centropages*, with a remarkable dorsal spine, and a new species of *Labidocera*.

On February 6th, at the north end of the pass, opposite the village of Pamban, at 7 A.M., the sea-temperature was 76° F. and the specific gravity only 1·019 ; at 7 P.M. in the middle of Palk Bay the sea-temperature was 78° F. and the specific gravity 1·021. This day was spent trawling and dredging in Palk Bay, a wide shallow area lying between Adam's Bridge and the northern end of Ceylon, and partly enclosed by the chain of islands extending southwards from Jaffna, with, for the most part, a muddy bottom at a depth of from 6 to 8 fathoms. Parts of it near the islands are much blocked, as we found later, by luxuriant coral growths, but the centre presents a large open expanse with a uniform soft bottom suitable for trawling. Pearl oysters are said to be found in a few feet of water in some places round the shore, but there are no fisheries, and our object here was not to look for "paars" but for *fish*, as I had undertaken to report upon any grounds suitable for the use of the European fish- or shrimp-trawls if occasion presented itself.

We first took a haul of the dredge to ascertain the bottom and, finding it soft and muddy, put over the large fish-trawl about 7 miles north-east of Rameswaram, at a depth of 7 fathoms, and towed for 6 or 7 miles in a south-easterly direction parallel with the length of the island. A second haul of the trawl was made from the point reached onwards in the same direction to a point due north of about the centre of Adam's Bridge and distant about 9 miles. The third haul was from that point onwards in a more easterly direction towards the Island of Manaar. The beam of the trawl came up damaged on this occasion and had to be shortened by about a foot. The fourth and last haul of the day was taken rather further out than the last and further east, off the western end of Manaar Island, and about 9 miles off shore. Here the beam again broke and required to be repaired, but the contents of the net were saved. The hauls varied from 4 to 7 miles in length and the trawl was generally down nearly two hours. The bottom remained the same and the depth was very uniform. In the middle of the stretch it deepened to 8 fathoms, but towards the end we ran into 7 again. As these hauls were practically continuous, and as the conditions and the results were so much alike in all cases, I think it best to consider the whole day's work as one locality (Station XVIII.), lying to the north of Adam's Bridge and contrasting markedly with the much more irregular bottoms and hard ground lying to the south in the Gulf of Manaar.

STATION XVIII.—South-west part of Palk Bay, off Rameswaram Island and Adam's Bridge, from 7 to 9 miles off shore; depth 7 to 8 fathoms; bottom fine soft bluish-grey mud containing casts of various Molluscan shells; four hauls of fish-trawl and one haul of dredge:—

Holothurian (white and minutely spinous, apparently a new species of *Synapta*), *Salmacis bicolor*;

Nemertine (large red, like *Valencia splendida*, and also two slender white ones), (?) Terebella tubes, (?) Sabella tubes, *Chlœia ceylonica*, *Gastrolepidia clavigera*, other Polychætes;

Anilocra sp., *Squilla* sp., Macrurids (sev.), Portunids and other crabs;

Eburna sp., *Turbinella rapa*, *Fusus turricula*, *Nassaria acuminata*, *Mitra pyramidalis*, *Cerithium citrinum*, *Murex tenuispina* (many), *Natica* (with egg-coil), *Mya* sp., *Pinna fumata*, *Lithodomus* sp., *Dentalium* (up to 3½ inches long), Cephalopod eggs;

Balanoglossus (probably *Glandiceps haekii*).

The Fish* caught on this occasion were:—

"Cat-fish" (*Arius venosus*, Cuv. and Val.);

"John Dory" (*Gazza equalaformis*, Rüpp., and *Equala splendens*, Cuv.). Up to

* I give the English rough equivalent as entered at the time in the diary, followed by the scientific name as determined since by Mr. J. Johnstone, who will report upon the fishes in detail.

6 inches long. Even those of 3 inches long showed the ovaries mature. Intestine dark green in colour and contents consisted entirely of a large Navicula-like Diatom;

"Arnoglossus" (*Psettodus erumei*, Bl.);

"Sand-eels" (several small *Tæniolabrus* sp. and another);

"Bass" (*Sciæna maculata*, Bl. Schn.);

"Soles" (*Cynoglossus* spp.);

"Pomfret" or "Pamplette" (*Stromateus sinensis*, Euphr.);

"Plaice" (*Pseudorhombus arsius*);

"Mackerel" (*Caranx hippos*, Linn., probably = *Scomber heberi*, Bennett).

During the day (February 6) several tow-net gatherings were taken. In the morning (8 a.m.) there was a large amount of material, chiefly Alima and other Crustacean larvæ, also some large *Sagitta*, a few Mysids and large Copepoda (*Labidocera acuta* and *Pontella tenuiremis*). In the afternoon there were fewer animals, but an enormous amount of *Trichodesmium erythræum*, which in places formed a dirty reddish scum on the surface.

This same locality (Station XVIII.) was also visited later on (March 14th) and trawled over again with much the same results. [Station XIX. is in the northern part of Palk Bay, and was worked on March 16th—see below, p. 83, and map, p. 82.]

Palk Bay measures about 34 miles from north to south (roughly from off Jaffna to the middle of Manaar Island) and 40 miles from east to west along the south (say from Manaar to Rameswaram), and is 20 miles across further up between Delft Island and Devil's Point. It is about 100 miles round the coast from Rameswaram to Punkudutiva, and another 30 across the entrance; and must contain over 900 square miles. Of this area probably two-thirds is trawlable ground, with an even muddy bottom at a depth of 7 fathoms nearly all over, while outside is the still wider area of similar character known as Palk Strait, between Ceylon and the Tanjore Coast. Our hauls in both the north and the south parts of Palk Bay showed that there are plenty of fish, and apparently this shallow area serves as a very valuable "nursery" for young fishes.

A great part of the Ceylon coast would certainly be very difficult to fish according to European methods, and in some cases it is practically impossible to trawl because of the coral reefs and other obstacles; but Palk Bay is one of a few areas where there is a considerable extent of ground suitable for trawling, and containing an abundant fish fauna.

The "Lady Havelock" now steamed round the north end of the island from Palk Bay to Trincomalee. After the Gulf of Manaar I regarded Trincomalee as the most important place I had to visit and report upon—in the first place, because of Dr. Kelaart's experiments and observations in regard to pearl oyster cultivation there some fifty years ago, and secondly, because pearl oysters are known still to live in some parts of the inner bay, where they are collected and eaten by the natives and where pearls are occasionally found. About the time we arrived in Ceylon some letters appeared in the Colombo newspapers on the matter, and a Mr. J. B. Colomb, resident in Trincomalee, sent to me one or more specimens of oysters from which pearls had been obtained.

On February 7th, at 7 A.M., we were off Muletivo Shoals, on the north-east coast, and the sea-temperature was 77° F. and the specific gravity 1·021; at 7.30 P.M. that night in Trincomalee inner bay the temperature of the sea was 78·3° F. and the specific gravity 1·022. About 2 P.M. we reached Back Bay (fig. 2), outside Trincomalee, and took a haul of the dredge (Station XX.) in order to see whether the

Fig. 2. Sketch-plan of the bays round Trincomalee, showing Stations XX. to XXXI.

ground was suitable for pearl oysters. The bottom was hard and bore a mixed fauna, but no oysters were found. The tow-net contained a number of Copepoda, including *Oithona minuta* and a new *Labidocera*, close to *L. kroyeri*.

STATION XX.—North part of Back Bay, Trincomalee; depth 11–13 fathoms; bottom hard; dredged. Amongst the animals obtained were:—

Anemones attached to *Fusus tuberculatus*, *Heterocyathus aequicostatus*, and *Heteropsammia michelini* (with Gephyreans);

Stellaster sp. (many), *Astropecten hemprichii* and *A. euryacanthus*, *Ophiocnemis marmorata* and other Ophiuroids, *Cucumaria imbricata* (several);

Aspidosiphon corallicola, &c.;

Cardium rugosum, *Fusus tuberculatus*, *Cerithium citrinum*, *Tudicla spirillus*, *Philine* sp.

We divided up the days devoted to work in the neighbourhood of Trincomalee so as to examine as much as possible of the fauna of this extensive and complicated region (see fig. 2). About twelve bays were explored either with the steamer or the small boats, and we also managed to do some collecting along the shore. The general arrangement was:—

On February 7th, Back Bay;
,, ,, 8th, Back Bay, Dutch Bay, and off Foul Point;
,, ,, 9th, at anchor, shore-collecting, and investigating the pearl oysters;
,, ,, 10th, dredging from the boats in the creeks of the inner bay;
,, ,, 11th, Tamblegam Bay.

On February 8th, at 7 A.M., the sea-temperature in the inner bay was 77·5° F., and at 8 A.M., in Back Bay, was 78° F., the specific gravity at both localities being 1·021. We started dredging at 8 A.M., in the southern part of Back Bay (Station XXI.), one of the localities where Dr. KELAART is said to have deposited pearl oysters in 1857, and where we were told the native fishermen occasionally found them.

STATION XXI.—In Back Bay, North of Fort Frederick; depth 8–12 fathoms; bottom firm sand, in places some mud; several hauls of dredge, but no traces of pearl oysters. Amongst the animals obtained were:—

Adamsia ? (on Chank shell), *Virgularia juncea*, *Pteroeides esperi*;

Laganum depressum, *Thyone fusca*, n. sp. (PEARSON), *Cucumaria imbricata*, various Ophiuroids and small Asterids (mainly young *Stellasters*):

Carinella sp., *Terebella* and other worm tubes;

Portunids (small), *Ebalia* sp. and other crabs;

Turbinella rapa. *Strombus succinctus*, and species of *Conus*, *Cerithium*, *Dentalium*, and *Cardium*;

Psammaplidium sp. and *Leptoclinum* (sev. spp.).

We then tried Dutch Bay (Station XXII.), to the South of Fort Frederick, with similar results, a hard bottom with an abundant general fauna, but no pearl oysters.

STATION XXII.—Across mouth of Dutch Bay from Fort Frederick to Dutch Point; depth 13 fathoms; bottom dead coral, shells, and Nullipores; dredged.

Fungia sp., *Dendrophyllia* sp., *Heteropsammia michelini* (with Gephyrea), *Sarcophytum* sp., and other Alcyonaria;

Linckia diplax, *Astropecten zebra* (?), and various Ophiuroids;
Halsydna sp., *Serpula actinoceros*;
Pontonia sp., *Lambrus* sp., and other Decapods;
Molgula sp., and a few common Molluscs.

As we had heard that pearl oysters had been found "off the Suami Rock," Fort Frederick, between Dutch Bay and Back Bay, I considered it necessary to examine the ground further in close to the rocks where the steamer could not be taken. So we engaged a pilot's large boat with a native Tindal and crew and took with us Mr. J. B. COLOMB, from Trincomalee, who professed to know where specimens had been obtained by native fishermen. We took haul after haul of the dredge close in along the northern edge of the Suami Rock (Station XXIII.), beginning abreast of the detached rock off the point of Fort Frederick peninsula and working along parallel with the shore past the old Dutch boat-jetty. We were all the time on the ground indicated by Mr. COLOMB and the native pilot, and obtained good hauls, but nowhere was there any trace of pearl oysters—not even fragments of dead shells.

STATION XXIII.—Close to Suami Rock, Back Bay; depth $4\frac{1}{2}$ to 8 fathoms, mostly between 5 and 6 fathoms; bottom sand, shells, and in places stones and corals. Half-a-dozen hauls of the dredge.

Caryophyllia sp. and other small corals, *Rhipidogorgia* sp. and other Alcyonaria;
Spatangoid, *Antedon* sp., Ophiuroids, *Holothuria atra*, *Linckia multiforis*;
Melita obtusata, *Ebalia*, and other small crabs;
Malleus vulgaris, *Octopus* sp.

We then steamed across the mouth of "Great Bay," in order to try a haul of the trawl in the open off Foul Point. Unfortunately the bottom proved unsuitable, the trawl eventually caught fast, and, before the strain could be relieved, the bridle parted and the wire rope came in, bringing with it the ring of the bridle (in which was entangled a beautiful dendritic Antipatharian colony) and leaving the trawl at the bottom. We then dredged over the same ground in the hope of entangling the dredge in some part of the trawl, but in vain. We may unite these hauls as:—

STATION XXIV.—Two and a-half to three miles north of Foul Point; depth ranging from 46 to 24 fathoms; bottom hard and rough—probably rock.

Sponges (many), various corals;
Various Gorgonacea, including *Juncella juncea* and *Solenocaulon tortuosum*; *Antipathes* sp., and *Cirrhipathes spiralis*;
Antedon reynaudi (on Gorgonids), various Ophiurids (on Gorgonids);
Bonellia punicea (in Coral);
Melita obtusata and other Amphipods;
Ischnochiton ferreus, n. sp. (SYKES).

We landed with a party of our Maldivian lascars at Shell Bay, near Foul Point, to examine and collect on the beach. Many "calling-crabs" (*Gelasimus*) were seen, and a large quantity of molluscan shells was obtained—a species of *Bulla* was especially common. Only one specimen of pearl oyster (dead, but having the valves still attached) was found, and a closely allied species of *Avicula* with a longer wing was also taken. Amongst the other shells obtained here, and at other places round Trincomalee, were such typical Indian forms as :—

Pecten plica, *Pinna bicolor*, *P. fumata*, *P. chemnitzii*, and *P. zebuensis*, *Modiola tulipa*, *Psammobia amethystus*, *Cardium asiaticum*, *Ostrea hyotis*, *Vulsella rugosa*, *Avicula vexillum*, *Arca decussata*, *Chama foliata*, *Malleus vulgaris*, *Placuna placenta*, *Ricinula arachnoides*, *Rotella vestiaria*, *Trochus niloticus*, *Margarita acuminata*, *Phasianella lineolata*, *Fasciolaria trapezium*, *Pyrula ficus*, *Fusus tuberculatus*, *Murex haustellum*, *M. tenuispina*, *Eburna zeylanica*, *Triton lotorium*, *T. pilearis*, *T. gallinago*, *T. tripus*, *Xenophora calculifera*, *Solarium perspectivum*, *Strombus succinctus*, *S. sibbaldii* and *S. canarium*, *Cassis glauca*, *C. canaliculata*, *Dolium maculatum*, *D. olearium*, *Conus tessellatus*, *C. terminus*, *C. miles*, *C. betulinus*, *C. striatus*, *Oliva maura*, *O. gibbosa*, *O. ispidula*, *O. elegans*, *O. torsans*, *O. candida*, *Cypræa arabica*, *C. lynx*, *C. moneta*, *C. ocellata*, *C. errones*, *C. caput-serpentis*, *C. coffea*, *C. tigris*, *C. mauritiana*, *C. asellus*, *Natica mammillata*, *Pterocera scorpius*, *Harpa conoidalis*, *H. ventricosa*, *Eburna ceylonica*, *Pyrazus palustris*, *Turritella duplicata*, *T. attenuata*, *Telescopium fuscum*, *Terebra tigrina*, *Turbinella spirillus*, *Bulla ampulla* and *Spirula peronii*.

Two hauls of the dredge were now taken nearer Foul Point (Station XXV.) in much shallower water and on smoother but less interesting ground.

STATION XXV.—Three-quarters of a mile to a mile west-north-west of Foul Point; depth 8 fathoms; bottom firm, Orbitolites sand and Nullipores; dredged.

Orbitolites complanata, *Heterostegina depressa* and other Foraminifera;

Fungia dentata; *Antedon* sp.;

Hyalinœcia sp. (numerous), *Sigalion* sp.; various crabs; *Molgula* sp.;

*Amphioxus** (two, young), *Saurida nebulosa*, *Leptocephalus* and a small Sole.

Several TOW-NET gatherings had been taken during the day (February 8th), but they contained comparatively little except *Trichodesmium erythræum*, which was present in great abundance, some *Euchæta* sp., *Labidocera kroyeri*, *Euterpe acutifrons*, and many young Copepods.

The following day (Sunday) we lay at anchor in Trincomalee harbour, and employed the time in very necessary examination, preservation, and packing of specimens, and unpacking of stores, and writing up of notes. We also did some shore-collecting and obtained local evidence in regard to the occurrence of the pearl oysters at Trincomalee. Mr. COLOMB had brought on board, for our inspection, a number of the empty shells of oysters which had been picked up by the natives in shallow water between Powder

* Specimens apparently not kept, so species not certain.

Island and Victoria Wharf. They had been gathered alive in January and used for food. We measured 240 valves, which ranged in size from 2·2 to 5 centims. in diameter. The average size was 4 centims. So these, as well as all we collected ourselves, were of small size.

Trincomalee is an admirable collecting ground for molluscan shells; some of the numerous beaches in the neighbourhood have fine specimens cast up—for which natives are constantly on the look out—and there are Moormen in the town who are expert dealers, and have large stocks. I examined several of these collections, with the object of looking for large specimens of the pearl oyster; but although nearly every little box or basket of shells, made up for sale to passengers on the steamers, contains a couple of valves of pearl oysters, these are all of small size, and none were seen comparable with those from the Gulf of Manaar.

Some detached valves, about $1\frac{1}{4}$ inches long, were found on the shore close to the Cutch Company's bungalow. Near the same spot were some heaps of a large *Mytilus*, having masses of quartz gravel entangled in the byssus, and also quantities of *Pinna*—evidently all used for food. Many small rock oysters were seen adherent to boulders and masonry at various points round the bay (see fig. 3).

The sea-temperature this day (February 9th) in the harbour was 78·2° F. at 8 A.M., and 78° F. at 7 P.M. The specific gravity at both times was 1·021.

Next day (February 10th) at the same place, at 7 A.M., the temperature was 78° F., and at 7 P.M. was 78·8° F. At both times the specific gravity was 1·020. There had been some rain in the night. The temperature in our various tanks in the ship, in which we kept animals under observation, now began to vary considerably. In the ship's baths the water was 80° F., while some of our wooden tanks were only at 75·5° F. February 10th was devoted to dredging in the various smaller bays or coves which open off the so-called "harbour" (fig. 2) or inner bay of Trincomalee. We may regard each bay as one station, although several hauls of the dredge may have been taken in it.

STATION XXVI.—Outer part of Yard Cove, between Plantain Point and Middle Point and inwards to the "narrows"; depth 2 to 8 fathoms; bottom coarse sand and gravel with thin layer of mud on surface. Several hauls of dredge.

Much black branched and pale lilac Renierid sponges;

Astropecten sp.; *Synapta striata* (lilac and white, in branches of sponge masses);

Sipunculids, Lumbrinereids;

Various Ebalid, Portunid and Eurynomid crabs;

Strombus succinctus (many), *Neritina* sp. (common); *Molgula* sp.

STATION XXVII.—Entrance and middle of Cod Bay; depth 4 to $6\frac{1}{2}$ fathoms; bottom muddy sand; several hauls of dredge.

Gelliodes carnosa, *Halichondria* sp., *Clathria* sp.;

Thyone calcarea, n. sp., *Holothuria tenuissima*, *H. atra*, and *H. marmorata*;

Polynoe sp., *Glycera decipiens;*
Strombus sp. and other common Molluscs;
Amphioxus (apparently undetermined).

STATION XXVIII.—Middle of China Bay; depth 7 to 14 fathoms; bottom black sandy mud; several hauls of dredge.

Holothuria gallensis, n. sp. (PEARSON), *Astropecten hemprichii, A. polyacanthus;*
Glycera (small pink), and some long calcareous worm tubes, &c.

STATION XXIX.—French Pass; depth 4 to 7 fathoms; bottom mud with a few stones; several hauls of dredge.

Holothuria marmorata (the large yellow, spotted brown trepang);
Some Molluscs, Annelids and Polyzoa (including *Adeona* sp.).

STATION XXX.—Nicholson's Cove; depth $4\frac{1}{2}$–10 fathoms; bottom muddy sand; dredged.

Euspongia officinalis; and a Cubomedusa;
Holothuria atra (the large black and pink trepang);
Hyalinœcia sp.;
Strombus succinctus, S. sibbaldii, and a few other common Molluscs.

The shoal at the inner end of Nicholson's Cove has a hard bottom with occasional boulders, which are covered with small rock oysters up to $3\frac{1}{2}$ inches long (average size 2 inches). It is one of the few spots at Trincomalee which would probably do well for the pearl oyster.

Mr. HORNELL and I managed to land also during this day at various points to examine the shore and the shallow-water fauna—which was very important here because of the remarkable fact that the pearl oyster is found living naturally between tide-marks.

At the far end of Nicholson's Cove we found one or two dead specimens of the commercial sponge, and we also dredged a piece which proved to be *Euspongia officinalis.* This showed that it evidently grows in the neighbourhood, and we have since found it in quantity. In the mangrove swamps which fringe the ends of this and some other coves there are great numbers of small land crabs (*Ocypoda macrocera*) and also of the semi-terrestrial fish *Periophthalmus*, some of which we caught, with some difficulty. We tried to keep the *Periophthalmus* alive in our tanks on the ship, but the little fish persisted in coming out of the water and getting on deck. They scrambled up the vertical wooden sides by taking advantage of the angles at the corners of the tanks.

We waded over all the shallower parts of the harbour where Dr. KELAART had investigated the pearl oysters in 1857, and where Mr. COLOMB reported that oysters are now found by the natives. The chief place is between Powder Island and the shore near the wharf (fig. 2). Here the bottom is hard gravel with some rock *in situ* and large boulders. Rock oysters and a species of *Arca* are abundant on the rock and boulders (fig. 3) and on pieces of wreck, also quantities of

Fig. 3. Rock oysters (*Ostrea* sp.) in Trincomalee harbour at low tide.

Mytilus of good size were living on and in the gravel anchored by the byssus. Attached to these and to other objects were many pearl oysters of smallish size. Samples of these were taken alive to our laboratory on board ship. In the sand around the island *Pinna bicolor* lives in abundance, of large size, almost wholly buried, the tips of the valves just projecting beyond the level of the sand, and the byssus deep below, generally having some larger objects such as small stones and dead shells attached to it. On the shores of Powder Island we also found *Periophthalmus kohlreuteri* and thick-bodied land-crabs, and also a shore-crab with a long crenated front margin between the eyes; a *Neritina* and a *Littorina* were common, and we found a large rough Nudibranch, yellow and grey speckled, under a stone.

I obtained a native dug-out canoe and went across the bay towards Orr's Hill to see some natives diving for trepang in a few fathoms of water. The species were *Holothuria marmorata* (spotted yellow and brown forms) and *H. atra* (black, with a lighter pinkish under-surface). The divers were said to obtain 75 cents (one shilling) per 100 for these.

We next examined a reef of rock and coral lying off the Cutch Co.'s bungalow. Here by wading, or by using the water-glass in the deeper parts, we saw living coral in quantity (chiefly *Porites* and Astræids), much sponge, and many fair-sized pearl oysters attached either to mussels as before or to the rock by their byssus. They appear to extend sporadically across the sand from Powder Island to Orr's Hill. *Pinna bicolor* and *P. fumata* were present in the sand and gravel around, and an *Ostrea* on the rocks. We caught a small yellow *Ostracion* amongst the pearl oysters. Undoubtedly this spot, and the ground round Powder Island and the shoal at end of Nicholson's Cove are the best spots in Trincomalee for the cultivation of the pearl oyster. The bottom is suitable, and apparently the animals live naturally and grow fairly well there. Most of the other bays and creeks we examined are useless because of the large amount of mud present. We deposited in the harbour a number of living pearl oysters brought round from the Gulf of Manaar. They were enclosed in a wire cage anchored and buoyed at a spot duly recorded outside Little Powder Island. Mr. HORNELL will examine these on his next visit to Trincomalee.

Of the pearl oysters collected at Powder Island and on the reef off the Cutch Co.'s bungalow, 33 were at once examined as to the sexual condition—18 were males, 11 females, and 4 quite immature. The males ranged in size from $1\frac{7}{16}$ inch to $2\frac{1}{4}$ inches, and the females from $1\frac{5}{16}$ inch to $2\frac{1}{2}$ inches. Some of these were ripe, and we fertilised some ova with the spermatozoa.

On the following afternoon we examined the shore in the other direction (south), between the wharf and York Island, by means of small boat and wading. Here we came again upon rock oysters, small land crabs and a large *Ligia*, also living corals and *Pinna*. The bottom round York Island and towards the rocks near the Admiral's house is hard and seems suitable for pearl oyster cultivation; we found several dead pearl oyster valves on the shores of the island.

On the whole Trincomalee presents several distinct advantages as a locality in which experiments in pearl oyster cultivation might be carried on; but on the other hand it has several disadvantageous characters. As to the first, the pearl oyster already lives there in a healthy state, and sometimes, at least, produces pearls. Secondly, the locality is protected from the monsoons and sheltered in all weathers, so that work and observations could be carried on at all times of the year. Thirdly, there are several places in the bay where the bottom is hard and seems suitable for the attachment of pearl oysters. The greater part of the area is, however, very muddy; it is said that large quantities of clay are washed down by the rains, the specific gravity of the water is rather lower than that usually found in the Gulf of Manaar, and, so far as our observations show, the plankton or microscopic life floating in the water is relatively small in amount and that will probably mean poor feeding for the larger animals. The pearl oysters we found at Trincomalee struck us as looking rather dwarfed or poorly nourished, and they were found to be sexually mature at a much smaller size than was the case with those of the Gulf of Manaar. Hence while experiments might be carried out at Trincomalee when impossible elsewhere because of weather, the conditions of water and food are probably not so favourable as in the Gulf of Manaar and would probably not lead to such active growth and shell (including pearl) formation.

The greater part of our last day (February 11th) at Trincomalee was devoted to the examination of Lake Tamblegam, an enormous shallow sea-water area opening by a narrow entrance from Great Bay. The sea-temperature at 7.20 A.M. in Great Bay, off the entrance to Tamblegam, was 78° F. and the specific gravity 1·0166; at 9 A.M. in Lake Tamblegam the temperature was 80° F. and the specific gravity 1·0145; at

7 P.M. in Trincomalee harbour the temperature was 78° F. and the specific gravity 1·0202. The entrance to Tamblegam is obstructed by a long curved sand-spit on the south and a number of scattered rocks and reefs on the north, so the steamer was unable to get within a mile or more of the channel. From there we sailed in the ship's gig with a strong easterly wind which carried us into the lake in fine style, but gave considerable trouble when we tried to return in the afternoon. The passage was found to be too narrow and too much obstructed to beat out against the wind, and when we lowered the sails and started to row out through the breakers now coming in from Great Bay, first one and then a second of the six oars broke, followed by the snapping off of one of the brass rowlocks at a critical moment. The boat then made way very slowly, dodging where possible behind the rocks at Noddi Tevu, and so eventually got through the worst of the sea and out of the narrow channels into the open bay.

Lake Tamblegam has long been known as the scene of a fishery of the flat thin "window-shell" oyster, *Placuna placenta*, a remarkable form (see fig. 4) in which

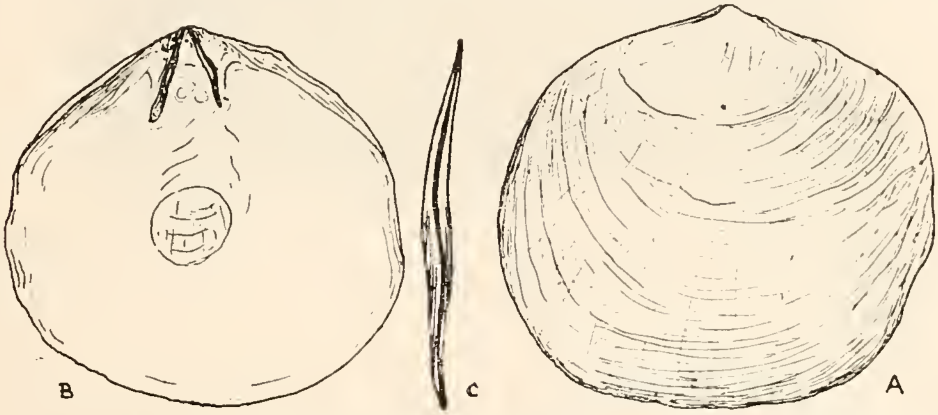


Fig. 4. *Placuna placenta*, from Lake Tamblegam; half natural size. A, outside of shell; B, inside; C, edge view.

an exceedingly thin body is contained—or compressed—between two almost flat discoidal valves of considerable size (up to 6 inches across) which can easily by scraping off the outside be rendered at least translucent to light, and are said to be used as window-panes in Chinese huts and at Goa. Pearls are not unfrequently found in these window-shell oysters and profitable fisheries have been held in the past at Tamblegam. The pearls are mostly small and these are said to be exported to India to be calcined to make chunam for betel-chewing. We did not on this visit see any living specimens of *Placuna*, although Mr. Hornell has seen them since; but the great gleaming piles of dead shells seen at various points along the shore (fig. 5) were evidence of the enormous numbers that had been taken in the former fisheries, and especially at the last fishery fifteen years ago, when the stock in the lake seems to have been nearly cleared out. There were also in places heaps of piled up rock-oysters (*Ostrea* sp.), some of very large size. These, as well as a large species of *Venus* and a mauve *Psammobia*, are used as food by the natives. The whole lake, measuring more than 20 miles round, is very shallow, most of it being under a fathom in depth. On the southern coast we found there was not enough water to row round near the shore in the ship's boat, so we crossed to near Corrinjahvat in the north

Fig. 5. Heaps of window-shell oysters (*Placuna placenta*) on the shores of Lake Tamblegam, from the last fishery.

where great piles of *Placuna* valves line the shore. We took a few hauls of the dredge here in about 1 fathom of water, and also dredged across the mouth of the inlet known as Narche Coudar (fig. 2, p. 31). In both spots (the whole of Lake Tamblegam may be regarded as Station XXXI.) the bottom was mud with a little sand, and there were few animals:—some worm tubes, a few small Medusæ, a flat Clypeastroid and some Pagurids in Gastropod shells.

The bad weather, and a knowledge that the difficulty we should have in getting out would be increased with delay, prevented our spending longer time in Tamblegam Lake, and unfortunately fully as many days as could be spared had now been given to the Trincomalee district. But I arranged with Mr. Hornell that after my departure from Ceylon he should take an early opportunity of visiting Trincomalee and Tamblegam by land, and by making use of native fishermen and divers from the shore, satisfy himself as to any of the matters which we had left undecided.

The main points on which I wished him to get further evidence were:—

(1.) Whether the water of the harbour differed much in muddiness and salinity at other seasons;

(2.) Whether the commercial sponge which we had found lived in any easily accessible spot in sufficient quantity to constitute a fishery;

(3.) Whether the window-shell oyster was still present in abundance in any part of Lake Tamblegam.

Mr. HORNELL carried out these instructions in October, 1902, when he spent a week at Trincomalee and made a thorough examination of Tamblegam Lake. He was successful in settling, I think, all the points referred to him. He found that the specific gravity of the water varied about 1·019, at a temperature of 84° F. to 90° F. But he was told this had been an unusually dry season at Trincomalee.

With the help of native divers he found the bath sponge living in quantity, of good size and suitable form, in a few feet of water along the shores of Plantain Point and in Yard Cove. I have examined the specimens he sent to Liverpool and have shown them to Professor ARTHUR DENDY, our leading specialist on the subject. Professor DENDY determines them as *Euspongia officinalis*, the common bath sponge, and describes the samples we had before us as being a fairly good, compact, resilient bath sponge, but containing a certain amount of grit in the form of broken foreign spicules in the primary fibres. He adds: "The possibility of establishing a sponge-fishery is worth consideration."

Mr. HORNELL examined a number of pearl oysters from round Powder Island and elsewhere in the harbour. They had increased in size since our visit in February but were not so numerous.

In his visit to Tamblegam (Station XXXI.) he found the temperature of the water varied from 87° F. to 90° F. and the specific gravity from 1·016 to 1·019. Amongst the animals he obtained were:—

Tetractinellid sponge (a curious Suberitid species which lives anchored in the soft mud by silky tufts of spicules, and the presence of which is regarded by the divers as an indication of *Placuna*);

Sagartia sp. (on *Cassis*) and a (?) Cerianthid (in tube);

Various crabs, including a burrowing form with scarlet antennæ;

Venus sp. (collected as food by natives near mouth of Kinnia River), *Psammobia* sp. (mauve, eaten by natives), *Placuna placenta*, Trochoid shell (abundant). *Ostrea* sp. (rock oyster).

We left Trincomalee on the night of February 11th, for Galle, and the following morning at 10 A.M., when 30 miles south of Batticalloa, found the sea-temperature to be 78° F. and the specific gravity 1·0215. We took a haul of the dredge (Station XXXII.) some distance further on, off the south-east of the island.

STATION XXXII.—Five miles East of Arugam Bay; depth 17 fathoms; bottom fine sand.

Solenocaulon tortuosum and other Alcyonaria;

Astropecten (two species);

Serpula actinoceros:

Ampelisca macrocephala, Pagurids;

Cassis glauca and a few other Molluscan shells.

A TOW-NET gathering taken at the same time yielded 26 species of Copepoda along with *Trichodesmium erythræum*.

Another haul of the dredge was taken further on at—

STATION XXXIII.—Halfway from Arugam to Little Basses, about 4 miles from land; depth 18 fathoms; bottom dead shells and Nullipore.

Axinellid sponge (large, orange, branching, gorgonid-like form, which is probably a new genus);

Solitary corals, *Plexaura indica* and some other Gorgonacea;

Rhinobrissus pyramidalis (?), various Ophiuroids;

Ampelisca macrocephala, and other Amphipoda.

We reached Welligam (or Belligama) Bay, near to Dondra Head, the most southerly point of the island, in the early morning of February 13th. One of the points I had to determine during this preliminary survey of the marine biology of the Ceylon coast was the most suitable spot for a small marine laboratory in which Mr. HORNELL could continue our work at the pearl oysters during the monsoon after I left. All naturalists know of Professor HAECKEL's visit to Ceylon in the winter of 1881–2, and of how he carried on shore and pelagic work for some months at the southern end of the island, and especially at Welligam (the "Bella-Gemma" of the enthusiastic German professor), where he found congenial quarters, ideal natives and an interesting fauna. His happiness in his general surroundings is reflected in his glowing description of the bay as a zoological paradise. Hearing that I was going to Ceylon, HAECKEL kindly wrote pressing "Bella-Gemma" upon my attention as an ideal spot for a biological station. He also very fairly mentioned Trincomalee as a place where his friends Dr. PAUL and Dr. FRITZ SARASIN had worked but which he did not himself know. Welligam looked charming on land, but seemed to us to have a poor bottom fauna compared with either Galle or Trincomalee. HAECKEL however worked mainly, if not wholly, on the surface animals collected with the tow-net; and these no doubt, so far as the oceanic forms are concerned, are much the same as at Galle.

While the "Lady Havelock" lay at anchor in Welligam, we went off in the boat and had seven hauls of the dredge scattered fairly over the bay so as to adequately sample the ground. As all parts seemed alike in character and fauna I propose to unite them as—

STATION XXXIV.—Welligam Bay, various parts; depths 2 to 7 fathoms; bottom shell-sand and a little mud; sea-temperature at 7 A.M. 77·8° F., specific gravity 1·0225; dredged.

Orbitolites complanata, *Polytrema miniaceum*, and small sponges;

Hydractinia sp., small Gorgonids;
Echinodiscus auritus, *Lovenia elongata*, *Antedon* sp.;
Glycera lancadivæ, *Serpula* sp., and some other small worms. Lepralid Polyzoa;
Ampelisca brevicornis, some Pagurids and small crabs;
Turritella duplicata, *Philine* sp. and many dead molluscan shells;
Molgula sp. (small), *Amaroucium* sp. and Amphioxus* (2).

We landed at the south-eastern corner of the bay, near the fishing village of Mirissa, which seemed the most promising part—zoologically—as it may possibly be a little sheltered from the south-west monsoon, and examined a good deal of the beach and of the shallow water near from the boat. There are red cliffs of coarse gneiss at the extremities of the bay, which no doubt give it its chart name "Red Bay." Pagurids of several species, some inhabiting the shells of Helix and other land Molluscs, were very common on the upper part of the beach and in the cocoa-nut plantations beyond. A crowd of several dozen were found congregated upon a small heap of dung evidently feeding. Others were sheltering in numbers about the roots of the trees. A *Pterocera* shell (*Pt. lambis*) was found on the beach, small Limpets were abundant on the red rocks at the point, and many long-spined purple Echinids (*Stomopneustes variolaris*) were in hollows in the rock pools, and also under the sea in cavities and crevices of the rock. Living Corals were seen from the boat in the shallow water just inside the point.

On the whole this was a disappointing bay. There is no place where experiments in the cultivation of the pearl oyster could be carried on. There is no ground where we could expect to find the animal, or where it would probably be able to live. The bay is open to the full force of the south-west monsoon, and this would introduce difficulties in collecting and other biological work during a great part of the year. It is unsuitable both for the general work of a biological station and also for the special purposes of the pearl oyster investigation.

We went on the same night to Galle—the last of the localities round the coast which I had noted for comparison with the Gulf of Manaar.

Altogether five days were spent on this occasion investigating Galle and its surroundings, and another visit of several days was paid later on, in March.

February 14th was spent in dredging in the bay, and shore-collecting;
February 15th in dredging near Watering Point, and shore-work;
February 16th in examining the Coral reef and the lagoon (see fig. 6);
February 17th in dredging off entrance to Galle Bay and neighbourhood;
February 18th in dredging and trawling in deeper water outside Galle and onwards.

On February 14th we had several hauls of the dredge in the entrance to the bay, between the points, which may be united as—

* Probably *Branchiostoma lanceolatum*, but the specimens have apparently not been preserved.

STATION XXXV.—Entrance to Galle Harbour, near the black buoys and Mata-Mada Rocks; depth $4\frac{1}{2}$ to 7 fathoms; bottom coarse sand; sea-temperature, at 6.30 A.M. 78·5° F., at 9.30 A.M. 79° F.; specific gravity 1·023; dredged.

Calcareous sponge (*Clathrina* sp.), *Hymeniacidon* sp.;

Diphasia mutulata;

Glycera sp., *Leanira* sp.;

Ampelisca brevicornis, Hippa asiatica, and several Brachyura;

Pteropods, and some shells of the genera *Cucullæa, Ostrea, Anomia, Turritella:*

Branchiostoma lanceolatum.

Fig. 6. Sketch chart of Galle Bay, showing Stations XXXV. to XLI., the Coral reef, Lagoon, position of the Biological Station (B.S.), &c.

Four hauls of the dredge taken in the afternoon and evening near Gibbet Island and the Kata Rocks may be united as—

STATION XXXVI.—Galle Harbour, off Gibbet Island and Glosenburg from Kata Rocks inwards; depth 2 to $4\frac{3}{4}$ fathoms; bottom fine sand and mud; dredged.

Some sponges, and *Hydractinia* sp.;

Nereis foliosa, *Glycera* sp., *Serpula quadricornis*;

Ebalia sp. and other small crabs;

Shells of *Dentalium octagonum*, *Eburna canaliculata*, and other Molluscs;

Leptoclinum sp., and *Branchiostoma* (*Dolichorhynchus*) *indicus*.

Halobates was seen on the surface in quantities during the afternoon, and a tow-net gathering taken in the evening, after dark (about 9 P.M.), contained *Corycæus obtusus*, *Labidocera paro* and *L. kroyeri*, *Pseudodiaptomus serricaudatus*, and a new species of *Centropages*. On the following evening, after dark, we again got very much the same series of Copepoda.*

In the little bay between Gibbet Island and Glosenburg (fig. 7) the bottom is fine sand, ripple-marked, and with occasional boulders. The entrance is bounded by a chain of submerged rocks covered with Algæ and Corals. The bottom and sides are not unsuitable as a locality for biological experiments when in the condition in which we saw them, but the situation is exposed, and there is probably a heavy surf rolling into the little bay during the south-west monsoon. We examined this bay and also the creek behind Gibbet Island with some care, as the locality had occurred to us as a possible position for the biological laboratory, and moreover HAECKEL in his book on Ceylon had strongly recommended it for the purpose (see below, pp. 46, 47).

On February 15th we examined the south-eastern corner of the bay inside Watering Point, both by dredging and on shore. The hauls are united as—

STATION XXXVII.—North-west to north-east of Watering Point, about 200 yards off shore; depth 7 fathoms; bottom fine dark sand with some broken coral in places. Nearer the shore, inside Watering Point, are small coral reefs.

Various Alcyonaria and living Corals, chiefly Madrepores;

Synapta sp. (?) and *Holothuria atra*;

Filograna sp. and *Leucodore* sp.;

Calappa sp. and some Ebalid Crabs, *Hippa asiatica*, and some Pagurids;

Margaritifera vulgaris (dead shells).

We then landed at Watering Point to examine the shore, and were struck by the filthy and insanitary condition of the water which was then being pumped into water-boats to supply ships, from the old Portuguese tank. We explored the beach in both directions, and also the cliffs above, and, from the boat, the shallow water lying off the beach, with a view to reporting on this corner of the bay as a possible site for our marine laboratory. The advantages are the shelter and protection from the monsoon afforded by the headland, purity of the sea-water, and the presence of hard patches at the bottom in places where there is a fringe of living coral, and where we had found evidence of a few pearl oysters living naturally. The disadvantages are however very serious, viz., the complete isolation and the comparative inaccessibility.

* Mr. HORNELL, tow-netting at Galle since, has obtained these same Copepoda with the addition of *Calanopia elliptica*, *Acartia centrura*, *Labidocera detruncata* and a new species of *Lichomolgus*.

During the monsoon it might often be difficult to reach this spot by boat across the bay, and the distance round from the town of Galle by land is considerable (see fig. 6), and the latter part of it steep and with no proper road.

The possible sites at Galle had seemed to be :—

(1.) In the Fort, where the Government offices and European quarters are situated (fig. 6).

(2.) On Gibbet Island or Glosenburg, in or about Bayley's Villa or the neighbouring native village (fig. 7).

(3.) At Watering Point (fig. 6).

We now ruled out the last; and made a further examination of Gibbet Island. This is much nearer the town, and has a good road leading to it. Some of the

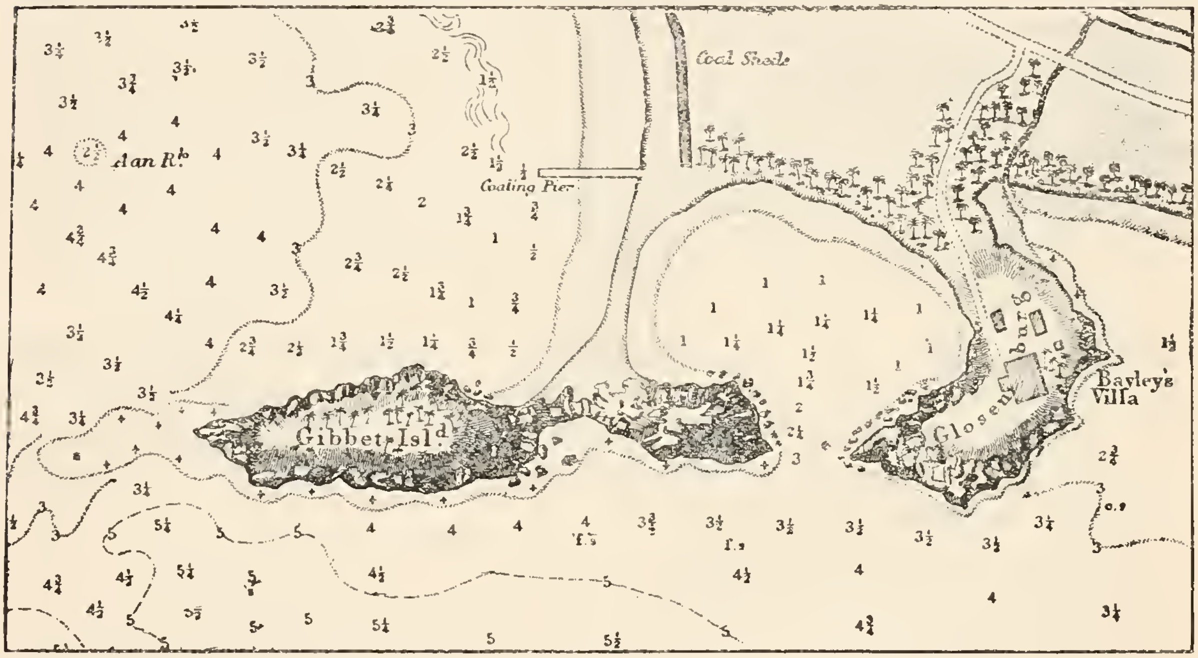


Fig. 7. Gibbet Island, Glosenburg and neighbouring creeks, in Galle Bay, showing the position of Bayley's Villa, recommended by Professor E. HAECKEL, in 1881, as the site of a Biological Station.

old P. and O. Co.'s quays and walls would no doubt lend themselves well for adaptation as tanks; but, as I have shown above, it is quite a question whether work would be possible in either of the adjoining creeks during the height of the monsoon, and whether therefore this locality presents any advantage over the Fort, which would be more convenient and satisfactory in many ways for European workers.

Professor HAECKEL writing, in 1881, his opinion of Galle as the site for a Marine Biological Station says*: "But more attractive to me . . . were the magnificent corals,

* English translation—'A Visit to Ceylon,' Kegan Paul, &c., London, 1883, p. 181.

which grew in extraordinary abundance on the surrounding rocks; even the little inlet used by Captain Bayley as a dock for his boat, and the stone mole where we disembarked, were closely gemmed with them, and in a few hours I had added considerably to my collection of corals. A very large proportion of the multifarious forms of animal life, which are distributed over the coral reefs near Galle, were to be seen crowded together in this narrow space—huge black sea-urchins and red starfish, numbers of crustaceans and fishes, brightly coloured mollusca, strange worms of various classes, and all the rest of the gaudy population that swarms on coral reefs and lurks between the branches. For this reason, Captain Bayley's bungalow . . . is particularly well-fitted to be a zoological station, and is only half an hour's distance from the conveniences of the town."

However, after full consideration, we differed from our German friend and decided to recommend a site in the Fort as the best position at Galle (see below, p. 92).

On two of these days we landed with a party of our Maldivians carrying ship's buckets, and, crossing the town, descended the ramparts of the Fort between "Triton" and "Neptune" Bastions (see fig. 6), in order to collect on the coral reef which fringes the shore along this side of the town, and in order to examine the possibilities of the lagoon inside the reef for purposes of pearl oyster work. The reef there runs at an average distance of about 500 feet from the shore, and the lagoon varies in depth at low tide from 1 to 6 feet. It is possible to wade over the greater part of it at a depth of 18 inches or 2 feet. The collecting is very rich, and the colouring gorgeous. Many common genera of Corals, such as *Madrepora*, *Montipora*, *Pocilopora*, and *Galaxea*, greenish-brown *Meandrina*, vivid grass-green *Astræa* or *Favia*, and others abound, but even more conspicuous in many parts of the lagoon are huge colonies of the massive leathery or slimy Alcyonaria belonging to the genus *Sarcophytum* and its allies *Sclerophytum*, *Lobophytum*, *Sinularia* and *Alcyonium*. We obtained about twelve species of the fleshy Alcyonaria in the lagoon, including *Sarcophytum ehrenbergi*, *Sclerophytum polydactylum*, *Sel. durum*, *Sel. densum*, *Lobophytum hedleyi*, *L. pauciflorum*, *L. densum*, *Alcyonium pachycladis*, and about four other species some of which are probably new to science. Amongst the other fixed forms Nullipores and incrusting Polyzoa are much in evidence forming smooth layers, filling up crevices and cementing together the separate coral colonies, branches and broken masses. STANLEY GARDINER has shown the importance of Nullipores in the formation of reefs. I am inclined to think from what I saw at Galle and also on the coral formations in the Gulf of Manaar that incrusting calcareous Polyzoa play at least as important a part in covering and consolidating the fragile, broken, or decaying coral colonies. The more abundant and characteristic Algæ (other than Nullipores) growing over the dead corals on this reef are: A small *Corallina*, three species of *Caulerpa* (probably *C. racemosa*, *C. plumaris*, and *C. sedoides*), *Halimeda tuna*, *Padina commerssonii*, *Peysonnelia rubra*, and the lace-like *Vanvoorstia spectabilis*. Bright green Zoanthids, one a long cylindrical form with two rows of tentacles, and compact masses of *Palythoa caribbæa* are also conspicuous. Even the compound Ascidians (Botryllids and Leptoclinids) are of a brilliant green colour. The Tunicate fauna of Galle includes a common *Ascidia* allied to *A. depressa* of European seas, a small red *Cynthia*, a dark brown *Ascidia* like *A. fumigata* of the Mediterranean, a dull-grey Polyclinid (? *Amaroucium*), and about half-a-dozen species of Leptoclinids, one of a lilac colour, one of a rich green, one of a very dark brown, several white and grey forms, and a large handsome new species with pinnacled upgrowths mottled black and white, which I propose to describe under the name of *Leptoclinum im-thurni*. Turning to non-colonial and more or less wandering animals, a feature of the lagoon is the huge black, brown and mottled Holothurians, which lie about on the coral sand and the commoner forms of which (*Holothuria atra*, *H. marmorata*, *H. vagabunda* and *H. tenuissima*) are fished as "trepang." Some others (*Actinopyga mauritiana*) have a flattened under-side and are coloured conspicuously black and white; and we were fortunate in finding three species which have been described as new by Mr. PEARSON, viz., *Thyone hornelli*, *Actinopyga serratidens* and *Holothuria gallensis*. Long-spined purple Echinids, large Ophiuroids, star-fishes, and other Echinoderms are found. There are Turbellaria, including a beautiful white species with black mottling which, Mr. LAIDLAW tells me, will require a new genus near to *Discocelis*. The Polychæte worms include spinous Polynoids, a large olive-green *Loimia*, *Eurythoe latissima*, *Onuphis maculata*, *Notocirrus trigonocephalus*, *Cirratulus* sp., a small speckled *Polymnia*, a huge *Sabellaria* (*S. bicornis*), *Spiochætopterus herdmani*, n. sp., HORNELL (under stones), species of *Amphinome*, *Nereis*, *Syllis* (with buds), *Sabella fusca*, *Lepidonotus crispatus*, *Ophryotrocha*, *Amphitrite*, *Pista*, and others. We got an orange-red Nemertine, and a white species with red lines; also a pale yellow *Balanoglossus* in the calcareous sand under stones. There were many Pagurids—one a brilliant species with scarlet facings, and having the chelæ and other limbs barred with light blue and black alternately. The Amphipods we collected in the lagoon include, Mr. WALKER reports, *Hyperia galba*, *Hyperoche cryptodactylus*, *Leptophoxus uncirostratus*, *Stenothoe monoculoides*, *Erichthonius abditus*, *Platophium* sp., *Mæra rubromaculata*, and a new species of *Ampelisca*. Amongst the numerous Molluscs are *Cypræa moneta*, *C. mauritiana*, a *Pleurobranchus*, an orange *Doris*, an *Aplysia*, an *Octopus*, *Harpa conoidalis*, *Pleurotoma nodifera*, *Nerita* sp., *Terebra* sp., several other Cowries and Cones, *Callochiton platessa*, and a new species of Chiton which Mr. SYKES has described as *Ischnochiton herdmani*. There were numerous brilliantly coloured fishes, including the curious little *Antennarius marmoratus*, LESS.

This, of course, does not attempt to be a complete list, but merely to give some idea of the variety and abundance of the shore fauna at the spot which we eventually selected as the best in Ceylon for a Marine Biological Station.

On February 16th, at 8 A.M., in Galle harbour, the sea-temperature was 79° F., and the specific gravity 1·023. On February 17th, at 7 A.M., off Watering Point, the sea-temperature was 78·8° F., and at 6 P.M., at the same place, it was 80° F. At both times the specific gravity was 1·023. On this latter day we dredged and trawled outside Galle Bay, beginning at the south-east off Watering and Unawatti Points and working westward to the Gallehogalle Bank. The first three hauls of the dredge may be considered as Station XXXVIII., on the eastern side of the entrance to the bay, while the remaining three hauls along with three hauls of the trawl form Station XXXIX., to the westward, up to Gallehogalle Bank.

STATION XXXVIII.—Outside Watering Point and Unawatti Point, from $\frac{1}{2}$ a mile to $1\frac{1}{2}$ miles off land; depth 9 to 22 fathoms; bottom sand and mud with many shell fragments; dredged.

Halicornaria saccaria, *Gorgonia* sp., *Spongodes* sp.;

Spatangoid, *Clypeaster humilis*, and *Echinodiscus auritus*, *Astropecten polyacanthus* (?), *Ophidiaster cylindricus;*

Thalenessa im-thurni, n. sp., *Glycera* sp., *Hyalinœcia* sp., and Worm-tubes;

Portunids and other Crabs, some Macrura;

Strombus sibbaldii, *Eburna canaliculata*, *Oliva gibbosa*, *Philine* sp., and *Arca compacta;*

Molgula (small species);

Branchiostoma lanceolatum (at 9 fathoms, several), *B.* (*Dolichorhynchus*) *indicus* (at 9 fathoms).

STATION XXXIX.—From 2 miles south of Point de Galle westwards to Gallehogalle Bank; depths 16 to 30 fathoms; bottom fine sand; stones and Nullipore on the bank; dredged and trawled.

Polytrema miniaceum and other Foraminifera;

Stephanoseris rousseaui, *Spongodes*, *Eunephthya* and Gorgonids (sev. spp.);

Astropecten hemprichii, *Stellaster* sp., *Salmacis bicolor*, *Lovenia elongata*, *Echinodiscus auritus*, *Clypeaster* sp., and *Antedon* sp.;

Serpula actinoceras, Polyzoa (many);

Squilla, *Gonodactylus*, *Alpheus*, Amphipods and Isopods, *Pontonia*, various Pagurids and Crabs (one infested by *Sacculina*);

Philine sp., *Strombus sibbaldii*, *Sepia* sp., *Sepiola* sp.;

About 1350 Fish—of which 500 were small flat fish belonging to about 5 species and ranging from $\frac{1}{2}$ inch to 4 inches in length, most being from 2 to 3 inches:—

Cynoglossus sp., *Rhomboidichthys* (2 spp.), *Arnoglossus* (?), Pleuronectidæ (very many), Gobiidæ (768, from 2 to 5 inches long), *Callionymus candicaudatus* (30, from 2 to $3\frac{1}{2}$ inches long), and *C. sagitta* (50, from $1\frac{3}{4}$ to 3 inches long).

This sandy area lying to the east of Gallehogalle Bank and giving a uniform stretch for some miles at a depth of 25 to 30 fathoms is evidently a fish "nursery," or region where young fishes, both flat and round, belonging to 8 or 9 species and including such valuable forms as "Soles," "Turbot" and "Plaice," congregate in great numbers. In one haul of short duration we obtained about 1350 young fish, including 5 kinds of flat fish.

The Tow-nettings this day (February 17th) were very rich and included :—

Trichodesmium erythræum, *Ceratium*, Radiolaria ;

Various Siphonophora and Ctenophora ;

Sagitta (large), Larval Annelides, and some Syllids ;

Copepoda—Many beautiful species, including *Calocalanus pavo*, *Metacalanus aurivillii*, *Labidocera pavo* and *L. acutum*, *Centropages gracilis*, *Candacia catula*, and *C. truncata*, *Oithona plumifera* (colourless with little plumes of scarlet, and having pale lilac egg masses), and a new species of *Euchæta*—36 species of Copepoda in all ;

Also many larvæ—Nauplei, Zoea, Phyllosoma (many), Erichthus and Alima, larval molluscs and worms ;

Appendicularia, *Doliolum* and *Salpa democratica-mucronata* (large).

On February 18th we left Galle, and spent the day in dredging in the deep water further out than on the previous day, and onwards up the west coast on our way to Colombo. A considerable part of the time was spent on and off the 100-fathom line south of Galle.

At 6.30 A.M. at about 3 miles south of Point de Galle the sea-temperature was 79·5° F., and at 6.30 P.M. when we anchored for the night at $3\frac{1}{2}$ miles south of Barberyn Lighthouse it was 80° F. ; at both times the specific gravity was 1·023.

The day's dredging may be divided into 3 stations—

STATION XL.—About 10 miles off Watering Point, direction south by west ; depth 34 fathoms ; bottom coarse sand, shells, coral fragments, Nullipores and *Halimeda* ; dredged.

Polytrema miniaceum, *Alveolina boscii*, *Orbitolites complanata*, *Heterostegina depressa*, and *Amphistegina lessonii* ;

Tethya sp., some Tetractinellids, *Rhizochalina fistulosa*, and Horny sponges ;

Chironephthya variabilis, *Plexaura indica*, *Briareum* sp., *Solenocaulon* sp., Gorgonids (many), *Cavernularia obesa*, *Lituaria phalloides* and several species of Pennatulids, *Flabellum* sp., *Caryophyllia* sp., *Stephanoseris rousseaui* ;

Hydroids—*Sertularia distans*, *S.* (? n. sp.), *Antennella allmani*, *Zygophylax tizardensis*, *Idia pristina*, *Lytocarpus* (? n. sp.) ;

Clypeaster scutiformis (?) ; *Lovenia elongata*, *Phyllacanthus baculosa* and *Cidaris metularia*, *Echinothrix calamaria* ;

Species of *Protula*, *Glycera*, and *Hyalinœcia* ;

Polyzoa—a large number of species, of which Miss Thornely has already identified the following, *Cellepora cidaris*, *C. boryi*, *C. tritubereulata*, *Flustra spoliata*, *Chorizopora brongniartii*, *Cribrilina radiata*, *Micropora coriacea*, *Smittipora abyssicola*, *Membranipora cornigera*, and also species of the genera *Lepralia*, *Stomatopora*, *Idmonea*, *Cellaria*, *Schizoporella*, *Membranipora*, *Steganoporella*. *Smittia* and *Adeona*;

Galathea sp., *Dromia* sp., and several other small Crabs;

Tonicia pectinoides n. sp. (SYKES), *Turritella* sp., *Ceratosoma*, and other Molluscs;

A red species of *Cynthia* and *Ascidia* sp. (probably both new).

STATION XLI.—South of Galle, about 12 miles off land; depth, along the 100-fathom line; bottom composed of masses of calcareous branched and ramifying Foraminiferal tubes (*Ramulina* sp.); dredged.

Tetractinellid sponges;

Dendrophyllia sp., *Caryophyllia* sp., *Cirrhipathes spiralis*, *Antipathes* sp., Gorgonacea (many— half a dozen species);

Actinocucumis donnani, n. sp. (PEARSON), *Phyllacanthus baculosa*, various Ophiuroids, *Asterina cepheus*, *Stellaster* sp., *Actinometra* sp., *Echinanthus rosaceus*;

Pagurids and small Crabs;

Avicula radiata (living on Gorgonids), *Pleurotoma nodifera*, *Conus* sp., and a few other shells.

STATION XLII.—Off the Coast, about 4 miles south of Barberyn; depth 40 fathoms; bottom muddy; dredged.

Stephanoseris rousseaui (many, with Gephyrea), *Caryophyllia* sp., *Paracyathus* sp. (?);

Echinids (small), *Pentaceros nodosus*, *Astropecten hemprichii*, *Pteraster* sp.;

Aspidosiphon sp., *Pectinaria* sp., and some muddy worm tubes;

Dentalium sp.

On February 19th, at 6.30 A.M., 6 miles west of Kaltura, the sea-temperature was 79·3° F. and the specific gravity 1·023. At 1 P.M. this afternoon we lowered a white enamelled dish measuring 9 inches by 12 inches on the sounding line and found that it was distinctly visible to a depth of at least 17 fathoms—the sky being cloudy and the sea calm.

A good deal of ground was covered during the day (the last of our present cruise), and nine hauls of the dredge were taken between Kaltura and Colombo, at depths of from 20 to 30 fathoms. These may be divided into four stations:—

STATION XLIII.—Six miles due west of Kaltura (or Kalutara); depth 22 fathoms; bottom hard sand with Nullipores; dredged.

Axinella donnani;

Juncella juncea and *Scirpearella* sp., *Epizoanthus* sp. (on *Murex*), *Stephanoseris rousseaui*, and *Heteropsammia michelini* (with Gephyrea), *Flabellum* sp., *Caryophyllia* sp., and other small solitary Corals;

Cucumaria imbricata, *Clypeaster scutiformis*, *Lovenia elongata*;

Aspidosiphon corallicola, *Hyalinœcia* sp., *Pectinaria* sp.;

Melita obtusata, *Mæra rubromaculata*, and other Amphipods, some Pagurids, and some Peneids;

Murex tenuispina, *Terebra* sp., and some Lamellibranchs.

STATION XLIV.—Five miles north-west of last station; depth 30 fathoms; bottom fine sand and worn fragments of Coral; dredged.

Hydroids—*Halicornaria setosa*, and *H. saccaria*, *Lytocarpus* (? n. sp.), *Monostachys dichotoma*, *Idia pristina*, *Sertularia distans*, *Sertularella* sp., *Halecium* sp., and others;

Stellaster sp., *Linckia diplax*, small Temnopleurids, *Clypeaster humilis;*

Clœosiphon aspergillum, *Pectinaria* sp., *Sabellaria bicornis*, and some worm tubes;

Caprellids, *Calappa* sp., Portunids and other Crabs;

Philine sp., *Murex tenuispina* and many other Gastropods;

Molgula sp.

STATION XLV.—Four miles West of Pantura (or Panadure); depth 25 fathoms; bottom sand, shells and dead Corals; dredged.

Various Corals; *Gorgonia*, and *Melitodes;*

Astropecten sp., *Ophiothrix aspidota* and other Ophiuroids;

Hyalinœcia sp. (many), *Thalenessa im-thurni*, n. sp. (HORNELL), *Iphione muricata*, *Lepidasthenia fulvovittata*, *Eunice* sp., *Stylarioides iris*, *Cirratulus* sp., *Serpula actinoceros*, and some worm-tubes;

Various Crabs (not yet determined);

Strombus succinctus, *Malleus vulgaris*, and a few other Molluscs;

Molgula sp.

STATION XLVI.—From off Mount Lavinia northwards to off Colombo, from 7 to 12 miles off shore; depth 25 to 30 fathoms; bottom Nullipore balls (*Lithothamnion fruticulosum*), Coral fragments, and some Orbitolites sand; five hauls of the dredge.

Orbitolites complanata, *Alveolina boscii;*

Rhizochalina fistulosa, *Tethya* sp., and other sponges;

Hydroids—*Sertularia distans*, *Sertularella* sp., *Halecium* sp., *Monostachys dichotoma*, *Idia pristina*, *Halicornaria setosa*, *Lytocarpus* (? n. sp.);

Chondractinia sp., and some sand-encrusted Anemones, *Chironephthya variabilis* (splendid arborescent colony having the axis and main branches white, and the twigs crimson lake), *Solenocaulon tortuosum*, *Juncella juncea*, *Scirpearella* sp., and other Gorgonacea (many), small species of *Fungia*, and other solitary Corals;

Actinometra sp. (dark coloured, on the dark twigs of *Chironephthya*), *Actinometra* sp. (large, orange coloured), Antedon sp. (small), *Phyllacanthus baculosa* (many large), various Ophiuroids, *Laganum depressum*, *Clypeaster humilis;*

Nemertine (red), *Trophonia* sp., Polynoids, *Serpula actinoceros*, *Eunice* sp.;

Polyzoa—(many, including *Retepora* sp., *Cellepora*, *Schizoporella*, *Adeona*, *Gemelli-*

pora, and *Cribrilina*). Most of the Polyzoa are strongly calcareous and brightly coloured (scarlet) forms;

Crabs (porcelain white, two species (?) on the white branches of *Chironephthya*), and other small Crabs;

A new species of *Chiton* (*Tonicia pectinoides*, SYKES), *Harpa conoidalis*, *Strombus succinctus*, *Murex tenuispinus*, *Murex haustellum*, *Conus betulinus*, *Natica mammilla*, *Malleus vulgaris*, *Philine aperta* (?);

Leptoclinum sp., *Rhodosoma* sp., *Styela* sp., *Molgula* sp., *Cynthia* (? n. sp.);

A small banded Sole (*Synaptura cornuta*).

TOW-NET gatherings taken during the day were notable for the abundance of Radiolaria, colonial as well as solitary—*Collozoum* and others, also *Trichodesmium erythræum*, some pelagic planarians, Syllids, Halobates, Tornaria, and the Copepoda—*Centropages furcatus*, *C. gracilis* and *C. tenuiremis*, n. sp., *Calocalanus plumosus*, *Mecynocera clausi*, *Oithona plumifera*, and about 20 others.

Although the depths were greater than that of the paars further north, it is important to note that the bottoms at several of these localities off Mount Lavinia and elsewhere south of Colombo were hard, clean, and apparently very suitable for the attachment of pearl oysters, being largely formed of the same balls of Nullipore (*Lithothamnion fruticulosum*) which characterise the paars in the Gulf of Manaar. It is very probable that this bottom extends into shallower water, and that suitable spots may be found nearer shore upon which the pearl oyster might be cultivated. It is said that a pearl oyster bank once existed off Mount Lavinia.

On the evening of February 19th we arrived at Colombo. In this first cruise in the s.s. "Lady Havelock," in addition to making a preliminary survey of the more important pearl oyster banks, we had sampled the bottom conditions and the fauna at various points round the island, and had made a special examination of the several localities (Palk Bay, Trincomalee and Galle) to which our attention had become directed. We had also considered these last and other localities very carefully with the view of choosing the best site for a small marine laboratory in which to carry on investigations and experiments with the pearl oyster. Our conclusion at the end of the cruise was that of all the places seen in coasting round the island only two would be at all suitable for this purpose, viz., Trincomalee and Galle.

Of these, Trincomalee has the distinct advantages of (1) complete shelter from the monsoons, and (2) natural beds of pearl oysters living in the harbour; but on the other hand the following may be noted as more or less serious objections:—

(1.) The specific gravity of the water is low, between 1·019 and 1·021 as compared with 1·023, the usual reading in the Gulf of Manaar;

(2.) The plankton at the time of our observations seemed sparse compared with that at Galle and in the Gulf of Manaar;

(3.) The distance, and therefore the time necessary in taking live oysters round, from the Gulf of Manaar is much greater. In the case of Trincomalee a steamer such as the "Lady Havelock" would take about 30 hours from the Cheval Paar, while Galle could be reached in about 18 hours;

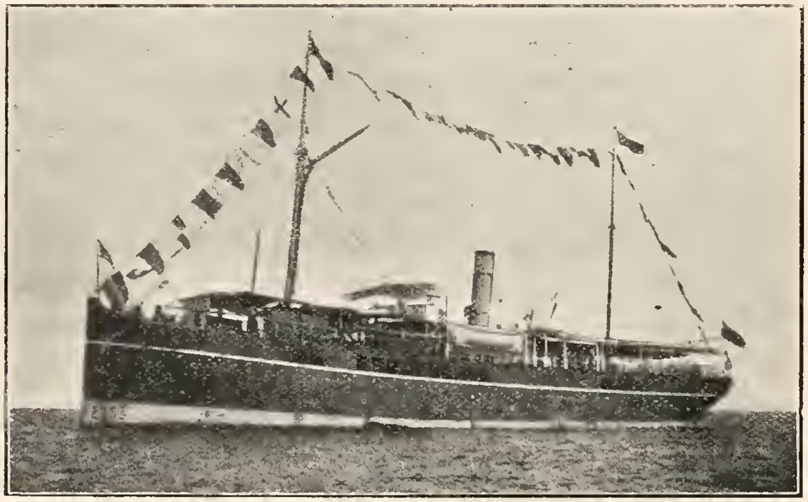
(4.) The bottom is muddy and is, in most parts, unsuitable for oyster culture, and the water is not comparable in purity with that in the Gulf of Manaar. Consequently it is probable that although some oysters may live at Trincomalee, they will not grow so rapidly and healthily as on the pearl banks;

(5.) The difficulty of access from Colombo and the distance from the scientific libraries and museum would be a real disadvantage to naturalists working continuously at Trincomalee;

(6.) Finally, for a Marine Station where ordinary biological investigations would be conducted, Galle presents a richer general fauna than Trincomalee, and has the additional special advantage of a coral reef and lagoon where collecting and observation can be easily carried on.

Galle as a locality no doubt also presents some disadvantages, the worst of which is that the bay lies open to the south-west monsoon; still there is the lagoon, parts of which could no doubt be made use of. The other advantages, the purity of the water, the richness of the plankton, the shortness of the journey from the Gulf of Manaar and the convenience of proximity to Colombo, render Galle, in my opinion, much the best site in Ceylon for a Marine Biological Station, and these eventually caused us to fix there our temporary laboratory, in which Mr. HORNELL was to carry on his work after I left the island.

I was asked, however, before deciding finally, to consider various spots in the Gulf of Manaar, such as Aripu, Chilavaturai, Kodramallai and Manaar, all on the shores of the pearl oyster region, and these I visited during our second cruise in the "Lady Havelock."



The s s. "Lady Havelock," employed by the Ceylon Government for the pearl oyster investigation, February and March, 1902.

SECOND CRUISE.

On returning to Colombo, from this first cruise, for the purpose of joining Captain DONNAN, the Master Attendant of Colombo, in his inspection of the pearl oyster banks, I saw for the first time the native barque "Rangasameeporawee" and the steam-launch "Serendib," and on examining them critically it was obvious, both to myself and to the ship's officers who were with me, that neither vessel would be able, without considerable changes, which could not be effected in time, to carry on the work which I still had to do. On pointing this out to Captain DONNAN, he agreed with me, and when we waited upon the Lieutenant-Governor and represented the matter to him, he promptly authorized us to arrange for the engagement of the "Lady Havelock" for a further period of three or four weeks, as might be necessary, from 24th February. Thus it resulted that the "Lady Havelock" accompanied the two native barques "Rangasameeporawee" and "Sultan Iskander" and the s.s. "Serendib" to the Gulf of Manaar, where, in addition to carrying on my special work, she was on occasions of service in towing Captain DONNAN's barque and so saving some valuable time.

This second cruise of the "Lady Havelock" lasted from 24th February to 20th March, inclusive, three weeks and four days. During the greater part of that time our steamer kept near to Captain DONNAN's barque, and we accompanied him in his inspection of the banks. Not only had we thus the full advantage of the various vessels and their crews by means of which to obtain specimens and information, but Mr. HORNELL and I were also able to talk over the work daily with Captain DONNAN and his successor, Captain LEGGE. Later on we were joined by Sir WILLIAM TWYNAM from Jaffna. That gave a unique opportunity of hearing from these two veteran inspectors and investigators about former conditions of the various banks and details of the past history of the pearl fisheries.

During this cruise the early morning and forenoon were usually occupied in following the operations of the divers, and in examining and recording the material brought up from different parts of the various "paars." About midday, when the divers ceased work, we started off in the "Lady Havelock" to dredge the neighbouring grounds between the oyster banks, or on parts of the paar in regard to which we wanted further information. In this way, beginning in the north of the district of Aripu, we examined the large and important East and West Cheval banks and the Periya Paar and several smaller banks lying some to the north and some to the south. We also, when in that neighbourhood, landed at various parts of the coast in the endeavour to find a suitable spot for a small Marine Laboratory, from which oyster culture and experiments could be conducted close to the banks. We tried Manaar, Aripu, Chilavaturai, Kodramallai, and later on the shores of Portugal and Dutch Bays, but without success. We could find no spot on the shores of the Gulf of Manaar that seemed suitable for the purpose, and none certainly with the natural advantages of Galle. On several occasions we, in the "Lady Havelock," left Captain DONNAN and the barques for a couple of days in order to run lines of dredgings across some of the deeper or more remote parts of the region, especially to the north and west.

Our journal of this cruise is as follows:—

We left Colombo on the afternoon of February 24th, having the barque "Rangasameeporawee" in tow. At 7 P.M., when off Negombo, the sea-temperature was 79·8° F. and the specific gravity 1·0235. The following morning, at 7 A.M., off Kalpentyn Island, the temperature was 79° F. and specific gravity 1·023; while at 7 P.M., when we anchored at 2¾ miles south-south-west of Chilavaturai, the temperature was 80·8° F. and the specific gravity 1·022—these temperatures being about 2° F. higher than we had found in the same sea three weeks before.

A tow-net gathering was taken at 5 miles north-north-west of Kodramallai Point. It contained a great quantity of the zoeas of Crabs, some new green Copepods (*Pontella danæ*, n. var., *Labidocera*, n. sp., and *Pontellopsis*, n. sp.), Sagitta, Lucifer, larvæ of Gastropods and Lamellibranchs. There were also many green filamentous Algæ, about 20 other Copepoda (*Eucalanus subcrassus*, *Rhincalanus cornutus*, *Ilyopsyllus affinis*, and *Centropages*, n. sp.) and many diatoms. One large bluish-green Copepod (the new *Pontellopsis*) had a plate-like radially marked mass of spermatophores on its hinder end (genital segment) which was so conspicuous as to be visible to the naked eye as a yellowish patch.

We went ashore at Chilavaturai, running in as far as we could in the "Serendib" and then in the ship's boat. Where the "Serendib" stopped, in 13 feet of water, the screw stirred up quantities of delicate red Algæ (*Hypnea musciformis* and *Polysiphonia* sp.) and very fine filamentous green stuff (*Cladophora* sp.) such as we also found growing in some parts of the Cheval Paar, and to which the minute oyster spat commonly becomes attached. These Algæ apparently grow on a coarse sandy bottom in various parts of the district.

Chilavaturai is famous in the annals of the Ceylon pearl fisheries as having always been the site of the fisheries camp during British times, except in the case of the small fishery of 1832 and the three fisheries of the Muttuvaratu Paar in 1889, 1890 and 1891. Sir W. TWYNAM and Captain DONNAN have shown however that there are reasons why Marichchukaddi, about 10 miles further down the coast, would be, in some respects, a better site for the camp in future fisheries of these northern paars.

Chilavaturai was one of the spots to which attention had been directed as a possible locality for the marine laboratory, and we consequently examined some empty rooms which adjoin the Rest-house; but found them inconvenient and in poor repair. They might no doubt be adapted to the purposes of a scientific workshop if the locality were suitable in other respects; but the shore is an impossible one.

We then steamed along the coast to Aripu, about 4 miles further north, where I had been asked to examine an empty government bungalow. This had four large, lofty rooms, a fine broad verandah and a large walled compound. Beside it were still to be seen fragments of the ruins of the old Dutch fort, to which our countryman ROBERT KNOX made his way in 1679, when he escaped from Anuradhapura, after 20 years' captivity in the hands of the King of Kandy. This bungalow, so far as the house goes, could be made a perfectly suitable residence and workshop for the marine biologist were the locality suitable in other respects—but it is not.

At Aripu we visited the ruins of the "Doric," a classic structure often referred to in the reports of the pearl fisheries, and which we had been using as a landmark. It was built by Lord GUILDFORD a century ago, as the official residence of the Governor when he attended a fishery, but being unused it later on fell into ruins. It has always served however as a useful and conspicuous object from which to take

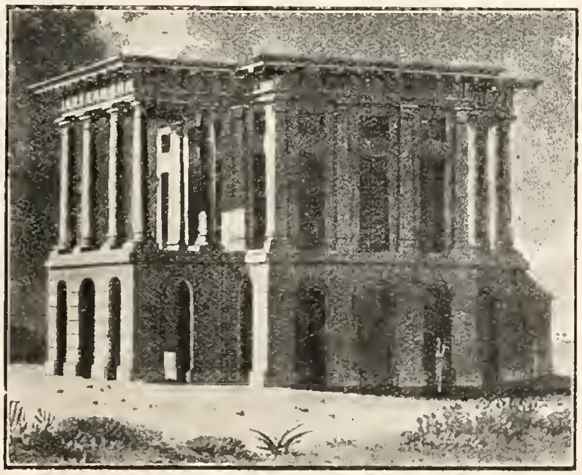


Fig. 8. The "Doric" as it was at the beginning of last century—from CORDINER'S plate.

Fig. 9. The "Doric" as it now is—from a photograph taken in February, 1902.

bearings on the pearl banks. The figures given here show (fig. 8) its original appearance, from the plate in CORDINER'S "Ceylon," 1807, and (fig. 9) its present condition from a photograph I took in February, 1902, with Captain J. DONNAN, C.M.G., late Inspector of the Pearl Banks, in the foreground.

In the evening (February 25) we put two tow-nets out, one near the bottom and the other at the surface. The deeper net contained a large amount of the filamentous red Algæ (*Hypnea musciformis*, *Polysiphonia*, &c.), along with Molluscan and Annelid larvæ, Coscinodiscus, &c.

The surface net had Coscinodiscus and 14 species of Copepods, including *Calanopia aurivillii*, *Metacalanus aurivillii*, *Ilyopsyllus affinis*, and a new species of *Peltidium*.

On February 26th, at 7 A.M., $2\frac{3}{4}$ miles south-south-west of Chilavaturai, the sea-temperature was 78·1° F., and at 7 P.M., on the south central part of the Cheval Paar, the temperature was 79·5° F. At both times the specific gravity was 1·023.

A bottom tow-net which had been down all night was found on the morning of February 26th to contain great quantities of small Copepoda with very long caudal setæ (*Ectinosoma roseum* and *E. atlanticum*), also *Euterpe acutifrons* and a dozen other species, along with some Medusoids and Ctenophores.

About mid-day, when going under easy steam, we put out a tow-net which we had contrived with a canvas funnel in front of the mouth and having the narrow end forwards, so as to reduce the volume of water entering and so the pressure on the net. It worked well and gave us good hauls containing chiefly Nauplei, Zoeæ, 41 species of Copepoda, including the large blue *Pontella securifer* and the small long-tailed *Ectinosoma atlanticum*, *Centropages violaceus*, *Metacalanus aurivillii* (common), *Pseudodiaptomus aurivillii* (male previously unknown), and also *Ceratium* (two species), *Peridinium*, some Trochospheres, Radiolaria, many Diatoms, especially *Coscinodiscus* and long rod-like forms, *Sagitta*, *Salpa*, Appendicularians, Pteropods, and some Lamellibranch fry. It was evident from this and many other hauls that the microscopic plankton of the sea, both at surface and bottom, was very abundant in the Gulf of Manaar, and this must be of very great importance in feeding the pearl oysters.

We boarded the barque "Rangasameeporawee" later in the morning, and found that she was anchored on the position of the "shoal-buoy," a mark that Captain DONNAN has been in the habit of bringing with him on each inspection in order to indicate the north end of the long shoal which runs northwards from Karativo Island to the southern part of the Cheval Paar. The buoy (a large structure of casks and planks bearing a mast) is anchored over a sunken tank, and serves as a useful mark to take bearings from during the inspection of the banks.

We now set the divers to work to bring us up samples of the bottom, a rather coarse white quartz sand upon which great masses of fine green and red filamentous Algæ grow. These contained *Hypnea musciformis*, and undetermined species of the genera *Cladophora*, *Ceramium*, and *Chætomorpha*.

The divers brought up quantities of this weed, upon which, when put in our small glass aquaria, we soon found great numbers of very young pearl oysters—the spat being densely crowded in some places on the filaments of Algæ. The smallest size, of which there were very many, was about 0·5 millim. in diameter, but other samples measured up to 4 millims. This spat was evidently very young and the smallest had probably just become attached during the last few days. A quantity was kept alive under observation, some in wooden tanks on the barque and some in our glass aquaria on the "Lady Havelock." It was found to be restless and active, and to leave its attachment and crawl freely about on the Algæ or on the glass sides of the aquaria. For example, one specimen (*a*) crawled 5 inches up the glass within 18 minutes, the last $2\frac{3}{4}$ inches in 12 minutes; another (*b*) crawled 3 inches in

12 minutes; while a third (*c*) did $1\frac{1}{8}$ inch in the same time. Both *a* and *b* travelled at a greater rate at the beginning than towards the end of the time.

In the green weed were also large numbers of a white Leucothoid Amphipod (which Mr. WALKER considers to be a new genus), some interesting new Caprellids, and a good many Rissoa-like Gastropods about 7·5 millims. in length. Some specimens of a small white *Synapta* were also brought up in the sand.

In the afternoon we dredged and trawled from the "Lady Havelock" in the area lying south-west of the Cheval Paar. All these hauls may be united as—

STATION XLVII.—About 4 miles south of the West Cheval Paar; depth $8\frac{1}{2}$ to 9 fathoms; bottom sand overgrown with green Algæ; dredged.

Phyllospongia holdsworthi, Axinella donnani;

Astropecten hemprichii, Amphiura sp.;

Sabella phæotænia, Serpula sp.; various Crabs;

Pearl oysters (a few large and many very small), *Aplysia pulmonica* (?);

Molgula sp.;

Fish—both round and flat—including *Pegasus draconis, Upeneoides tragula, Gobius biocellatus, G. masoni, Teuthis oramin, Percis pulchella.*

On February 27th we joined Captain DONNAN in the morning on board the barque in order to see the work of the divers. During this and some following days two sets of diving operations were carried on simultaneously. Four large whale boats, each containing 10 or 12 natives under the charge of a tindal or boatswain, were engaged in making a survey by means of concentric equidistant circles—the boats circling first within a distance of $\frac{1}{4}$ mile, then between $\frac{1}{4}$ and $\frac{1}{2}$ mile, and finally between $\frac{1}{2}$ and $\frac{3}{4}$ mile from the barque, which was anchored in the centre—and keeping their distances approximately by means of radially placed buoys bearing flags. From these boats the divers went down at frequent intervals, and the result of each dive was recorded by the tindal on a plan. At the same time we had a set of two or three divers in the "Serendib" (fig. 10), and with these we took samples from between the paars or in any other localities where we wanted further information to supplement the results of the inspection boats.

The ground we worked over this morning was mostly formed of dead coral and Nullipore with some *Sargassum* and other Algæ, the depth being 6 to $6\frac{1}{2}$ fathoms. Pearl oysters of two ages were found; the larger being estimated at 3 years old and the smaller size at 6 months (see fig. 11). The oysters were accompanied by great quantities of small boring Gastropods (the "Oorie" of the divers) belonging to the genera *Purpura, Nassa, Sistrum, Pinaxia, Natica, Murex* and *Turbinella* (mostly *Sistrum spectrum* and *Pinaxia coronata*), and in places were entangled in the byssus nests of masses of "Suran" (*Modiola barbata*). A deep purple spreading sponge (? *Pachychalina multiformis*), upon which were opisthobranchs of the same colour (*Aplysia* sp.) was common.

Around such hard patches the bottom is all sand, in some parts coarse, in others finer, and varying in constitution from almost pure quartz to a neritic deposit formed mainly of the shells of Foraminifera (*Orbitolites*, *Heterostegina*, *Alveolina*, &c.). On the sand fewer oysters are found, but they cannot be said to be absent, especially in the neighbourhood of a "paar" (or hard patch). When present they are generally

Fig. 10. Our two divers on the "Serendib."

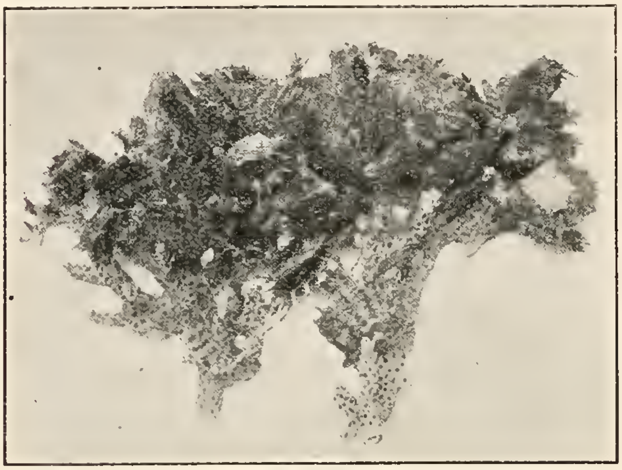


Fig. 11. Young pearl oysters, about six months old, attached to a dead Madrepore Coral.

united in clumps of several fastened together by their byssus threads or attached by some hard object such as a Nullipore nodule, a dead shell or a fragment of coral. In some cases two or three large oysters (about 3 years old) will form a centre upon which a great many young ones (about 6 months old) are fastened (fig. 12). In some places there is undoubtedly overcrowding, the larger oysters being completely surrounded with masses of young piled so closely as to smother some and probably interfere with the growth of all. This is a precisely similar case to that of the overcrowding found in European mussel beds, where the advantage of thinning out and transplanting is well known.

We got the divers to construct for us, after several dives to verify the details, a model on the deck of the "Serendib" showing the distribution of oysters on the rock and sand at the bottom. Fig. 12 is from a diagrammatic drawing (in bird's-eye-view) showing what they produced.*

Although oysters lying on the sand may manage to survive for a time, especially if

* These and our other conclusions in regard to the configuration and constitution of the paars and the distribution of the pearl oysters were verified later on by Mr. Hornell when, at the fishery in the spring of 1903, a European diving costume being available, he was enabled to make a personal inspection of the bottom.

united in clumps, it is evident that they are in a dangerous position and are liable to be overwhelmed and smothered at any time by a shifting of the loose bottom.

There is apparently plenty of available hard ground with a dead coral, or consolidated sand, or Nullipore bottom round about the known paars to which young oysters from unsuitable sandy grounds or from overcrowded spots could be easily

Fig. 12. Diagram showing the arrangement of pearl oysters (large and small) in clumps on the sand and singly attached to flat ledges of rock.

moved. We accumulated many observations bearing on this question during the next few weeks and also during Mr. HORNELL's inspection visit to the banks in November, 1902, and during the fishery of March and April, 1903. It will be further discussed in our Recommendations at the end of this report.

In order to trace the extension of the pearl oysters beyond the limits of the recognised paars, we took a number of hauls of the dredge, in the afternoon, from south to north in the middle between the East and West Cheval paars on, in the main, a sandy bottom. These may be joined as—

STATION XLVIII.—Between East and West Cheval paars; depth $6\frac{1}{2}$ to $7\frac{1}{2}$ fathoms; bottom sand, fragments of dead Coral, shells and Nullipore; dredged.

Some solitary Corals, *Halicornaria saccaria*;

Salmacis sulcata and *S. dussumieri*, *Laganum depressum*, *Lovenia elongata*, many *Clypeaster humilis*, *Echinolampas oviformis*;

Polyzoa—13 species, amongst which are *Lepralia dorsiporosa*, *Micropora coriacea*, *Scrupocellaria scrupea*, *Schizoporella lineata*, *Cellepora avicularia*, *Idmonea serpens*, *Smittia reticulata* and *Brettia* sp.;

Stenothoe marina (variety) and other Amphipods; pearl oysters (very many, mostly young), *Turbinella rapa* and a few common Molluscs;

Asymmetron (*Heteropleuron*) *cingalense*. A new species of *Emmelichthys* was also obtained here at a later date.

A single haul (the second) in the middle of the area in question gave us nearly 2 cwt. of pearl oysters, large (3 years old) and small (6 months). Most of them were attached to fragments of worn coral or to one another.

Two hauls of the dredge upon the northern end of the Cheval region, depth $6\frac{1}{2}$ fathoms, gave much the same bottom and result, but with fewer living pearl oysters. The sea-temperature this day was, at 7 A.M., 78·3° F., and at 9 P.M., 79·5° F., and the specific gravity on both occasions 1·023, at anchor on the South Cheval. The following day (28th) the temperature, at 7 A.M., was 78° F., and at 6 P.M. it was 79·3° F. on the South-east Cheval. The specific gravity was still 1·023.

We now had various sets of pearl oysters under close observation in our wooden tanks, glass aquaria, and sea-water baths, on both the barque and the "Lady Havelock," in order to test powers of detaching and travelling and re-attaching, regeneration of the byssus when cut and when torn out, and similar matters; but the results of these experiments will be given separately further on in the report.

On the morning of February 28th we (in the "Serendib") traversed from south to north the inspection circle ($1\frac{1}{2}$ miles in diameter) which covered the southern end of the East Cheval, 18 dives being taken at about equidistant points with the following results. This will serve as an example of the many lines of dives we traversed during the next few weeks.

Dives.	Bottom.	Pearl oysters.	Any other animals.
1	Sand	Few, large and small	*Malleus vulgaris.*
2	Rock	Large oysters	*Modiola*-"suran."
3	Sand	Few large, many small	
4	Rock	Many large, few small	
5	Sand	Many small, some large	"Oorie."
6	Rock	Large and small	
7	,,	,, ,,	
8	,,	,, ,,	
9	Sand	Few clumps, large and small	
10	Rock	Clumps of large	Green corals (*Favia*), dark green *Antedon*, and *Alphæus* of same colour.
11	Sand	Few clumps, mostly small	*Pinna bicolor.*
12	Rock	Clumps of large and small	*Campanularia juncea* ("Heather").
13	Sand	None	
14	Rock	,,	,, ,,
15	,,	Small, few	,, ,, and sponges.
16	Sand	None	
17	Rock	One large	,, ,,
18	,,	None	

The large Hydroid Zoophyte *Campanularia juncea*, which grows in tufts a foot in height and looks somewhat like old withered masses of heather, is very characteristic of this East Cheval paar. The beautiful large pinnate *Halicornaria insignis* is also found here, and usually bears the protectively-striped *Avicula zebra* which is almost invisible on the Zoophyte. We also found *Meleagrina margaritifera*, the large mother-of-pearl oyster on the south part of East Cheval Paar.

In the afternoon we dredged over the ground lying between the shoal buoy and the south end of the Periya Paar.

STATION XLIX.—South-west of Cheval to off south end of Periya Paar; depth $8\frac{1}{2}$ to 13 fathoms; bottom sand, Nullipores, and dead shells; 6 hauls of dredge.

Lorenia elongata, Echinolampas oviformis, Maretia planulata, Clypeaster humilis, Echinodiscus auritus, and *Echinanthus rosaceus, Holothuria atra;*

Worm-tubes (*Sabellaria, Serpula, Filograna*);

Tritæta tenuipes, Leucothoe spinicarpa and other Amphipods, *Calappa* sp., and some other Crabs, and Peneids;

Mollusca (*Turritella maculata, Cassis glauca, Strombus succinctus, Pinaxia coronata*, &c.), also pearl oysters, *Dolabella* sp., and a few small Octopods;

Cynthia sp.;

Branchiostoma lanceolatum, var. *belcheri* (14 specimens), *Asymmetron* (*Heteropleuron*) *cingalense* (2 specimens).

When in one of the hauls we touched the south end of the Periya Paar we obtained a great number of young pearl oysters, just as we had found before, and were to find again in our later examination of this bank.

On March 1st we moved our centre southwards on to the Modragam paars. At 7 A.M., on the south end of East Cheval, the sea-temperature was 78·7° F., and at 7 P.M., on the North Modragam, it was 79·7° F.; in both cases the specific gravity was 1·023. In the morning we made a diving traverse from south to north through the Modragams to the Cheval. The pearl oysters were not very numerous, but were exceptionally large, although probably not older than those on the Cheval Paar. Captain DONNAN, from his close observation of the oysters on these paars extending over many years, feels confident that the shells grow more rapidly, and to a larger size, on the Modragam than on the Cheval paars, and on the East Cheval than on the West. Our own measurements made later on bear this out. It is very possible that these differences may be due to feeding, and that the explanation is that the conditions become less favourable further from the shore and towards the north-west. The Modragams are also sheltered by the shoal running up from Karativo Island to the Cheval.

The details of these dives need not be given. On the whole they show much the same distribution as those given above. Between the North Modragam and the South Cheval, in $6\frac{1}{2}$ fathoms, along with abundance of young pearl oysters a few months old, we found quantities of red Algæ (*Polysiphonia*, &c.) covered with minute "spat" evidently quite recently deposited.

In the afternoon we dredged again over Station XLIX., from the south-west corner of the West Cheval to the south of Periya Paar; the depths found varied from

8 to $13\frac{1}{2}$ fathoms and the bottoms and animals were much the same as before (including two species of Amphioxus). We found quantities of young oysters in our last haul, about 5 miles south of Periya Paar, 12 to $13\frac{1}{2}$ fathoms, on a firm bottom of Nullipores and Orbitolites sand, showing that there are outlying patches beyond the limits of the known paars where oysters may be found. This particular spot would, however, even if the oysters attained maturity, be too deep for most of the native divers to work. Their usual limit is about 9 fathoms. We had them a few weeks later making a few descents for us in 11 fathoms on the Periya Paar, but they had just time to get a sample of the oysters or whatever lay before them on arriving at the bottom. Captain DONNAN has had exceptional divers who have made descents for him in 15 fathoms, but they had barely time to secure a single handful of the bottom before having to come up in an exhausted condition. I timed many dives and none reached two minutes, very few were over a minute and a half.

Samples from all the pearl oysters we obtained on the different paars from the divers or by dredging were examined as to their food, their reproductive condition, their general condition of body and parasites and as to any stages in pearl-formation. All these matters will however be dealt with separately further on in the report.

On March 2nd, being now in the neighbourhood of Kodramallai Point and Marichchukaddi, which was the site of the Camp during the three last pearl fisheries (1889 to 1891), and also during the recent fishery of 1903, we took the opportunity to go ashore and inspect, as Captain DONNAN thought that possibly we might find a sheltered corner of the bay suitable for the marine laboratory.

We landed at Kodramallai Point, and examined the coast (fig. 13) for a little way

Fig. 13. Part of the pearl-divers' fleet at Marichchukaddi—from a photograph by J. HORNELL.

northwards towards the Modragam River, but found it quite hopeless for our purpose. The rock at the point forms a moderate headland and runs out seawards as a little reef. It is apparently all sandstone; there is no coral, and it gives practically no protection from the south-west monsoon. The shore of the bay is muddy and the water shallow for a long way off. There is much *Zostera*, but every living thing seems covered with a fine deposit of mud.

In the afternoon we sailed for Manaar, which I had been asked to examine and report upon. The sea-temperature at 7 A.M. on North Modragam was 79° F. and at 7 P.M. on the south bar at Manaar it was 81° F., the specific gravity as usual was 1·023 at both times.

We had caught a number of Sea-snakes (Hydrophidæ) during the last few days, and the stomachs of all these were examined to see whether any foundation in fact existed for the belief that they feed upon the pearl oysters. We found no evidence of that. Without exception the stomach contents in the snakes we caught were the more or less digested but still recognisable remains of various kinds of fish. Such examinations, and the recording of our pearl-oyster experiments and statistics, went on during the time spent in getting from one spot to another, and when lying at anchor. Dr. W. HANNA, of Liverpool, has kindly examined the Hydrophidæ I brought back and finds that three species are represented, viz., *Enhydris curtus*, *Hydrus platurus* and *Hydrophis fasciatus*.

On arriving off the south bar at Manaar we took a tow-net gathering which contained, amongst other Copepoda, *Oithona rigida*, *Euterpe acutifrons* and *Labidocera acuta*. We also caught a large Remora (*Echeneis naucrates*) measuring fully 24 inches in length and having a sucker 6 inches long. It was slate-blue dorsally and of a lighter colour ventrally. On laying it with the sucker against the upright bare back of a diver, in the air, it at once adhered so firmly that one could grasp it by the tail and pull with some force without detaching the fish (fig. 14).

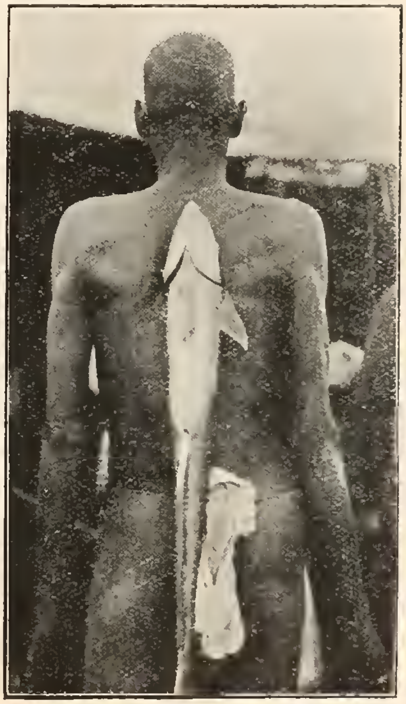


Fig. 14. Remora attached to the back of a diver.

March 3rd was occupied in enquiring into the marine biological possibilities of Manaar. The sea-temperature at 7 A.M. was 79°·3 F. and at 7 P.M. on the north end of the East Cheval was 80° F., the specific gravity being 1·023.

We crossed the south bar in the ship's boat with some difficulty, and went aground several times in the long shallow muddy passage leading up to the town of Manaar. The Assistant Government Agent sent for Mr. V. VRASPILLAI, the respected and experienced Adigar of Musali, who took us round to the various bays and creeks, showed us the different kinds of shore, and gave us full information as to the fishing and the shell-fish found locally, and the influence of the tides and winds. The Adigar entirely confirmed our own opinion, formed from what we saw, that there is no spot in the neighbourhood of Manaar suitable for pearl-oyster work. The North channel we found is as unsatisfactory as the South, and the great creek immediately to the north-east of the Fort is quite shallow and muddy. Not even cockle-like shell-fish can be got to live there, and in fact dead shells have to be imported from Aripu for calcining to make the "chunam" for betel-chewing. *Pyrazus palustris* is most abundant in these muddy shallows. Turtle are also plentiful round Manaar and are caught by the harpoon, which is a short four-sided iron spike sharpened at one end and having a ring on one side to which a long cord is attached. The spike is loosely fastened to the end of a pole, from which it readily becomes detached when implanted in the plates of a turtle's back, leaving the animal anchored by the long cord. Dugong are also taken here, they feed upon the Zostera which is plentiful all around.

On March 4th we were back again with Captain DONNAN and his inspection boats on the north end of the East Cheval, where at 7 A.M. the sea-temperature was 79° F. and specific gravity 1·023. The forenoon was spent examining with the divers, in the "Serendib," the middle part of the East Cheval and the area to the west of it, on which we found more oysters both large and small than within the usually recognised limits of the paar itself. In three dives on this western part the oysters came up attached to coral blocks, in the fourth they were in clumps lying on sand; they averaged 15 oysters to a dive.

In the afternoon we dredged from the "Lady Havelock" in the same region and northwards to the Periya Paar Kerrai and Vankali Paar; and obtained striking proof, as on many other occasions, of the superiority of dredging over diving as a method of obtaining the pearl oysters. The first haul, during which the dredge was only off the deck 10 minutes, brought up 65 large oysters along with other organisms. The first few hauls were practically upon Station XLVIII., dredged on February 27th, and the more abundant animals obtained* were the same as before (see p. 61); while the remaining hauls further north may be divided into two sets, those about Periya Paar Kerrai (Station L.) and those of Vankali Paar (Station LI.).

STATION L.—On Periya Paar Kerrai and to the north; depth 7½ fathoms; bottom sand and dead shells; dredged.

Various common Corals;
Serpula actinoceros;
Mæra rubromaculata and other Amphipods;
Pearl oysters, mainly small, *Oscanius* sp.;
Branchiostoma lanceolatum and variety *belcheri* (large and plentiful).

* It will of course be recognised by naturalists that many other minute or obscure forms (Amphipods, Hydroids, Polyzoa, &c.) were obtained at nearly all these hauls; and these will be treated of in the special reports that follow.

STATION LI.—West of the last Station, on Vankali Paar and southwards; depth $7\frac{1}{2}$ to 8 fathoms; bottom sand, dead shells and Coral fragments; dredged.

Some common Corals (*Madrepora* and *Turbinaria*), and *Heterocyathus æquicostatus* (with Gephyreans), several Gorgonids (large colonies);

Clypeaster humilis and *Echinodiscus auritus;*

Aspidosiphon sp.;

Lilljeborgia pallida (a British species!);

Pearl oysters, plentiful—both large and small (60 large in a haul).

The Tow-Nets on March 4th gave us:—Medusæ, *Sagitta, Alciopa*, Appendicularians and about 35 species of Copepoda—some of them in great abundance—amongst which may be mentioned *Metacalanus aurivillii*, *Centropages*, n. sp., and *Calanopia minor*.

Fig. 15. Two of the divers on the "Rangasameeporawee" with the wire-net and coir cages in which our experimental pearl oysters were suspended over the ship's side for two months.

Some experiments were made during this and succeeding days in towing pearl oysters of different sizes, under various conditions, and at different rates up to 8 knots an hour, which showed us that it would be easier to transport young than old oysters in bags, nets or crates hung over the ship's side (see fig. 15), and also that old oysters are apparently less able to withstand the action of a strong current than younger forms. From the cages and baskets (generally made of the coir fibre of the cocoanut) used on these and subsequent occasions when pearl oysters were hung out over the side of the ship we obtained various small animals, especially Hydroids, amongst which were a *Clava*, two species of *Sertularia*, a scarlet *Eudendrium*, a *Bougainvillea*, and several Plumularians.

On March 5th the sea-temperature was slightly over 79° F. both morning and evening, on the north end of the Cheval, with a specific gravity of 1·023. In the morning as usual we were with the divers (who work from 6 A.M. till noon) working over the northern end of the East Cheval and outside the paar to the north and east. Practically no oysters were found. Some fine colonies of the hydroid Zoophyte *Halicornaria insignis*, with *Avicula zebra* attached, were found here (off north end of Cheval, 6 fathoms). On moving south-east along the edge of the paar to its middle portion we came upon quantities of a fine brown fucoid Alga smothered in young oyster "spat." The Alga was growing on what the divers call "flat rock"—a calcrete formed by the cementing together of the sand and shell fragments *in situ*. We also obtained at the same spot a fine tuberculated dark green Holothurian (*Stichopus chloronotus*).

In the afternoon we dredged to the north of the East Cheval Paar, running a line of hauls to the Vankali reef lying about 6 miles to the north and then north-west along the outer face of the reef and so back. Six hauls were taken which may be united as—

STATION LII.—Between north of Cheval Paar and Vankali reef; depth 3 to 6 fathoms; bottom sand; no pearl oysters; dredged.

Halicornaria setosa and *H. saccaria*, *Lytocarpus* (? n. sp.) and *Sertularia tenuis*, *Cavernularia obesa* (many), *Virgularia juncea*;

Hermadion sp., *Panthalis melanonotus*, *Psammolyce* sp., *Onuphis* sp.;

Ostracod (very large, possibly *Cypridina formosa*, or a new form); *Modiola* sp. (in gelatinous nests), and other Lamellibranchs, *Turbinella pyrum*, *Strombus succinctus*, *Pinaxia coronata*, *Pyrazus palustris*, *Persona ridens* and *Buccinum melanostoma*;

Asymmetron (*Heteropleuron*) *cultellum*.

The Tow-Nets at this locality gave us about 28 species of Copepoda, representing 12 genera. These like the other tow-net results will be given in detail in the report on the Copepoda, but Messrs. Thompson and Scott give the following as noteworthy from this haul:—*Mecynocera clausi*, *Paracalanus parvus*, *Acrocalanus longicornis*, *Centropages furcatus* and a new species, *Pseudodiaptomus aurivillii*, *Labidocera pavo*, *L. kroyeri* and a new species.

During parts of this day we had living pearl-oyster spat under observation in flat wooden tanks and in our narrow vertical "window" aquaria. In the latter, numbers

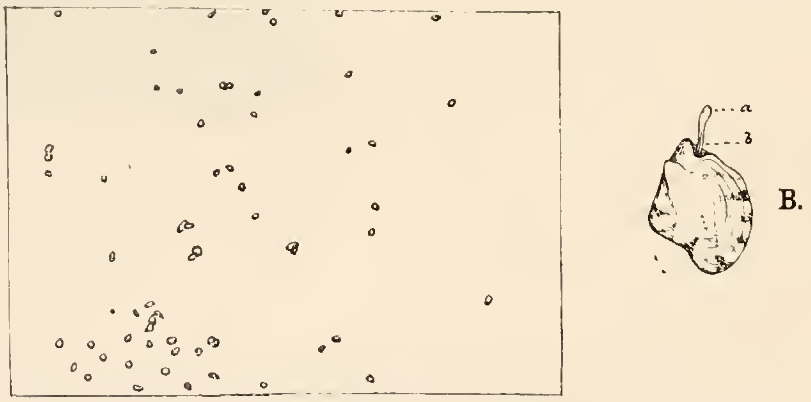


Fig. 16. Arrangement of spat on glass of aquarium 7 minutes after all started from bottom. B, one individual enlarged, showing the extended foot.

of individuals placed at the bottom started at once to climb up the glass sides and travelled on the average at the rate of about an inch per minute. At the end of the first minute 65 individuals were crawling up the glass. At the end of seven minutes six had reached the surface of the water, a distance of $3\frac{1}{4}$ inches. Most of the rest had attached themselves at various points lower down. The actual disposition on the glass side of the small aquarium at the end of seven minutes, and an enlarged figure of an individual when climbing, to show the expanded foot, are given in fig. 16. The object of this record is to emphasize the great activity and the locomotory powers of the spat at this stage, when it is usually regarded as a sedentary and in fact a fixed animal. In climbing, attachment is made by the base *b* of the foot, the distal portion being elongated. Then the tip *a* fixes and *b* at the same time is freed and the animal is drawn upwards by the contraction and shortening of the muscular foot. Then *b* fixes once more, *a* is extended to a new position and the process is repeated.

Fig. 17. Sketch of young pearl-oyster spat attached to *Sargassum*.

We frequently observed that spat collected on weed (such as *Sargassum*, fig. 17, and *Hypnea* or *Cladophora*) very readily detached itself and wandered on to other objects or became transferred to the walls of the vessel, or even adhered together in balls of from 4 to 10 individuals.

We now moved to the north end of the West Cheval Paar, where on March 6th, at 7 A.M., the sea-temperature was 79·3° and at 7 P.M. 79·5° F.; the specific gravity as usual being 1·023. In the morning we ran 2 lines of dives, from the "Serendib" north-eastwards from the northern end of the West to the northern end of the East Cheval, getting a small number of large oysters (with some dead shells) and considerable quantities of young. We also brought up a very fine specimen of *Toxopneustes pileolus* with very beautiful and conspicuous pedicellariæ, in which the 3 valves are united by a discoid reddish membrane bordered by a conspicuous white line.

The rest of the day was spent in dredging at a point about 10 miles north of the morning position. Here 5 hauls were taken which may be regarded as—

STATION LIII.—Ten to twelve miles north of Cheval Paar and about 12 miles west of Vankali (or Bangalli) Church; depth $7\frac{1}{2}$ to 9 fathoms; bottom muddy sand with some dead shells; no large pearl oysters, only a few small; dredged.

Halimeda and some Nullipores, green Algæ and *Halophila ovata*;

Axinella donnani, and other sponges;

Lytocarpus spectabilis, *Campanularia juncea*, and species (which may be new) of *Halecium*, *Obelia*, *and Campanularia*; Pennatulids and various living Corals;

Clypeaster humilis, *Laganum depressum*, *Antedon* sp. (sev.), and *Actinometra* sp.;
Psammolyce sp. and other worms;
Polyzoa belonging to the genera *Lepralia*, *Adeona*, *Crisia*, and *Scrupocellaria*;
Melita obtusata, *Erichthonius* sp., *Siphonœcetes* sp. and other Amphipods, *Elsia indica* and *Lysianassa* (? n. sp.), *Lambrus*, *Pleurophyllidia* sp., and *Kalinga ornata*;
Branchiostoma lanceolatum, and variety *belcheri*.

The bottom Tow-net at 7 P.M. contained, amongst other Copepoda, *Pontella securifer*, *Ectinosoma atlanticum* and *E. roseum*, *Metacalanus aurivillii* and *Pseudodiaptomus aurivillii*—22 species in all.

At the end of the day's work we anchored about 15 miles to the north of our morning position on the Cheval with the view of spending the following two days in working this northern end of the Gulf of Manaar, above the recognised paars.

In the intervals of dredging and when moving from place to place, we were now continuously engaged in examining the parasites of the pearl oysters and their influence upon pearl-formation. We also decalcified such small pearls as were found. This work was continued as time permitted during the next few weeks, and also by Mr. Hornell after I left. We found various parasites, in the liver especially, some of which were Platyhelminthian and others Sporozoan in their nature, and some of which were enclosed in calcareous capsules. Mr. Hornell afterwards determined that these were Tetrarhynchus larvæ of Cestodes, and we have no doubt that they are in many cases the nucleus of the pearl, and the irritating cause of its formation.

On March 7th, at 7 A.M., the sea-temperature was 79·5° F. and at 6 P.M. it was 80° F., about 10 miles south of Adam's Bridge. This day and the following one were spent in continuous dredging in the northern end of the Gulf of Manaar, south of Adam's Bridge, from south of Thanni-Kodi on Rameswaram Island to south of Talamanaar on Manaar Island. Eight hauls were taken on the first day and 13 on the second, but although a wide extent of ground, about 18 miles from west to east, was worked over no natural limits present themselves, and I consider it best to unite the 21 hauls as a single locality (Station LIV.). We started at about 15 miles south of Thanni-Kodi and worked westwards into shallower water for two hauls and then southwards into much deeper water (30 fathoms), the dredge eventually falling "out of soundings." The 5th haul was in 40 fathoms at about 16 miles south of Thanni-Kodi. Here we obtained *Panthalis melanonotus*, in a muddy mucous tube very like the condition in which we find the same genus in water of the same depth in the Irish Sea. We then ran north into 15 fathoms (6th haul) and dredged eastward for the two remaining hauls in depths of 10 to $8\frac{1}{2}$ fathoms, at about 10 miles south of Adam's Bridge. We anchored for the night with Thanni-Kodi bearing north, 18° W., and distant 10 miles.

The following morning we began dredging at the same spot and worked eastwards and then south-east through depths averaging 8 or 9 fathoms. In the 8th haul, south of Talamanaar, we came upon a rough bottom of living coral at 4 to 5 fathoms.

The 11th haul was upon the Anaivelundan Paar where some of the elephant's-ear coral (*Turbinaria cinerascens* and *T. crater*) from which the paar gets its name was brought up. The two final hauls were a little south of this on sand and dead shells, and then we ran for the south end of the Cheval Paar where the barques were then at anchor.

STATION LIV.—In northern part of Gulf of Manaar, south of Adam's Bridge; depths from 4 to 40 fathoms; bottom varied, from sand to living Coral—over 20 hauls of the dredge during two days.

Nullipores, *Halimeda*, *Corallina* and other Algæ;

Orbitolites complanatus, *Heterostegina depressa*, *Amphistegina lessonii* and other Foraminifera;

Petrosia testudinaria, *Halisarca* sp. (black), and other Sponges;

Pennatulids, various dendritic Alcyonaria, *Sclerophytum gardineri*, and *Lobophytum hedleyi* (?), *Sphenopus marsupialis*, *Fungia crassitentaculata*, *Goniopora* sp., *Pachyseris* sp., *Pocillopora grandis*, *Turbinaria cinerascens* and *T. crater*, *Porites arenosa*, *Cœloria sinensis*, and other Corals;

Hydroids—*Plumularia setacea*, *Monostachys dichotoma*, *Pasithea hexodon*, *Sertularia* (? n. sp.);

Phyllacanthus baculosa, *Linckia biforis*, *Astropecten hemprichii*, *Pentaceros lincki* and *P. nodosus*, *Actinometra parvicirra*, and *Antedon palmata*, *Holothuria atra*, *H. kurti*, *H. monacaria*, *Colochirus doliolum*, *Col. quadrangularis* and the new variety *mollis*, *Havelockia herdmani*, n. gen. et sp. (PEARSON) and many Ophiuroids;

Worm tubes (*Serpula*, *Sabella*, &c.), *Physcosoma asser*, *Panthalis melanonotus*, *Thelepus* sp., *Terebella* sp., *Nothria* sp., *Lingula*;

Polyzoa—many, belonging to the genera *Crisia*, *Buskia*, *Amathia*, *Ætea*, *Alcyonidium*, *Cellepora*, *Cellaria*, and *Porella*;

Lambrus sp., *Dromia* sp., *Pinnotheres* sp., *Leucosia urania*, and other Crabs;

Pearl oysters (very few—scattered), and *Modiola* (in gelatinous nests), Nudibranchs, *Ranella albivaricosa*, *Triton* sp., *Pleurotoma crispa*, *Turritella maculata*, *T. candida* and another sp., *Nassa rufula*, *N. micans* and *Dolabella* sp.;

Leptoclinum (several spp.); *Asymmetron cingalense*; Syngnathid with dendritic filaments.

TOW-NET gatherings taken both on the surface and at 12 fathoms, on March 7th, showed vast quantities of diatoms—chiefly *Biddulphia* with some *Ceratium tripos* and some small Radiolaria; also *Trichodesmium erythræum*, *Sagitta* and over 20 species of Copepoda, including:—

Paracalanus crassirostris, *Centropages furcatus*, *Calanopia elliptica*, *Labidocera minuta*, *Ectinosoma atlanticum* and *E. roseum*, *Oithona similis*, *O. plumifera* and *O. rigida*, *Corycæus obtusus* and *Euterpe gracilis*.

On March 8th we obtained, in addition to most of the above:—

Calanus vulgaris, *Centropages orsini* and *C. kroyeri*, *Labidocera acuta*, *Pseudodiaptomus serricaudata*, *Acartia erythraea*, *Calanopia elliptica* and *C. minor*.

On March 9th the sea-temperature at 7 A.M. was 79·8° F. and at 5 P.M. was 80·1° F., and the specific gravity was a shade under 1·023.

In the morning we worked with the divers over the south part of the region between the East and West Chevals. The oysters found here were mostly small (6 months old), growing in clumps or attached to the large valves of *Pinna bicolor*, which is very abundant here partly imbedded in the sand (fig. 18)—there are probably about 3 or 4 to the square yard. A shoal extends from this point (about the shoal buoy or south centre of Cheval Paar) southwards to the northern end of Karativo Island some 10 miles away. There is a tradition among the divers

Fig. 18. Large specimen of *Pinna* covered in its upper part with young pearl oysters and in the lower part with tags of byssus, indicating where oysters had been attached.

Fig. 19. Sketch-chart showing the shoal extending northwards from Karativo Island to the Cheval Paar.

that in former days Queen ALLIYARASANI, an Amazonian princess who ruled the Tamils in the northern part of Ceylon and personally superintended her pearl fisheries, used to sit on the north end of the long island of Karativo and watch the divers at work on the Cheval Paar. Karativo is now out of sight of the Cheval and there is no reason to think that the paar ever extended further south; but the soundings along the shoal (see fig. 19), taken along with the evidences of coast erosion that we found at Kodramallai Point and along the shores of the Bight of Kondatchi (see fig. 20, showing an old cannon near the Doric, at Aripu, nearly toppled over through the

Fig. 20. Captain J. DONNAN, late Inspector, and Captain J. LEGGE, present Inspector of the Pearl Banks, on an old cannon near the ruins of the Doric: to show the erosion of the coast in the bight of Kondatchi—from a photograph taken February, 1902.

washing away of the land by the sea), render it highly probable that Karativo in former times extended northwards along the line of the shoal; and so, possibly, the tradition of Queen ALLIYARASANI is a record of the time when Karativo reached the Cheval Paar.

On March 9th we dredged about the southern part of the Periya Paar. The first haul was taken across the paar, and immense quantities of small oysters (about 6 months old) and a bucketful of large ones (3 years old) were obtained.

The remaining three hauls (Station LV.) were outside the paar, and to the south, and extended westwards to "out of soundings."

STATION LV.—To the west and south-west of southern end of Periya Paar; depth 11 to 24 fathoms; bottom sand, Nullipores and dead Corals; dredged.

Codium bursarium, *Bryopsis*;

Orbitolites complanatus, *Heterostegina depressa*, &c.;

Axinella tubulata, *Suberites inconstans*, var. *digitata*;

Some Corals, Antipatharia, *Juncella juncea*;

Nemertine, *Physcosoma agassizii*, *Clœia ceylonica*;

Toxopneustes pileolus, *Cidaris metularia*, *Echinolampas oviformis*, *Lovenia elongata*, *Maretia planulata*, *Schizaster* sp.; *Stichopus variegatus*;

Balanus sp., various Macrura, *Lambrus* sp., and other Crabs;

Pearl oysters (both large and small), *Modiola* sp. (in gelatinous nests), *Murex tenuispina*, *Melibe* sp., *Doridium* sp., *Hexabranchus* sp., and small Octopods.

On March 10th we had a long day of dredging (17 successful hauls) on and outside Dutch Modragam, Karativo, and Col. HAMILTON'S Alentura paars, all lying outside the northern part of Karativo Island.

The hauls may be grouped into three stations (LVI. to LVIII.).

STATION LVI.—West of Kodramallai Point, about 10 miles off shore, on and around Dutch Modragam Paar; depth 8 to 9 fathoms; bottom coarse quartz sand, with red weed (*Hypnea musciformis*, &c.) in places on which were immense quantities of pearl-oyster spat; 4 hauls of dredge.

Virgularia sp. (several);

Laganum depressum, *Echinodiscus auritus*;

Sipunculus sp., *Hermione ridgewayi*, n. sp., *Lepidonotus carinulatus*, *Chlœia ceylonica*, *Sabella phæotænia*, *Sigalion mathildæ*;

Leucosia sp., and other small Crabs;

Pearl oysters (young, 6 months old), *Aplysia* sp.; *Asymmetron cingalense.*

STATION LVII.—To the west of last station, outside Dutch Modragam Paar; $11\frac{1}{2}$ to 36 fathoms; bottom Orbitolites sand, Nullipores and dead Corals; 5 hauls of dredge.

Orbitolites complanatus, *Heterostegina depressa*;

Petrosia testudinaria and other sponges;

Stephanoseris rousseaui (with Gephyreans), Pennatulids, Gorgonids, and Reef Corals;

Phyllacanthus imperialis, *Laganum depressum*, *Clypeaster humilis*, *Fibularia volva*, *Actinometra parvicirra*, *Antedon bella* and *A. milberti*;

Nemertines, *Aspidosiphon* sp., *Sigalion mathildæ* (in Coral), *Elasmopus subcarinatus*, and other Amphipods; *Isocardia* sp. and *Doriopsis* sp.

STATION LVIII.—Further south than last Station, on and outside Karativo Paar and the adjacent Colonel HAMILTON'S Alentura Paar; depths mainly 9 to 26 fathoms, but once or twice the dredge may have slipped into deeper water—we were close to "out of soundings"; bottom Orbitolites sand, and some Nullipore and Coral fragments; 8 hauls of the dredge.

Orbitolites complanatus, *Heterostegina depressa*, *Rotalia calcar*, *Alveolina boscii*;

Various sponges;

Gorgonia sp., *Juncella juncea*, *Sphenopus marsupialis*, Corals (from living reef);

Antedon sp., *Holothuria atra*, *Stichopus chloronotus*, var. *fuscus*;

Hyalinœcia sp., *Distomum* sp. (on gills of pearl oyster), *Stylochus* sp.;

Lysianassa (? n. sp.), *Leptophoxus uncirostratus*, *Elasmopus subcarinatus*, and a new species of *Lambos*;

Pearl oysters (a few old and young), and *Avicula vexillum;*

Ascidia-like Clavelinid, *Branchiostoma lanceolatum*, var. *belcheri* (several).

A tow-netting taken below the surface, at 6 to 10 fathoms, gave amongst other things a large new Ostracod, a new species of *Centropages, Mecynocera clausi, Metaealanus aurivillii, Oithona plumifera, Clausocalanus furcatus*, and *Pseudodiaptomus serricaudatus*—over 20 species of Copepoda.

On March 10th, at 7 A.M., south of Cheval, the sea-temperature was 79·8° F.; on the 11th, at 6.30 A.M., off north end of Karativo Island, it was 80° F., and at 6 P.M., on Periya Paar, it was 81·1° F., the specific gravity as usual being about 1·023.

On March 11th, we continued dredging amongst the smaller paars to the south of the Cheval district and lying outside Karativo Island. The 9 hauls may be grouped in two sets, as follows:—

STATION LIX.—On and around DONNAN'S Muttuvaratu Paar; in shallow water, $6\frac{1}{2}$ to 9 fathoms; bottom Nullipore and dead Coral fragments; 5 hauls of dredge.

Tetractinellids, and other sponges;

Madrepora (spp.) and other living Corals, *Sarcophytum* sp. and *Selerophytum densum;*

Clypeaster (young), *Culcita sehmideliana;*

Palmyra aurifera, Stylarioides parmatus, Lepidonotus carinulatus, Eunice teretiuscula, Ammochares sp., *Sabella phæotænia, Elsia indica;*

An Ascomyzontid Copepod which will require a new genus;

Pearl oysters, *Doris* sp., *Casella* sp., and a number of small Octopods.

STATION LX.—Outside DONNAN'S Paar; in deeper water, 20 to 30 fathoms; bottom Orbitolites sand, a little Nullipore and dead Coral; 4 hauls of dredge.

Orbitolites complanatus, and other Foraminifera;

Raspailia thurstoni, and other sponges;

Pennatulids, *Umbellula* and other Alcyonaria, *Sphenopus marsupialis*, and some living Corals, Antipatharia;

Phyllacanthus baculosa, Astropecten polyacanthus, Culcita sehmideliana, Nardoa tuberculata, Ophiocoma scolopendrina, Cucumaria tricolor;

Various Molluscan shells (undetermined) and some Nudibranchs (*Doriopsis*).

A TOW-NETTING taken at the same time gave:—Amongst 28 species of Copepoda, *Pontella securifer, Calocalanus pavo, Oithona plumifera* and *Candaeia ethiopica.*

We now returned, northwards, to the Periya Paar in order to investigate its condition more thoroughly, as it was evidently the deepest and furthest seawards of the paars where oysters in any quantity were to be found. It was also by far the most extensive area covered with young oysters, and yet its past history has shown that it cannot be relied upon to yield fisheries. Again and again it has been reported as covered with young oysters, again and again they have all disappeared.

Captain DONNAN in his forty years' experience has only had one fishery on the Periya Paar—the only one to his knowledge (he told us) that had ever occurred. It has frequently, at an inspection, been found to have abundance of newly deposited small oysters, while at the next inspection these oysters have gone and a fresh deposit of younger ones may be in their place. Occasionally a few may have remained for a second year, but they have always disappeared before becoming large enough to fish, except in the one case of the fishery in 1879—and even that was of limited extent and only involved a small part of the bank.

The shallow-water plateau round the coast in the northern part of the Gulf of Manaar, upon which the pearl-oyster paars are placed, can usually be distinguished very clearly by the navigator on account of the difference in the tint of water. Even 20 miles from shore, in fine weather, the yellow sandy bottom shows up through the clear water, and the slope is so steep that there is an abrupt change from the dark blue of the deep ocean "out of soundings" to the lighter tint of the plateau. I am told that captains who know the district, making for the Pamban Pass, know it is useless to take soundings for the banks until the lighter coloured water is reached; and the line of junction is usually sharply marked.

Now the Periya Paar is close to the edge of the plateau, about 18 miles from land and at a depth of 8 to 10 fathoms (fig. 21). It runs for about 11 nautical miles north and south, and varies from 1 to 2 miles in breadth, and this—for a paar—large extent of ground has been called by the natives the "mother-paar" under the impression that the young oysters, that come and go in fabulous numbers, arise there and migrate or are carried inwards to supply the inshore paars with their populations. During a careful investigation of the Periya Paar and its surroundings we satisfied ourselves that there is no basis of fact for this belief, and it became clear to us that the successive broods on the Periya Paar, amounting probably within the last quarter century alone to many millions of millions of pearl oysters, which if they had been saved would have constituted enormous fisheries, have all been overwhelmed by natural causes, due mainly to the configuration of the ground and its exposure to the south-west monsoon.

The following table shows in brief the history of the Periya Paar for the last twenty-four years:—

February, 1880. .	Abundance of young oysters.
March, 1882. . .	No oysters on the bank.
March, 1883. . .	Abundance of young oysters, 6 to 9 months old.
March, 1884. . .	Oysters still on bank, mixed with others 3 months old.

March, 1885. . .	Older oysters gone and very few of the younger remaining.
March, 1886. . .	No oysters on bank.
November, 1887 .	Abundance of young oysters, 2 to 3 months old.
November, 1888 .	Oysters of last year gone and new lot come, 3 to 6 months old.
November, 1889 .	Oysters of last year gone; a few patches present of 3 months old.
March, 1892. . .	No oysters on the bank.
March, 1893. . .	Abundance of oysters of 6 months old.
March, 1894. . .	No oysters on the bank.
March, 1895. . .	No oysters on the bank.
March, 1896. . .	Abundance of young oysters, 3 to 6 months old.
March, 1897. . .	No oysters present.
March, 1898. . .	No oysters present.
March, 1899. . .	Abundance of oysters, 3 to 6 months old.
March, 1900. . .	Abundance of oysters, 3 to 6 months old; none of last year's remaining.
March, 1901. . .	Oysters present of 12 to 18 months of age, but not so numerous as in preceding year.
March, 1902. . .	Young oysters abundant, 2 to 3 months old. Only a few small patches of older oysters (2 to 2½ years) remaining.
November, 1902 .	All the oysters gone.

It is shown by the above that since 1880 the bank has been naturally re-stocked with young oysters at least 11 times without yielding a fishery.

The 10-fathom line skirts the western edge of the paar and the 100-fathom line is not far outside it (fig. 21). An examination of the great slope beyond is sufficient to show that the south-west monsoon running up towards the Bay of Bengal for 6 months in the year must produce a current which will beat with full force on the

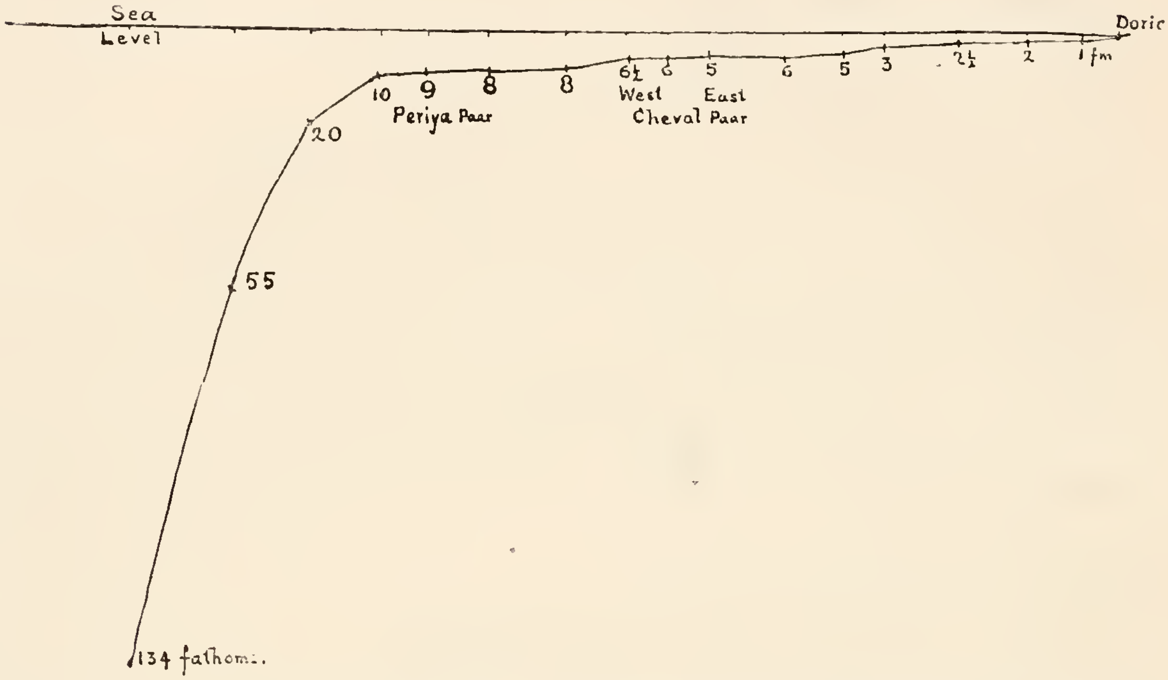


Fig. 21. Section across the sea from the Doric at Aripu westwards through the Cheval and Periya paars into deep water. Horizontal scale, ¼ inch = 1 mile; vertical scale, ¼ inch = 10 fathoms.

exposed seaward edge of the bank and cause great disturbance of the bottom. Figure 21 shows diagrammatically the sudden change in slope outside the paar.

In our previous hauls on the Periya Paar we had found very large numbers of young oysters, and wishing to ascertain how extensive the bed was, on March 12th we steamed in the "Serendib" to the northern extremity of the paar and then south for over 6 miles along its length, diving at intervals. We have the details of 18 dives recorded, and all of them except two give "small pearl oysters in abundance." We were convinced both from this day's work and our previous experiences when dredging that the Periya Paar was covered in March 1902 over the greater part of its extent with enormous quantities of young oysters. Now the area of the paar we take to be, from Captain Donnan's charts and our own observations, about 16 square miles, and we estimated at the time that the oysters were so closely placed that the bank must have held not less than about a hundred thousand millions. In the preliminary Report to the Colonial Government, written in July, 1902, I gave this rough estimate and stated my belief that these young oysters were doomed to destruction and ought to be removed at the earliest opportunity to a safer locality further inshore. Mr. Hornell was authorised by the Government of Ceylon to carry out this recommendation, and went to the Periya Paar early in November with boats and appliances suitable for the work, but found that he had arrived too late. The south-west monsoon had intervened, the bed had apparently been swept clean, and the enormous population of young oysters which we had seen in March, and which might have been used to stock many of the smaller inshore paars, was now in all probability either buried in sand or carried down the steep declivity into the deep water outside. This experience, taken along with what we know of the past history of the bank as revealed by the Inspectors' reports, shows that whenever young oysters are found on the Periya Paar, they ought without delay to be dredged up in bulk and transplanted to suitable ground in the Cheval district—the region where the most reliable paars are placed.

From this example of the Periya Paar it is clear that in considering the vicissitudes of the pearl-oyster banks we have to deal with great natural influences which cannot be removed, but which may to some extent be avoided, and that consequently it is necessary to introduce large measures of cultivation and regulation in order to increase the adult population on the grounds, give greater constancy to the supply, and remove the disappointing fluctuations in the fishery. The depth of water at the spots where our divers went down on the Periya Paar varied from 9 to 12 fathoms, the bottom is hard, so-called "rock," in most parts; in some places the flat "rock" is covered by a thin layer of coarse quartz sand. A certain amount of dead shells, bored by Gastropods, occurred, and a good many "Oorie" were brought up. Some coral fragments were found in places, and a few other animals, Terebellids in sandy tubes, and small fish (*Gymnapistus niger*), &c., were obtained.

The sea-temperature on the Periya Paar at 7 A.M. was 80·3° F., and in the evening (6 P.M.) on the Periya Paar Kerrai, much further inshore and north of the Cheval, it was 82° F., the specific gravity on both being 1·023.

We then, on March 12th, had 4 hauls of the dredge off the northern end of the Periya Paar to the west and south-west. These may be united as—

STATION LXI.—To the west and south-west of northern end of Periya Paar; 12 to 14 fathoms; bottom sand, Nullipore and Coral, with Sargasso weed.

Axinella tubulata and *A. donnani*, *Petrosia testudinaria;*

Heterocyathus aequicostatus (with Gephyrea) and other Corals;

Physcosoma scolops (in *Axinella tubulata*), *Nicomache* sp., *Gastrolepidia clavigera;*

Phyllidiella sp.; *Asymmetron* (*Heteropleuron*) *cingalense.*

The TOW-NET at the same time gave some Copepoda, including *Pontellopsis strenua* and *Corycaeus gracilicaudatus.*

On March 13th the day was spent in dredging from Periya Paar Kerrai westwards, across Periya Paar and outwards to the west and south into deep water. Thirteen hauls were taken, which may be grouped as two Stations—

STATION LXII.—Between Periya Paar Kerrai and Periya Paar, working westward; depth 7 to 13 fathoms; bottom coarse quartz sand, some Orbitolites sand and Nullipores. Three hauls of dredge.

Orbitolites complanatus, and other large Foraminifera;

Chætopterus appendiculatus, *Sabellaria bicornis*, *Filograna* sp., a tube-building Amphipod (*Cerapus* sp.);

Echinostrephus molare, *Echinodiscus auritus*, *Stichopus chloronotus;*

Craspedochiton laqueatus (several), Pearl Oysters (small very abundant), "Suran," *Ostrea* sp., *Venus* sp., *Murex* sp., *Ficus ficoides;*

Molgulids, flat Polystyelid colony (on oyster shell);

Branchiostoma belcheri (11 specimens), "Sand-eels" (*Trichonotus* sp.).

STATION LXIII.—To the west of Periya Paar, going south; depths 17 to 55 fathoms (we sounded in 80 fathoms when the dredge was put over for one haul, but it is doubtful whether the dredge touched the bottom before we drifted in to about 40 fathoms); bottom Orbitolites sand, some dead Coral, shells and pieces of Nullipore. Amongst the animals were :—

Orbitolites complanatus, *Heterostegina depressa;*

Ciocalypta tyleri, var. *manaarensis*, *Spirastrella* sp., and other sponges;

Heteropsammia michelini (orange), with Gephyreans, *Flabellum rubrum*,* *Dendrophyllia* sp., *Juncella* (? n. sp.), *Pteroeides* sp.;

Actinometra parvicirra, and another species, *Salmacis dussumieri*, *Clypeaster scutiformis*, *Lovenia elongata*, *Echinolampas oviformis*, *Fibularia volva*, *Echinoneus cyclostomus*, *Pectinura gorgonia*, *Ophiopteron elegans*, *Astropecten polyacanthus;*

Chlœia sp., *Serpula* sp.; *Hippa*, *Thia*, and other Crabs;

Polyzoa—*Lepralia edax*, and *L. robusta*, and species of the genera *Scrupocellaria*, *Adeona*, *Gemellipora*, *Schizoporella*, *Membranipora*, *Microporella*, *Bowerbankia* and *Ascopodaria;*

Mollusca—including, *Mitra crebulirata*, *M. militaris*, *Cerithium armatum*, *C. citrinum*, *Strombus pulchellus*, *Natica albumen*, *Pleurotoma tigrina*, *Nassa* sp., and *Dentalium* sp.; Molgulids.

The sea-temperature at 7 A.M. on the west of the Periya Paar Kerrai was 81° F., and at 6 P.M. on the Vankali Paar was 82°·1 F., the specific gravity as usual being 1·023.

We tow-netted during the day, and obtained on the surface numerous deep blue Copepoda (*Labidocera acuta*) a deep blue Porpita and colonies of Compound Radiolaria (*Collozoum* sp.) with black pigmented individuals, also Erichthus and other larval

* Mr. STANLEY GARDINER informs me that this belongs to the "facies" or variety which has the form known formerly under the name *F. stokesi* (ED. and H.). See GARDINER 'Mar. InvestS. in S. Africa,' p. 117, 1902.

Crustacea and much *Trichodesmium erythræum*. Twenty-four species of Copepoda have already been identified by Mr. ANDREW SCOTT from this haul.

The deep TOW-NET brought up *Sagitta*, a violet Appendicularian, filamentous Algæ forming balls, a large new Ostracod, and 15 species of Copepoda including *Clausocalanus furcatus* and *Ectinosoma atlanticum*.

In the evening, at 9 P.M., the sea was dotted with bright phosphorescent lights of considerable size singly placed at some distance apart. These for over an hour continued to glow with a pulsating appearance *in harmony*—all shining brightly at the same moment, and then all flickering out together, to re-appear simultaneously a few seconds later. We went out at once with a net and obtained a sample of the plankton, but could not be sure that we had caught any of the pulsating forms. The gathering contained *Sagitta* (very many), *Appendicularia*, Copepoda—half-a-dozen common species and *Sapphirhina sinuicauda*, *Pontella fera*, *Calocalanus pavo* and some smaller forms, along with half a-dozen one-inch-long Heteronereids of a reddish-brown colour. We suspected the light to be due to the last-named, and if that is so, possibly the periodicity was a result of the epitocous condition and was accompanied by a simultaneous discharge of genital products.

On March 14th, at 7 A.M., at the southern end of Pamban Pass, the sea-temperature was 82°·5 F. (5 degrees higher than it was at the same spot on February 5th) and the specific gravity was 1·022. At 6 P.M. in Palk Bay, the sea-temperature was again 82°·5 F. (4½ degrees higher than on February 6th) and the specific gravity was 1·021. We anchored for a couple of hours one mile off the village of Rameswaram and landed in the boat, examining the beach, the coral shoals on the way in, and the raised coral platform along the shore alluded to by THURSTON ('Notes on the Pearl and Chank Fisheries, &c.,' Madras Museum, 1890).

Two long hauls of the large shrimp-trawl were now taken in Palk Bay on the way across to Jaffna. The first was over the same region trawled on February 6th (Station XVIII.), but at right angles to our former course (see fig. 22). Starting due east of Rameswaram, about 4½ miles off shore at a depth of 5 fathoms, we towed for about 10 miles to the north-east, towards the island of Catchetivo, the water deepening gradually to 7 fathoms. The bottom was soft grey-blue mud, containing small concretionary nodules and many casts of the interior of Gastropod shells. The animals obtained were mostly the same fish and invertebrates as on February 6th, a few small Crabs, Molluscs and Echinids; also a species of *Arcania* with large lateral projections of a deep violet colour on the carapace. Several pearl oysters were obtained in this haul, and a sea-snake.

The second haul was taken to the south-east of Catchetivo Island, in a depth of 7 fathoms. The trawl was worked rather more rapidly with the result that it did not hug the bottom so closely, and brought up no mud and very few invertebrates, but a large haul of small Scopelid fishes which filled half-a-dozen ship's buckets and numbered over 2500 specimens. They apparently belonged to only 3 or 4 species

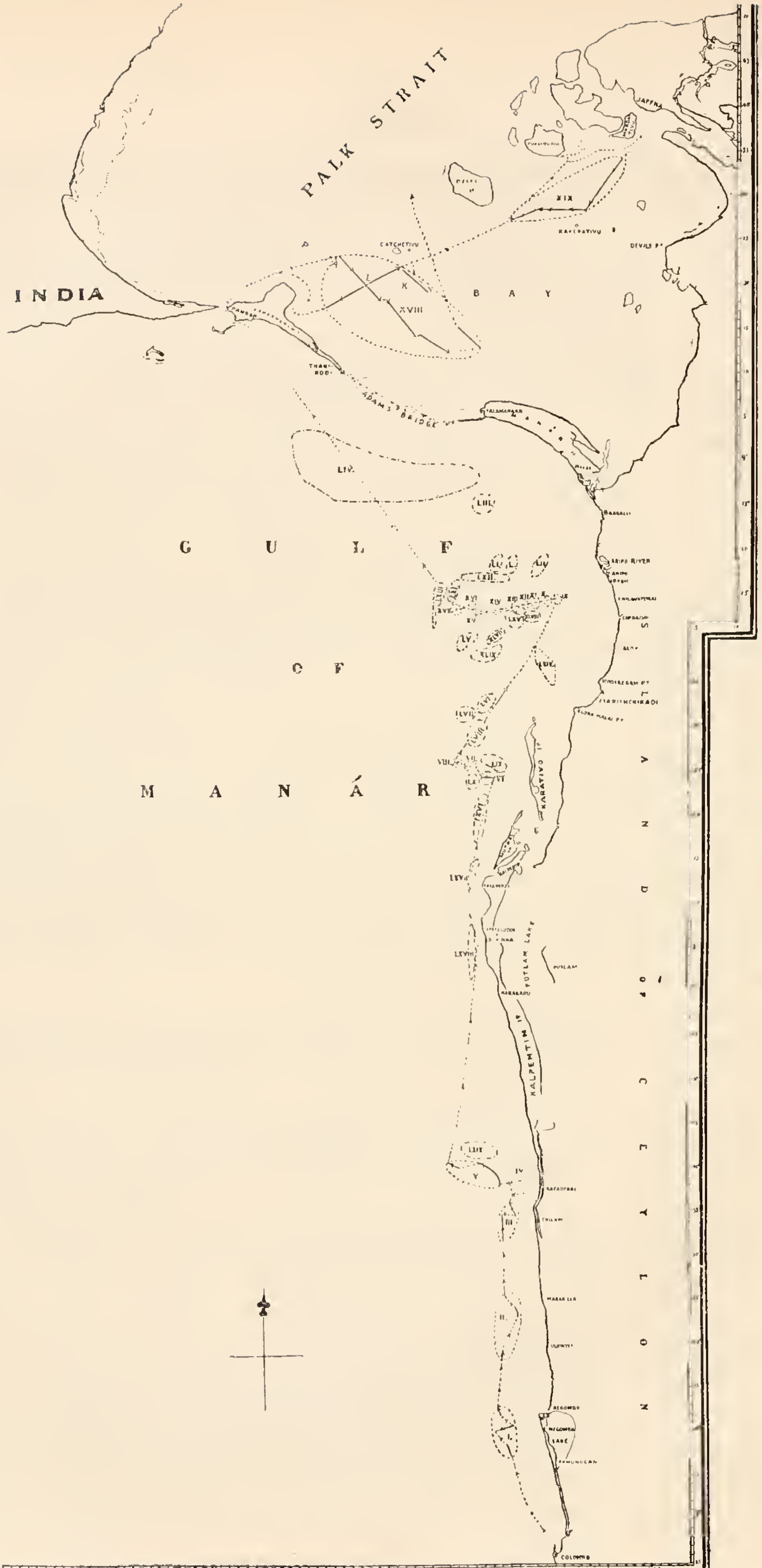


Fig. 22. Sketch-map of Gulf of Manaar and Palk Bay, showing Stations I. to XIX. and XLVII. to LXIX. The course of the first cruise is shown by the dotted lines with arrows. The stations of the second cruise are surrounded by dot-and-dash lines.

(*Saurus indicus*, *S. myops* and *Saurida tumbil*), all of silvery aspect. The trawl also contained 6 sea-snakes, 2 small Octopods (*Polypus granulatus* and another species), and 6 or 7 very fine prawns (*Penæus* sp.).

On March 15th we lay at anchor off Jaffna, taking in supplies and arranging for Sir WILLIAM TWYNAM to join our party. At 8 A.M. the sea-temperature was 82°·8 F. and the specific gravity 1·021; at 8 P.M. both readings were the same.

On March 16th we trawled in the northern part of Palk Bay, down the broad passage between the islands from Mandativo to Delft Island at depths increasing gradually from $4\frac{1}{2}$ fathoms outwards to 8. About 12 miles were covered in 3 hauls, the first southwards from off Mandativo towards Kakerativo; the second from east to west about 2 miles north of Kakerativo, depth 7 fathoms; and the third half-way between Kakerativo and Delft Island, depth 8 fathoms. The last haul was on the mud with concretions, as at Station XVIII. (March 14th), but the two previous ones were on sand and shells with some living Coral. I consider all this day's work as being one locality (see fig. 22).

STATION XIX.—In north part of Palk Bay, east of Delft Island; depth $4\frac{1}{2}$ to 8 fathoms; bottom sand and shells to mud; sea-temperature, 7 A.M. off Mandativo Island 82·8° F., 5 P.M. off Jaffna 84° F., specific gravity in both localities 1·020; 3 hauls of the large shrimp-trawl.

Various sponges;

Medusæ (*Nausithoë*, &c.), *Turbinaria cinerascens* and other Corals;

Some Amphipods, Erichthus, Phyllosoma, Prawns and Crabs;

Arca tortuosa, *A. compacta*, *A. tetragona* (?), *A. virescens* (?), *Mytilus barbatus*, *Cerithium citrinum*, *Mitra pyramidalis* (?) and other shells, and Octopods (*Polypus*);

A number of Polyzoa belonging to the genera, *Bugula*, *Cellepora*, *Lepralia*, *Schizoporella*, *Smittia* and *Crisia*;

Leptoclinum (2 species), *Rhabdocynthia* sp., *Rhodosoma* sp., *Polycarpa* sp., and *Salpa runcinata-fusiformis* (large, many);

Small Sole (*Solea oculus*).

On the way back to Jaffna to pick up Sir WILLIAM TWYNAM, we anchored for a couple of hours on the edge of the large shoal lying south and east of the Island of Punkudutivo (marked on the chart "Pearl beds") and went off in the boat to examine the coral reef and see if any trace could be found of the pearl-oysters said to have formerly existed there. We expected from the chart to have to row for at least a mile before coming to the reef, but in a couple of hundred yards progress was stopped by coral growing to within a foot or so of the surface, and on trying several other passages inwards to the land all were found blocked by luxuriant coral growth. We had then to leave the boat and wade over the coral plateau on the tops of enormous branched Madrepores and other flattened expanded colonies (the largest I saw anywhere round Ceylon) which crushed and snapped under one's weight and occasionally gave way altogether, letting one down into a hole with much laceration of skin on legs and arms. No traces of pearl oysters were seen, but possibly we were not able to get far enough inshore. On returning to the ship we found she had shifted her position, as on swinging round to her anchor in what according to the chart was 3 fathoms of water, she hit the rudder against the edge of a mass of growing coral reaching to within a couple of feet of the surface. The officers, from the deck, had fished up several large pieces of colonies for me with boat-hooks. It is evident that the coral reef is extending rapidly at this spot. It must not be supposed that a coral reef once it is surveyed remains stationary. Under some conditions it may become reduced in size, and under others it may show rapid growth both horizontally and vertically. The most abundant forms we obtained were:—*Madrepora cervicornis* and several other allied species, *Pocillopora grandis* and *P. cæspitosa*, *Porites palmata*, several species of *Montipora*, and various Astræids.

On March 17th in Pamban Pass at 7 A.M., the sea-temperature was 82° F., and the specific gravity 1·0206; at 6 P.M., on Kallatidel Paar, the temperature was 82·7° F., and the specific gravity 1·023. After rejoining Captain DONNAN and the inspection boats in the South Cheval district, we took 4 hauls of the dredge between the South Modragam Paar and Kodramallai Point. These may be united as:—

STATION LXIV.—From between South Modragam and Jaggerboom paars along a line south-east towards Kodramallai Point; depth $4\frac{1}{2}$ to $5\frac{1}{2}$ fathoms; bottom coarse sand, with much fine green-weed and small pearl oysters.

Some Renierid sponges;

Lytocarpus (? n. sp.), *Campanularia juncea*, *Fungia dentata* (many), large solitary Corals, and some Pennatulids;

Echinaster purpureus, *Pentaceros lincki* and *P. nodosus*, and many Ophiuroids;

Chlœia sp., *Harmothoë imbricata*;

Many Amphipoda including a new species of *Lambos*, *Lysianassa* (? n. sp.) and a remarkable new species of *Leptochelia* with immense chelæ considerably longer than the body;

Craspedochiton laqueatus, *Margaritifera vulgaris* (many small), *Turbinella rapa* (large), *Pleurotoma crenulata*, *Nassa reticosa*, *Pterocerus* sp., *Vertagus ulnco*, *Vermetus* sp., *Lamellaria* sp., *Dolabella* sp., *Aplustrum thalassiarchi*.

The fine green-weed from the bottom had very young spat of pearl oysters on it. The small oysters dredged were about 8 or 9 months old, and were in quantity at about $3\frac{1}{2}$ miles off Kodramallai Point. A tow-netting on March 17th gave us a new species of *Centropages* with a prominent dorsal spine.

On March 18th the sea-temperature on Kallatidel Paar, at 7 A.M., was 82·2° F., and on Cheval Paar, at 6 P.M., was 82·7° F.

In the morning I visited Aripu Coral Reef in one of the boats, and waded over parts of it. It was very rich zoologically, the coral growth being exceedingly luxuriant. The most prevalent forms were:—several species of *Madrepora*, *Montipora*, *Turbinaria*, *Goniastræa*, *Favia* and *Porites*. Large *Cypræa tigris*, large *Ascidia* sp., a pinkish *Rhabdocynthia*, *Cynthia* sp., *Eurythoe latissima*, *E. longicirra*, *Notocirrus trigonocephalus*, and some Holothurians (including *Holothuria monacaria*) were amongst the other conspicuous forms collected.

In the afternoon we dredged round the shoal buoy at the south end of the Cheval Paar, and in a north-westerly direction.

STATION LXV.—From shoal buoy up West Cheval Paar; depth $7\frac{1}{2}$ to 8 fathoms; bottom white quartz sand; 4 hauls of dredge.

Campanularia juncea; *Pseudoboletia* sp.;

Hyale nilssoni (variety), *Pisa* sp. (many) and other Crabs;

A few adult and very many young Pearl Oysters, *Doris* sp., *Aplysia* (green coloured);

Branchiostoma lanceolata, var. *belcheri* (9 specimens), and the long worm-like fish *Opichthys timorensis*.

On March 19th, at 6.30 A.M., on the south-east of Cheval the sea-temperature was 82·5° F., and at 7 P.M. it was 83·5° F. The day was spent in dredging down the coast from DONNAN'S Muttuvaratu Paar (Station LXVI.) through Mudalaikuli Paar and Talaivillu Paar (Station LXVII.) to Coppeluddi and Navakaddu Paar (Station LXVIII.). Eight hauls were taken, grouped in three stations.

STATION LXVI.—From south of DONNAN'S Muttuvaratu Paar along the west of the northern part of Mutwal Island as far as off Mudalaikuli Paar; depths 10 to 35 fathoms; bottom Nullipore and Orbitolites sand, some red Algæ and dead Coral; three hauls of dredge.

Orbitolites complanata, *Alveolina boscii*;

Tetilla poculifera, n. sp. (DENDY), *Stelletta* sp., a Calcisponge and others.

Halicornaria setosa, *Sarcophytum*, Pennatulids and other Alcyonaria, *Flabellum* sp., *Heterocyathus æquicostatus* (with Gephyreans), and living Madrepores;

Phyllodoce foliosopapillata and *Mystides* sp. (afterwards found in our pearl-oyster cages at Galle, and may have come from this paar), *Aspidosiphon corallicola*;

Antedon palmata (?), *Holothuria atra* and *H. kurti*, *Cucumaria imbricata*;

Mæra rubromaculata;

Terebra sp., *Pteroceras* sp., *Phyllidia nigra* and small Octopods (*Polypus* sp.);

Cynthia dura (?), *C.* sp., *Polycarpa* sp., *Leptoclinum* sp.

STATION LXVII.—On and off Talaivillu Paar, off south end of Mutwal Island; depth 10 to 14 fathoms; bottom dead Coral and Nullipore; 2 hauls of dredge; *Halimeda tuna*, *Padina commerssonii*. No Pearl Oysters.

Various sponges, chiefly Tetractinellids; *Stephanoseris rousseaui* and *Hetero-*

psammia michelini (with Gephyreans), *Caryophyllia* sp., *Lobophytum pauciflorum*, *Sclerophytum* (? n. sp.), and *Alcyonium pachycladis;*

Hermione sp. and other Annelids; *Asterina cepheus* and *Echinanthus* sp.;

Dexamine sp. and other Amphipods;

Vertagos pharos, and various undetermined Molluscs;

Branchiostoma lanceolatum, var. *belcheri* (several) and *Rhodosoma* (? *papillosum*).

STATION LXVIII.—From off Coppeluddi southwards to Navakaddu Paar; depth 8 to $18\frac{1}{2}$ fathoms; bottom Nullipores (*Lithothamnion fruticulosum*), Coral and muddy Orbitolites sand; three hauls of dredge.

Orbitolites complanatus and other Foraminifera;

Auletta aurantiaca, Axinella tubulata;

Various living Corals—*Cœloria* sp., *Madrepora* (sev. spp.), *Fungia crassitentaculata*, *Flabellum* sp.;

Colochirus sp. (?);

Pagurids and various small Crabs;

Molluscan shells (undetermined), *Doris* sp. (with black branchiæ).

A Tow-net gathering yielded many Copepoda of a bluish colour, including *Pontellopsis armatus, Pontellina plumata, Labidocera kroyeri* and *L. acuta.*

On March 20th Mr. Hornell and I were on our way back to Colombo, on the "Lady Havelock," with a cargo of oysters for Galle. We dredged at two points, (1) on the north end of Chilaw Paar, just north of Station V., and (2) off Negombo. At the latter spot we were again on the bed of oysters we had found on January 31st (Station I.) and obtained some young (about 6 months) on a bottom of coarse yellow sand containing *Caulerpa plumaris* and *Halophila ovata.* At the Chilaw Paar locality we had three hauls which are united as—

STATION LXIX.—On and to the east of the north end of Chilaw Paar; depth 8 to 11 fathoms; bottom yellow quartz sand, with some Coral fragments. Yellow Algæ with Oyster-spat; dredged.

Heterocyathus æquicostatus (with Gephyreans);

Echinodiscus auritus, Clypeaster humilis, Actinometra sp. (deep olive-brown with yellow tips to pinnæ, harbouring an olive-brown *Alpheus* striped with grey);

Aspidosiphon corallicola, Lumbriconereids and other Worms;

Balanus sp., Amphipods and some Decapoda;

Large and small Pearl Oysters and some other common Lamellibranchs, gelatinous Nudibranchs (*Melibe fimbriata*);

Large colony of a reddish Polystyelid, many Leptoclinids (white and drab), *Branchiostoma lanceolatum*, var. *belcheri* (numerous).

A Tow-netting at the same locality gave us, amongst other Copepoda, the large blue *Pontella princeps* and *P. securifer*, *Pontellopsis armatus* and *Labidocera kroyeri*.

We reached Colombo at 4.30 P.M., and this brought to an end the second cruise of the "Lady Havelock," which had lasted for three weeks and four days. We had left Captain DONNAN before the end of his inspection of the banks, because now that I had seen all possible spots on the coast which might serve for a biological laboratory and had selected Galle as being unquestionably the best, it seemed desirable—as the result of correspondence with the Lieutenant-Governor—that I should see for myself the several quarters at Galle that had been proposed and plan out with Mr. HORNELL the necessary alterations and fittings. We took with us various samples of living oysters, both large (3 years old) and small (about 6 months) which were conveyed safely from the pearl banks to Colombo in our steamer tanks and from Colombo to Galle by train in large earthenware "chatties" of sea-water. The journey occupied, with our necessary stoppages, four complete days at a very hot time of year. We were, however, able at the end of it to deposit most of these oysters in a living condition in the sea at Galle on the evening of March 22nd. They soon recovered activity, and were found next morning to be climbing up the chatties and on the netting in which we had enclosed them. The next three days were spent at Galle in examining, along with Mr. H. W. F. C. BRODHURST, the Government Agent, and Mr. T. TWYNAM, the Master Attendant, certain offices and bungalows in the Fort, in the native Bazaar and near Bayley's Villa on Glosenburg (see fig. 7, p. 46). Notwithstanding Professor HAECKEL's favourable opinion of the last named as a site, given 20 years ago, we found it necessary to reject that end of the bay in favour of the Fort; and in the end for several reasons, which I reported to the Lieutenant-Governor, a portion of the former Military Hospital conveniently situated on the ramparts at Akersloot or Sailors' Bastion, close to a good supply of clean sea-water, was selected as being the locality best fitted for adaptation as a marine laboratory (fig. 25). This report was acted on soon after I left Ceylon, with the result that Mr. HORNELL, upon his return from the pearl-banks in April with a further supply of oysters, was very soon established in a simple but efficient laboratory at Galle—carrying on the work I had left in his hands. Since then Mr. HORNELL has, by fortnightly letters, and frequent longer reports, drawings and specimens, kept me in close touch with all the details of his work; and I have sent him what information and instructions were necessary from time to time. The results of these observations at the Galle Laboratory will be given in the later parts of this report.

After having settled matters at Galle so far as was then possible, and having deposited our pearl oysters in bags and baskets suspended from buoys and spars anchored out in the bay (fig. 23), Mr. HORNELL and I returned to Colombo late on March 25th. The following day was occupied in seeing the Lieutenant-Governor in regard to the laboratory at Galle, and other business, and in packing and despatching some of the collections. Early in the morning of the 27th we started by coach to Chilaw, whence we went on by small boat next day to join the "Serendib," which was sent down the coast by Captain DONNAN to meet us. I had now only about ten days left in Ceylon and was anxious to spend most of that time on board the inspection barque seeing

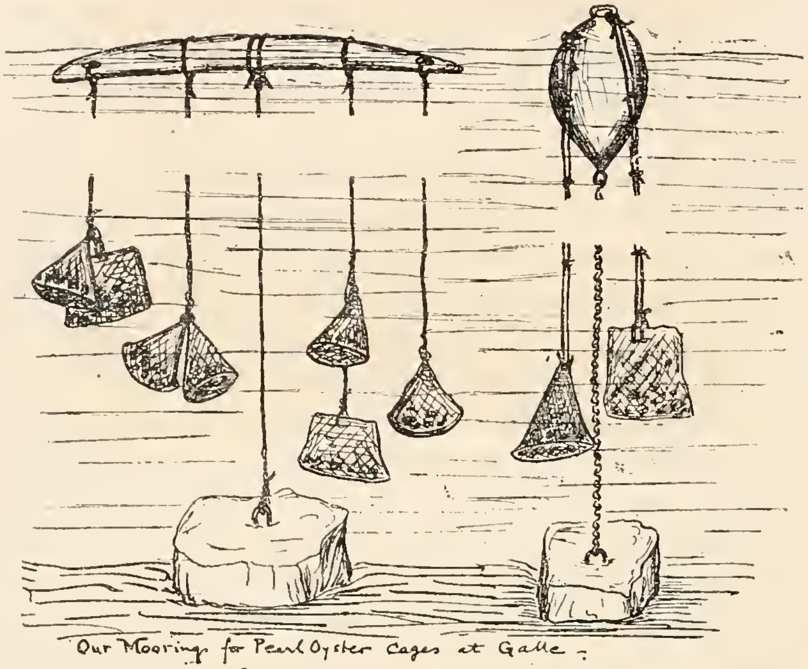


Fig. 23. Experimental oyster cages moored in Galle Bay.

the divers at work and following their results day by day. We reached the "Rangasameeporawee" on the Muttuvaratu Paar in the evening of the 28th, and rejoined Captains DONNAN and LEGGE and Sir W. TWYNAM. On the 29th March we were working on DONNAN'S Muttuvaratu Paar all day. There were plenty of oysters, and the divers brought us up samples and other specimens enough to keep all hands busy. Amongst other interesting forms found here was a new species of Chitonidæ, *Ischnochiton ravanæ*, n. sp. We had now re-started all the tanks and tubs and had many experiments under observation. The paar was estimated to have about 277,000,000 of oysters between $1\frac{1}{2}$ and $2\frac{1}{2}$ years old, but quite a number of them, in the samples we examined, were found to have a dwarfed or ill-grown appearance, accompanied by a yellow discoloration of the mantle and other tissues. We carefully examined this yellow and stunted condition of these oysters both at the time and since, and shall discuss it later on in the report. A good deal of our time was now occupied in examining the food in the stomachs and the sexual condition of the oysters (fig. 24 shows our work place on the barque). We also took tow-net gatherings and obtained samples of the bottom and the bottom fauna by means of the divers, but we had no further dredging or trawling.

The TOW-NET on March 29th, over DONNAN'S Paar, yielded *Trichodesmium, Sagitta.*

Pteropods, and 35 species of Copepoda including—*Corycaeus venustus* and *C. speciosus*, *Clytemnestra scutellata*, *Ectinosoma roseum*, *Acartia erythraea*, *Oncaea mediterranea*.

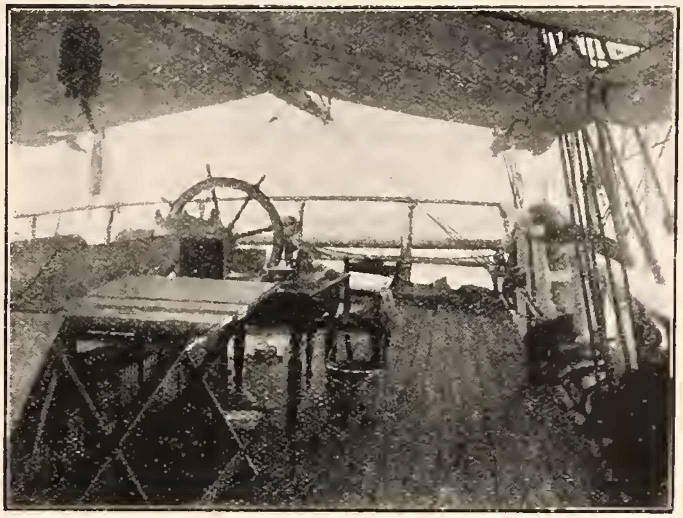


Fig. 24. The deck laboratory on the "Rangasameeporawee," from a photograph by J. HORNELL.

Rhincalanus cornutus, *Euchaeta marina*, *Eucalanus subtenuis*, *Setella gracilis*, *Tortanus forcipatus*, *Calocalanus pavo* and *C. plumosus*. We also obtained from this paar a remarkable Copepod, described below (see p. 245) as the type of a new genus *Ridgewayia*, in honour of His Excellency Sir J. WEST RIDGEWAY, Governor of Ceylon at the time of these investigations.

The sea-temperature on March 29th at 5.30 P.M. was 84° F., and specific gravity was 1·023. The temperature in our wooden tanks on board at the same time was 83° F., and we generally managed, by covering the tanks with moist canvas, to keep the temperature of their contents a degree or two below that of the sea.

The weather was now very hot. On March 30th, the sea-temperature at 7 A.M. was 84° F., and at 5 P.M. was 85° F. We now moved to the southern part of the paar, and in the afternoon rowed to the coral reef lying off Dutch Bay, where Captain LEGGE and I waded over the reef and collected various samples of the fauna.

On March 31st the weather was still warmer. The sea-temperature was 85° F. in the morning and 88° F. in the afternoon, but we managed to keep that in our tanks on board down to 83°·5 F. to 84° F., and the oysters remained very healthy. We moved this morning to the Mudalaikuli Paar, which we found to be practically a living coral reef with no oysters. Fine coral colonies (*Cœloria sinensis*, *Prionastraea* sp., *Pachyseris* sp., *Goniopora* sp., *Hydnophora microcona*, *Galaxea* sp., and *Fungia patella*) and sponges (*Axinella carteri*, *Phyllospongia holdsworthi*, *Spongionella nigra*) were brought up by the divers, but not a single oyster. In the afternoon we took boat and landed at Kattanattu Point, where a long sandy spit runs out to the north-west with a coral reef continuing onward in the same direction and others parallel outside it, so as to give some shelter to a little bay inside the point. We found however that the locality was quite unsuitable for oyster cultivation. In the south-west monsoon the surf evidently breaks over the spit and without doubt churns up the water and the bottom of the bay. This opinion was entirely corroborated by what we heard from the natives on shore.

The Tow-netting on March 30th over the Mudalaikuli Paar gave very much the same results as on the previous day. As additional forms obtained may be noted—

Calanopia elliptica, *Centropages orsini* and a new species of *Centropages*, *Pseudodiaptomus serricaudatus*, and *Eucalanus monachus*.

On April 1st we moved the barque to Talaivillu Paar, where again we found no oysters, the bottom being practically a living coral reef. At 8 A.M. the sea-temperature was 86° F., and at 5.30 P.M. 87° F., and the water in our tanks 84° F. The specific gravity was 1·0229. On Talaivillu Paar we obtained, on a brown (largely calcareous) sand with much *Halimeda* (*H. gracilis* and *H. tuna*)—

Axinella donnani, various incrusting and some Tetractinellid sponges;

Cœloria sinensis, *Porites arenosa*, *Fungia crassitentaculata*, *F. patella*, Madrepora (sev. spp.), *Montipora* sp., *Favia* and other Astræids, *Flabellum* sp., *Sarcophytum roseum*, and other Alcyonaria;

Clæosiphon aspergillum, *Sabellaria bicornis*;

Dexamine sp. and other Amphipods;

Phyllidia varicosa and *P. ceratosoma*; *Leptoclinum* sp.

The Tow-nets gave 22 species of Copepoda, amongst which may be mentioned:—

Setella gracilis, *Oncæa mediterranea*, *Corycæus longistylis*, *Acartia erythræa*, *Pseudodiaptomus aurivillii*, *P. serricaudatus*, and *Tortanus forcipatus*.

On April 2nd, at 6.40 A.M., the sea-temperature was 85° F. and at 6 P.M. it was 86·5° F., the specific gravity being 1·0228. We had moved to the Navakaddu Paar, where the usual diving operations were continued all forenoon. The bottom here consists largely of great blocks of dead Coral much encrusted with Polyzoa, Nullipores, compound Ascidians, &c., together with a certain amount of living Coral, such as Astræids and *Porites*.

Amongst other organisms brought up on Navakaddu were:—*Halimeda gracilis* and various red Algæ (*Hypnea musciformis*, *Polysiphonia*, &c.).

Asterina cepheus and *Antedon* sp. (? *A. palmata*);

Chætopterus appendiculatus, *Trophonia* sp.

Amphipods, Compound Ascidians, and a new species of Chitonidæ, *Callochiton sublævis*, n. sp. (Sykes). There were no pearl oysters.

The Tow-nets this day, in addition to *Trichodesmium* (very abundant) and *Ceratium*, contained a number of Copepoda, including *Setella gracilis*, *Corycæus venustus*, *Calanus minor*, *Ectinosoma atlanticum* and *Oithona plumifera*.

In the afternoon, still continuing south, we moved down upon the Udupankarai Paar. We found that there were no oysters on the ground, and not likely to be, as this paar, like several of the smaller ones in this neighbourhood, is now practically a living and growing coral reef; but from the older records it seems probable that in Dutch or Portuguese times these ranked amongst the productive oyster banks.

On April 3rd we moved down south to the Jokkenpiddi Paar, the last I was able to examine personally. The sea-temperature at 7 A.M. was 85·5° F. We anchored the barque on the north end, and in the "Serendib" ran south for about 7 miles and then steamed slowly back, sending the divers down every $\frac{1}{4}$ mile. Most of the dives gave a "rock" bottom with dead, and occasionally living, coral, and in several places young oysters (3 to 6 months) in quantity; depth $8\frac{1}{2}$ to 10 fathoms. Amongst the animals brought up were :—

Axinella donnani, an abundant lilac *Chalina* and other sponges;

Various Gorgonoids and common living corals;

Echinostrephus molare (in deep burrows in coral blocks), *Antedon* sp. (with commensal *Alpheus comatulorum*);

Sabellaria bicornis and other Worms; Dromiad and other small Crabs;

Chama foliata, and some coral-boring Lamellibranchs, Pearl Oysters, "Suran" (*Modiola*) and "Oorie" (*Sistrum*); *Leptoclinum* sp.

At 10 P.M., on April 3rd, I had to leave the barque "Rangasameeporawee," and was conveyed by the "Serendib" down to Colombo—as I was booked to leave Ceylon on April 7th, and had still to discuss various matters with the Lieutenant-Governor, transact business at the Master-Attendant's and other Government Offices in Colombo and see to the preservation and packing of many specimens. Mr. HORNELL remained with Captain DONNAN for a few days longer to complete the inspection of the southern paars, and obtain a supply of pearl oysters of various ages to take with him to the marine laboratory at Galle. He examined the Jokkenpiddi, Karkapanni, Chilaw, Oolawitti and Negombo paars, and brought a quantity of young oysters from these banks to Colombo, where they were suspended in coir baskets from the stern of the barque lying in the harbour. He then took the "Serendib" north to the Muttuvaratu Paar, obtained a supply of large oysters (3 years old), returned to Colombo, picked up the young oysters and conveyed the whole cargo round to Galle, where they arrived in splendid condition, not one oyster having died on the way. This shows the practicability of conveying the pearl oysters, both old and young, from place to place in a healthy condition by the means we adopted. Great care is, however, necessary if the temperature be high (the sea averaged about 85° F. during our operations) and if the run be more than 36 hours without

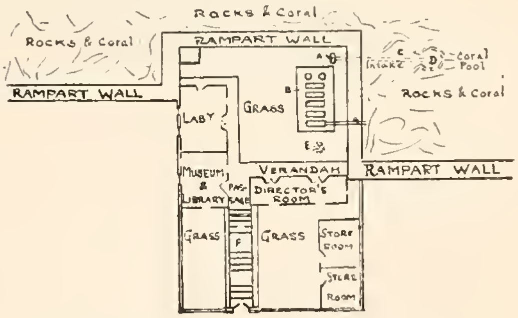


Fig. 25. Galle Marine Biological Station, at former Military Hospital on Akersloot or Sailors' Bastion.

A, semi-rotary hand pump; B, aquarium shed; C, inlet pipe from—D, coral pool; E, suriya tree; F, entrance steps from Dutch gateway dated 1759; G, overflow pipe.

a stop. On that account the November inspection would probably be a better time for transporting, as the temperature is lower then than in March and April.

For some time after this Mr. HORNELL was fully occupied in looking after his oysters sunk or suspended in bags and baskets and "chatties" from boats, and buoys and booms in various parts of Galle Bay; and in superintending the fitting up of the marine laboratory at Akersloot Bastion. In addition to the large rooms (fig. 25) obtained from the old Military Hospital, on the ramparts of the Dutch Fort, which had to be sub-divided and furnished with work-tables, shelving and cupboards, an outside shed formed of "cadjan" (the large leaves of the talipot palm) was erected as a tank-house (fig. 26) to accommodate the wooden tanks and glass aquaria containing

Fig. 26. Aquarium shed with wooden tanks at the Galle Marine Biological Station.

the oysters under experiment and observation. Care was taken in the site and construction of this tank-shed to make it as cool as possible, and the sides were closed in with "tat"-blinds (split bamboos tied together), as being airier and lighter than cadjan flaps. The tanks were connected with the sea by a semi-rotary pump and water pipes which were carried about 20 feet outwards from the base of the rampart in order that the intake might be placed in a deep clear pool lined with living coral. The reservoir into which the pump discharges and from which the sea-water runs through the tanks is formed of two large iron tanks such as are used for citronella oil, with their upper ends cut out, and joined by a pipe at the base. The various observational tanks and aquaria (which had been brought out from Liverpool) were joined up by means of glass and rubber tubing, and were provided with arrangements devised by Mr. HORNELL for distributing air in finely sub-divided bubbles throughout the water. This marine laboratory has proved in every way satisfactory and suitable for our work during the last year. Mr. HORNELL—as the later parts of this report will show—has been able to investigate there the greater part of the matters I left in his hands; but there is still much useful work connected both with the Pearl Fisheries and with other marine industries that he could continue to carry on in this scientific workshop. Moreover, with a little extension of accommodation and permanent equipment it would be an eminently desirable and well-fitted establishment for general marine biological investigation, and would add to the scientific resources and attractions of the Colony. As examples of this it may be mentioned that during the past year (1) Mr. HORNELL has been able to supply specimens of marine algæ to workers at the Peradeniya Botanical Gardens, and types of marine animals to the Medical College at Colombo; (2) a Swedish Botanist, Dr. NILS SVEDELIUS, from Upsala University, has already made use of the laboratory as a place of research, and has expressed the opinion that it is very favourably situated for a tropical Marine Biological Station; and (3) it would naturally afford accommodation and material to the other scientific men of Ceylon. It is conveniently and centrally situated in the Fort, easy of access from the railway station and near the boat jetty, close to pure sea-water, opposite the Vellikoko Reef, adjoining good collecting grounds and with a living coral reef fringing the base of its walls—it seems in short an ideal spot for the purpose. Dr. ARTHUR WILLEY, F.R.S., Director of the Museum at Colombo, writes to me in regard to this Galle Marine Station (May 8th, 1903)—"I shall certainly hope to see the Laboratory which you established at Galle made a permanent institution after the publication of your report. . . . I have been twice to Galle and have seen HORNELL there hard at work, and he has shown me the admirable though simple appliances which render so much service."

Mr. HORNELL's work at the Galle Laboratory since April, 1902, has been chiefly on the following points—all of importance in connection with our understanding of the mode of life, the prosperity and the reproduction of the pearl oyster:—

1. Byssus formation, attachment, detachment, casting off the byssus and re-attachment.
2. Locomotion, both in old and young, crawling by means of the foot, and movement of the shells.
3. Effect of being partially or completely buried in sand. A healthy oyster can free itself from a thin layer of sand, and usually does so; but it cannot get out of 3 inches of sand and soon dies when buried.
4. The sexual condition of the oyster, the production of eggs and spermatozoa, their emission, the fertilisation and the early stages of development.
5. The "spat"—its characters and stages, and comparison with small species of *Avicula*.

6. Food and feeding, and the respiratory and nutritive currents of water. Varying "condition" of different oysters.
7. Growth, increase of the shell and repair of injury.
8. Parasites—Sporozoa, Cestodes, Trematodes, Nematodes, &c., and Commensals: their effect upon the oyster.
9. Other diseased and abnormal conditions of the oyster.
10. Pearl-production, both artificial and natural.

Some of these inquiries were merely the continuation of observations and experiments we had made during our work in the "Lady Havelock," others were undertaken with the object of settling definitely doubts that had been expressed or difficulties that had been raised in the Inspectors' reports and other previous writings, such as Sir W. C. Twynam's "Report on the Ceylon Pearl Fisheries," Colombo, 1900—a most useful summary of many previous documents, illuminated by a personal experience of nearly half a century. Our results, although no doubt they could be added to by further work, are I believe conclusive so far as they go; and consequently must be recorded even when, as in some cases, they merely corroborate or extend what was observed by Kelaart, Thomas, Holdsworth, Thurston or others.

The powers of locomotion we found to be unexpectedly great, especially in the case of young oysters (see some instances we gave on p. 58); and the capability of detachment and re-attachment, and of renewed byssus-formation, is considerable. These are clearly points of great practical importance in connection with our recommendations as to the thinning out and transplanting of young pearl oysters. Such transplantation could only be successfully undertaken in the case of oysters able to find suitable stations in their new environment and to re-attach themselves securely. The effect of burying in sand throws light upon some of the catastrophes that have affected promising beds of oysters in the past, and the knowledge will be useful in leading us to remove the stock in dangerous positions from such risks in the future. The sexes are separate, and, as our experiments show, remain the same from season to season: each individual is permanently either male or female. The natural emission of both ova and spermatozoa has taken place in our tanks at the Galle Laboratory, and we have reared the young pearl-oyster from the egg to a shelled larval stage similar to one obtained in the tow-nets. On all the other points we have I believe made some additions to knowledge which will be discussed below in the special articles.

In October, 1902, Mr. Hornell carried out my suggestion of a further examination of Trincomalee Harbour and Tamblegam Lake. He gave ten days to the work and got satisfactory results which I have already noted (see p. 41).

Early in November he joined Captain Legge in the inspection of the pearl banks for the purpose of obtaining a sample of oysters to be valued by the pearl experts at Colombo in view of the proposed fishery. The following paars were inspected :—South, East and West Cheval, and Periya Paar Kerrai in considerable detail, and from these samples were lifted (fig. 27); while the following were less fully examined :—Kondatchi Paar, Dutch Modragam Paar, Muttuvaratu Paar, Chilaw Paar, and the ground off Negombo. Mr. HORNELL examined large numbers of oysters from the

Fig. 27. Valuation sample of pearl oysters from the Cheval Paar, being brought on board the "Rangasameeporawee" from the inspection boats—from a photograph by J. HORNELL.

various paars as regards their sexual condition, parasites and the occurrence of pearls. He also investigated the plankton as fully as possible, and found, on Muttuvaratu Paar, the youngest stages of the larval Cestode which we regard as the chief cause of pearl-formation free-swimming in the water.

Mr. HORNELL also took a considerable number of living oysters round with him from Muttuvaratu and Chilaw paars to Galle, where he placed them at various chosen spots in the lagoon for observation and experiment.

The official samples of pearl oysters taken from the Cheval Paars and Periya Paar Kerrai in November were valued in Negombo by five expert native merchants and Captain LEGGE, the Inspector of Pearl Banks, with the following results :—

12,000	oysters	from the	South-East part of the Cheval Paar,	at Rs. 10 25 c.	per 1000
1,000	,,	,,	East Cheval Paar,	at Rs. 18 $17\frac{1}{4}$ c.	,,
2,000	,,	,,	North-East part of the Cheval Paar,	at Rs. 23 $12\frac{1}{2}$ c.	,,
2,000	,,	,,	Periya Paar Kerrai	at Rs. 13 25 c.	,,

As a result of this valuation it was decided to hold a pearl-fishery in the spring of 1903; and it was announced in the Ceylon Government Gazette Extraordinary No. 5896, of December 22, 1902, that the fishery would take place at Marichchukaddi, which is about 8 miles south of Chilavaturai, on or about 22nd February, 1903.

The paars announced for fishing were :—

South-East Cheval Paar,	with	49	million	oysters	sufficient	for 120	boats	for 40	days
East Cheval Paar,	,,	11	,,	,,	,,	28	,,	40	,,
North-East Cheval Paar,	,,	13	,,	,,	,,	32	,,	40	,,
Periya Paar Kerrai,	,,	8	,,	,,	,,	20	,,	40	,,

Making in all . . . . . 81 millions of pearl oysters estimated as fishable.

Mr. Hornell left Galle on January 27th and arrived off Marichchukaddi, the head-quarters of the fishery, on January 31st, and in this neighbourhood he remained for the next three months, leaving on April 23rd and arriving back at the Galle Laboratory on 4th of May.

The fishery did not commence until March 3rd and it ended on April 15th, having lasted for 38 days and resulted in a revenue of Rs. 830,151 93 c. Thirty-nine millions of oysters are estimated to have been obtained from the eastern Cheval paars, and an inspection made by Captain Legge at the conclusion resulted in the estimate that 22 millions of adult oysters were still left on these paars alone. This demonstrates one of the obvious imperfections of the method of fishing by means of native divers. When the divers have made enough money, or are wearied of the work, or find that the scattered condition of the oysters makes it more difficult to fill their baskets, they can declare that the bank is exhausted and so cause a premature stoppage of the fishery. Under such circumstances most of the oysters left at the bottom might still be recovered by dredging.

In addition to the paars fished, a number of the neighbouring smaller paars were inspected, and Mr. Hornell was able, by means of the European diving suit which was now available, to make a personal examination of the bottom and acquire a fuller knowledge of the conditions than had before been possible. He made about 40 descents in all—upon the Cheval, North and South Modragam, Periya Paar Kerrai, Kondatchy, Aripu, Periya, Dutch Modragam, Naddakudda, Vankali, Anaivel-unden, Karativo, Alentura and Muttuvaratu paars. On the larger paars several descents were made, eleven upon the Cheval as the one deserving most attention. One important result of this personal inspection of the bottom was to establish—if that was necessary—the correctness of the conclusion we had arrived at during our work on the "Lady Havelock," that the greater part of the bottom on the pearl-banks is suitable for dredging, and that the oysters could be obtained from the paars during a fishery much more effectively and speedily by dredging from one or more small steamers than by diving. On the Muttuvaratu Paar Mr. Hornell reports that three dives showed a dredgable bottom, while the fourth dive was on a spot where the dredge could not be worked as the "rock rose from the bottom in great plateau-like ledges." A similar condition was found at one spot on the Dutch Modragam Paar, but otherwise the bottom all over the productive paars is perfectly suitable for dredging. The Cheval paars and the North and South Modragams present ideal bottoms for dredging, or even for working a small trawl upon, being level and consisting mainly of a thin layer of sand covering a firmer substratum of the cemented material known as "rock." I shall return to this matter of dredging for the pearl oysters, in place of diving, in my Recommendations at the end of the Report.

During this period Mr. HORNELL also examined large numbers of pearl oysters of various ages and from different paars and so was able to confirm and extend our previous observations. He was especially successful in obtaining stages in the formation of pearls, and in the life-history of the pearl-causing parasites. The details obtained during this three months' work on the pearl-banks have been incorporated with our other investigations (1) on the condition of the ground (see p. 99); and (2) on the parasites and pearl-formation, in the parts that follow.

For some weeks after this Mr. HORNELL was engaged at Galle in completing his notes and records of observations and in packing off to me the specimens which had to be examined in Liverpool, and so finished his work as my Assistant in this investigation. If he is enabled to continue his observations as a Marine Biologist at the Galle Laboratory, judging from the industry, energy and ability he displayed during the time we were associated in work, I can confidently predict that he will render signal service to the pearl, sponge, trepang and other marine fisheries of the colony.

The inspection barque "Rangasameeporawee."

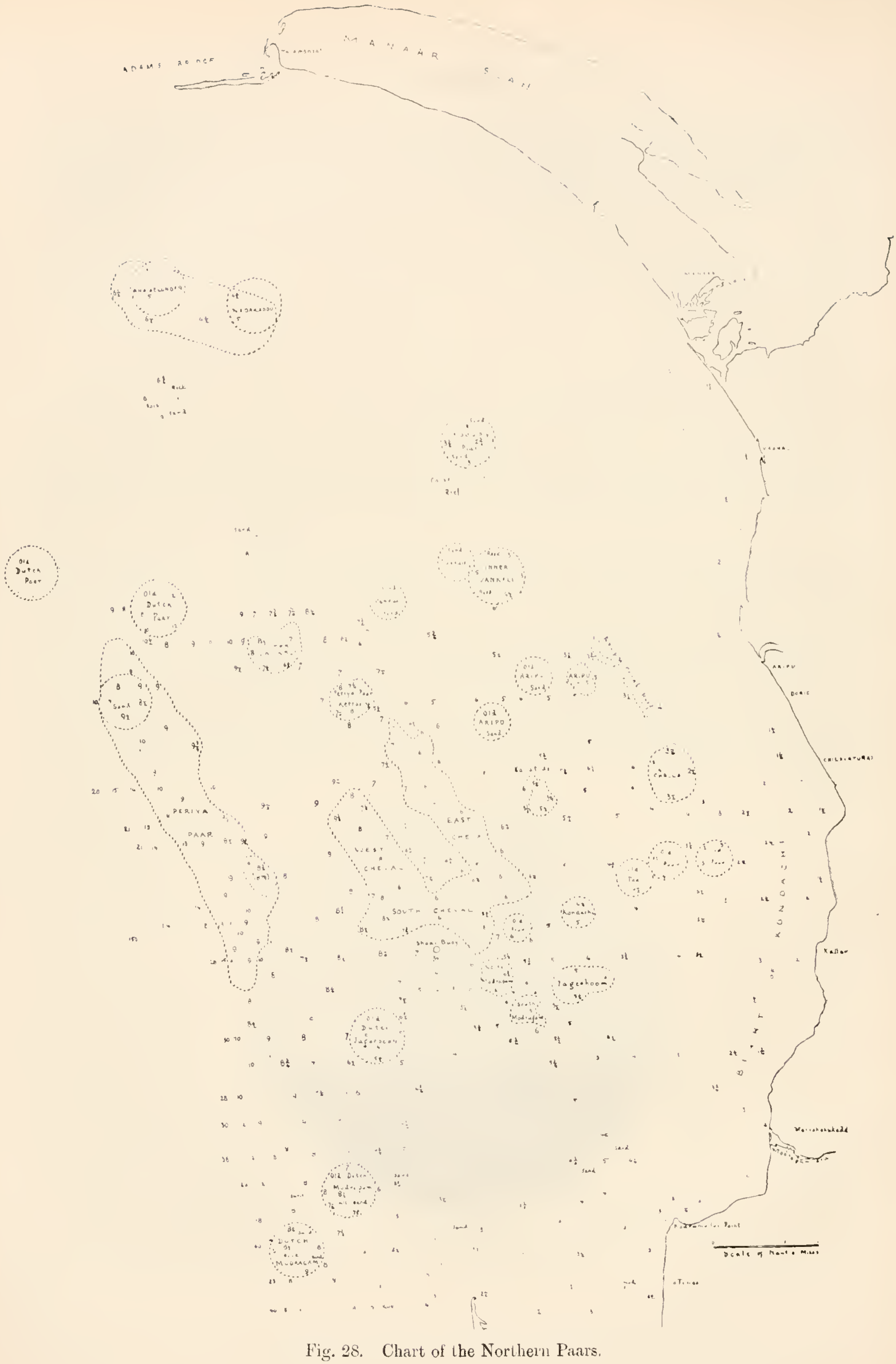


Fig. 28. Chart of the Northern Paars.

DESCRIPTION OF THE PEARL-OYSTER BANKS OF THE GULF OF MANAAR.

THE following account of the physical and biological characteristics of the various "paars" on the Ceylon side of the Gulf of Manaar is drawn up partly from the information obtained by dredging over the ground from the ss. "Lady Havelock," partly from our lines of dives from the "Serendib" during the inspection of March, 1902, and partly from the additional information which Mr. HORNELL obtained during the fishery of 1903. On this last occasion a European diving dress was available for use—which we had not had in 1902—and consequently Mr. HORNELL was enabled to descend himself, and so corroborate, correct, and supplement the information derived from the natives* by many further details. The lists of animals found on the "paars" given here are not intended to be exhaustive, or even full. The object is merely to mention a few of the more characteristic organisms in each case.

The paars may be arranged in two groups, the Northern from Adam's Bridge down to Kodramallai, and the Southern from that point onwards; we give a chart (fig. 28 and fig. 37) of each group. The Northern is by far the more important; it contains more paars, they are of larger extent, and have produced most of the recorded fisheries. The pearl-bank plateau, bounded for the most part by the 10 or 12-fathom line, widens greatly in the northern part of the Gulf of Manaar as it approaches Adam's Bridge (see fig. 1, p. 19); for whereas off Negombo and Chilaw it is only 3 to 6 miles from shore, off Aripu and Kondatchi it is from 16 to 20 miles.

This widening of the plateau north of Kodramallai allows the northern paars to form several series, one outside another, and roughly parallel with the coast, the inner series being about 4 and the outer 18 miles from land. Outside the paars the ground shelves away rapidly to 20 or 30 fathoms, which marks the top of the steep slope down to the mud-floored abyss forming the central portion of the Gulf. Along the line of this slope soundings in some places jump in very short distances from 20 fathoms to anything between 100 and 1000, with, of course, interesting differences in the fauna. Within the 10 or 12-fathom line, on the other hand, the ground is for the most part very level, especially on the wider northern part of the plateau. At the Cheval Paar a distance of 12 miles is run from shore before a depth of 7 fathoms is reached—a gradient of 1 in 1700. The surface of this plateau is for the most part

* Mr. HORNELL, writing to me of the results of his inspection, says that he finds the diagrams compiled from the divers' reports erroneous, and adds, "On the other hand, the results obtained by dredging—which sometimes clashed with the divers' reports—were proved to be reliable, and indeed wholly accurate. The conclusions based upon this source of information require no emendation—merely amplification."

sand, diversified here and there by outcrops of so-called "rock," generally in the form of flat or slightly-inclined ledges, sometimes stepped to form low terraces, sometimes level with the surface, and sometimes even a few inches under it, the rock being then covered by a thin layer of sand, which shifts from time to time with the currents.

Some of the paars, such as the Muttuvaratu, Karativo, Dutch Modragam, and parts of the Western Cheval, are formed almost entirely of rock, and the small amount of sand found in crevices and sprinkled over parts is mostly of organic origin—*Heterostegina*, *Alveolina*, *Orbitolites*, and other large Foraminifera and fragments of shells. On other paars, such as the East and South Cheval, angular quartz sand predominates, sometimes underlaid by flat rock which crops out at intervals. Mr. J. Lomas, F.G.S., who has examined the samples of "rock" we obtained from the paars, is of opinion that they are all of recent origin, and are in fact merely a consolidation or cementing of the sand *in situ*. Further details of the nature of these modern calcareous rocks or "Calcretes," and of their mode of formation on the paars, will be given in Mr. Lomas' report which follows.

The calcretes naturally vary considerably from place to place, being in some cases mainly composed of terrigenous materials and in others being mainly neritic or formed of organic remains. The rock may be a grit stone formed of the yellow-tinted quartz sand, which is so abundant, cemented by carbonate of lime, or it may be largely dead worn and altered coral, or it may be a shelly mass, an agglomerate of the dead valves of pearl-oysters, cockles, and Pectunculids with Nullipores (*Lithothamnion*) and Polyzoa (Lepralids) intermingled.

In addition to the paars described below, there are a few others, marked on the chart as "Old" or "Old Dutch" (see figs. 28 and 37), which are either erroneous positions of other paars now more accurately determined or are patches which formerly bore oysters and have since changed their character.

We must not, however, try to be too precise in regard to the positions, sizes, and outlines of the paars. Our work in the "Lady Havelock" showed us that some spots around and between them are more or less hard-bottomed, and even in some cases bore oysters and are capable of becoming paars. On the other hand, it is known from the inspections that many parts of the known paars are temporarily, and possibly some parts even permanently, unsuitable for the attachment or rearing of oysters. We may consider, then, the whole plateau as potentially "paar" ground—some parts of it better suited for one purpose and some for another, some parts more constantly covered by the shifting sands, others more regularly bare and hard. This renders possible the farming operations, such as "culching" and transplanting, which we discuss in our "Recommendations."

Cheval Paar.

This is the most important and the largest of the paars, and is the central member of the northern set, most of the other paars being grouped around it (see fig. 28).

It lies from 9 to 13 miles off the coast, opposite the bight of Kondatchi, the northern point being due west of Aripu and the southern of Kallar tower. The paar extends for about $6\frac{1}{2}$ miles from north to south, and $4\frac{1}{2}$ miles from east to west, but is not all occupied by pearl oysters. The depths vary from 5 to $8\frac{1}{2}$ fathoms. The paar is usually divided into an eastern, a western, and a connecting southern portion, and in most of the fishery charts since the time of STEUART (1843), these have been combined to form a conventional horse-shoe shape, which, however, does not now correspond at all accurately with the area covered, or likely to be covered, by pearl oysters.

The parts of the paar differ considerably in character, the east and south being more or less sandy, and the west, and especially north-west, more rocky; and the effect of this difference can be traced in the condition and history of the pearl oysters from these parts.

The Cheval Paar has yielded many important fisheries. During the nineteenth century we find that the whole or parts of it were fished in 1804, 1806, 1808, 1809, 1814 (the largest fishery recorded), 1816, 1820, 1829, 1830, 1831, 1836, 1837, 1855, 1857, 1858, 1859, 1863, 1874, 1877, 1880, 1881, 1887, and 1888. In the earliest records the Cheval and Modragam paars are united as the Aripu banks.

West Cheval.—Here the bottom, especially towards the north, is very rocky, with little sand. The depth is mostly about 7 to 8 fathoms. The rock is a compact shelly limestone with some quartz sand cemented to it by carbonate of lime. It is much overgrown by Algæ and Sponges, and the *Sargassum* weed is especially abundant. Bare parts of the rock are of a reddish-yellow colour from ferruginous staining, and it is all much tunnelled by *Clione* and boring Molluscs. Between the long level stretches of rock are smaller sandy tracts, especially towards the south, where the sand is irregular, rising up into little hillocks, amongst which are scattered Nullipore balls and hemispherical Astræid corals. This large extent of rock, some hundreds of acres of continuous hard bottom, offers favourable conditions for the attachment of spat, and the area is notably prolific. During our inspection in March, 1902, Captain DONNAN estimated that there were, on the West Cheval, 123 millions of oysters as against 74 millions on the eastern side of the paar. This abundance carries with it, however, the attendant danger of overcrowding as the oysters grow older, and appears to result in a stunted condition and, it may be, disease and wide-spread mortality. The dwarfed state of the oysters on both the North-west Cheval and the Muttuvaratu Paar has been recognised by the divers, and by the Inspectors in their reports, as the "Koddaipakku" variety (see, for example, Sir W. TWYNAM'S "Report"). Captain DONNAN remarks, under date 18th March, 1901, "I have noticed on previous occasions that young oysters on the East Cheval grow much larger and quicker than oysters on the West side of the Cheval." We found the average size of a fair sample of oysters from the North-west Cheval to be (March 27th, 1903): $61{\cdot}50 \times 58{\cdot}33 \times 26{\cdot}84$ millims., while the average size from North-east Cheval was $76{\cdot}05 \times 71{\cdot}45 \times 31{\cdot}45$ millims., and the average from Muttuvaratu was

57·54 × 54·00 × 24·42 millims., all being of the same season, from $3\frac{1}{4}$ to $3\frac{3}{4}$ years old. The stunting, although less marked than in the case of the Muttuvaratu Paar, is apparently a permanent characteristic of the North-west Cheval, and is due, we consider, to the conditions which favour an abundant deposit of spat leading afterwards to overcrowding and insufficient food.

The characteristic organisms on the bottom are :—

Sargassum and other Algæ (*Padina* and small Florideæ) in profusion ;

Spongionella nigra, and a few Corals such as *Turbinaria cinerascens* and some Astræids; the large red starfish *Pentaceros lincki*, a fine species of *Cidaris* and *Antedon*. Quantities of *Aplysia* were seen, also *Lamellaria*, *Chromodoris*, *Scyllaea* and *Eolids; Pinna* lay flat on the rock in place of being partially buried in sand. The large pinkish Ascidian *Rhabdocynthia rosea* was also present.

East Cheval.—The bottom here consists of fragments of rock embedded in or covered with a few inches of sand. One piece brought up by the divers from the North-East Cheval ($6\frac{1}{2}$ fathoms) was a tabular calcareous mass, 4 feet by 2 feet by 4 or 5 inches thick, upon which about a dozen pearl oysters were attached, distributed as follows:- One end of the block projected above the sand and bore most of the oysters and some small Algæ, &c. ; the other end was covered with a thin layer of sand, but had 5 oysters attached, the byssus passing through the sand to join the rock below—several other byssus tufts were also present ; finally the middle, lowest, part was more deeply buried in sand and showed no trace of oysters. This case was typical of many "rocks" examined. The block was composed mainly of dead coral, upon which old worn shells and quartz grains had become cemented ; partly by deposition of carbonate of lime and partly by incrusting calcareous Algæ, Polyzoa, and Serpulid tubes. The deeper parts showed ferruginous staining, and the cavernous condition of the interior in this and other blocks was due partly to the irregular disposition of the original components now cemented, and partly to boring by *Clione* and Molluscs. While at the north end of the paar the rock seems to be mainly dead coral, a little further south it becomes a grey-green compact grit stone cemented by carbonate of lime and incrusted with Nullipores and Polyzoa.

Over much of the East Cheval sand predominates on the surface, underlaid by rock, at a depth of 6 inches to 2 feet, from which in places corals and other colonies project above the sand. The pearl oysters, in our experience, were fairly evenly distributed, and in quality they proved to be the best of all those examined or fished. They were well-grown and vigorous (fig. 29), and richer in good pearls than any others.

In the sandy parts the pearl oysters are attached through the sand to buried fragments of rock, coral, or any firm substance. Sometimes one oyster is attached to a piece the size of a walnut, and two or three others are fixed to the shell of the first.

On this part of the paar large Algæ are scarce, but there were plenty of small Florideæ, *Padina*, *Laurencia* (boiled into jelly and eaten by the natives), *Poly-*

siphonia, *Corallina*; and a *Caulerpa* straggles through the sand. Amongst the commoner animals were hemispherical Astræid Corals, a small *Fungia* (*F. dentata*,

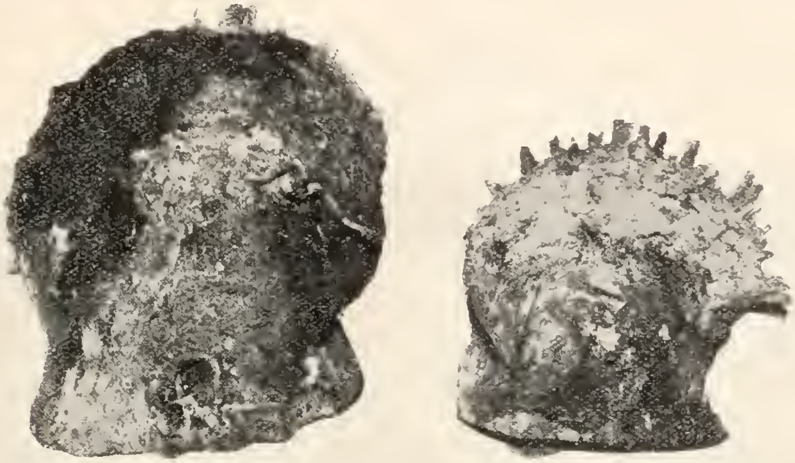


Fig. 29. Pearl-oysters from East Cheval Paar showing growing edges.

young, see fig. 30), a few Holothurians (*H. atra*), and the red *Pentaceros* and very many young *Aplysia*. But the most characteristic animal of this part of the Cheval Paar is the large Hydroid Zoophyte *Campanularia juncea*, which comes up in great bunches not unlike cut "heather," the name by which it has been sometimes indicated in the Inspectors' reports. The sand is largely composed of shell fragments, Nullipores

Fig. 30. *Fungia dentata*, living and expanded specimens from the East Cheval Paar, natural size.—From a photograph by J. Hornell.

and Foraminifera. Other animals found here were *Spongionella nigra*, *Linckia* sp., orange Gorgonids, and species of *Haliotis*, *Arca*, *Cardium*, and *Turbinella*.

At the south-east corner of the Cheval we found that out of 307 dives 11 brought up adult oysters (7 from rock and 4 from sand), 216 brought up young oysters, 64 were on bare sand and 16 on rock without oysters.

About the middle of the East Cheval there are rocky patches of quartzose gritstone, which are too rugged to be fished by dredging, and yet are crowded with oysters. The few such areas on the pearl-banks might be cleared by divers, or if left unfished would no doubt form valuable breeding reserves.

South Cheval.—Unlike the eastern and western regions to the north, a remarkable uniformity characterises the whole of the southern part. The bottom is very level and is composed of sand and shell gravel, the latter chiefly the broken and worn fragments of pearl-oysters, Pectunculids, and Cockles. Scattered about in great profusion lie also fragments of dead coral, calcareous rock, shell-conglomerate, balls of *Lithothamnion* (fig. 31), from the size of a hazel nut to that of a cricket ball, and dead

Fig. 31. Nullipore ball (*Lithothamnion fruticulosum*) with tags of byssus where pearl-oysters have been attached (to the right), and similar ball still covered with young pearl-oysters (to the left); natural size.

shells. These fragments rarely exceed 6 inches in diameter, but some larger blocks of rock lie buried under the sand. Very rarely, however, is there any sign of extensive rock, such as is seen in the more northern parts of the paar, and none rises above the surface. This, like so much of the ground on the pearl-banks, is excellently suited for dredging over.

The pearl oysters lie for the most part loose on the sand in bunches, each bunch having in its centre one of the fragments of coral, rock, or nullipore. Often one oyster has three or four small stones and shell fragments entangled together in its byssus, while other individuals, usually younger, cling to its valves. There may be any number from 3 or 4 up to 15 or 16 oysters in a bunch. Some of the bunches (fig. 32) are formed of young and old individuals, ranging from 1 month up to nearly 4 years of age, joined together.

Non-calcareous Algæ are scarce here, *Pentaceros* and Holothurians are fairly common, and the Hydroid Zoophyte *Campanularia juncea* is characteristic of the eastern end and extends north along the East Cheval. *Spongionella nigra*, *Fungia dentata*, and Astræid Corals are also common, and a large mass of the delicate Annelid tubes, *Filograna*, was obtained near the shoal buoy. Dead oyster shells are very abundant at the eastern end, and it is here that we find the occasional lumps of shell-conglomerate formed of pearl oyster valves up to 4 years old, shells and casts of

Pectunculids, *Cardium*, *Macra*, *Venus*, &c., cemented together by mere films of carbonate of lime, supplemented in places by patches of *Lithothamnion* and Lepralid Polyzoa. This shell-conglomerate may be ferruginous like the Red Crag Deposits.

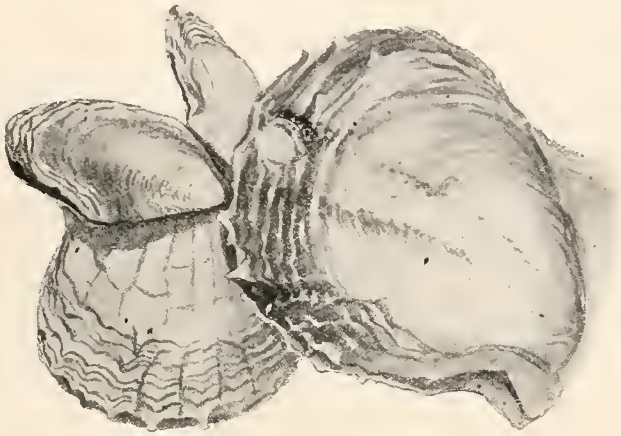


Fig. 32. Four generations of pearl-oysters from the Cheval Paar. The largest is $3\frac{3}{4}$ years old, the next is 18 months, two (above) are 8 months, and one (on the large shell) is about a month old. —From a photograph, March, 1903.

The cup-shaped horny sponge *Phyllospongia holdsworthi* is abundant at the western end, and, though not confined to this region, as has been supposed, is so characteristic that the native divers have named the western part of the bank the Koddai (or "Umbrella") Paar.

A comparison of these different parts of the Cheval Paar shows the great importance of scattered "culch" such as dead coral fragments, Nullipores, and old shells as a basis of attachment for the pearl oysters. The large embayment (fig. 32A) between the East and West Cheval has a bottom of sand, much of which could be made available for oyster cultivation by a system of "culching" with material brought from the beach or from any of the coral patches (Aripu, Kodramallai, &c.) in the neighbourhood. The limits of the paar might also, by the same process, be extended at least half-a-mile further to the east.

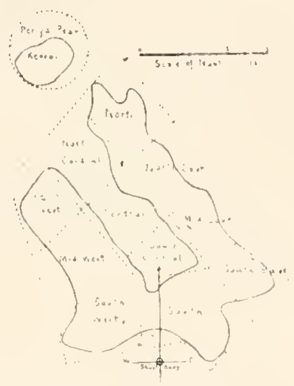


Fig. 32A. Proposed culture areas recommended for the Cheval Paar and Periya Paar Kerrai.

Modragam Paar, North.

This paar lies south-east of the central part of the Cheval Paar, at from $\frac{1}{2}$ mile to 1 mile distant, and is nearly 1 mile in diameter. It is about $8\frac{1}{2}$ miles west of Kallar tower. The depth is from $5\frac{3}{4}$ to $6\frac{3}{4}$ fathoms.

The bottom is sandy, ridged and furrowed ; no rock is to be found.

The pearl-oysters are in bunches lying on the sand, chiefly in furrows, each bunch having in its centre some fragment of dead coral, nullipore, calcrete, or other hard substance, to which most of the oysters are attached. In the first four bunches examined the numbers were 10, 8, 21 and 11 respectively. A characteristic feature is the number of barnacles and small rock oysters incrusting the valves.

Caulerpa (? *C. scalpelliformis*) is common here, growing in the sand along with the Phanerogam, *Halophila ovata*, of similar habit.

Amongst the animals noticed were :—*Clypeaster humilis*, *Salmacis bicolor*, *Luidea maculata* and *Pentaceros lincki*.

Captain DONNAN reported that the pearl oysters on this paar were "in great abundance in large clusters" in 1856 and again in 1857. These were fished in 1859 and in 1860. The paar yielded a small fishery in 1877 and a larger one in 1887, and again in 1888, when both Modragams were fished along with the whole of the Cheval Paar. The oysters on this paar are well grown, but seem limited in number for want of a hard bottom for attachment. The benefit of "culching" such a locality as this must be obvious.

MODRAGAM PAAR, SOUTH.

This lies 1 mile south-south-east of the North Modragam, and is about $\frac{1}{2}$ to $\frac{3}{4}$ mile in diameter. It is about 7 miles north-north-west of Kodramallai Point, and has a depth of $5\frac{1}{2}$ to 6 fathoms. The bottom is rocky but very level, and appears to be covered in its entire extent with a thin layer of sand, in which there are many broken shell fragments, especially pearl oysters, *Cardium* and *Pectunculus*. There are some Algæ, but when we examined the paar, very few pearl oysters.

Amongst the characteristic animals are :—the sponges *Axinella donnani* and *Spongionella nigra*, and many Astræid corals—small hemispherical colonies projecting through the sand and apparently attached to underlying rock.

This paar, along with the North Modragam, has usually been fished at the same time as the Cheval, but it apparently yielded important fisheries alone in 1828 and in 1860.

KONDATCHI PAAR.

This lies closer in-shore than the Cheval Paar, and about 1 mile due east of its southern end. It is about 1 mile in diameter, 7 miles off-shore, and has depths of 4 to 5 fathoms.

The greater part of the area is sand. Out of 171 dives 14 only were on rock, 157 on sand. There are occasional little patches of partly buried rock projecting from the smooth sandy surface. This paar is recorded to have only once yielded a fishery—that of 1801. There are now only a few pearl oysters, of mixed sizes, along with *Pinna bicolor*, *Luidea maculata*, and several kinds of *Pentaceros*—one very common species (?) is nearly black in colour, with red tops to the rounded tubercles, another form is grey, and another shows orange blotches and tubercles. Pennatulids, spinous and purple coloured, which had obviously been embedded in the sand, were also brought up. The shells of the pearl oysters were incrusted with small rock oysters (*Ostræa* sp.).

When we saw this bank in March, 1902, it had a crop of pearl oysters estimated at $5\frac{3}{4}$ millions. These had nearly all gone by March, 1903, and it is probable that their disappearance may be accounted for by the very large numbers of starfishes present, especially *Pentaceros lincki* (fig. 33).

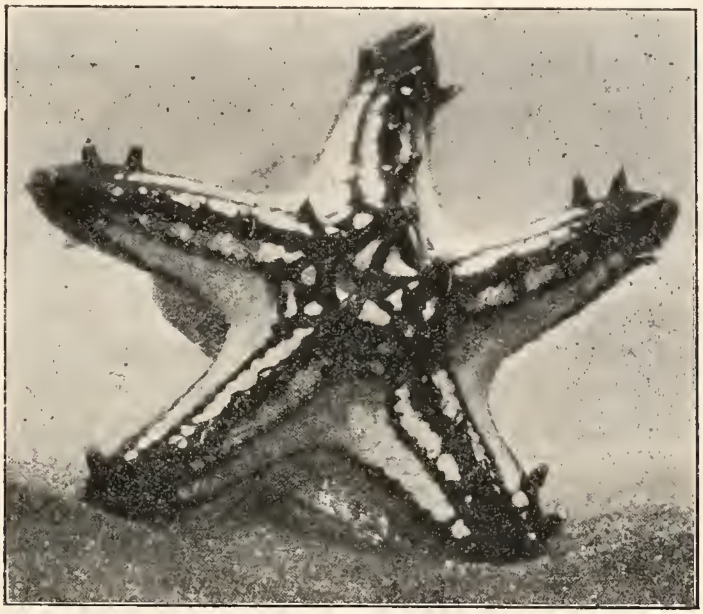


Fig. 33. *Pentaceros lincki*, DE BL., lying on a large pearl-oyster, half natural size.—From a photograph by J. HORNELL.

JAGERBOOM PAAR.

This lies 2 miles south of Kondatchi Paar and about $6\frac{1}{2}$ miles off-shore, opposite Kallar. It is about $1\frac{1}{2}$ miles across and has depths of 4 to $5\frac{1}{2}$ fathoms. The divers brought up pieces of the "rock" bottom, which consisted of rough quartz sand cemented by carbonate of lime, together with fragments of shell.

There are many starfishes (*Pentaceros lincki*) on this paar, as on Kondatchi Paar, and these probably contribute to the mortality of oysters.

An old Dutch "Jagerboom" bank is also marked on the charts about 2 miles south of the West Cheval and outside the Modragams—it is now covered with sand.

KALLATIDEL PAAR.

This little paar lies $1\frac{1}{2}$ miles to the east of the Cheval Paar and is about 7 miles off Aripu. It is nearly 1 mile in diameter and the depth is $5\frac{1}{4}$ fathoms. It is, in its present condition, unimportant.

ARIPU PAAR.

This lies 6 miles due west of Aripu, and 4 miles north-east of the north of the Cheval Paar. It is 1 mile in diameter, and the depth is 4 to 5 fathoms. Some old Dutch paars, marked on the charts as "Aripu," lie close to and outside. They are now covered with sand and are unimportant. About 1 mile further inshore lies Aripu

Coral Reef, round which is a hard patch of nearly 1 mile across, with depths of $2\frac{1}{2}$ to $4\frac{1}{2}$ fathoms. This, although itself unsuitable for oysters, is of value in supplying dead coral fragments, &c., as "culch" to neighbouring grounds. The bottom is level, consisting of sand and shingle lying on a foundation of flat rock. The sand varies from a mere sprinkling to a good depth. There are also some Nullipore balls, coral and shell fragments, and masses of cemented sand. Living corals are more abundant than on any part of East Cheval, no doubt owing to the proximity of the reef.

Amongst the more abundant organisms were :—

Various Algæ (including a *Galaxaura*, a fleshy *Laurencia* and *Halimeda tuna*), *Spongionella nigra*, *Axinella donnani*, *Phyllospongia holdsworthi*, *Turbinaria cinerascens* and *T. crater*, *Sarcophytum* sp., *Pentaceros* sp., *Linckia* sp., and other starfishes, *Holothuria atra* and other species, Ophiuroids and *Palinurus* sp.

The records of important fisheries early in the Nineteenth Century (between 1804 and 1820) on Aripu Paar do not refer to this little patch alone but to the great banks lying "off Aripu," viz., the Cheval and Modragam paars.

When we examined this paar there were comparatively few pearl oysters, but they were of various ages.

Challai Paar.

This little paar lies 5 miles to the east of the Cheval Paar, and about 4 miles south-west of Aripu. It is the nearest paar to land in this region, is about 1 mile in diameter, and $2\frac{1}{2}$ to $4\frac{1}{4}$ fathoms in depth. It does not now support any oysters, and is unimportant.

Periya Paar Kerrai.

This lies about 1 mile north-west of the most northerly point of the East Cheval Paar, and is about 12 miles west of Aripu. It varies from $\frac{1}{2}$ mile to $1\frac{1}{2}$ miles across.

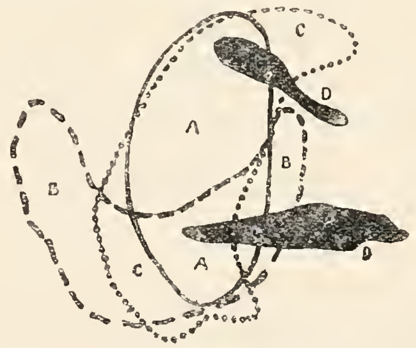


Fig. 34. Plan of the Periya Paar Kerrai. The whole line surrounding A shows the area as inspected in 1882, the dashed line round B shows the paar in 1884, the dotted line round C shows the condition in 1886, while the two black patches indicate the parts fished in 1835 and 1836.

and has depths of from 7 to 9 fathoms. The diagram (fig. 34) shows how the hard area forming the paar has varied in extent and shape from time to time.

The bottom is flat, being a continuous stretch of "rock" overlaid by a thin layer of sand. The samples we obtained were calcretes, largely encrusted with Polyzoa and Nullipores, and some shell conglomerates (fig. 35) formed of casts of the valves of pearl oysters, *Cardium*, *Pectunculus*, *Murex*, and *Cerithium*. Here and there the surface of the rock is exposed and coated by Nullipores and other encrusting organisms, and there pearl oysters (fig. 36, *o.*), or the marks of their byssus (*b.*), are found in quantity. Many crushed valves and broken fragments were also seen, showing that many more pearl oysters had been present lately. We attribute the destruction in this case to the carnivorous fish *Trygon uarnak* browsing over the bottom.

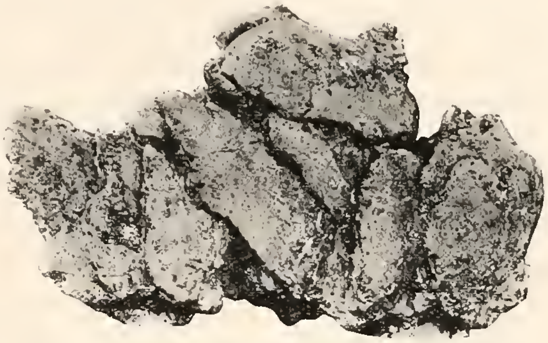


Fig. 35. Shell conglomerate from Periya Paar Kerrai.

Very little coral is present here—a few Astræids only were found. There is some *Sargassum* and a few other Algæ (*Acetabularia*, *Laurencia*, and *Lithothamnion* balls),

Fig. 36. Diagram illustrating the distribution of pearl-oysters and old byssus on "rock" and sand.

some black sponge (*Spongionella nigra*), a few trepang (*Holothuria atra*), and some starfishes (*Pentaceros lincki*). This paar yielded important fisheries in 1833, 1835, 1836, and then was not fished until 1903.

Outer or True Vankali Paar.

This lies 2 miles north-west of Periya Paar Kerrai, and about 14 miles due west of Aripu. It is $1\frac{1}{2}$ miles in diameter and the depth is $6\frac{1}{2}$ to $8\frac{1}{2}$ fathoms.

The bottom is flat "rock" covered with very many dead shells of pearl oysters, and other Mollusca, with comparatively little sand.

Amongst the other animals noticed were:—

Spongionella nigra, Astræids (small colonies), *Juncella juncea*, *Antedon*—black and grey on the Gorgonids, *Psolus* sp., *Balanus* sp. (large), *Galathea comatulorum* (this and a similarly coloured *Myzostomum* were attached to the *Antedon*), *Turbinella rapa*, *Murex regius* and some fishes (Labridæ and species of Balistes).

Inner Vankali Paar.

This lies 6 miles further east and is about 7 miles west of Aripu. It is about $1\frac{1}{2}$ miles in diameter, and the depth varies from 3 to 6 fathoms. This is a patch of rocky bottom, but close outside it are several old paars, named Vankali on the charts, which are now covered with sand.

Young oysters have been found on various occasions on the Vankali paars, but there has never been a fishery. In April, 1862, Mr. Vane reported a large bed of young oysters in this region, covering an extent of 3 miles, but they did not remain.

Anaivelundan Paar.

This is the most northerly paar, and lies $4\frac{1}{2}$ to 5 miles south of Adam's Bridge and nearly 8 miles south-south-west of Talamanaar. It is about $1\frac{1}{2}$ miles in diameter and has depths of 4 to 6 fathoms.

The bottom is composed of level "rock" overlaid with a thin sprinkling of sand. Attached to the rock is found much broad-jointed *Halimeda* (*H. tuna* var. *platydisca*), and also other Algæ, including *Chrysymenia uvaria*, *Udotea flabellata*, *Dictyurus purpurascens*, *Kallymenia perforata* and species of *Laurencia*, *Polysiphonia*, *Corallina*, *Acetabularia*, and quantities of *Sargassum*.

The most characteristic animals of this paar are the corals *Turbinaria cinerascens* and *T. crater*, the so-called elephant's-ear corals, from which the paar takes its native name.

Naddakadda Paar.

This lies $2\frac{1}{2}$ miles east of Anaivelundan Paar and 7 miles south of Talamanaar in Adam's Bridge. It is $1\frac{1}{2}$ miles in diameter, and the depth is $4\frac{1}{2}$ to $5\frac{1}{2}$ fathoms.

The bottom is formed of ridged sand, the underlying rock only showing in a few places. There are some Algæ (*Kallymenia perforata*, &c.) on the bottom, and some *Axinella donnani*, but no coral was found, and no pearl oysters.

The pearl oysters which have sometimes been found on this paar, and are sometimes washed up on the south of Manaar Island, are said to be of a flat shape and to have very few pearls.

To the south of this, and near the north end of the Periya Paar, two old Dutch paars are marked on the charts, which may be either erroneous positions of the Anaivelundan and Naddakadda or may be former paars now covered with sand.

Periya Paar.

This is a very long bank running north-north-west and south-south-east about 16 to 18 miles from land. It is about 11 miles in length and averages $1\frac{1}{2}$ miles in width. It is the paar that lies furthest from the shore, and has only been fished once, and then only the south-eastern part, in 1879. The depth varies over the different parts of the area from $7\frac{1}{2}$ to 13 fathoms, but the greater part of it is about $9\frac{1}{2}$ to 10 fathoms.

The bottom is a few inches of coarse quartz sand covering flat rock. The sand has ridges about 2 feet apart, and has plenty of small "culch," chiefly shells, lying in the hollows. In other parts the rock is exposed and covered with abundance of *Padina* and other Algæ, also Nullipore balls (*Lithothamnion fruticulosum*). The rock is, in the northern part, a fine grained calcareous sandstone much incrusted with Polyzoa, while further south it is a looser, more porous calcrete of a whiter colour.

Amongst the common animals found were :—

Axinella donnani, *Spongionella nigra*, *Petrosia testudinaria*, pink and white mottled Pennatulids, *Heteropsammia*, Astræids and *Turbinaria*, Eunicid worms, *Linckia* sp., *Cassis*, *Pectunculus*, *Arca*, *Chama*, *Venus* and other shells, *Labrus*, *Balistes*, Gobies and other fishes.

Even where the rock is exposed on this paar it would be suitable for dredging over —a matter of great importance, as this is the ground from which the largest supplies of young oysters can be obtained for transplanting to more reliable paars. Some further particulars in regard to this paar will be found in the "Narrative" (p. 76).

The SOUTHERN PAARS form for the most part a single series running north and south parallel with the coast from Negombo to Kodramallai. Off Chilaw, however, they become more extensive and allow of division into an outer paar and several inside it. At the northern end, also, off Karativo Island, the plateau widens, and is occupied by the large and important Muttuvaratu and several smaller paars. The chart of the Southern group (fig. 37) shows the paars from Kodramallai Point down to Navakaddua. The few banks remaining to the south of this (Jokkenpiddi, Oolawitti, and those off Chilaw and Negombo) are too distant to be included in the same figure, and scarcely require separate illustration. Their general position can be seen from fig. 1 and fig. 22, in the "Narrative."

These more southerly paars resemble closely in character the Periya Paar on the outside of the northern group. They are stretches of sea-bottom where the underlying calcrete or modern rock comes to the surface at intervals, or where loose fragments—lumps of calcrete, Nullipore balls, and dead shells—lie upon the surface, forming natural "culch" to which oyster spat can become attached. The exact conditions vary at different points along the coast, and, as might be expected, there are local differences noticeable in the fauna of the paars, which is affected by such factors as differences in depth, degree of exposure, and proximity to inlets of fresh water.

DUTCH MODRAGAM PAAR.

This lies 10 miles due west of Kodramallai Point and about 10 miles south-west of the North and South Modragams, and due north from Karativo Paar. It is $1\frac{1}{2}$ miles in diameter, and varies in depth from 8 to 14 fathoms.

Fig. 37 Chart showing most of the Southern Paars.

The bottom is rocky—a very coarse quartz grit cemented by lime, and with dead coral imbedded in places (*Madrepora*, *Montipora*, &c.). Foraminiferal sand (*Heterostegina*, *Orbitolites*, &c.) is present between the harder parts.

Out of 260 dives, 144 brought up adult pearl oysters, in 7 cases on sand and in 137 on "rock." The remaining dives were 83 on sand and 33 on rock not occupied by oysters. The pearl oysters are not very abundant and look rather stunted, and are overgrown with Leptoclinids, Sponges, small Algæ, and Serpulids; they are very similar to those on the Muttuvaratu Paar. Living *Fungia*, *Manicina*, and a few other corals are found, also *Culcita schmideliana*, *Linckia lævigata*, *Margaritifera margaritifera* (the "black-lip" pearl shell), many fishes, such as *Balistes mitis*, *B. stellatus*, and some Gobies.

This is one of the few paars on which it would be difficult to fish the pearl oyster by means of dredging. The bottom is so uneven and so rough with corals that the nets would be torn to pieces and the frames be broken, unless great care and skill were employed.

This paar is placed a couple of miles further to the north-east in an old Dutch chart. That may either be an erroneous position or may indicate a former patch of hard bottom.

Karativo Paar.

This lies 5 miles due west of the northern end of Karativo Island and 1 mile south of the Dutch Modragam. It is about 1 mile in diameter, and has depths of 8 to 10 fathoms. The bottom is very rocky and uneven, and it is one of the few spots that would be impossible for dredging. The rock is in the form of ledges, steps, or escarpments, with sometimes fully two feet of rise.

Scarcely any pearl oysters were seen, but amongt the few there was a living "black-lip" pearl oyster (*Margaritifera margaritifera*, Linn.). We also noted:—Madrepores, abundant, *Tridacna* sp., *Psolus* sp., *Asterias* sp., and shoals of Plectognathid fishes.

This paar was fished in 1832, and then again in 1890 and 1891, one day in each during the fishing of the Muttuvaratu Paar.

Alantura Paar (Hamilton's).

The paar lies about 1 mile to the south of Karativo Paar and $4\frac{1}{2}$ to 5 miles off Karativo Island. It is nearly 1 mile in average diameter, and the depth is 8 to 11 fathoms.

The bottom is very even—strewn with quantities of Nullipore fragments and other pieces of "culch," under which is *Heterostegina* and *Orbitolites* sand covering the flat "rock." There are few attached coral colonies, but very many of a thin brown species of *Flabellum* lying on the sand.

This paar presents an excellent bottom both for the deposit of spat and also for dredging.

Muttuvaratu Paar (Donnan's).

This lies 5 miles west of Karativo Island and 3 to 4 miles south of Hamilton's Alantura Paar. It is $2\frac{1}{2}$ miles long (north to south) and $1\frac{1}{2}$ miles wide (east to west). The depth is 5 to 10, mostly 7 to 8 fathoms. On the whole it has a level hard bottom, and any little sand present is Foraminiferal. Of 289 dives, all were upon "rock," and 238 yielded adult oysters. Only the dives to the west part, in deeper water (fig. 39, A), were unproductive. This paar was covered, when we examined it, with plenty of pearl oysters, which are small for their presumed age, but thick, and with little or no signs of rapid or recent growth on the margins.

Oysters on this paar are rather characteristically associated with corals of the genera *Madrepora*, *Porites*, *Pocillopora*, *Montipora*, *Favia* and *Goniastrea*, growing upon the left valves which always lie uppermost in the usual position of the oyster (fig. 38). Some specimens are much overgrown with Polyzoa, sponges, &c. The

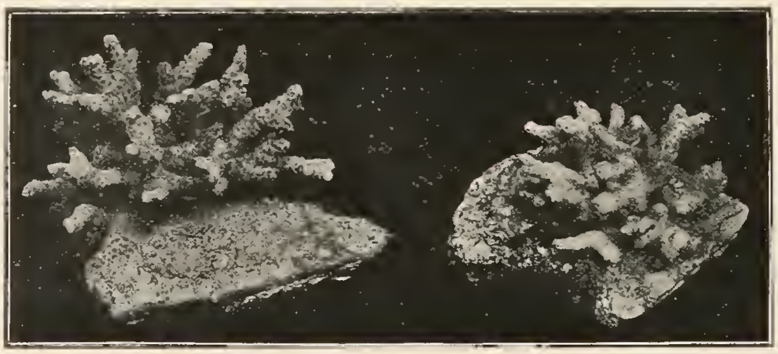
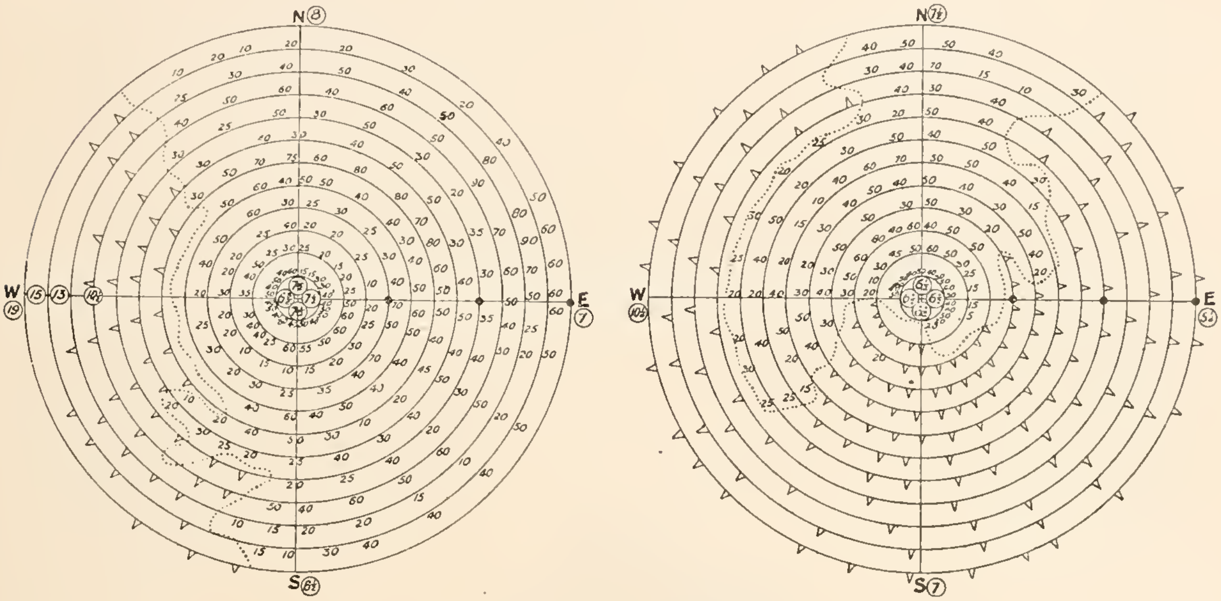


Fig. 38. Old pearl-oysters from the Muttuvaratu Paar, with large Madrepore Corals growing on the shell—half natural size.

oysters are also notably stunted in appearance, and their small size, compared with oysters of the same age from Cheval Paar, is well known, and has been recognised by various writers.

We found the specific gravity of the sea to be unusually low in this neighbourhood (1·0208, at a temperature of 85° F.). This may be due to proximity to the mouth of Putlam Lake, which probably discharges a considerable amount of fresh water derived from the Kala Oya and the Mi Oya Rivers. The bottom on this paar is flat "rock" with many small colonies of *Astræa*, *Cœloria*, and allied low-growing corals, with occasional bushes of large branched Madrepores, such as *M. cervicornis* and *M. cytherea*, rising to 18 inches or 2 feet in height. The pearl oysters on this paar in March, 1903, were "incredibly numerous, thousands in sight, crowding and even hiding the rock to which they anchor. One had to trample on them as one walked—no vacant spots to put the feet." Mr. HORNELL estimated them at about 125 adult oysters to the square yard. Captain DONNAN'S estimate in March, 1902, was 277 millions for the whole paar. This number has probably been greatly reduced since by disease. Fig. 39 gives some idea of the number and distribution of oysters in November, 1902.

Balistes stellatus, the file fish, seemed, during the inspection, to be very abundant on this paar, much more so than in the Cheval district. Many were seen in the water, and the boat's crew caught six in a quarter of an hour. It is interesting to note, in



A. B.

Fig. 39. Inspection charts of (A) northern and (B) southern parts of Muttuvaratu Paar in November, 1902. There are four concentric circles made by the divers' boats between the centre and the $\frac{1}{4}$-mile buoy, four between that and the $\frac{1}{2}$-mile buoy, and four from that to the $\frac{3}{4}$-mile. Each complete area is therefore $1\frac{1}{2}$ mile in diameter. The numbers enclosed in rings indicate depths in fathoms. The numbers on the concentric circles give the quantities of oysters brought up at a dive on that spot. The cones indicate dives on a rocky bottom with no oysters. The dotted line therefore surrounds the oyster-bearing area.

connection with this abundance of *Balistes*, that the oysters examined here are infested with Tetrarhynchus cysts to a much greater degree than those from any other bank.

This paar is essentially a rocky bank, well adapted for the deposit of spat, but less suitable than the Cheval Paar for rearing adult well-grown healthy oysters. It is the same type of paar as the Dutch Modragam and the Karativo. Amongst the other animals seen were the sponge *Phyllospongia holdsworthi*, the starfishes *Pentaceros lincki*, *Nardoa tuberculata*, *Ophiocoma scolopendrina* and *Linckia lævigata*, various living corals (*Turbinaria*, *Montipora*), *Sarcophytum*, *Socarnes schmardæ*, *Tridacna* sp., and *Arca* sp.

This paar yielded important fisheries in 1889, 1890, and 1891, the last being one of the most valuable fisheries that has ever been held, over 44 million oysters being fished at a return to Government of over 963,000 rupees. The bank had never been recorded as fished before 1889, and it is said that it was unknown to the Dutch in 1757, although we believe we have evidence that it was the source of fisheries in earlier Portuguese times. Captain DONNAN says that a bed of oysters died on this paar unfished in 1860; another bed disappeared in 1899.

To the north and east of the paar proper, in 7 to 8 fathoms, we found a hard and in some places rough bottom with plenty of "rock" and other hard fragments which would serve as "culch" for oysters. In places there are large branching Madrepores and great vase-like elephants-ear corals (*Turbinaria*); also *Phyllospongia holdsworthi* and other sponges. While the greater part of the ground, like the Cheval, the Modragams and the Periya Paar could be readily worked with the dredge, there are certain parts of this paar and the neighbouring ground which are unsuitable for dredging, and would, if that method of obtaining the pearl oysters were adopted to the exclusion of diving, form valuable preserves where the necessary stock of breeding oysters might remain undisturbed.

There is a diseased condition that the Muttuvaratu pearl oysters seem liable to, in which the body is stunted and shrunken, and the mantle and other tissues become of a markedly opaque yellow colour. This yellow condition has been noticed in the past by Sir W. TWYNAM and by Captain DONNAN. We found some affected specimens during our first cruise in the "Lady Havelock" in February, 1902, and others on every occasion when the bank has been visited since. On 14th April, 1903, out of 227 oysters examined, 25 were affected with the yellow disease, over 11 per cent. This condition, which seems to cause considerable mortality amongst adult oysters, will be discussed in the account of our laboratory work later on in the Report.

HAMILTON'S MUTTUVARATU PAAR.

This bank lies 2 miles south-east of HAMILTON'S Alantura Paar and $2\frac{1}{2}$ miles off Karativo Island. It is 1 mile in diameter, and the depth is from $4\frac{1}{4}$ to $6\frac{1}{4}$ fathoms. The bottom is irregular, partly rock and partly sand.

There were no oysters, and this paar is unimportant.

MUDALAIKULI PAAR.

This lies 3 to 4 miles south of Muttuvaratu Paar and 1 to 2 miles off Mutwal Island. It consists of two areas, an outer rocky part $1\frac{1}{2}$ mile in diameter and $4\frac{1}{2}$ to 8 fathoms in depth, and an inner more sandy part 1 mile in diameter and from $2\frac{3}{4}$ to 5 fathoms in depth.

This and a few small neighbouring paars are comparatively unimportant. They have not, so far as is known, yielded fisheries, but may bear crops of young oysters and so be of use under a system of cultivation.

Talaivillu Paar.

This lies 1 mile off Talaivillu on Kalpentyn Island, and is $2\frac{1}{2}$ miles from north to south, and 1 mile wide. The depth is from 4 to 9 fathoms, and there is much deeper water just over the outer edge. The bottom of the paar is irregular and rocky.

Navakaddu Paar.

This lies about 9 miles south of Talaivillu, less than 2 miles off shore, and 8 miles due west of Putlam Fort. It is over 2 miles from north to south and 1 mile from east to west. The depth is 4 to 14 fathoms, and the bottom irregular and rocky.

Jokkenpiddi Paar.

Jokkenpiddi Paar is one of the paars lying off Chilaw. In this region there are many little hard patches known as paars, although they rarely bear oysters. Their exact positions are unimportant, as the whole area is potentially paar-ground.

On the bottom patches of "rock" alternate with sandy areas. Out of 312 dives on the southern part of the paar, 236 were on "rock," and 76 on sand. The samples of hard bottom we obtained consist of coarse quartz sand cemented into masses evidently of recent origin, which may be described as a coarse calcrete (fig. 40),

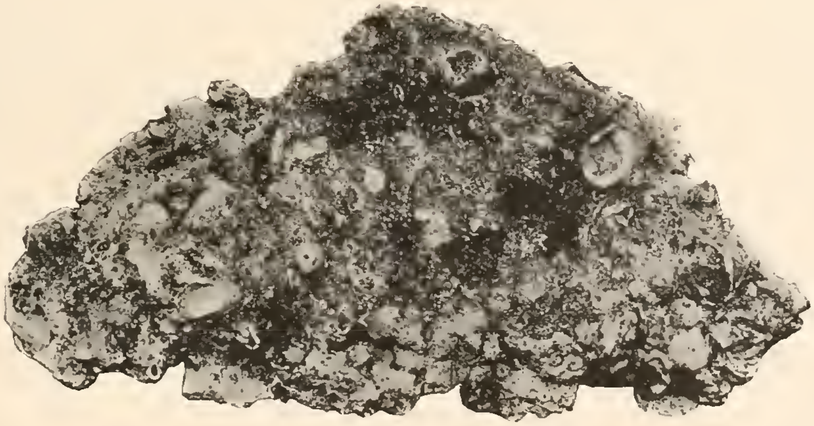


Fig. 40. Lump of calcrete showing large quartz grains and felspars with fragments of coral, shells and worm tubes, along with many Polyzoa colonies. From Jokkenpiddi Paar.

together with blocks of dead and some living coral. All the materials are largely cemented together by colonies of Polyzoa. There are also dark brown ferruginous nodules of phosphates.

We found a plentiful supply of small oysters (1 to 3 months) on some parts of the paar, along with very many dead shells. The living Coral consists of Madrepores and two species of *Turbinaria*. We also noticed:—*Axinella donnani*, *Echinostrephus molare*, *Ophiothrix* sp., *Asterina cepheus*, *Pentaceros lincki*, *Nardoa tuberculata*, *Filigrana* sp., *Trophonia* sp., Serpulids, Sabellaria, Pagurid (scarlet-maroon, hairy) in chank shell, and *Murex regius*, Pearl Oysters, *Avicula*, *Chama*, *Modiola* (suran), and *Vermetus*.

Captain DONNAN reports that a million and a half of large oysters which he found on this paar in April, 1878, had disappeared in the November following. This may become a valuable ground for obtaining a stock for other paars.

CHILAW PAARS.

The outer, largest paar lies about 7 miles off the mouth of the Dedera-oya River, near Chilaw, and is over 8 miles in length and about 2 miles in average breadth. It has a depth of 8 to 9½ fathoms.

The bottom is sand and masses of calcareous sandstone, which may be described as a medium-grained calcrete, with a few larger quartz grains up to ¾ inch diameter.

We found considerable quantities of small pearl oysters (6 months old) in large clusters, attached to one another by byssus and lying on sand, when not attached to the cemented masses. Amongst other animals found were:—Branched Gorgonids, with specimens of *Avicula radiata*, *Salmacis dussumieri*, and a species of *Hesione*.

A large supply of young oysters found here by Captain DONNAN in April, 1875, gradually disappeared during the next three years. Although there have been no fisheries on the Chilaw Paars during recent years, they yielded important fisheries in the past (1803, 1815, and 1884), and there seems no reason why a crop of pearl oysters should not mature upon them at any time. We have evidence* that the Pearl Fisheries controlled by the Singhalese Kings of Kandy were those lying off Negombo and Chilaw, while those of Manaar and Aripu were in the hands of the Tamil Kings of Jaffnapatam.

There are also several smaller paars off Chilaw lying nearer the shore, about 3 or 4 miles off land, and averaging about 1 mile each in diameter; and two further out north-east of the large paar and about 5 miles off-shore; in addition, many other hard patches in this neighbourhood are named as paars by the natives. In fact, there is a good deal of ground here that might at any time become a "paar" and bear crops of pearl oysters.

KARKOPANNI PAAR.

This paar lies off Karkopanni, to the North of Chilaw, about 3 miles off-shore, and at a depth of 7½ fathoms. The bottom is rock and sand intermingled, the latter

* From the Singhalese poem, 'Kovul Sandésaya' (about 1460), and IBU BATUTA'S 'Travels' (1344), and also various Dutch records of the eighteenth century. These have been searched by Mr. HORNELL, who expresses his indebtedness to Mr. P. E. PIERIS, C.C.S., for translations from the Singhalese.

greatly predominating. Only a few pearl oysters were found, on the small patches of rock, when we examined the ground.

The sand here is a coarse, yellow quartz sand, and the "rock" is a coarse, calcareous sandstone—or calcrete—the large quartz grains, up to an inch in length, being apparently embedded in a matrix of carbonate of lime. There are dark, ochreous patches in places. Out of 187 dives, 140 were on sand and 47 on rock.

Scarcely any living Coral was seen, and no Algæ; amongst the commoner animals were:—Branched Gorgonids and Hydroids, Terebellids (many, large), *Arca* sp., *Avicula radiata* (on Gorgonids), and *Leptoclinum* sp.

Oolawitti Paar.

This lies about 8 miles north of Negombo, at a depth of $7\frac{1}{2}$ to $8\frac{1}{2}$ fathoms. On the bottom coarse, yellow quartz sand predominates; but there is "rock" in patches, and there some small (6 months) pearl oysters were found.

The "rock" is consolidated sand, of a dark brown colour, as if iron were present in the cementing material. Mr. Lomas describes it as a "reddish-brown calcrete with the sand rather loosely united."

On these masses, and penetrating them, are found upright, branched, tough leathery tubes in abundance. Professor M'Intosh, in the "Challenger" Report on the Polychæta, figures a similar tube from the Gulf of Manaar, and states his belief that it will prove to be the home of a Eunicid. Mr. Hornell has been able to establish the correctness of this suggestion, as he has removed two fine Eunicids* from these tubes.

Negombo Paar.

This lies off Negombo, about 3 miles off-shore, at a depth of 8 to 9 fathoms. The bottom is sand and patches of "rock" (reddish-brown blocks of calcrete), exactly similar to that of the Oolawitti Paar. The oysters present when we examined the paar were probably from 2 to 6 months old, and were mostly attached to the rock, some in clusters on the sand. They were in considerable abundance.

There is another small paar, south of Negombo, which was found by Captain Donnan in 1901. It is similar in character to the Oolawitti Paar. Neither of these Negombo Paars, however, corresponds to the spot off Negombo where we dredged up young pearl oysters from the "Lady Havelock" in February, 1902. Mr. Hornell, who has been examining the early charts, is of opinion that the "Lady Havelock" paar is the original Oolawitti Paar. That does not matter much. What is of real importance, is to recognise that there are a number of small, more or less hard areas in the shifting sand, on which from time to time "strikes" of young oysters may make their appearance, and may possibly grow to maturity, but more usually become thinned out by their natural enemies or overwhelmed by sand. These small paars

* To be described in Mr. Hornell's Report on the Polychæta, in a later Part.

close to the deep water are evidently unreliable, and yet may be made use of in cultivation, and have probably in the past, on occasions, borne a crop of mature oysters.

The history of the Pearl Fisheries in the past, especially during the nineteenth century, has shown that :—

(1.) Some of these paars, such as Jagerboom, Kallatidal, Aripu, Anaivelundan, and others, are practically worthless from an economic point of view.

(2.) Some, such as the Periya Paar, might be used as most valuable sources of supply of young brood oysters for transplantation ; but cannot be relied upon to produce an adult stock suitable for fishing.

(3.) Some, such as the great Cheval Paar, with its various sub-divisions, and the North and South Modragams, the Periya Paar Kerrai, and the Muttuvaratu Paar, are very valuable and reliable grounds upon which most of the successful fisheries of the past century have taken place. Others, such as those off Chilaw and Karativo, are less reliable, but may be valuable on occasions.

It became clear to us during our work on the "Lady Havelock," when we began to understand why it is that the Periya Paar is unreliable and the Cheval so much more satisfactory, that the main hope of introducing constancy of result and a regular succession of fisheries must rest upon a system of transplanting young strikes or broods of oysters when they make their appearance upon useless or unreliable paars, to wherever there is room for them at the time upon ground where we know they will have a better chance of living and growing to maturity.

This raises the whole question of the causes of death of the Pearl Oyster, the reasons of the intermittence in the history of the fisheries, and the conditions which render some paars more reliable than others. As we propose to have a section later on dealing with our observations and experiments on the Pearl Oyster and ending with our Recommendations, into which these matters will naturally fall, it will be sufficient here to give the following summary of our results :—

(1.) The most important agent in causing wide-spread death of Pearl Oysters, both young and old, in the Gulf of Manaar, is the shifting of sand due to the strong currents, to the south-west monsoon, and no doubt occasionally to exceptional storms. We obtained a good deal of evidence as to the manner in which the sand is carried about and piled up by the currents, and is churned up in places by the heavy seas at the time of the south-west monsoon, and we made observations as to the effect of burying oysters of different sizes in various amounts of sand. The successive broods which have appeared and as regularly disappeared upon the Periya Paar during the last quarter-century have, there can be no doubt, been overwhelmed by the bottom currents caused by the monsoon upon the bank which faces the deep water of the Indian Ocean.

(2.) Next in importance come, we consider, the ravages of natural enemies—the most destructive of which are :—

(*a.*) Voracious fishes—chiefly Rays (*Trygon warnak*) and File-fishes (*Balistes mitis* and *B. stellatus*) ;

(*b.*) Boring Molluscs—chiefly *Sistrum spectrum* and *Pinaxia coronata*, along with species of *Nassa*, *Murex*, *Purpura* and *Turbinella ;*

(*c.*) The boring sponge *Clione indica ;*

(*d.*) Boring worms (*Leucodore*) ;

(*e.*) Star-fishes—chiefly *Pentaceros* and *Luidea ;*

(*f.*) Smothering Mollusca—such as *Modiola barbata*, the "Suran," which weaves nests and other entanglements around masses of young oysters, and may, when present in quantity, cause serious mortality.

(3.) There are still three other causes of death that require mention, and may on occasions be serious, perhaps disastrous, viz. :—

(*a.*) *Overcrowding.*—The older are sometimes buried in masses of younger ones. The young are often piled together in such profusion as to interfere with each other's nutrition and growth. Thinning out must and does take place. If it were done artificially all or nearly all might be preserved ; if we leave it to be effected naturally by survival of the fittest the survivors may be very few indeed ;

(*b.*) *Disease* due to the invasion of parasites—either (1) worm parasites, which are moderately large and usually not very numerous, and which, unless abnormally abundant, do little harm ; or (2) the more minute Protozoon parasites, which may be present in enormous quantities and probably cause epidemic diseases ;

(*c.*) *Overfishing.*—That is, the exhaustion of the breeding stock of the district at a time when no further supplies of young in the larval stages were being brought by currents from neighbouring grounds. This will comparatively rarely happen, and is only likely to be serious during the last year of a series of fisheries. So long as there are three and four-year old oysters on adjoining paars which will be fished in the two succeeding years, it is safe to take every older oyster that can be got off the ground, as those coming on, although not yet ready to fish, are sexually mature and may be relied upon to supply spat ; but in the final year of a series, when no further mature oysters remain for future years, it is important to leave a sufficient stock for breeding purposes.

In the future, however, if transplanting is adopted, it may be expected that such a state of affairs as the last fishery of a series with no younger oysters growing up in the neighbourhood will be very unlikely to recur.

OBSERVATIONS ON THE SEA AROUND CEYLON, AND ESPECIALLY IN THE GULF OF MANAAR.

Although we were not prepared to make detailed physical observations on the sea-water, as I had not considered that necessary for our purpose, we kept a daily record of such approximate temperatures and densities as we could obtain with ordinary laboratory thermometers and hydrometers, sufficient to enable us to compare localities and seasons. During the cruises of the "Lady Havelock" the temperature and specific gravity were taken twice daily, in the morning after we had started the dredging operations—generally at 7 A.M.—and in the evening when work was finished, about 7 P.M. After I left, Mr. Hornell continued the records at Galle, and on occasions at Trincomalee and in the Gulf of Manaar, and took the observations once daily, between 8 and 10 in the morning, generally at 8.30. We also took all opportunities of making such observations as were possible on the surface drift of the sea, and obtained such information as we could as to prevailing currents at different seasons, as these movements of the water must be of great importance in connection with the distribution of the young pearl oysters.

During the period (January to April, 1902) of the two cruises in the "Lady Havelock" and our first inspection of the pearl banks, the sea temperature was steadily rising. At the beginning of the time, in the Gulf of Manaar, it was about 77° F., in February it averaged 79° F., in March 84° F., and in April 86° F. The specific gravity was nearly constant at 1·0230 in the Gulf of Manaar, while at Trincomalee, in February, it was lower—varying from 1·017 to 1·020.

In July, 1902, the sea temperature at Galle ran up to 86° F., and the specific gravity was constant at 1·0236. Mr. Hornell found that the temperature of the water in our shaded aquarium tanks was considerably lower (say 3° F.) than that of the sea outside.

In August the temperature of the water in our aquarium reservoir, taken at 8 A.M., ranged from 78° F. to 82° F., the average being 80·37° F.

In September the temperatures were taken in the open water at the jetty and ranged from 81·5° F. to 85° F., and the specific gravity from 1·0216 to 1·0220.

In October the temperature at Galle jetty fell from 86° F. to 82·5° F.; at Trincomalee the range was 84° F. to 89·5° F., and in Tamblegam Lake 87° F. to 90° F.

In November Mr. Hornell was again on the pearl banks and found that the sea temperatures ranged from 83° F. to 85° F., and the specific gravity from 1·0200 to 1·0227. At Galle jetty at the end of the month the sea temperature was 85° F.

In December, at Galle jetty, the sea temperature was nearly always at 84·5° F., the extremes in range being only 83·5° F. and 85° F.

In January, 1903, at Galle jetty, the range was from 82° F. to $84\frac{1}{4}$° F., and the specific gravity was close on 1·022. At the end of the month, in the Gulf of Manaar, the sea temperature was 82° F., and the specific gravity slightly above 1·023.

In February, on the pearl banks, the sea temperatures ranged from $80\frac{3}{4}$° F. to $84\frac{3}{4}$° F., and the specific gravities from 1·0229 to 1·0239.

In March, in the same locality, the temperature rose from 83° F. to $86\frac{1}{2}$° F., while the specific gravities lay between 1·0228 and 1·0234.

Finally, in April, in the same locality, the temperature rose from 86° F. to 88° F., while the specific gravity was very constant at 1·0228.

These observations, extending over 15 months, show a range of only 13° F. in the year, 77° F. to 90° F., for the seas around Ceylon; while in the Gulf of Manaar the lowest and highest recorded temperatures are 77° F. and 88° F. THURSTON found the temperature at Rameswaram in July, 1888, to vary from 79° F. to 91° F.

The specific gravity in the Gulf of Manaar is fairly constant at about 1·023, except at occasional spots; off Chilaw, on 22nd November, 1903, it was 1·0194, and on the Muttuvaratu Paar in the same month it varied about 1·0200; while at Galle it is rather lower than the Gulf of Manaar, averaging 1·022, and at Trincomalee it is lower still, 1·019, and at Tamblegam goes down to 1·015.

Further exact knowledge as to the movements of the water over the pearl banks in the Gulf of Manaar is urgently needed. On the "Lady Havelock" we had neither the means nor the time necessary for undertaking this investigation. It is probably the most important matter still requiring settlement, involving as it does the normal distribution of pearl-oyster spat. Till we know more accurately how the surface-drift acts at the chief spatting seasons, we cannot be certain of the source of supply to particular beds, or of the destiny of the larvæ produced from our adult oysters. We have not yet the means of arriving at conclusions as to the conditions of wind and weather which are required in order to constitute a favourable spatting season for the replenishment of say the Periya Paar or the Inner Vankali Paar, where young oysters frequently appear. Nor are we able to say with certainty whether the Cheval Paar supplies the Muttuvaratu, or the southern paars replenish the northern, or whether there is any definite relation as to spat-supply between the Ceylon pearl banks as a whole and those off Tuticorin on the Indian Coast.

We know that there is a general drift of the water over the banks from south to north from about the end of April to the end of September, and from north to south during the height of the north-east monsoon, with intermediate periods of calms and variable winds from February to April and usually again in November. Now it is essential that we should have more definite knowledge as to the resulting surface-drifts in these periods of variable winds between the monsoons, for it is during November and in March and April that the chief spatting seasons of the pearl oyster occur. Information in regard to the stronger and more constant currents which may be sufficient for the purposes of navigation will not suffice for fisheries purposes. We require to know where floating bodies, liberated at certain spots under known conditions, will drift to during given periods of days at different seasons; and this can only be ascertained by systematic "drift-bottle" experiments such as have recently been made for fisheries purposes in several European seas (see, *e.g.*, 'Fishes and Fisheries of the Irish Sea,' by HERDMAN and DAWSON, London, 1902, p. 7). Moreover, it is only after such work has been carried on systematically for two or three years at least, that it will be possible to determine the course taken by the larval pearl oysters between the time of hatching and the deposit of spat, and again between the attachment to floating Algæ and the appearance as young oysters on a paar. These are details which it was impossible for us to settle in the time at our disposal in 1902, but which will naturally, in the future, form an important part of the work of a marine biologist resident in Ceylon.

Our inspection barque "Sultan Iskander" towing the divers' boats to a new position.

OBSERVATIONS AND EXPERIMENTS ON THE LIFE-HISTORY AND HABITS OF THE PEARL OYSTER.

I. Determination of Sex.

At an early date in the investigation it became clear that the pearl oyster is diœcious or of one sex only—whether permanently so or only temporarily was a matter that could not be settled in one season, but which Mr. Hornell determined later on in the Galle laboratory. The dissections made during the cruises of the "Lady Havelock" in the Gulf of Manaar and in Trincomalee showed that each mature individual functions as male or female only. In no cases were even stray ova found in the gonads that were determined as male, nor any spermatozoa in the females—although such traces of hermaphroditism were carefully looked for.

In the Gulf of Manaar, during February and March, 1902, our dissections showed a considerable preponderance of males over females, and further work by Mr. Hornell at Galle showed the same disproportion, to the extent of about 10 per cent. of the total number examined, during other parts of the year. We have several lists, of which the following may be taken as a sample. Here out of 210 oysters from four distinct localities the sex of 158 was determined, 87 being male and 71 female—the remainder were indeterminable owing either to immaturity or their spent condition.

Date.	Males.	Females.	Spent or immature.	Locality.
16 October, 1902 . . .	13	9	4	Trincomalee.
5 November, ,, . . .	13	13	4	Cheval Paar.
6 ,, ,, . . .	9	4	2	,, ,,
6 ,, ,, . . .	5	3	—	,, ,,
7 ,, ,, . . .	6	9	1	,, ,,
9 ,, ,, . . .	5	3	2	Periya Paar Kerrai.
11 ,, ,, . . .	4	6	10	Cheval Paar.
12 ,, ,, . . .	7	6	7	,, ,,
14 ,, ,, . . .	4	4	8	,, ,,
15 ,, ,, . . .	18	9	4	,, ,,
18 ,, ,, . . .	3	5	10	Dutch Modragam.
Totals	87	71	52	

The further question—the permanence of the sexual condition—was one of those points which could only be settled in a marine laboratory, where the animals could be kept under observation from season to season, and formed a part of the work which I left Mr. Hornell to settle at Galle.

On May 17th, 1902, four of the pearl oysters in our aquarium were found to be emitting sexual elements, three being determined as males and one as female. They were marked individually and put in a separate tank, and later in a cage suspended from a buoy in the bay. On September 23rd two of these verified males were brought into the laboratory and both proved, on dissection (October 1st), to be still in the male condition. Over four months had elapsed since the end of the observed emission of sperms, and the gonads had filled up again for the next breeding season. The larger individual especially showed vigorous growth in all parts, the shell had increased from $\frac{1}{4}$ to $\frac{5}{16}$ inch, in addition to a great development of marginal processes. The gonad was fully developed, creamy yellow in colour, and swollen with active spermatozoa. The two remaining verified individuals were brought in and dissected on October 3rd, and were found after the $4\frac{1}{2}$ months' interval to be still of their respective sexes. The male contained ripe spermatozoa, and the female had the gonad large and swollen with ova in exactly the same condition as those emitted in May. Spawning might have taken place within a day or two had they lived.

Mr. Hornell has observed the natural emission of the eggs in a $2\frac{1}{2}$ years old pearl oyster living healthily in the aquarium tanks of the Galle Laboratory. He was also able, by pouring some of the sea-water charged with freshly laid ova into a tank containing other pearl oysters, to stimulate three ripe males to discharge spermatozoa. The first male commenced within two minutes of the addition of the ova to the tank, and while the stream issued as a milky cloud from the exhalent orifice the animal at intervals snapped its valves together several times, thus effectively dispersing the spermatozoa through the water. One minute after the first a second male commenced to spout and continued to pour out a stream for six minutes. After an hour's interval it re-commenced for four minutes, followed by occasional puffs for nearly half an hour, when the emission ceased finally. The third male became active some hours later, but all proceeded in a similar manner.

These observations show that the ova are extruded direct from the oviducts, by means of the supra-branchial passage, to the sea. They do not pass any time within or upon the gills—and do not undergo fertilization within the parent. The development of the larva takes place entirely in the sea.

II. Embryology and Early Life-History.

We tried artificial fertilization on several occasions, and although we have not yet reared the pearl oyster from the egg to a young shelled Mollusc that would be recognised by the divers, still we have had, in our tanks and under our microscopes, all stages from the fertilized ovum to free-swimming larvæ, similar to those we caught in the tow-net on the pearl banks, and which again we traced into the attached spat on the Algæ. So that we have seen, either in our experimental tanks or in collections from the sea, every stage from the egg to the adult pearl oyster. Mr. HORNELL has made a careful study of the young stages as observed by him at Galle in May, 1902, but as we hope to get still further details, the full account of the embryology will be given later on in this report. It will suffice to state now that the ovum when extruded is pyriform and floats, after fertilization it becomes spherical. The segmentation is complete but unequal, and within 2 hours results in an embryo of one large macromere and six micromeres. After 4 hours, segmentation was completed and the embryos were swimming freely by means of cilia, while about 20 hours after fertilization they were in the trochosphere stage, with a well-marked pre-equatorial band of long cilia, an apical pre-oral tuft and a patch or circlet of cilia at the opposite pole. As the body elongates, the equatorial band moves further and further forwards and becomes a pre-oral circlet, most strongly marked along the anterior margin which becomes the velum. Towards the end of the second day the larva is a veliger, and the shell has commenced to form posteriorly. On the third day the velum was considerably reduced in size and the bipartite shell increased, and this brought the larva to a stage corresponding with the forms we caught in our tow-nets, which bridged over the gap between the latest stage reared from the egg in the tanks and the earliest attached stage or "spat."

From a consideration of the sizes of the free-swimming larvæ and the youngest spat, and knowing the age at which the veliger obtains a shell, we are of opinion that attachment may be made within five days of fertilization. At the same time, from the large size of some of the free-swimming larvæ, it is probable that under certain circumstances, such as the absence of suitable areas for attachment, the period of free-swimming existence may be considerably extended.

One of the earliest free-swimming stages was taken in the tow-net on February 2nd, 1903, on Modragam Paar. It shows some slight advance upon the oldest stage reared in the Galle Laboratory, as rudiments of three branchial filaments and of the otocysts are present. Otherwise, in the form of the shell, the large size of the velum and the sub-central position of the digestive gland the two agree. The digestive gland is yellowish and granular, the cells being filled with large oil-globules.

In the same haul numbers of an older stage (fig. 41, I.), nearly twice the diameter of the last, were also present. In these the shell had developed prominent umbones placed equidistant from the two ends. A few more branchial filaments had appeared and the velum was relatively smaller. The digestive gland is now conspicuously two-lobed, and by great increase in size has come to occupy the interior of the umbones dorsally as well as extending ventrally beyond the plane of the otocysts. The rudiment of the adductor muscle at the anterior end was also visible.

A fortnight later (16th February), while on the Cheval Paar, in plankton taken between 8 A.M. and noon, we obtained a great multitude of shelled larvæ, many of which were in a later stage. The shell-valves showed for the first time a slight asymmetry, the anterior end being now rather sharper than the posterior (fig. 41, II.). The velum was greatly reduced, occupying only a comparatively small space between the anterior adductor muscle and the anterior margin of the gills. The gill filaments were 6 to 7 in number and of larger size. A posterior adductor muscle was also present, and the digestive gland, still markedly two-lobed, had increased in size. In several of these larvæ the foot was prominent and active, being frequently protruded and moved about in a tactile manner; a distinct prominence (the byssal gland) is seen about the middle of the posterior edge (fig. 41, III.). The otocysts lie close to the base of the foot, and each is a large clear sac containing 6 to 9 tiny otoliths which were in constant vibratory motion. The shell is still clear and transparent, with no pigment and no sign as yet of prismatic structure.

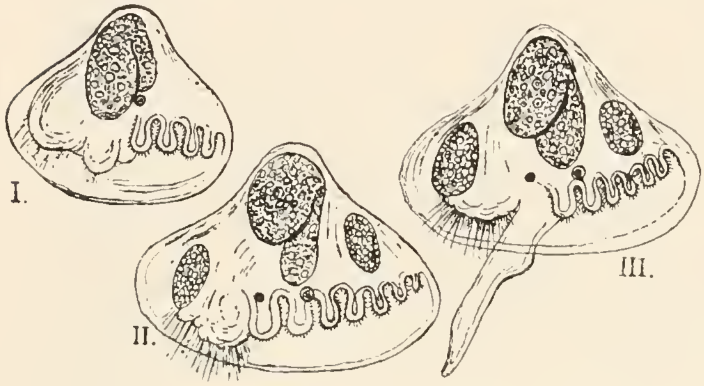


Fig. 41. Free-swimming larval stages of pearl-oyster caught in the tow-net. I. has the ciliated velum retracted. II. and III. show the stage at which the larva becomes attached to Algæ. III. has the mobile foot extended.

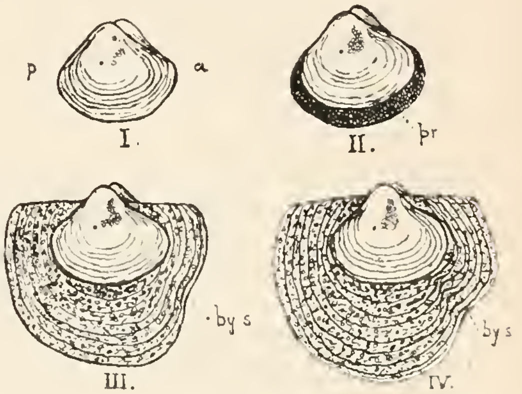


Fig. 42. Stages in the growth of the shell after the attachment of the larva. I. is identical with the latest free-swimming stage; *a*, anterior, *p*, posterior end. II. shows the first formation of prismatic shell (*pr.*). III. and IV. show the change in shape and the byssal sinus (*by. s.*).

From this stage, ready to make attachment, we pass to the earliest attached stage ("spat"), where the little Mollusc begins to form shell layers of a different character.

Our youngest spat was found clinging to the Hydroid Zoophyte *Campanularia juncea*, in November, and later stages, still very young, on the Algæ *Hypnea musciformis* and species of *Sargassum*, *Cladophora* and *Polysiphonia* on the Cheval Paar in February and March, 1902. The smallest stage, 0·1 millim. in antero-posterior extent, is identical with the oldest free stage referred to above, and is presumably just attached. From this to a shell length of 0·175, increase is effected by marginal additions which are clear and transparent like the larval shell. These additions show, however, faint circumferential lines, but no prismatic appearance (fig. 42, I.). The dark digestive gland shows conspicuously in the umbonal region, and the rows of branchial filaments are also visible through the thin shell.

After a size of about 0·175 is reached, prismatic shell substance begins to be deposited marginally, as seen in fig. 42, II., III., IV. The embryonic shell persists, but the shape of the valve changes to one which is recognisable as the adult type. The umbones become less prominent, and, as a result of the asymmetrical marginal growth, become more anterior in position. Even at this early period the byssal sinus (*by.s.*, fig. 42) is recognisable, and a very delicate byssus can be seen anchoring the little Mollusc. If the spat be attached, as the young stages, in our experience, generally are, to floating—or for a time rooted—Algæ, they seek the under, shady, side of the branches, and sooner or later drop off and sink to the bottom, being dislodged either by shaking or by the disintegration of the floating weed The further history will then depend upon whether they fall upon ground where there is suitable "culch" for attachment, or upon sandy areas where they probably get buried, scoured out, or rasped to pieces by the constant movements of the sand grains. The enormous number of minute shells of the fry or spat of pearl oysters which we found in some sandy deposits indicates the extent of the destruction which is going on, and which might, in part at least, be prevented by artificially increasing the area covered by "culch."

We have also evidence that the ground may vary from year to year in the covering of fine Algæ which it affords for the attachment of the young spat. This is shown by the following observations :—

On the south end of the Cheval Paar, not far from the Shoal buoy, on February 26th, 1902, we hauled up great masses of mostly green delicate Algæ thickly covered with oyster spat. The Algæ proved to be *Hypnea musciformis,* along with a *Cladophora*, a *Ceramium*, and some *Chætomorpha* and *Polysiphonia*, mostly infested with Cyanophyceæ and various microscopic animals. Much the same assemblage of plants, but of a redder colour, was found on the Modragam paars on March 10th, and we also obtained them in smaller amount elsewhere on the pearl banks. In all cases these weeds supported vast quantities of spat. Later on in the season we found masses of the weed detached and floating on the surface. This season, however (1903), Mr. Hornell finds, after a careful examination of the same grounds in a diving suit, that the weed is entirely absent, and that the sand in these localities is bare and shows no spat. This marked difference in the condition of the bottom on two consecutive years throws an interesting light on the factors which may determine on occasions the productivity of a bed, and lends support to our contention that putting "culch" on the bottom at selected spots would lead to an increase in the amount of spat deposited.

III. The Byssus and Locomotion.

Although the formation of the byssus threads comes more appropriately in the section on the Structure of the Pearl Oyster, still the connection of the byssus with fixation, locomotion, and possible migration or transplantation is so close and so important that we shall give here the results of our experiments on the matter.

Kelaart showed, in 1858, that the young pearl oyster can move from place to place, can detach its byssus and can re-attach in a new spot. Sullivan Thomas, in 1886, added some fresh observations on young oysters, about $\frac{1}{2}$ inch in diameter, which he found moved up the smooth side of a glass 4 inches in 8 or 9 minutes. He also made some observations on the byssus, and found that a young oyster, measuring $1\frac{1}{4}$ inches in diameter, withstood steady tension measured with a spring balance till it reached $2\frac{3}{4}$ lbs., when the byssus came away at the root. He adds:— "I conclude that a pearl oyster is not likely to be dislodged by the force of wave action or current, and that, if it moves, it moves voluntarily."*

Some of our observations on the rapid movements of very young pearl oysters—much younger than those dealt with by Kelaart and Thomas—and on the readiness with which they detach and re-attach, were given in the "Narrative" (p. 68), and we have many others, which, however, it is unnecessary to give in detail. But although the very young are thus actively locomotive, it has been doubted, and may still be doubted by some, whether the adult oyster is capable of movement, or even of re-attaching, if the byssus be torn. Our observations settle this point definitely, as the following examples show:—

A $2\frac{1}{2}$ years old pearl oyster, obtained from the Muttuvaratu Paar on April 11th, 1902, had the byssus broken by being torn from its attachment to rock. Two days later it was marked and suspended in a wire-net cage in Galle Harbour under observation. After 3 days it was found to have re-attached to another oyster in the same cage. On May 9th it was removed to a tank in the Biological Station, and the new byssus was then found to be normal, stout-fibred, and of a bronze-green colour. It was then torn across by force, thus breaking the byssal strands, and was placed in a small glass dish sunk in the tank. On May 10th an inch and a half of sand was put over the top of the oyster. On May 11th it had freed the ventral margin of the valves from the sand, and appeared healthy. On May 12th the shells were half uncovered, and the animal was breathing and feeding normally. On May 13th and 14th the animal still lay unattached. On May 15th, at 8 A.M., the old byssus was still present; at 9 A.M. the foot was protruded, and shortly after a new byssal strand had been formed attaching the oyster to the side of the glass. The old byssus was still retained, but was ejected during the night, as at 8 A.M., on May 16th, it lay just beyond the byssal sinus of the shell, and two additional strands had been added to the new cable. The rest may be quoted from the laboratory diary kept by Mr. Hornell:—

May 17th, 8.10 A.M.—The oyster had travelled $3\frac{1}{4}$ inches during the night, sloughing the 3 byssal strands, formed the night before, together with the common root. The thrown-off byssus remained attached to the glass. At the place of second re-attachment, 5 pale-coloured strands connected the oyster with the glass.

* 'Madras Journ. of Literature and Science' for Session 1886–87.

At 7 P.M.—Watching the same individual by candle light, as it showed signs of unrest, frequently protruding the tip of the foot, I at length saw the foot thrust out to the utmost extent (about 1 inch from the tip to the opening of the byssal gland)

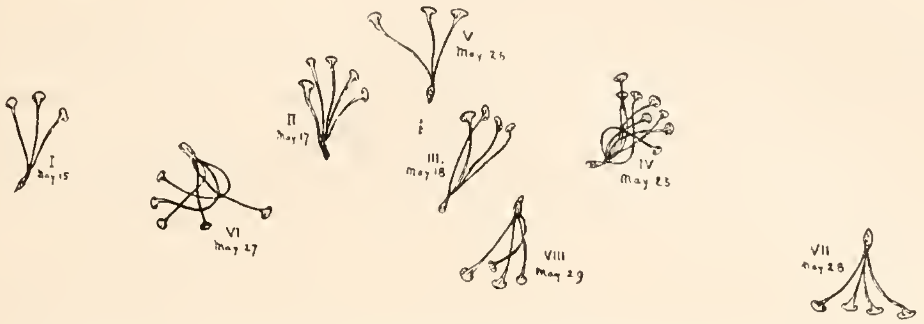


Fig. 43. Diagram showing the eight successive positions in which a pearl oyster formed new byssus strands in a fortnight. One-half natural size.

straight in front of the byssal sinus. A strong contraction then shortened the foot, pulling the animal forwards. For a few seconds it rested, then repeated the operation, during which the base of the last-formed byssus slipped out from within the shell and was cast off. The pearl oyster was now free of its mooring, and in the course of the next hour and a half, after several rests, it travelled $1\frac{1}{2}$ inches. It then settled down; the foot, after feeling about tentatively, remained quiescent at its fullest extent (1 inch) for about 5 minutes, then retracted within the shell, revealing a newly formed byssal thread, clear and almost colourless, attached at the distal end to the glass by an elliptical disc. After an interval of 7 minutes the foot was again protruded, and another strand was added in the same way as the first.

May 18*th*, 8 A.M.—Two additional strands had been formed during the night, making 4 in all (fig. 43, III.).

May 23*rd*, 8 A.M.—During the preceding night this oyster travelled $1\frac{1}{4}$ inches further, re-attaching by 5 new strands, and sloughing the old byssus.

May 25*th*, 8 A.M.—Four additional strands have been formed since 23rd inst. This last move was the fourth re-attachment since brought ashore, and the fifth since removal from the "paar." At sunset, signs of restlessness were again apparent, the foot being occasionally extended in a tentative way. At 6.45 P.M. it began crawling in a definite direction, returning upon its previous course. At the second "step" the byssal root came away. At 7.15, it was still progressing, and had covered 2 inches within 30 minutes.

May 26*th*, 8 A.M.—It had come to anchor $2\frac{1}{2}$ inches from the preceding day's position, with 3 new strands formed (fig. 43, V.).

May 27*th*.—Another nocturnal move of 3 inches—5 new strands.

May 28*th*.—The longest single journey yet made had taken place during the night, to position VII. (fig. 43, where the distances are half actual size).

May 29th.—Another of the usual nightly moves. This time a distance of $3\frac{3}{4}$ inches had been covered, 4 strands being formed at the new anchorage—this was the seventh journey within 14 days. From this date to the time when replaced in the cage at the harbour buoy, 10 days later, no further movements took place—the animal at last appearing contented with its position.

Individual No. 2 was of the same age as No. 1, and had a similar history. On May 9th it was placed in No. 1 tank, and $5\frac{1}{2}$ days later was found anchored by a stout, pale-yellow tinted byssal strand to the outside of a glass vessel, against which it rested. Close by lay its old byssal bundle, with white sloughed-off root. The attachment had been made (as usual) during the night. Pearl oysters are always most active after sunset.

May 16th, 8 A.M.—Three new byssal strands were formed during the night. The older one had now assumed a dark-green colour.

May 17th, 8.30 A.M.—Five new strands have been made since the preceding sunset.

May 18th.—This morning this oyster was removed to another tank, and the byssal attachment was forcibly torn. It was laid under the inflow-pipe, and within 5 minutes thereafter the foot was protruded, feeling slowly all around. Then, after one or two momentary withdrawals into the shell, the foot was placed in position, the anterior part being pressed sucker-like against the tank side. In $4\frac{1}{2}$ minutes the foot withdrew, showing a new byssal thread anchoring the oyster to the tank. The old byssus was thrown out in the course of the next hour. During the rest of the day 4 other strands were formed, and 16 more in the course of the ensuing two days.

May 21st, 8 A.M.—During the night this oyster had cast off the byssus, travelled 2 inches, and then made a re-attachment by 14 new byssal strands.

May 24th showed another night march to have taken place. The distance travelled was 1 inch. The new byssus, the fourth since being brought into the aquarium, consisted of 3 strands. The next night again showed another move of $2\frac{1}{4}$ inches, with re-attachment by 9 new stout silvery fibres. After this it made no further change, remaining affixed to the bottom of the tank till July 3rd, when it was removed. The length of its fully extended foot was $1\frac{1}{4}$ inches from the tip to the centre of the mouth of the byssal gland.

The other oysters of this batch took from 5 to 7 days to form their first re-attachment after being brought in from the cages in the harbour. Subsequently, when the water-circulation in the aquarium was improved, re-attachment of freshly introduced individuals took place much more quickly. Thus, of a number placed in the tanks on June 1st, at 12.30 P.M., one threw off the old byssus, crawled 2 inches, and re-attached, all within 2 hours after being brought in. At 6.30 P.M. (sunset) the same day all the remainder became active—the first sign in nearly every case being the casting away of the old byssal root. A few crawled a short distance, but the majority merely protruded the foot, feeling round, and then at once began the work of forming new cables. At 8.30 P.M., the greater number had made new attachments, and the remainder had thrown off their old byssus and were preparing to attach, probably waiting for the observer's candle to be extinguished.

The next morning all had attached. Several had crawled very long distances; one had gone nearly to the opposite side of the tank, 27 inches (the greatest distance we have seen covered in the 12 hours), another had travelled 8 inches, and a third, 13 inches. This rapidity of re-attachment under healthy conditions (one within 2 hours, the majority within 8, and all within 20 hours) has obviously an important bearing upon the proposed transplantation operations on the pearl banks.

Pearl oysters are extremely sensitive to light when preparing to attach, and there is always difficulty in seeing the actual operation of byssal fixation. While watching the oysters in one tank, those in another will be fixing, and when the light is brought to bear upon these last, they will withdraw the foot as soon as the strand they are engaged upon is finished, and refuse to again protrude until the light is removed.

When the pearl oyster is crawling, while advancing the foot the valves are widely open. When fully protruded the animal contracts the foot to the utmost, thus dragging forward the body. At the same time the valves are usually brought together with a snap, whereby the advance is materially aided.

Our observations show that the disc of attachment of a byssal thread is not formed, as KELAART supposed, by a fosset-like expansion of the pedal groove at the tip of the foot. In reality the pedal groove subserves two distinct functions, the anterior or distal part being used wholly for locomotion and having nothing to do with byssus formation, which is effected by the hinder region of the groove alone. The front end of this hinder section, at its junction with the locomotor surface and about midway between the pedal tip and the anterior margin of the byssal pouch, expands to form an oblong cup-shaped pit or sucker. Behind this again the margins of the groove are usually curved inwards, meeting medianly, to form an extemporised laterally compressed cavity, the pedo-byssal tube: anteriorly this communicates with the median sucker-pit and posteriorly with the byssal pouch.

When the foot is protruded for the purpose of forming a byssal thread, the fore part of the pedal groove is flattened out to act as a sucker, holding the foot in position. The lips of the median pit also expand, forming an oval sucker attachment, while the edges of the hinder part of the pedal surface remain approximated, and may not even touch the surface to which attachment is to be made. For about 4 to 6 minutes, the oyster remains at rest in this position, while a secretion is flowing actively from the byssogenic glands into the extemporised tube along the hinder part of the foot, and so into the median sucker-pit. The latter is the only spot at which the secretion is in contact with the exterior. At the end of the time mentioned the distal part of the pedal surface frees itself, the margins of the proximal tubular region open, and the foot as a whole is gently withdrawn within the shell, leaving behind a pale, glassy-looking, laterally compressed thread attached distally to the extraneous body by an oval disc, and at the inner end to the base of the byssal pouch. The oval attachment-disc is the internal mould of the median pit, and the body of the thread that of the laterally compressed tube formed by the approximation of the margins of the proximal part of the pedal groove. The secretion forming the byssus hardens upon contact with sea water. At first it is pale yellowish in colour and almost transparent; in the course of 48 hours it becomes opaque and of a deep bronze-green with extremely lustrous surface. The sensitiveness to bright light of pearl oysters on the move after sunset, when crawling or when forming new byssal threads, has been noted above. When visiting the tanks it was noticed that no sooner did the candle flash upon them than they either withdrew the foot instantly or did so the moment the thread they were secreting was finished. Locomotion during daylight is very seldom seen, the habit is undoubtedly to travel after darkness sets in—a time when danger from predaceous animals is no doubt reduced.

Pearl oysters are equally sensitive to passing shadows during daylight. In the aquarium tanks the hand passed slowly between them and the sun will cause them to snap-to their valves; and on the sea bottom, at a depth of 6 to 9 fathoms, the same result of a passing shadow can be seen. It must be remembered that on the pearl banks of the Gulf of Manaar the water is so clear that at the depths named the sea bottom is brilliantly illuminated when a bright sun is shining.

To some extent the habits of very young spat are exceptional. Thus when the spat that adhere to floating weed are shaken off into an aquarium tank, they do not, as older individuals would, lie quiescent on the bottom till after sunset, but at once, whatever the condition of the light, start crawling up the sides of the tank, and fix themselves on any objects well above the bottom. Probably an instinctive impulse makes them endeavour to attain a higher level in order to avoid the risk of being buried in the sand on the sea bottom. And it is remarkable what comparatively long distances they cover within a few minutes. We have already shown ("Narrative," p. 68) that minute spat from floating weeds can crawl at the rate of 1 inch a minute.

IV. Food and Feeding Habits.

The food of the pearl oyster is microscopic and of similar character to that of allied Molluscs; it consists largely of unicellular organisms—spores of Algæ, Diatoms, Infusorians, and Foraminifera in the main, with smaller numbers of Radiolarians, the minute embryos and larvæ of various animals, and occasional considerable quantities of delicate algal filaments (chiefly Rhodophyceæ). Non-nutritious particles are also met with in fair amount, such as the spicules of Alcyonarians and of sponges, with small numbers of minute sand grains. On the whole, Diatoms, spores, and embryos are the most important sources of food supply.

Under natural conditions the pearl oyster lies with the right or less convex valve beneath, and with the posterior edge of the shell elevated at an angle of about 20 degrees. If a detached oyster be placed on the bottom on its left or deeply convex valve, its first movement before making a byssal re-attachment is to protrude the foot to the utmost extent, and give a violent contraction so as to cant the shell over on to the right side. When lying undisturbed the pearl oyster separates the ventral edges of the shell to the extent of about $\frac{1}{3}$ inch. This aperture is, however, reduced to a mere slit by the inwardly directed edges of the pallial lobes from either side which nearly meet, and interlock by means of the marginal digitate tentacles.

Through this sieve-like slit, guarded by these sensitive branched processes, an indraught of water is carried by the constant lashing of the cilia covering the gill surfaces. Any large particle unsuitable for food, or any intruding animal touching the pallial tentacles, causes the valves to close with a snap. Otherwise a constant stream of small particles, diatoms, spores, protozoa, and other microscopic organisms, is carried in with the water flowing towards the branchiæ, which function as very fine strainers, able to sift out and arrest every particle from the incoming current. The food particles so arrested are carried by the cilia along the furrows to the crest of the branchial lamella. There the band of specialised cilia forms a path from end to end, along which the particles pass forwards at a rapid rate to the anterior branchial apex, where they are carried into the palpar gutter of that side. In all, four ciliated pathways lead along the branchial crests to the palpar gutters, two on each side.

Occasionally, too, particles find their way into one of the six ciliated paths at the base of the branchial lamellæ. In this case they may either be propelled forward along this basal pathway, or, as usually happens, be drawn away, after travelling a short distance, by the ciliary current of the branchial furrows, and so be transferred to the crest and follow the normal course.

Observations show that the palps can exercise a power of rejection. Thus if there be sediment in the water, the particles of mud after being sifted out by the gills and passed to the palps are retained by the latter until enough accumulate to form a tiny pellet. This is rotated slowly just within the truncated ends of the palps for a time, and is then suddenly ejected by a slight movement of the palps on to the surface of the broad ciliated band that runs outwards to the pallial edge from the base of the palps. Along this the rejected pellet is carried, round the inside of the pallial edge, till, arriving opposite the posterior tips of the branchiæ, it is thrust out. The ciliated path there terminates at the distal end of the lip-like twist of the pallial margin on the ventral border of the exhalent orifice. As the pellet leaves the pallial edge it comes under the influence of the excurrent stream from the gills, and thus is carried some little distance away from the oyster.

On the other hand, nutritious particles received on the palpar surfaces from the branchial ciliated paths are passed on at once to the mouth.

V. Shell-Growth and Repair.

Such subjects as rate of normal shell-growth, power and extent of shell-reparation, and cases of arrest of growth, are all closely related, and may be considered together.

1. Size and Growth.

There are two ways of assessing the rate of shell-growth, first the direct one of keeping marked individuals under observation and noting accurately the dimensions from time to time, and second the indirect method of visiting certain banks periodically and, by taking the average measurements of a number of individuals at each visit, deducing the average growth from period to period. Both these plans were adopted during the present investigation, and the following may be stated as a summary of the conclusions arrived at.

Growth during the first two years of life is very vigorous under healthy conditions and in the presence of an abundant food supply. During the third year the rate of increase is reduced, and in the fourth still further so. After that there is little or no increase superficially, although the shell may grow greatly in thickness.

During the first three years the marginal outgrowths or "fingers" show great development under healthy conditions. Thereafter there is less and less tendency to produce these processes, the activity of the oyster's shell-growth in later years being concentrated upon thickening the nacreous internal layer, largely to counteract the ravages of boring enemies such as sponges and annelids. With variation in the food supply, consequent upon the more or less overcrowded condition seen on several of the "paars," there is marked variation in the rate of growth of the shell (fig. 44).

Fig. 44. Pearl oysters of the same age from the Muttuvaratu and East Cheval paars, to show difference in size. Traced from a photograph.

Large numbers of measurements of oyster samples from different paars have been made in the course of this enquiry. It is unnecessary to publish these in full,* so we give here the results of our tables and such comparisons and conclusions as it seems possible to draw. It must be stated that in computing the ages of the oldest oysters now on the pearl banks, we have relied upon the accuracy of Captain DONNAN'S

* I have in my hands considerable lists, tabulated by Mr. HORNELL, which may possibly be inserted as an appendix at the end of the report if it seems desirable.

estimate in March, 1900. In his report on the inspection of that date he announced the discovery of two wide-spread falls of spat over the Cheval and Muttuvaratu paars, which must have taken place about June and December, 1899, respectively, as he gave the ages, when found in March, 1900, as from 3 to 9 months. Consequently the oysters fished from the East Cheval Paar in the spring of 1903 cannot have been older than 3 to $3\frac{3}{4}$ years, a conclusion which makes the yield of pearls in this last fishery an eminently satisfactory one considering the comparative immaturity of the oysters. We must also conclude that, notwithstanding differences in size and appearance, the oldest oysters on the Muttuvaratu Paar and on the Cheval Paar are of the same age, as they are grown from the spat which DONNAN found in March, 1900.

A sample of 50 adult oysters from the Muttuvaratu Paar, measured in April, 1902, gave as the average $2\frac{6}{32} \times 2\frac{1}{64}$ inches, or 55·50 × 51·0 millims.* A sample of 38 oysters from the same bank, measured in November, 1902, gave an average of 58·84 × 54·32 millims., by 22·07 millims. in thickness. Twelve oysters from the same locality, measured in March, 1903, gave an average of 57·54 × 54·0 millims., by 24·42 millims. in thickness.

These figures show an increase during 7 months (April to November, 1902) of 3·34 millims. × 3·32 millims., with a slight decrease during the ensuing 4 months. The very slight increase during the former period, and the arrest of growth after that, agrees well with the impression we formed as to this bank from the oysters we have seen. Coral growths are very rich on the valves along with other incrusting organisms—Polyzoa, Sponges, Tunicates, and Algæ chiefly. The oysters are small but thick, with no marginal processes or "fingers." If they have ceased to grow superficially, they are adding to the thickness of the shell. Our field notes say (November, 1902): "The pearl oysters on this bank are more thickly crowded than on any other; their size is the most stunted of any yet seen, and they are thin and miserable within, with little food in the alimentary canal in most cases." In March, 1903, when Mr. HORNELL inspected the bank with the diving apparatus, he found that the oysters were densely crowded together, approximately 125 to the square yard, along with various other animals, chiefly corals, which were both on and around the oysters. He noted "The oysters were all small and stunted and unhealthy looking, showing no vigorous shell growth and no marginal processes. On dissection, it was found that all those collected had internally the same stunted appearance. The bodies of all were equally shrunken and thin, the gonads spent or not seasonably developed, and at the best, extremely small; indeed all tissues were equally meagre, even the byssus weak and of few strands." We have other observations, and extracts might be multiplied, all tending to show that the poorly nourished and diseased condition of the oysters on the Muttuvaratu Paar is due to overcrowding.

* The first measurement given is always the depth (dorso-ventrally, at right angles to the hinge), and the second the length (antero-posteriorly).

In marked contrast to the poor growth seen on this bank was the rapid rate of increase shown on transplantation to a locality under better conditions. Two of our experiments may be cited to show this :—

(1.) A number of oysters collected on April 11th, 1902, from the Muttuvaratu Paar, were suspended 5 days later in wire-net cages, at a depth of $3\frac{1}{2}$ fathoms, from the outrigger of a native boat moored in Galle Bay (see fig. 23). By May 9th a marginal increase varying from 1·20 millim. to 1·50 millim. had been effected, and, in addition, numbers of long finger-like processes had appeared, an evidence of very vigorous growth—due, no doubt, to the abundance of food with which the stomach and intestine of specimens examined were found to be crammed. The internal parts had undergone a corresponding increase, and the tissues from being thin and shrunken had now become plump and healthy in appearance. We have the detailed measurements of a number of transplanted individuals, from which we may select three as samples :—

Specimen B, on April 13th, measured 58·50 × 54·50 millims., and by May 9th it had reached 61·60 × 56·70 millims., an increase of 3·10 millims. × 2·20 millims. during 26 days, and not including the finger processes which had begun to form along the margin.

Specimen C (omitting details), from April 15th to May 9th, showed an increase

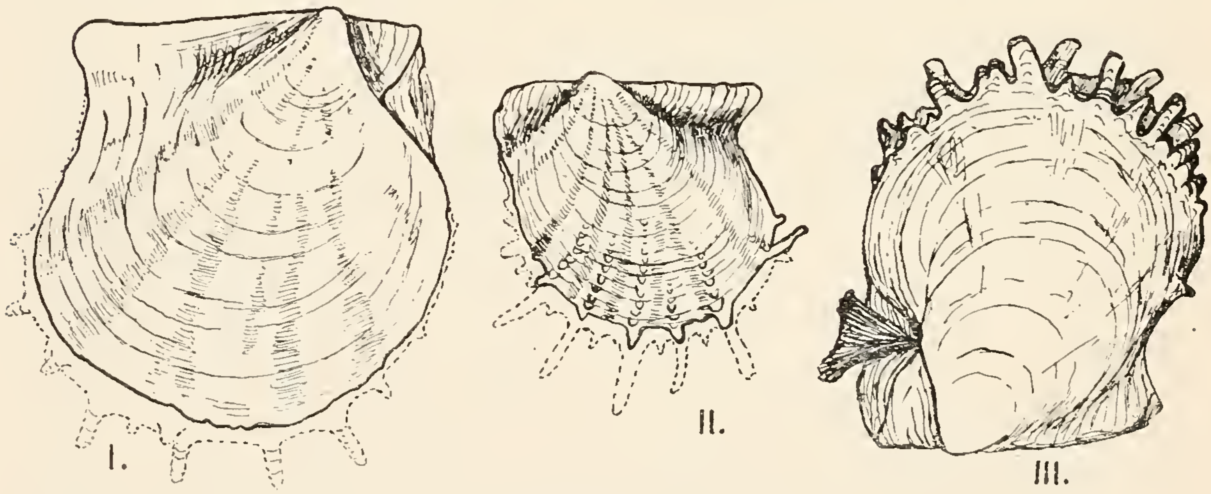


Fig. 45. Three transplanted pearl-oysters showing rapid growth. I. The dotted line shows the new shell formed in 23 days. II. The dotted line shows the new shell formed in 21 days. III. Oyster taken from Muttuvaratu to Cheval, showing a month's growth. All natural size.

varying round the margin from 0·75 millim. to 3·80 millims. ; while if the fingers be included, the growth during these 23 days was 9·50 millims. (see fig. 45, I.).

Specimen D was younger, 6 months old, brought from Chilaw Paar. From April 15th to May 7th the increase was 1·85 millim. on the average, not including "fingers." The latter were present when put out at the buoy in Galle Bay, but a new set, enormously larger, were formed under the more favourable conditions, and some of these were 10 millims. to 11 millims. long (fig. 45, II.).

(2.) A number of the same pearl oysters were transplanted the following year, during the fishery, from the Muttuvaratu Paar, on March 14th, 1903, to the Cheval Paar, where they were kept under observation until April 19th. The great improvement both in external size and internal appearance was especially interesting, since we had an excellent control experiment in the similar oysters left on the Muttuvaratu, which were examined on April 14th and found to be practically unchanged. Those taken to the Cheval Paar had the margin thick and entire, with no new growth and no fingers. After 36 days 4 of them showed the following increase of size (one of these is shown in fig. 45, III.):—

A added to margin	7 millims.,	and fingers	9 millims.	in length.
B ,,	,, 6	,,	,,	8	,,	,,
C ,,	,, 6	,,	,,	10	,,	,,
D ,,	,, 5	,,	,,	$12\frac{1}{2}$	,,	,,

A very striking result, due in part possibly to suspension above the bottom; but the point is that the animal even when adult will re-act rapidly to improved conditions.

Some additional records from our lists of the average sizes of oysters from different localities and of different ages may be of use. They may be conveniently given in tabular form as follows:—

Locality.	Date.	Number.	Age.	Average of measurements.
			months	millims.
South-east Cheval . .	November, 1902	21	11 to 14	$50 \cdot 57 \times 47 \cdot 52$.
North-west Cheval . .	,, ,,	14	11 ,, 14	$47 \cdot 64 \times 44 \cdot 36$.
South-east Cheval . .	March, 1903	34	15 ,, 18	$54 \cdot 41 \times 49 \cdot 75 \times 20 \cdot 38$.
North Modragam . .	,, ,,	12	15 ,, 18	$61 \cdot 17 \times 54 \cdot 50 \times 24 \cdot 28$.

These, then, are young oysters in the beginning of their second year, and it will be seen, comparing those of like age, that the North Modragam are larger than the South-east Cheval, and the latter are larger than the North-west Cheval.

Those given below are older oysters, mostly in their fourth year (see next page).

Locality.	Date.	Age.	Number.	Average of measurements.
		years		millims.
Periya Paar Kerrai . .	November, 1902	$2\frac{11}{12}$ to $3\frac{5}{12}$	22	74·36 × 68·59.
,, ,, . .	March, 1903	$3\frac{1}{4}$,, $3\frac{3}{4}$	33	74·76 × 67·15 × 31·25.
North-east Cheval . .	November, 1902	$2\frac{11}{12}$,, $3\frac{5}{12}$	16	80·25 × 74·06.
,, ,, . .	March, 1903	$3\frac{1}{4}$,, $3\frac{3}{4}$	20	76·05 × 71·45 × 31·45.
Mid-east Cheval . . .	November, 1902	$2\frac{11}{12}$,, $3\frac{5}{12}$	8	74·12 × 67·5.
,, ,, . . .	March, 1903	$3\frac{1}{4}$,, $3\frac{3}{4}$	31	75·45 × 68·55 × 31·10.
South-east Cheval . . .	November, 1902	$2\frac{11}{12}$,, $3\frac{5}{12}$	36	69·81 × 64·44.
,, ,, . . .	March, 1903	$3\frac{1}{4}$,, $3\frac{3}{4}$	35	75·77 × 69·57 × 31·00.
North-west Cheval . .	November, 1902	$2\frac{11}{12}$,, $3\frac{5}{12}$	6	71·33 × 67·83 (sandy ground).
,, ,, . .	March, 1903	$3\frac{1}{4}$,, $3\frac{3}{4}$	3	61·5 × 58·33 × 26·83 (rocky).
South-west Cheval . .	November, 1902	$2\frac{11}{12}$,, $3\frac{5}{12}$	36	71·25 × 65·39.
Mid-west Cheval . . .	,, ,,	$2\frac{11}{12}$,, $3\frac{5}{12}$	31	65·68 × 60·39.
Dutch Modragam . . .	,, ,,	$2\frac{11}{12}$,, $3\frac{5}{12}$	18	64·0 × 61·0.
Muttuvaratu	,, ,,	$2\frac{11}{12}$,, $3\frac{5}{12}$	—	58·84 × 54·32.
,, ...	March, 1903	$3\frac{1}{4}$,, $3\frac{3}{4}$	—	57·54 × 54·00 × 24·42.

Taking now the average for all the banks at the November, 1902, and March, 1903, inspections separately, we find that the (say) 3-year-old oysters average 69·96 × 64·79 millims. for all localities, and the (say) $3\frac{1}{2}$-year-old oysters average 70·18 × 64·84 × 29·33 millims. It is, however, probably not instructive to take an average for all of the banks, since two distinct types of oyster occur—those exemplified by the Eastern Cheval and the Muttuvaratu respectively. It is, therefore, better to group the Periya Paar Kerrai with the East Cheval in order to ascertain the normal rate of increase under favourable conditions, at the age considered :—

Locality.	Average size in millimetres. November, 1902, $2\frac{11}{12}$ to $3\frac{5}{12}$ years.	Average size in millimetres. March, 1903, $3\frac{1}{4}$ to $3\frac{3}{4}$ years.
Periya Paar Kerrai	74·36 × 68·59	74·76 × 67·15
North-east Cheval	80·25 × 74·06	76·05 × 71·45
Mid-east Cheval	74·12 × 67·05	75·45 × 68·55
South-east Cheval	69·81 × 64·44	75·77 × 69·57
The averages at the two dates being .	74·63 × 68·53	75·51 × 69·18

This gives an increase of only 0·88 × 0·65 millim. for the 4 months ending March, 1903, which bears out the statement made above that growth after the third year is very slow. Comparison with the growth of the much younger (second year) oysters on the South-west Cheval, from 50·57 × 47·52 millims. in November, 1902, to 54·41 × 49·75 millims. in March, 1903, shows how very rapid the increase is at this age, 3·84 × 2·23 millims. in 4 months.

As, however, the shell can grow in thickness of valve as well as in superficial extent, it is of some importance to consider the weight in relation to age. We are able to give a table of the weights of shells of one generation of pearl oysters as determined by Captain DONNAN annually from the first year to the time when fished at 4 and 5 years of age. As after the third year there is but little increase in size, the figures for the later years may be taken as indicating the additions to the thickness of the shell.

WEIGHT of Cleaned Pearl-oyster Shells.

Locality and date.	Age.	Number weighed.	Average weight per pair of valves.
	year	pairs	drams
North-west Cheval—			
March, 1871	1	13	4
„ 1872	2	13	12
„ 1873	3	50	19
November, 1873	$3\frac{3}{4}$	100	$20\frac{1}{2}$
March, 1874	4 (fished)	45	$24\frac{1}{2}$
„ 1875	5 (fished)	47	30
South-east Cheval—			
March, 1874	1	33	$3\frac{2}{3}$
„ 1875	2	60	$13\frac{1}{2}$
„ 1876	3	150	$21\frac{1}{2}$
„ 1877	4 (fished)	51	30

The stunted condition of the oysters on the Western Cheval which we saw on the ground, and have noted elsewhere in this report, is shown by these figures to have been as marked a quarter of a century ago. While the South-east Cheval produced shells which at 3 years of age weighed $21\frac{1}{2}$ drams each and at 4 years 30 drams, those of the same ages from the North-west Cheval weighed only 19 drams and $24\frac{1}{2}$ drams respectively.

All the above figures, as well as the non-numerical observations which we made upon the banks during two inspections and a fishery, tend to show that, of the reliable paars, the Southern and Eastern parts of the Cheval, the Periya Paar Kerrai and the North Modragam are, at present, those that produce the most rapid growth and healthy development of the pearl oysters. The conditions at these paars which seem to determine the good results are :—

(1.) The local abundance of microscopic food. This was shown by the richness of the plankton in our tow-net gatherings.

(2.) The absence of competing organisms, such as those that are present in quantity on coral ground.

(3.) The impossibility of overcrowding, as there are no extensive sheets ot rock emerging from the sand, and therefore the pearl oysters cannot, at these localities, form a continuous layer almost hiding the underlying rock, as they do in some places.

These are all important points, especially perhaps the last. The oysters on these more favoured grounds, although abundant enough, are not overcrowded, but lie in separate bunches or little isolated groups. Sometimes, as on the Periya Paar Kerrai, the foothold consists of little patches of flat rock (see fig. 36, p. 109), 3 or 4 feet in extent and separated by sandy tracts 2 or 3 yards in width. At other places, as on the South Cheval, little or no rock appears on the bottom, and the oysters are attached in bunches to the scattered natural "culch," fragments of dead coral and of calcretes, broken shells and Lithothamnion masses, lying on the sand. A certain amount of sandy bottom, interspersed with harder tracts, and with plenty of "culch"—natural or artificial—scattered over the sand, is probably the most favourable ground for the Ceylon pearl oyster from the point of view of those interested in the fisheries. The presence of more culch in many places would, however, be an improvement. It would give more foothold for new broods of oysters, and at the same time would probably help to stiffen the shifting sand and prevent, in some degree, the wash-out and turn-over of the surface which is caused by a heavy swell.

The reliable paars which produce less rapid growth and are characterised by their stunted oysters (the "Koddaipakku" variety of the divers and the Inspectors' reports) are the Muttuvaratu, much of the West Cheval and the Dutch Modragam. These are all localities with great stretches of continuous rocky bottom which may be covered, during favourable seasons, by myriads of pearl oysters closely crowded together. Thus Captain DONNAN estimated, in 1902, that on the sandy East Cheval (11,804,676 acres) there were 74,413,000 pearl oysters, while on the rocky West Cheval (10,500,000 acres) there were 123,357,600, showing a much denser population per acre in the latter case, but not equalling the density on the Muttuvaratu Paar, where an area of rather less extent (10,206,725 acres) supported in March, 1902, the enormous total of 277,000,000 pearl oysters—which have since suffered great losses, due no doubt to their overcrowded condition.

2. Shell-Repair.

Pearl oysters have considerable recuperative power after injury, and can usually repair damage done to the shell. This is of importance from two points of view, first in connection with the ravages of some of their natural enemies, and secondly, because of its bearing upon occasional pearl-formation. Many cases were noticed in our field work where injuries had been effectively repaired, and it is significant that a number of these were found on the Periya Paar Kerrai during March, 1903, immediately after the time when we have evidence that Rays (*Trygon uarnak*) were feeding on the bank and had crunched up many shells. Some of the oysters we found showed that fragments of the ventral margin had been broken off, others that the anterior or the posterior "ear" had been smashed—all had been repaired more or less perfectly so as to enclose the animal and enable the valves to function.

To ascertain the extent and rapidity of the process of repair, a number of experiments were made both on the pearl banks and at Galle. The following give the details of a few typical cases :—

(A.) During the removal of oysters from the "Serendib" at Galle in April, 1902, a $2\frac{1}{2}$-year old oyster had a large semi-circular fragment broken from the right valve. The oyster remained for the next 26 days suspended in a wire-net cage from one of the buoys in the bay. On May 9th, when brought into the laboratory, the gap was mended completely and an additional marginal growth of 1·4 to 2 millims. had formed. The only departure noticeable from the original condition was that neither of the two involved radial bands of colour had been continued in the repaired area, the pigment being spread out instead in a diffused manner.

(B.) In February, 1903, a number of oysters from the Cheval Paar were purposely damaged in various ways. When examined on the 23rd, 8 days later, they all showed extensive repair. In one case $5\frac{1}{2}$ millims. of new shell had been added at the damaged spot, and in two others $3\frac{1}{2}$ millims.

(C.) This was another oyster which had a piece fully 15 millims. in vertical depth removed from the right valve on February 15th. In 9 days a fresh growth, measuring 7 millims. in depth, had formed, while by March 8th the whole of the damage was made good by a further growth of 8 millims., so that within 21 days a total growth of 15 millims. depth of new shell had taken place.

(D.) Even more rapid repair was shown by some oysters damaged on February 27th, due possibly to the fact that they were suspended in the purest sea-water on the banks for the whole period of the experiment, whereas (B.) and (C.) above were kept in muddy water off Chilavaturai for several days. The growth shown in (D.) was very uniform, and the damage was completely repaired in all cases. Of three photographed on March 8th (two are shown in fig. 46) :—

No. 1 showed	9	millims.	of new	solid shell,	12	millims.	including	the	"fingers,"
,, 2 ,,	7	,,	,,	,,	13	,,	,,	,,	,,
,, 3 ,,	$7\frac{1}{2}$	,,	,,	,,	12	,,	,,	,,	,,

a surprising growth for 9 days. The colours of the new shell were very brilliant in these cases, rich brown-red and bright yellow.

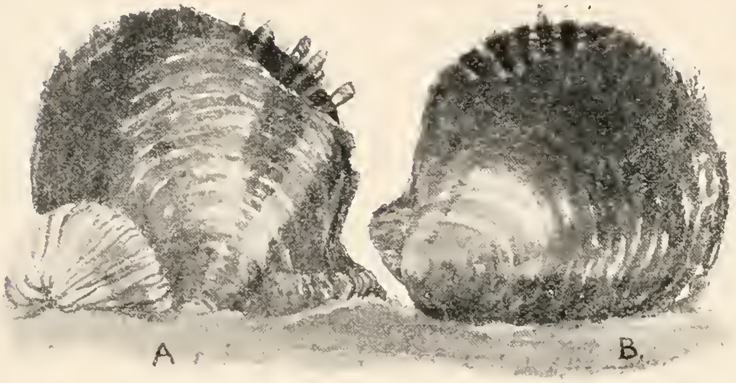


Fig. 46. Two pearl-oysters showing damaged shells repaired in 9 days (February 27th to March 8th).—Copied from the photograph.

Two other oysters of this same series (D.) were photographed on March 10th. Within the 10 days, one had formed 6 millims. of new solid shell and 15 millims. in

Fig. 47. Pearl-oyster damaged on February 27th and photographed on March 10th to show complete repair. The arrows point to the new growth.

all including the "fingers," the other (fig. 47) had formed $11\frac{1}{2}$ millims. of shell and $16\frac{1}{2}$ millims. to the end of the "fingers."

(E.) In the case of a number of oysters damaged on April 21st, new growth varying from 2 to 5 millims. in extent was seen in 2 days.

Many other instances might be given from our note-books, but the above will suffice to show the rapidity and thoroughness with which the pearl oyster makes good injury to its shell, and to effectually dispose of any objections that might be raised to extensive transplantation on the score that the oysters might be damaged and would not survive the operation.

Observations on the damaged oysters kept in our aquarium tanks at Galle throw light upon the methods of repair. Damage may either be marginal or superficial. If the latter, the cause is usually a blow fracturing one of the valves through both nacreous and prismatic layers and depressing the shell on the distal side of the break. In a specimen purposely so injured, the mantle-lobe separated from the proximal part of the shell for some $\frac{1}{4}$ inch, leaving a wedge-shaped recess under the shell-margin at the fracture. In this new position the external pallial epithelium secreted a fresh deposit of nacre, thus perpetuating permanently the crevice under the proximal fractured edge.

Cases where the mantle is extensively pierced or lacerated by the injury may be fatal, not apparently because the animal is unable to make good the damage, but rather because of the difficulty of keeping out small carnivorous animals such as worms and molluscs. In several cases, however, we have seen complete recovery from extensive laceration, the margins of the wound gradually approximating and finally uniting. While the temporary aperture exists, water may be drawn in through it, and the tip of the foot is sometimes protruded through the hole in the mantle and moved round the rough edge of the broken shell, with the result that loose fragments and dirt particles that accumulate between the mantle and the nacre, and which probably cause irritation, are removed. No repair-nacre is secreted until the damage to the mantle is made good.

When a fragment of the shell-margin is broken away, the mantle within is retracted in proportion to the extent of the damage, not only at the place of injury but for some distance on either side. Consequently, when the pallial edge begins to form a new shell-margin, it starts in the uninjured part from a point about $\frac{1}{8}$ to $\frac{3}{16}$ inch behind (internal to) the former edge. Along the line of fracture the pallial edge is advanced much closer, or quite up to the margin, beyond which the pallial tentacles can be seen projecting. This method of starting the new growth behind the existing edge in the case of injuries is also the normal method of adding to the margin of the valves in growth. Under normal conditions growth is discontinuous, periods of activity alternating with what appear to be periods of rest. Each fresh layer begins from a line about $\frac{1}{16}$ inch inside the edge; which process results in the formation of a number of successive layers of shell with projecting margins outside, the older overlapping the younger in imbricate fashion. Young rapidly growing pearl oysters show this imbrication most markedly, especially during the first two years. As they get older, attrition and the ravages of attacking and incrusting animals tend to remove the thin projecting margins and their delicate processes, and new ones are less frequently formed as the shell ceases to grow in extent but becomes thicker by deposits of nacre on the inside. The distance apart of the successive marginal ridges is a good guide to the vigour of the oysters, healthy conditions being indicated when the distances are considerable, and overcrowding or scarcity of food when they are massed thickly together, especially at the margin. Many of the Muttuvaratu oysters show this latter appearance to a marked degree, the edges of the shell, instead of being thin and delicate as they are on the South-east Cheval, being comparatively thick and formed of a number of very slight layers of growth, which do not imbricate, but are massed at the same level, so as to show like the edges of a pack of cards.

The connection of shell-repair with occasional pearl formation depends upon the fact that the pearl oyster has to withstand the attacks of various animals—sponges, worms, molluscs—which bore into the shell. In attempting to repair such ravages the oyster thickens the nacreous layer, and in some cases piles up pearly excrescences on the interior of the shell which may be separated as pearls of an inferior quality. It is probable, also, that when the shell is damaged fine particles, either splinters of nacre or foreign bodies, gaining access to the interior, may serve as the nuclei of free pearls. Finally, it must be remembered that shell-growth and pearl-growth are similar and comparable processes. In both cases limy salts in an organic matrix are deposited by the living tissues—in the one process on the outside of the body, and in the other around some internal particle, which in the case of the finest pearls is the Cestode larval *Tetrarhynchus*. I shall return to these matters in the later section of this Report, which will treat of pearl formation.

REPORT

ON

SEA-BOTTOMS AND CALCRETES

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

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[WITH ONE PLATE AND TEXT FIGURES.]

THE samples of sea-bottom, about thirty in number, were dredged mainly from four districts round the coasts of Ceylon :—(1) About Point de Galle, (2) Trincomalee Bay, (3) Palk Bay, and (4) the Gulf of Manaar—and most of them were from the last locality (see map, p. 161).

In addition to the material brought up by the dredge, about twenty specimens of rock were broken off from the bottom by divers, chiefly from the paars in the Gulf of Manaar and along the west coast of Ceylon.

The majority of the deposits were obtained from shallow water, 4 to 10 fathoms, but a few from the Gulf of Manaar and off Galle are from a greater depth.

POINT DE GALLE AND NEIGHBOURHOOD.

In **Galle Bay,** from depths of 6 to 8 fathoms, shells with sand were dredged. Large drifted shells, such as *Arca*, *Anomia*, *Ostrea*, *Cucullæa*, and *Turritella*, mostly in a rotten condition, made up the bulk of the coarse material, along with large barnacle valves and a few shark's teeth. The shells were worn, many brown in colour and polished, indicating a partial conversion into a phosphatic condition. Encrustations of Nullipores, Serpulæ, and Polyzoa covered the shells, and *Clione* borings were common in those shells composed of calcite, while aragonite shells were often not affected.

The finer material, obtained by sifting through a sieve with a mesh of 1 millim., contained from 61·41 to 62·52 per cent. of carbonate of lime, and included small Molluscs, Echinoid spines, plates and anchors of Holothurids, spicules of *Alcyonium* and *Leptoclinum*, as well as numerous Foraminifera, such as *Heterostegina*, *Globigerina*, *Textularia*, and *Spiroloculina*, Nullipores and *Crisia*. While the smaller organisms have a fresh appearance, and are indicative of the life at present in the district, the larger organisms are mostly dead, and evidently very old.

The inorganic constituents were quartz grains, clear and well rounded, not very plentiful, kyanite, corundum, zircon, rutile, tourmaline, and mica. A considerable amount of coal, well rolled, in pieces ranging up to $\frac{3}{4}$ inch in diameter, is no doubt due to the proximity of a coaling station.

At **Welligam,** to the east of Galle Bay, two samples were dredged. One, a fine calcareous mud with shells, yielded 76·50 per cent. of carbonate of lime; and another, obtained from a depth of 4 to 6 fathoms, contained many rotten shells, brown in colour and bored by *Clione*, barnacle valves and *Halimeda* in a fresh condition; a few quartz fragments, angular, ranged up to $\frac{1}{2}$ inch in diameter. The fine material in both hauls consists of a smooth mud which cakes on drying, and contains a few small quartz grains, tourmaline, zircon, spicules of sponges and *Leptoclinum*, Holothurian plates, and diatoms, especially *Coscinodiscus*. Foraminifera are not common.

Trincomalee Bay.

Off the mouth of Trincomalee Bay, at a depth of 12 fathoms, Foraminiferal sand was dredged, containing 67·7 per cent. of one form, *Heterostegina depressa*. Mollusca, including *Arca*, *Trochus* and *Patella*, mostly rolled and encrusted, made up 4·8 per cent., Corals and Polyzoa (*Retepora* and *Cellepora*) 0·2 per cent., Nullipores 8·0 per cent., *Alveolina* (two species) 0·9 per cent., and a few specimens of *Echinocyamus*. The material which passed through the fine sieve, 16·5 per cent., consisted almost entirely of small Foraminifera, including *Pulvinulina*, *Textularia*, *Discorbina*, *Miliolina*, *Cristellaria*, *Nonionina*, *Polytrema*, and *Nummulites*. Pteropods and *Alcyonium*, Holothurid and Sponge spicules were fairly abundant.

The inorganic constituents include quartz grains, well rounded and ranging up to 3 millims. in diameter, and a black powder, much of which could be removed by a magnet. The non-magnetic portion was fractionated by means of the double iodides of mercury and barium, and showed a great number of small garnets, corundum, tourmaline, and kyanite in the heavier fractions, while a little sub-angular quartz and a few grains of mica made up the lighter portions.

Palk Bay.

North of Rameswaram, in Palk Bay, where shallow water (6 to 7 fathoms) conditions extend over a great area, and where there is an almost complete absence of currents, a very extraordinary deposit occurs: it consists mainly of concretions, irregular in form, with here and there a cast of shell and a few large shells in a fairly fresh but broken condition. The shells include *Arca*, *Cardium*, *Chama*, *Pecten*, *Murex*, *Nassa*, and the pearl oyster. No double valves are found and the calcite shells are sometimes bored by *Clione*. The concretions on treatment with a weak acid effervesce strongly and yield a large percentage of fairly coarse sand. Plate I., fig. 1, shows shells, casts and concretions from this deposit.

The casts, which contain 64·80 per cent. of carbonate of lime and 2·2 per cent. of phosphate of lime, fall to mud when placed in water, and it was necessary to soak in thin balsam and harden before a section could be obtained. Round the periphery of the casts is a thin layer of calcite, which moulds itself into the inequalities of the shell's interior surface; this is succeeded by a darker layer, and then the whole interior is seen to consist of sand grains, quartz, tourmaline, felspar, and zircon embedded in a mass of secondary calcite. The sand grains increase in size on proceeding from the exterior inwards (fig. 1), and remind one of the well-known fact that when grains of different dimensions are shaken in a basin, the finer material sinks to the bottom and the coarser rises to the surface. It is probable, then, that the grains were rocked to and fro when in a loose condition inside the shell, and the cementing took place subsequently. Afterwards, owing to altered conditions, the outer shell was dissolved and the cast left. It is impossible, owing to the rolled and imperfect condition of the casts, to tell what shells formerly held the casts, but most of them have a form not unlike Natica. It is noteworthy that felspars are found in these casts, while they are absent, as a rule, from sea sands. They were probably embedded soon after breaking away from the parent rocks and before kaolinisation could reduce them to clay.

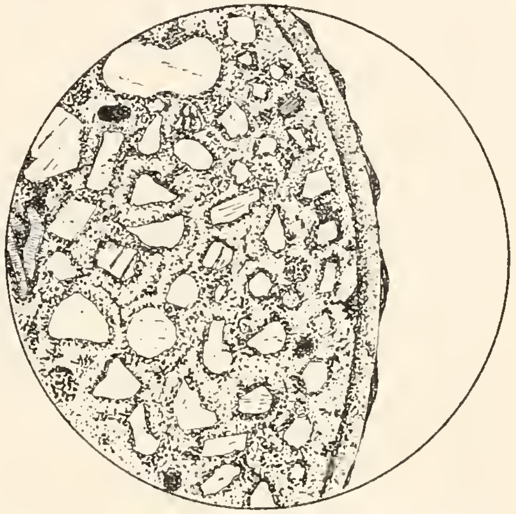


Fig. 1. Section of internal cast of shell from Palk Bay; showing the part in contact with the shell, and sand grains cemented by carbonate of lime in the interior. × 25.

The inorganic material dissolved out from the concretions by acids and fractionated showed a great preponderance of garnets. The heavier portions were pink in colour on this account. Other minerals found were corundum, tourmaline, zircon (enclosed in garnet and free), kyanite, quartz, mica (biotite), and felspar. A number of black grains were composed of ilmenite.

Further East and North of Adam's Bridge, at a depth of 7 fathoms, a fine black mud occurs which, on analysis, gives:—

Silica	55·00 per cent.	Alumina	15·80 per cent.
Carbonate of lime .	3·50 ,,	Magnesia	2·75 ,,
Phosphate of lime.	2·25 ,,	Water and organic matter	16·60 ,,
Ferric oxide. . .	4·10 ,,		

A few heavy minerals, zircon, tourmaline, and kyanite, occur; but the bulk is made up of a fine impalpable mud, smooth to the feel, with minute grains of quartz. Only a few organisms, one Foraminifer and a small shell fragment, were found in the sample examined.

Gulf of Manaar.

South of Palk Bay, and separating it from the Gulf of Manaar, is Adam's Bridge. Rameswaram Island and Manaar Island, which form the two chief links in the chain of islands almost joining Ceylon with Southern India, consist, according to Foote* and Walther,† of calcareous sandstone. This is continued across the Pamban Strait and forms the "sandstone quay" of the Tonitoray spit on the west and the coastal part of North Ceylon on the east. The smaller islands between Rameswaram and Manaar also show a similar rock, while through the passages separating them are loose drifting sands. The north coast of Rameswaram is fringed by an ancient coral reef, while living reefs are found in shallow water immediately to the north and to the south.

South of Adam's Bridge, the Gulf of Manaar stretches as a low sloping beach, deepening fairly evenly at the rate of about 1 fathom in two miles to 20 fathoms, where it sinks more rapidly to great depths. Along the west coast the slope of the shore is more rapid, and deep water is reached sooner. At places along the west coast, and also south of Manaar Island, spits of sand stretch across the platform, mainly near the mouths of rivers. They probably result from the detritus brought down by the rivers, and their general trend towards the north-west may be due to the combined flow of the streams and the prevailing inshore currents.

On the western shores of the Gulf, and in Palk Bay, the rivers form deltas of large size, and similar spits of sand extend near the river mouths towards the north-east. The coasts of India and Ceylon are swept by great marine currents running up or down the coast according to the monsoons, but owing to the longer duration of the south-west monsoon it produces greater effects, and all rivers flowing into the Gulf have a tendency to extend their deltas towards the north.‡ The sands covering the floor of the Gulf become coarser on approaching the west, and there can be no doubt that the material has been carried down from the high grounds by rivers and then distributed by currents on the ocean floor. The granulitic rocks of central Ceylon

* 'Memoirs of Geol. Survey of India'—Geology of the Madura and Tinnevelly Districts.

† Petermann's 'Mittheilungen,' Ergänzungsheft No. 102, 1891.

‡ Foote, *op. cit.*

are usually found in a friable sandy condition,* and thus provide material already disintegrated which can easily be transported by rivers to the sea. The sand forming the floor of the Gulf has, in many places, been cemented *in situ* into calcareous sandstones or "calcretes," locally known as "paars." In the north part the paars arrange themselves roughly into three groups, running parallel with Adam's Bridge, north-north-west to south-south-east. The first line is found at a depth of $3\frac{1}{2}$ to $4\frac{1}{2}$ fathoms, the second at 6 to 8 fathoms, and the third at 9 to 10 fathoms. Further south, on the West Coast, they have a north and south alignment, here again following the outline of the coast.

It would appear that the calcretes have grown out radially from centres, the smaller ones are mainly circular in outline, while the larger ones seem to have been formed by the growth and fusion of a number of smaller ones. Outliers exist in many cases near the larger paars, which seem to suggest that they too will eventually become fused with the main paars. Dredging and diving operations were mainly conducted in the neighbourhood of the paars, and most of the samples handed to me for examination were obtained from these localities. Hence the descriptions which follow readily group themselves round the most important paars.

Periya Paar.—This is the most westerly of the paars, and lies about 20 miles south-west of Manaar Island. It extends 11 miles north-west—south-east, and averages about $1\frac{1}{2}$ miles in width. Smaller paars exist as outliers at the northern and southern extremities. The rocky bottom has a depth varying from $8\frac{1}{2}$ to 10 fathoms, with a thin layer of sand covering the flat surface of the calcrete.

Outside the paar, to the west, the bottom rapidly sinks to 20 fathoms, and further out 80 fathoms and over are reached. Five specimens of the bottom were dredged in the neighbourhood of the paar and calcretes from three localities were broken off by hammers and brought to the surface by divers.

West and South-west of the North end of Periya Paar, at a depth of 10 fathoms, the contents of the dredge showed many shells in a fresh condition, Polyzoa, such as *Cellaria* and *Scrupocellaria*, *Halimeda*, and numerous Nullipores. These were accompanied by a fairly coarse angular quartz sand. The fine material yielded 27·64 per cent. of carbonate of lime, and under the microscope was seen to consist of quartz, sometimes stained with iron, many black grains of ilmenite and magnetite, tourmaline and zircon, and, as organic constituents, numerous Foraminifera, *Crisia*, and sponge spicules.

North-west of the Paar, at 12 fathoms, Foraminiferal sand with shells was dredged. The shells included *Pectunculus*, *Arca*, *Chama*, *Venus*, pearl oyster, and with these, forming the coarse material, were *Heteropsammia*, Echinoderms and a brown Alga. The smaller forms were Foraminifera—*Heterostegina* in great profusion—Nullipores, Polyzoa and Serpulæ. Only a few clear quartz grains were present.

* A. K. Coomáraswámy, 'Geol. Mag.,' August, 1903, p. 348.

From the surface of the actual Bank, at 9 fathoms, a quartz sand was obtained. It contained, in addition, numerous shells, not overgrown with encrusting organisms, *Lithothamnion*, brown Algæ and horny worm tubes. The fine material—24·20 per cent. of carbonate of lime—was principally clear quartz sand well rounded, and as rarer constituents, tourmaline, garnets, zircon, kyanite, rutile, and ilmenite.

Comminuted shell fragments, Echinoid spines, and Foraminifera—*Heterostegina* principally—made up the bulk of the calcareous portion.

Outside the Paar, to the West, at 20 fathoms, a Foraminiferal sand containing very little inorganic matter was obtained. The fine stuff yielded 85·86 per cent. of carbonate of lime. *Heterostegina depressa* and *Alveolina* were the principal constituents, and there were also included Polyzoa—*Crisia* and *Scrupocellaria*—*Alcyonium* spicules, Holothurian plates, and the spat of young bivalves.

Another haul, Outside, on the West, from 80 fathoms, brought up Foraminiferal sand with no large forms except a few broken shells. It contained 76·50 per cent. of carbonate of lime. Unlike the Foraminiferal sand from shallower depths, *Heterostegina* was not abundant, giving place in this group to small *Nummulites*, *Globigerina*, and *Textularia*; while Pteropods, the fry of Molluscs, Echinoid spines, nodes of *Crisia*, Nullipores, *Halimeda*, *Alcyonium* and *Leptoclinum* spicules, and a simple Coral were the other notable contents.

Turning now to the rocks occurring on this paar, we find :—

The North Part is composed of a fine-grained calcareous sandstone or calcrete, grey in colour, and containing a considerable number of black grains in patches.* The block brought up is thickly encrusted with Polyzoa, both adnate and erect, and Nullipores, green and white. Shells, such as *Chama*, are attached to the stone, and these in turn are covered with encrusting organisms. On the fractured surface, the centre is seen to be compact, but a thin band of less compact texture separates the interior from the organisms on the surface. Sometimes the Polyzoa lie directly on the sandstone, at other times a thin layer of Nullipore intervenes.

The quartz is clear and of fairly even grain, and between the particles the calcite is seen filling up spaces or lying as thin rods across the grains. A few shell fragments and Foraminifera occur along with the quartz.

A thin slice examined under the microscope shows quartz, mostly angular, and averaging about 1 millim. in diameter, with inclusions of apatite, zircon and tourmaline, felspars, both orthoclase and plagioclase, showing no signs of kaolinisation, green tourmaline, shell fragments, and sections of Nummulites.

Calcite occurs as a granular mass filling up spaces between the grains, and often as curved rods. The rods, as a rule, enclose sand grains; they are sometimes pitted transversely, and a dark line in some cases runs down the length of the rod. Brown

* Foote, *op. cit.*, mentions a sandstone containing magnetic iron sand as occurring in Valimukkam Cliffs, on the coast of India.

chitinous patches are often associated with the calcite rods. Their nature and origin will be discussed in the next example from the middle portion of the Paar.

Middle Part.—Nine specimens, labelled "*half way up Periya Paar*," consisted of loose porous calcretes, white in colour and heavily encrusted, and a large Chank shell filled with calcareous sand and coated with Polyzoa, Nullipore, calcareous worm tubes, byssus of pearl oysters, and sponges. Sections of the calcretes were obtained showing the encrusting organisms *in situ*. This was a matter of some difficulty, owing to the friable nature of the material, but on soaking in thin balsam and hardening, slices were cut and rubbed down on carborundum blocks.

On examining a thin slice with recent colonies on the outside, the surface layers showed Polyzoan cells arranged in parallel rows, two or three deep, with the avicularia, vibracula, and opercula in position. The irregular surfaces served to entrap and retain sand grains and Foraminifera drifting over them. Naturally, only those were held which fitted closely into the spaces provided, and thus a sifting action took place. Occasionally two small grains would fill the space in place of one of larger dimensions. Below the surface layer other cells were seen, nearly all of which contained a grain. The base and side walls were perfect, but the top wall had broken down to admit the sand grain, carrying with it the chitinous operculum. Proceeding towards the centre, succeeding layers have less prominent walls, owing to secondary calcite growing from them in tiny scalenohedra towards the interior of the cell, and finally we reach a stage when a thin dark line marking the junction of adjacent walls, the roughly linear arrangement of uniform grains, and the occasional remains of chitinous opercula are all that remain to indicate the former presence of Polyzoa. Cells which escape being occupied by sand grains become filled with secondary calcite showing a radial structure (see fig. 2).

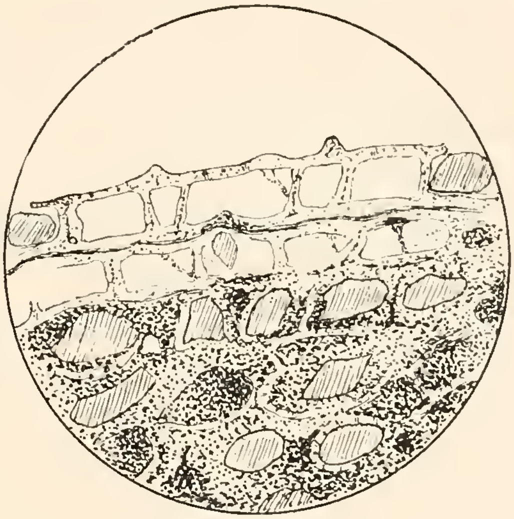


Fig. 2. Section of Calcrete with recent Polyzoa on surface, from Periya Paar Kerrai. The two upper layers represent sections of Polyzoon cells, and the lower part shows sand grains (shaded) in a calcareous matrix and fragments of the walls and opercula of the Polyzoa. × 25.

Nullipores sometimes alternate with Polyzoa and enclose grains, but it is not difficult to distinguish between the two even when structure has been lost. The grains cemented by Nullipore are sporadic in their distribution, there is no sifting into grains of uniform size, and when they appear in linear series they are mostly radial, not concentric. The action can be seen in masses of *Lithothamnion*, which send out club-shaped extensions from their surfaces. The spaces between the branches are often filled with loosely-held sand grains, and subsequent growth may enclose them. *Lithodomus* crypts and worm tubes, when deserted by their occupants, may also be filled with sand and become incorporated in the substances of the Nullipore. We shall return to this subject when discussing a Nullipore deposit from Chilaw. It is sufficient for the present to point out the importance of Polyzoa as cementing organisms, and indicate the criteria by which we can recognise their action.

South end of Periya Paar.—Here four pieces were obtained. Three of these were calcretes cemented mainly by Polyzoa, exactly similar to the one described, and containing grains of quartz, rutile, tourmaline, felspar, corundum and ilmenite, with shell fragments, Foraminifera, and sponge spicules; while the fourth was a piece of dead Coral, very rotten, covered with encrusting organisms, and bored by *Saxicava*.

Cheval Paar.—This paar lies to the south-east of Periya Paar. It is U-shaped, consisting of east and west arms with a connecting bar at the south.

The east arm is 6 miles long by 1 mile broad, and the depth averages $6\frac{1}{2}$ fathoms. Outliers to the north are seen at Periya Paar Kerrai, and Vankali Paar, and to the south lie Kondatchi and Jaggerboom paars.

The west arm measures 4 miles long by $1\frac{1}{2}$ to 2 miles broad, the depth is 7 to 8 fathoms. The connecting piece at the south end is 5 miles broad, runs north-east to south-west with a prolongation at the middle towards the south-east. Two small isolated paars, North Modragam and South Modragam, extend south-east from the prolongation.

Seven samples of the dredged material were kept from the parts surrounding the Paar, and 10 specimens of rock were obtained from the Paar itself and Periya Paar Kerrai.

Pearl Banks off Chilavaturai, $6\frac{1}{2}$ fathoms.—The coarser part of this haul consisted mainly of drifted shells, including Pearl Oyster, *Mactra*, *Pectunculus*, *Venus*, *Nassa*, and *Trochus*. They were nearly all broken, rotten, and some were bored by *Clione* and encrusted with Nullipore, Polyzoa, and Serpulæ. Echinids and Starfish also contributed to the contents of the sample as dredged. The only living organisms were Polyzoa.

The portion of medium size consisted of clear and milky quartz grains, well rounded and polished, averaging 5 millims. in diameter, echinoid spines and a few shell fragments.

The part which passed through a sieve of 1 millim. mesh was mostly quartz sand with 7·04 per cent. of carbonate of lime. On concentrating the heavy minerals by a high-density fluid magnetite, ilmenite and leucoxene, garnets, kyanite, tourmaline, rutile, corundum, and zircon were found; while in the lighter fractions were comminuted shells, Nullipores, Foraminifera, Echinoid spines, and spicules of *Holothuria*, *Alcyonium*, and sponges.

The material has all the appearances of a drifted shell bank swept by strong currents.

North of Cheval Paar, 7 fathoms. This consisted of a fine quartz sand with black grains, contained 28·36 per cent. of carbonate of lime, and included a few encrusted shells and *Echinocyamus.*

South-west Corner of Cheval Paar, 8 fathoms.—A fairly coarse shelly sand, with uniform grains about 5 millims. diameter, made up the bulk of the material. *Natica*, Pearl Oysters. Starfish arms, large *Heterostegina*, Nullipores and spines of Echinoderms also occurred in the coarser part.

The finer portion contained very little quartz, a little ilmenite and kyanite, sponge spicules, and the 34·32 per cent. of carbonate of lime was made up principally of Foraminifera and young Molluscs.

Middle of South End of Cheval Paar, 7 fathoms, immediately North of Shoal Buoy. This was nearly all fine sand of a light grey colour.

Pearl Oyster, *Pectunculus*, *Lima*, *Natica*, *Modiola*, and Chank shells were common, not very fresh and thickly encrusted. Barnacle valves, Sabellaria tubes and Echinoderms also occurred. Several pieces, about 1 inch long, of a chalky white stone on cutting proved to be decomposed Nullipore on the outside, and dark brown compact limestone with quartz and garnets in the interior.

The fine material yielded 22·20 per cent. of carbonate of lime, and contained quartz, zircon, kyanite, garnets, tourmaline, corundum, rutile, and mica with shell fragments, Foraminifera, and sponge spicules.

Shoal Buoy, $3\frac{3}{4}$ fathoms, is near the north-west termination of a spit of sand which extends from Karativo to Cheval Paar.

The bottom consisted of clean white sand with shells, 3·09 per cent. of carbonate of lime, and included a number of small black grains. The largest sand grain was 7 millims. in diameter. The shells were fresh, and some had the two valves in position.

In addition to quartz, garnets, kyanite, corundum, tourmaline, rutile, and ilmenite, were a few Foraminifera.

South Cheval Paar, $5\frac{1}{2}$ fathoms.—This was made up of a coarse sand with shells, some of the latter very fresh, with valves in apposition and retaining the epidermis.

The sand cakes on drying, owing to the presence of a considerable amount of mud. Pearl Oysters, *Modiola*, *Arca*, *Pectunculus*, *Nassa*, *Murex*, *Lithothamnion*, and a shark's tooth, occurred in the coarser stuff, and quartz well rounded, ilmenite, magnetite, garnet; tourmaline, zircon, and sillimanite were contained in the finer. No sponge spicules and very few Foraminifera were found.

South of Cheval Paar a coarse quartz sand occurs.

Dealing now with the rocks brought up from the Cheval Paar we find :—

Northernmost end of East Cheval is a mass of broken down coral. It is white in colour, with black grains filling in the pores. There is a slight iron stain round each grain. Only a few pieces of quartz are found adhering. The mass is bored with *Lithodomus*, and worm tubes are seen in section on the bottom surface. Some of these have a few grains of sand attached to the interior of the tube.

A few Nullipore patches of a white colour, scarcely distinguishable from the coral, are attached to the surface, but no Polyzoa.

A thin slice examined under the microscope shows that one or two pieces of shell and quartz have been enclosed in the walls of the coral, and towards the margin the thecas have been filled with secondary calcite and numerous Foraminifera.

North Central part of East Cheval and the Middle of West Cheval have calcretes exactly like those described from Periya Paar. They are thickly encrusted with Polyzoa, Nullipore, and worm tubes, and in section evidence of Polyzoa structure can be seen even in the middle parts of the blocks. The masses are cavernous, especially near the surface, and large worm tubes adhere to one side only of the cavities. The cavities have not been formed by boring animals, but are probably due to influences proceeding from the movements of the worm itself in setting up currents and thus preventing the growth of cementing organisms in the immediate neighbourhood. One block which has no worm tubes attached is not cavernous.

In the South Central part of East Cheval, the Central part of the Southern portion, North end of West Arm, and in the South-west part of the Paar a brown compact limestone occurs. It is usually encrusted with Polyzoa, Nullipores, and worm tubes. affords attachment to the byssus of the pearl oyster, and shells, especially *Chama*, are frequently adherent. In all cases the limestone is bored by Molluscs and *Clione*, but only for a short distance from the margin. It is slightly phosphatic, two specimens examined contained 0·21 and 0·36 per cent. respectively of phosphate of lime. In section we find a fine granular, light brown matrix with spots and streaks of reddish material at intervals. Traversing the matrix are zig-zag and branching lines of clear calcite, evidently filled-in cracks. Patches of Coral are seen showing clear calcite outlines with dark granular infilling. Quartz grains, mostly angular, occur, sometimes in patches, at other times in lines. Zircon, apatite, and garnet accompany the quartz, and magnetite occurs sporadically, usually showing a reddish border, which is, no doubt, due to the alteration of this mineral. The ground mass is mostly composed of shell fragments, Foraminifera, and small broken pieces of Nullipore. Incipient oolitic structure occurs round some of the grains. I should regard this limestone as the ultimate stage in the alteration of a coral reef. Coral structure is still to be seen in places, and we can trace the changes, step by step, by which a coral rock like that occurring at the north end of East Cheval is converted into compact limestone.

Periya Paar Kerrai.—Samples were obtained from three localities. Two of them were calcretes, showing Polyzoa and Nullipore structure among the grains, the third consisted of casts of drifted shells (Plate I., fig. 2).

Casts of pearl oysters were most frequent. All the valves were turned in one direction and overlapping. Lying on the sea floor with their concave surfaces facing upwards, they have been filled with sand. This has afterwards been cemented, and the shells subsequently dissolved. Thus viewing the specimen from one side we see the smooth cast of the interior of the shells, and on turning over only sand is visible. Other shells attached to the mass and still retaining their tests are *Cardium*, *Pecten*, *Murex*, and *Cerithium*. Colonies of Polyzoa and worm tubes have attached themselves to the smooth surfaces of the casts since the shells were removed.

Dutch Modragam Paar, to the southwards, lies 10 miles due west of Kodramallai Point. It is 1½ miles in diameter and has a depth of 8 to 14 fathoms.

From this paar two specimens were obtained, one a piece of Madrepore coral about 2 inches thick, with numerous borings of Molluscs proceeding downwards and obliquely from the upper surface. White Nullipore covered parts of the upper surface, and the byssus of pearl oysters occurred attached to both the top and bottom.

The other sample was a coarse calcrete, consisting of sand grains very uniform in size, each measuring 3 to 4 millims. in diameter. The grains were clear, well rounded quartz and felspar, loosely cemented by carbonate of lime and thickly encrusted by Nullipore and Polyzoa.

Muttuvaratu Paar lies 5 miles west of Karativo, and has a depth of 5 to 10 fathoms. Here dead coral, bored in all directions by Molluscs, was brought up. It was covered by green Nullipore, a few colonies of Polyzoa and worm tubes, and much byssus of pearl oysters was adherent to both upper and lower surfaces.

Dredging in the neighbourhood, at a depth of 7 fathoms, showed the bottom to consist of calcareous sand containing 78·36 per cent. of carbonate of lime. *Heterostegina depressa* was the chief constituent, and some of the larger forms were covered with green Nullipore. Other organisms present were *Alveolina*, small univalves, Diatoms, and spicules of *Leptoclinum*, Holothurian plates and shell fragments.

Chilaw Paar, the largest paar on this southern part of the west coast, lies 7 miles west of Chilaw. It is 8 miles in length and averages 2 miles in width. The depth varies from 9½ to 10 fathoms.

North of the Paar, at 10 fathoms, a calcareous sand was obtained, the finer material of which on analysis gave 95·5 per cent. of carbonate of lime. The small amount of inorganic matter present consisted of quartz grains, ·5 millim. in diameter, plagioclase felspar, zircon, garnet, tourmaline, kyanite and rutile.

Among the larger organisms present were shells and Nullipores in about equal proportions, containing such forms as *Pecten*, *Arca*, *Pectunculus*, *Astarte*, *Turbinella*, *Capulus*, *Nassa*, *Turritella* and *Echinocyamus*. Most of these were rotten and covered with Nullipores, Polyzoa and Serpulæ.

The finer material comprised many Foraminifera, including *Heterostegina*, *Polytrema*, *Alveolina* and *Globigerina*, Echinoid spines, young Molluscs, *Crisia*, Pteropods, and spicules of sponges, *Holothuria*, *Alcyonium* and *Leptoclinum*.

South of Chilaw, at 8½ fathoms, the bottom was mostly composed of Nullipores, corals and Sabellaria. *Lithothamnion fruticulosum* was the commonest species among the Nullipores, and many of the balls were overgrown with Polyzoa and worm tubes, and fine sand frequently adhered in the spaces between the branches.

On breaking, the exterior was seen to be white and compact (Plate I., fig. 4), while the interior consisted of a brick-red spongy mass, almost of a powdery consistency and containing grains of sand. A thin slice examined under the microscope showed the white margin to be composed of fresh Nullipore with clusters of quartz grains and magnetite enclosed and irregularly disposed. Nearer the interior the plant structure became less distinct, and no trace of structure could be distinguished at the centre. The spongy core evidently has resulted from the breaking down of the Nullipore and the staining is due to the hydration of the magnetite. The sand can be accounted for by irregular growth of the Nullipore enclosing grains attached to the surface.

Two pieces of calcrete from Chilaw Paar were very like those obtained from Dutch Modragam, except that the grains were larger and less uniform in size.

Jokenpiddi Paar.—The floor is found to be composed of a very coarse calcareous conglomerate. It contains large well-rounded clear quartz, felspars, and rounded pieces of a brown limestone resembling that described from Cheval Paar. Simple Corals, *Chama*, and tangled masses of calcareous worm tubes cover the block, and colonies of Polyzoa find lodgment in sheltered cavities. A delicate tracery of Polyzoa can be seen among the sand grains on a freshly fractured surface (Plate I., fig. 3).

Karkopany Paar, lying off Chilaw at $7\frac{1}{2}$ fathoms, consists of a medium grained calcrete with a few large well-rolled pebbles of quartz of larger size. Dark brown ochreous patches occur in places. Some parts are compact, others loosely cemented. Polyzoan walls can be seen with the naked eye all through the mass cementing and covering the grains. Large shells, corals, and worm tubes cover the exterior.

Oolawittee Paar lies north of Negombo, at $8\frac{1}{2}$ fathoms. Here two samples were obtained. They consist of a loose sandy reddish-brown material, with a white coating of Polyzoa completely covering the exterior. Simple Corals, *Chama* and worm tubes are attached to the surface, the latter being mostly found lining the walls of cavities.

The rock from Negombo Paar is exactly like that obtained from Oolawittee. In a thin section we see clear quartz and felspar embedded in a dark brown opaque matrix. Polyzoa structure is visible, and can readily be traced out from among the sand grains.

General Remarks.

In considering the deposits as a whole, one cannot help commenting on the fact that nothing has been found in them which gives the slightest clue to the character of the solid rocks forming the bottom of the sea. All are of recent origin and can be accounted for by the action of causes now at work. Rivers bring down large quantities of disintegrated material from the interior of the land, particularly in the season of the south-west monsoon; this is spread over the sea floor by the combined action of the rivers and ocean currents, and organisms living in the surrounding seas are responsible for the calcareons material which forms a considerable proportion of the deposits laid down in places distant from the shore.

As no rocks of undoubted Tertiary age are found on the adjacent coasts, it would appear that all through that period the district has been in a state of equilibrium. SUESS* has remarked on the fact that no distinct line can be drawn between the Miocene and succeeding formations in the east, no break is seen in the deposition, and newer beds have quietly overlapped those of earlier date. In the absence of any signs of tectonic movements during the Tertiary period, which, if they had existed, would certainly have left some traces in the rocks of Ceylon and India, we are driven to the conclusion that the shallow platform surrounding Ceylon and connecting it with India on the north is due to the filling up of the sea by detritus derived from the land (see map, p. 161).

On the west coast of Ceylon, near the mouths of rivers, spits of sand stretch across the submerged platform, towards the north-west, while across the Gulf of Manaar from the opposing shores of Southern India similar banks of sand extend to the north-east. Near the coasts the spits consist of coarse fragments, while further out the sands become successively of finer grain. Long continued growth of these spits would result in the formation of a platform arching to the north and produce exactly the conditions we find in the Gulf of Manaar and Palk Bay. WALTHER† records that to the north of Palk Bay, between Calimene Point and Jaffnapatam, there extends a string of shoals less than 3 fathoms under the surface, and these may represent a bank in the act of forming.

In describing the deposits it has been shown that in the Gulf of Manaar the loose material is at the present day being cemented into calcareous sandstones or calcretes at the "paars," chiefly through the agency of Polyzoa and Nullipores.

The important part played by Polyzoa in this connection has not hitherto been recognised. I am convinced that many square miles of the rocky paars are due to this cause alone. Coral reefs in all stages of decay, from living reefs to compact limestones showing but few traces of coral structure, are associated with the calcretes.

If an area of this character were raised above the sea level and acted upon by the waves of the sea, we should expect the harder paars and limestones to exist as islands, between which would be areas of loose drifting sand. Such is exactly the structure of Adam's Bridge—a remarkable chain of islands and shoals which stretches across the platform from Ceylon to India. According to FOOTE‡ and WALTHER§ one of these islands, Rameswaram, has an ancient coral reef along its northern border, and a

* 'Das Antlitz der Erde,' vol. 2, p. 648.

† "Die Adamsbrücke und die Korallenriffe der Palk-Strasse." Ergänzungsheft No. 102 zu PETERMANN'S 'Mittheilungen,' 1891.

‡ 'Memoirs of the Geological Survey of India.' "On the Geology of the Madura and Tinnevelly Districts."

§ *Op. cit.*

further exposure of coral rock, which has been described as a fossil atoll, lies in the interior immediately to the North of the Temple of Rameswaram. A large part of the island is covered by sand dunes which extend as a long spit as far as Thanni-Kodi on the south-east. These dunes hide the solid rocks of which the island is built, but a series of trial borings made across the island from north to south, two miles east of Pamban Town, did not show any southward extension of the coral reef, but a coarse calcareous sandstone—very modern looking and imperfectly consolidated. It is unfortunate that a piece of this rock was not available for comparison with the calcretes found on the paars, but from the detailed descriptions of FOOTE and WALTHER, it corresponds exactly with those found in the Periya and Cheval paar areas.

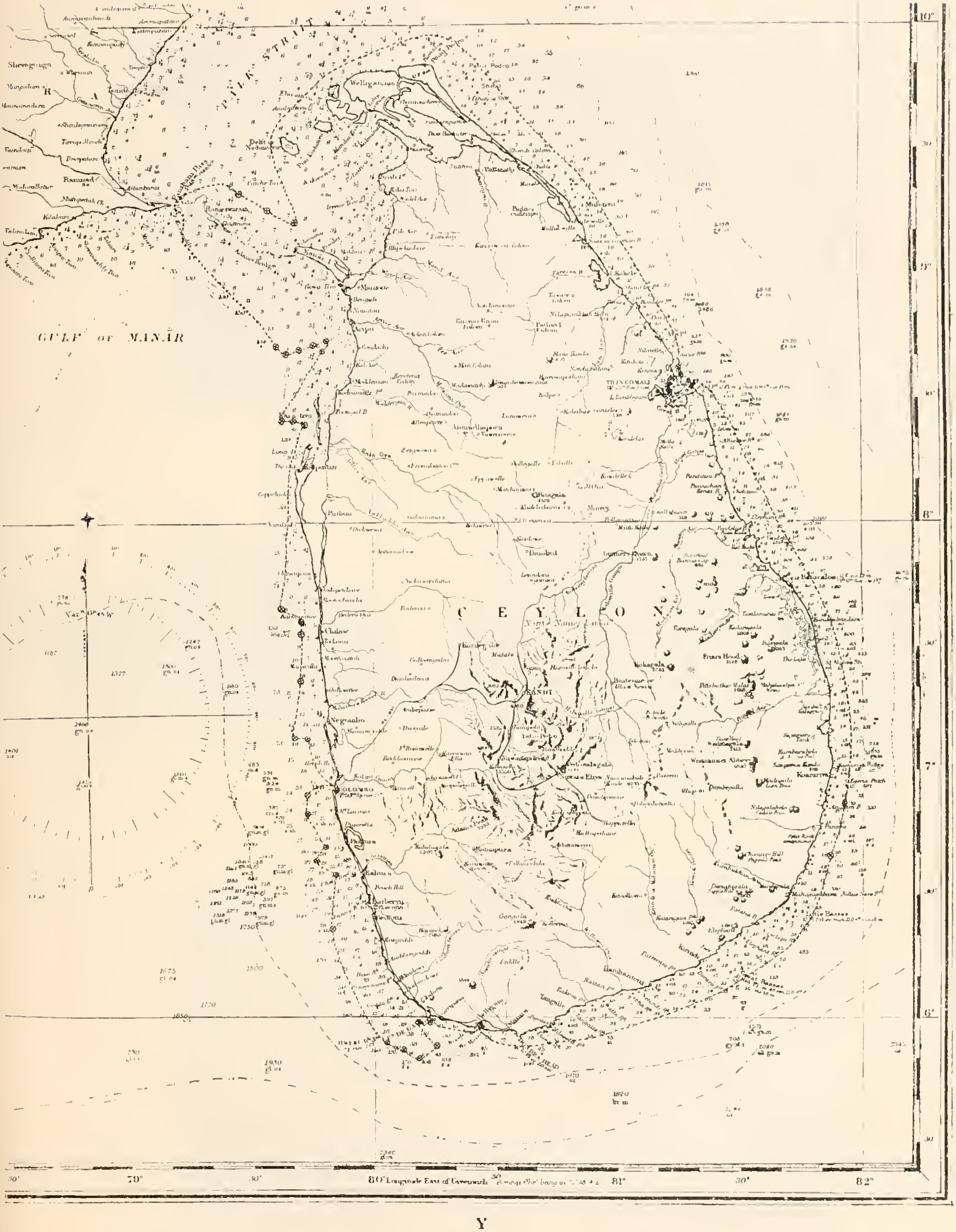
The chain of small islands east of Thanni-Kodi, and Manaar Island itself, also consist of similar calcareous sandstones. They are continued to the west across Pamban Strait and are seen bordering the coasts of Tonitoray Spit. On the east, according to RICHTHOVEN, the low lying plain forming the northern extremity of Ceylon has a coralline formation for its substratum. Similar rocks can be seen at intervals all along the East Coast of India, and have been described under the name of Cuddalore Sandstone. Again, along the West Coast of India, occurs the "littoral concrete," described by OLDHAM* as "an agglutinated calcareous shelly grit raised a little above sea level in several places." "It consists of shells, corals, pebbles, and sand cemented more or less thoroughly by carbonate of lime." "The beds may have originally been sand spits or beach deposits." All these deposits contain none but recent shells, exactly like those now living in the neighbouring seas.

SUESS† attributes the emergence of Adam's Bridge and the "littoral concrete" to a negative eustatic movement of the sea level in post-Tertiary times, and brings together a mass of evidence to show that the negative movement was widespread, embracing a large portion of the northern hemisphere. He surmises that the emergence may have been so recent that the great Hindu epic, the Ramayana, which treats of the building of Adam's Bridge, may be a poetical rendering of events witnessed by man. Although we have no certain evidence that the Bridge was at any time continuous, we have historic data to prove that the Island of Rameswaram was once united with Tonitoray Spit. If, as I suggest, the various links in the chain of islands represent emerged "paars," we have no reason to suppose, judging from the distribution of those now forming, that they were ever united.

In any case, the barrier, whether continuous or broken, would profoundly influence the deposits laid down in Palk Bay. Cut off from the currents sweeping up the coasts from the south, the conditions would be favourable to the deposition of mud, such as we find covering the floor of the bay, and sand would be confined to the shores. It will be noticed, however (p. 149), that casts of shells occur in the mud, and these are composed of sand. The shells have been completely removed, and the

* 'Manual of the Geology of India,' 1893.

† 'Das Antlitz der Erde,' vol. 2, p. 647.


GULF OF MANAR
C E Y L O N
TRINCOMALI
KANDY
10°
8°
7°
6°
79°
80° Longitude East of Greenwich
81°
82°

casts themselves, in many instances, have been reduced to shapeless spongy masses of cemented sand. It is not improbable that these shells were filled with sand previous to the building of the Bridge, when the currents were sufficiently powerful to carry coarser material.

Some of the deposits, as at Galle Bay and Palk Bay, are evidently very old. They represent the remains of a fauna where solution and chemical changes have been at work. The shells left are mostly composed of calcite, not aragonite, and many of them have become partially converted into phosphate of lime.

Stable minerals such as quartz, garnet, kyanite, tourmaline, and zircon are found everywhere, whereas the less resistent felspars only occur near the coasts in the Gulf of Manaar in places where material has been recently deposited, or in calcretes, or in the interior of shells where they have been preserved from kaolinisation.

My thanks are due to Professor HERDMAN for much kindly help, and to Mr. C. C. MOORE, F.I.C., of Liverpool, for the care he has taken in analysing some of the deposits for the purpose of this report.

EXPLANATION OF PLATE I.

Fig. 1. Concretions, shells and casts from Palk Bay.

Fig. 2. Casts of Pearl Oyster and other shells cemented together—from Periya Paar Kerrai.

Fig. 3. Coarse calcrete from Jokenpiddi Paar.

Fig. 4. Nullipore balls, some broken to show red spongy interior. A fragment of *Sabellaria* is shown at the extreme right of the middle line—from South of Chilaw Paar.

FIG. 1.

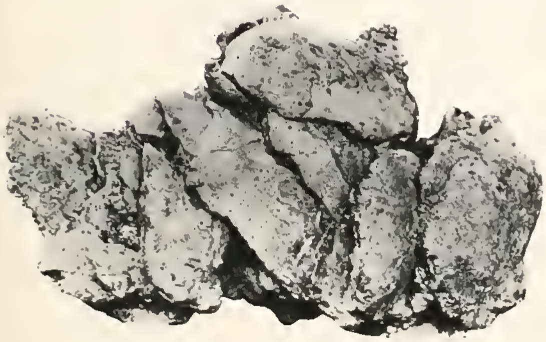


FIG. 2.

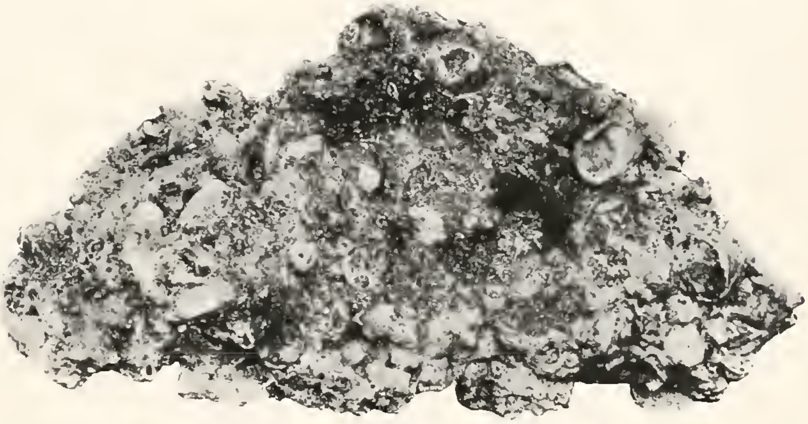


FIG. 3.

FIG. 4.

LIST

OF

MARINE ALGÆ

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902,

WITH

A NOTE ON THE FRUCTIFICATION OF HALIMEDA.

BY

ETHEL S. BARTON (MRS. A. GEPP).

[WITH TEXT FIGURES.]

THE list of species represented in the small collection of ALGÆ from the Gulf of Manaar sent to me by Professor HERDMAN is as follows:—

CHLOROPHYCEÆ.

Codium tenue, KÜTZ.

Geogr. distr. :—Indian Ocean, Red Sea, West Indies.

C. ovale, ZAN.

Geogr. distr. :—New Guinea.

C. sp. (? *elongatum*, AG.).

Valonia, sp.; a fragment only.

Caulerpa fergusonii, G. MURR.

Geogr. distr. :—Ceylon.

C. plumaris, AG.

Geogr. distr. :—All tropical seas.

Avrainvillea papuana, MURR. et BOODLE.

Geogr. distr. :—Indian and Pacific Oceans.

Halimeda tuna, LAM., forma *platydisca*, BART.

Geogr. distr. :—Mediterranean Sea, Atlantic, Indian and Pacific Oceans.

H. gracilis, HARV., with sporangia (see below, p. 165).

Geogr. distr. :—Indian and Pacific Oceans.

H. opuntia, LAM.

Geogr. distr. :—Tropical zone.

PHÆOPHYCEÆ.

Padina commersonii, BORY.

Geogr. distr. :—Indian, N. and S. Pacific and tropical Atlantic Oceans.

Dictyota, sp.

Sargassum; a fragment only, but Professor HERDMAN'S notes show that a species is present in great profusion on some parts of the pearl banks, and is of importance in connection with the attachment of the young pearl oysters.

FLORIDEÆ.

Galaxaura obtusata, LAM.

Geogr. distr. :—Warm Atlantic and N.W. Pacific Oceans.

G. rugosa, LAM.

Geogr. distr. :—Warm Atlantic, Indian and Pacific Oceans.

Actinotrichia rigida, DECNE.

Geogr. distr. :—Red Sea, Indian and N. and tropical Pacific Oceans.

Brachycladia marginata, SCHMITZ.

Geogr. distr. :—Indian, Pacific and tropical Atlantic Oceans.

Gastroclonium opuntia, KÜTZ.

Geogr. distr. :—Indian Ocean.

Hypnea musciformis, LAM.

Geogr. distr. :—Mediterranean Sea, tropical and sub-tropical oceans.

Dr. HERDMAN informs me that this species is of a green colour when alive, and that, along with a species of *Cladophora*, a *Ceramium*, *Chætomorpha* and *Polysiphonia*, all infested with Cyanophyceæ, it forms great masses, mostly of a green colour, on parts of the Cheval and Modragam banks, where it has many young pearl oysters attached to it.

Laurencia sp.; young plants.

Neurymenia fraxinifolia, J. AG.

Geogr. distr. :—Indian Ocean.

Polysiphonia sp.; sterile.

Dasya sp.; fragment with tetraspores.

Ptilota fergusoni, GRUN.

Geogr. distr. :—Ceylon.

Haloplegma preissii, SOND., var. *flabelliformis*, HARV.

Geogr. distr. :—Australia, Tasmania.

Dr. HERDMAN noted the presence of a few Algæ on the Coral reef at Galle, but was unable to bring any specimens. From what he says of them, and the rough sketches, I should suggest that they might be the following species, but it must be understood that this is mere suggestion :—

Caulerpa racemosa, var. *uvifera*, J. AG., or *C. sedoides*, AG.

Halimeda tuna, LAM.

Padina commersonii, HARV.

Peyssonelia rubra, J. AG.

Caulerpa plumaris, AG.

Vanvoorstia spectabilis, HARV.

Corallina sp.

A characteristic of the above is that they were all observed on dead corals.

A *Caulerpa*, which he noted as occurring on the Pearl banks, in the Gulf of Manaar, but of which he has no specimen, would appear from his sketch to be *C. scalpelliformis*, AG. Associated with it in quantity was a plant with ovate glossy dark green leaves, which from the sketch appears to be *Halophila ovata*, GAUDICH. They were growing through coarse quartz sand at a depth of 5 or 6 fathoms, about 10 miles from land.

The field diaries kept by Professor HERDMAN and Mr. HORNELL also contain records of the following Algæ from the Pearl banks :—

Halimeda tuna, f. *platydisca*, *Chrysymenia uvaria*, *Udotea flabellata*, *Dictyurus purpurascens*, *Zonaria lobata* (?), *Kallymenia perforata*, *Laurencia* sp., *Polysiphonia* sp., *Corallina* sp., *Acetabularia* sp., and "great quantities of *Sargassum* sp. both on the bottom and floating on the surface." These are all forms which are quite likely to have occurred.

Dr. HERDMAN has asked me whether any comparison can be drawn between the Algæ of the Maldive and Laccadive Islands and those of Ceylon. The only collection known from the former groups of islands was made by Mr. J. STANLEY GARDINER, and gathered on the coral reefs. It contained 23 species, chiefly of the Indian Ocean type, more than half of which had previously been recorded from Ceylon. The actual number of species common to that collection and Dr. HERDMAN'S is only two: *Halimeda tuna*, f. *platydisca*, and *Galaxaura rugosa*.

NOTE ON THE FRUCTIFICATION OF HALIMEDA.

Many of the specimens of *Halimeda gracilis*, HARV., are in fruit, a condition of this species which has never been noted or described. The only species of *Halimeda* of which the sporangia have hitherto been observed, are *H. tuna*, LAM., *H. platydisca*, DECNE, and *H. macroloba*, DECNE. In a paper published in December, 1901 ('The genus Halimeda, Siboga-Expeditie, Monographe LX.,' Leiden) I showed that *H. platydisca* should be regarded as a form of *H. tuna*, although Professor SCHMITZ

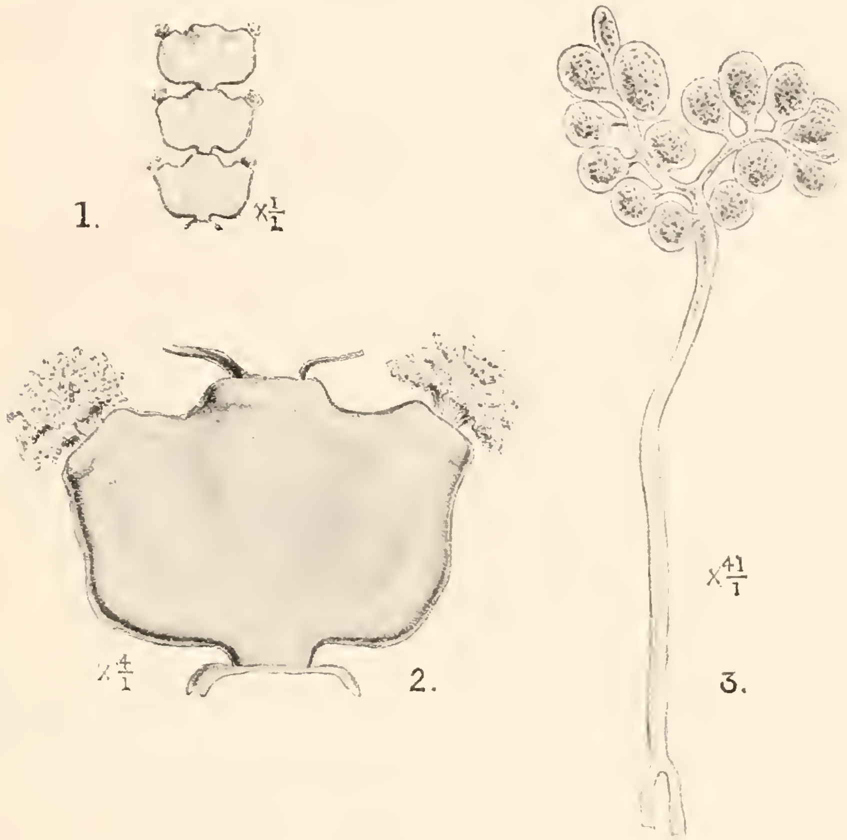
('Sitzungsber. d. Nied.-rhein. Gesellsch., Bonn, 14. Juni 1880,' p. 146) maintains that there are differences between *H. tuna* and *H. platydisca*, as regards the position of the sporangia on the sporangiophores, but he does not give any figures.

As to *H. macroloba*, the sporangia are mentioned by ZANARDINI ('Icon. Phyc. Adriat. et. Medit.,' vol. 3, p. 131) as having been seen by him, and they are stated to be similar to those of *H. tuna*. This remark on the fruits of *H. macroloba*, DECNE, is inserted by ZANARDINI in his description of Plate CXII., which represents a fruiting specimen of *H. tuna*. Hence the reader might be led to imagine that the fructification figured was that of *H. macroloba* and not that of *H. tuna*; ZANARDINI, however, merely emphasizes the point that he had not himself personally collected the fruiting specimens of *H. tuna* which he figures, and that he had in his possession fruiting plants of *H. macroloba*, from the Red Sea, a district which was outside the scope of his memoir. There is, therefore, no figure extant of the fruits of either *H. platydisca* or *H. macroloba*.

The fruits of *H. gracilis* grow out in small, short tufts from the margin of a joint (see text-figures), but these tufts are confined to those points on the margin at which the branches of the central strand emerge; and these branches, instead of continuing their course so as to form a new side-joint, grow out into tufts of fruiting filaments (figs. 1 and 2). In appearance, the fruiting joints of *H. gracilis* differ from those of *H. tuna*, which, according to the figures, bear a fringe of fruiting filaments along the upper margin, and in some cases even in an isolated tuft from the flattened surface of the joint. It is not quite easy to understand how this wide, marginal fringe in *H. tuna* can arise, since the strand of central filaments, from which the sporangiophores spring directly, runs up through the centre of the plant and branches inside a joint to form the side joints. If, as is always stated, the fruiting filaments of *Halimeda* arise only from the filaments of the central strand and its branches, then the points on the margin (or rarely surface) of a joint, where these strands emerge from the thallus, are clearly the only points at which fruiting filaments can be borne.

An examination of the fruiting material of *H. gracilis* shows that the sporangia are borne, as in *H. tuna*, on sporangiophores, which form a continuation of the filaments of the branches of the central strand. According to the system of classification of species followed in my paper referred to above, the distinguishing feature of *H. gracilis* lies in the complete fusion of the filaments of the central strand in pairs at the apex of a joint, the fused portion branching later trichotomously in the next joint. When the fused portion is destined, however, to bear sporangiophores instead, it branches dichotomously to form two sporangiophores, from which the sporangia emerge all round and form a kind of loose raceme (fig. 3). In the material from the Pearl banks of the Gulf of Manaar, most of the sporangia are empty, but it has been possible to find specimens in which the protoplasm still fills the sporangia and the apex of the sporangiophore. The protoplasm is studded with small, black dots, and the condition is probably one shortly preceding the ejection of the zoospores.

MM. Derbés and Solier ("Mém. Physiol. d. Algues," 'Compt. Rend.,' Suppl., vol. I., 1856, Plate XII., fig. 3) have figured a condition of the fruits of *H. tuna*, showing the sporangiophores and sporangia filled, all but the actual apex, with a dense, dark



Halimeda gracilis.

Fig. 1. Joints with fructification. Nat. size.

Fig. 2. One joint with fructification. × 4.

Fig. 3. Sporangiophores bearing sporangia in a condition shortly preceding the ejection of the zoospores. The point of fusion of the two filaments of the central strand is shown at the base. × 41.

green protoplasm. In the condition figured in this note, the development has advanced a stage further, and the dense protoplasm has become almost entirely concentrated in the sporangia and the apex of the sporangiophore.

Of the subsequent escape of the zoospores I can say nothing.

REPORT

ON THE

GEPHYREA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

ARTHUR E. SHIPLEY,

FELLOW AND TUTOR OF CHRIST'S COLLEGE, CAMBRIDGE, AND UNIVERSITY LECTURER ON THE ADVANCED MORPHOLOGY OF THE INVERTEBRATA.

[WITH ONE PLATE.]

THE collection of Gephyrea, made in Ceylon by Professor HERDMAN during his Expedition to inquire into the Pearl Fisheries of that Island, was small, but it contained at least two specimens of great morphological and systematic interest. These two specimens, obviously belonging to the same species, I have placed in a new genus which I have called *Centrosiphon*, their nearest allies amongst the Sipunculoids being *Aspidosiphon* and *Cloeosiphon*, and I have dedicated the species to its discoverer. The collection also included many specimens of the coral *Heteropsammia michelini*, ED. and H., with its associated commensal *Aspidosiphon corallicola*, SLUIT. There were also specimens of the corals *Heterocyathus æquicostatus*, ED. and H., and *Stephanoseris rousseaui*, ED. and H., which no doubt contain also their appropriate species of *Aspidosiphon*. Further, there were three specimens of *As. spiralis*, SLUIT., a single specimen of *As. steenstrupii*, DIES., a single specimen of *Cloeosiphon aspergillum*, QUATR., a few specimens of three species of *Physcosoma*, and a fragment of a *Sipunculus*. The Echiuroids were represented by a single specimen of *Bonellia pumicea*, SLUIT.

SIPUNCULOIDEA.

Aspidosiphon corallicola, SLUITER, Plate I., figs. 1, 2, 3, 11 and 12.

A few specimens of this species, recently described by SLUITER,* were found living in coiled tubes which penetrate the calcareous skeleton of the solitary coral

* C. PH. SLUITER, 'Die Sipunculiden und Echiuriden der Siboga-Expedition,' Leiden, 1902.

Heteropsammia michelini, Ed. and H., kindly identified for me by Mr. J. Stanley Gardiner. The specimens were all in a highly contracted condition, and most of them showed hardly any portion at all of the introvert, but Mr. Gardiner was able to place at my disposal a collection of the same species, made off Madras by Ramunni K. Menon, a former pupil of mine. The external appearance of one or two of these is shown in Plate I., figs. 1 and 2.

Sluiter's material enabled him to confirm Bouvier's view that the original home of the *Aspidosiphon* is a Gasteropod shell on which the young coral comes to rest. This shell becomes gradually embedded in the stony framework of the *Heteropsammia*. The smallest of Sluiter's examples showed the small Gasteropod shell, belonging to the genera *Cerithium*, *Natica*, and others, only partly overgrown and the young Gephyrean living wholly within the shell. In older stages the corallum spreads until it reaches and finally grows past the mouth of the shell, but the shell, according to Sluiter, is not absorbed, but can still be detected if carefully sought for.

On the body, mostly towards the posterior end and therefore, as the animal lies most remote from the opening, of several of Professor Herdman's examples, were a number of minute molluscs which Mr. Edgar A. Smith has kindly examined, and he is of the opinion that they might range with the genus *Mysella* of Angas. The animals are, however, so minute, that their exact determination is a matter of great difficulty.

These were so closely adpressed to the skin of the *Aspidosiphon* as to indent it, appearing as little pearls set in a matrix. The advantage they obtained by taking up such a position is not very evident, but there they were, and as far as one could judge they were, until Professor Herdman dropped them into his collecting jar, flourishing.

The whole question of such commensalism as exists between the *Aspidosiphon* and the coral is an interesting one. Commensalism is usually looked upon as conferring some mutual advantage on the contracting parties, and one or the other of these usually seeks the other out. But in the case in question the mutual advantage is far to seek. It can hardly help the coral to have a large portion of its base burrowed by a spacious canal, but the fact that the Gephyrean pulls the otherwise immovable coral about may be, and probably is, an advantage to the Cœlenterate. On the other hand, the Gephyrean gains protection and a home more spacious than the Gasteropod shell affords. The *Aspidosiphon* can hardly find, or attract the larval coral to come to rest on its burrowed shell, and it is unlikely that the larva is especially on the outlook for such shells as are inhabited by Gephyrea. It seems more probable that the *Aspidosiphon* may select for its home a Mollusc shell which already bears a young coral, but the whole matter seems to demand more careful study. It is certainly remarkable that three distinct genera of coral, each with but one species, should be inhabited by three distinct species of *Aspidosiphon*, and that neither commensal has hitherto been found apart from the other.

The specimens were obtained at various localities in the Gulf of Manaar (Stns. I., II., IV., &c.), and also off Trincomalee (Stns. XX., XXII.), and off Galle (Stns. XXXIX., XLII., and XLIII.).

The Ceylon collection also contains specimens of the corals *Heterocyathus æquicostatus*, Ed. and H., and *Stephanoseris rousseaui*, Ed. and H., showing perforations obviously made by burrowing Gephyrea.

Aspidosiphon spiralis, Sluiter.

Three specimens of this interesting species described by Sluiter from the Siboga Expedition were found living in the shell of three species of *Murex*, *M. fuscus*, *M. haustellum*, and *M. tenuispina*. The species is interesting because it resembles *Phascolion* in living in Mollusc shells, and because in the slight development of the posterior shield, and in the absence of a sharp line of division between the shields and the general surface of the body, it resembles *Physcosoma*.

The body is highly adapted to its home. Coiled spirally, it closely follows the contours of the Murex shell. The stout, tough circular anterior shield, on which the introvert opens excentrically but not quite at the edge, forms an effective guard to the entrance of the shell. This shield is supported by a stout, very muscular part of the body-wall which extends for some tenth or twelfth of the total body-length ; after this the skin becomes extremely thin and transparent. In two of the specimens collected by Professor Herdman the anterior shields were deep black, in the third it had a pinkish hue.

Between the Gephyrean and the Mollusc shell was a packing of sand held together by some secretion. This had a permanent opening at the mouth of the shell through which the introvert could be protruded.

Aspidosiphon steenstrupii, Diesing.

A single specimen, probably a young one, as the calcareous deposit was not visible. The musculature agreed, however, with that of this species, and differed clearly from that of *A. truncatus*. *A. steenstrupii* is the commonest *Aspidosiphon* in the Indian Ocean. The specimen in question was taken at East Cheval Paar, in the Gulf of Manaar, from a cavity in a block of coral.

Centrosiphon herdmani, n. g. et sp.—Plate I., figs. 4–10.

The length of the two specimens, taken at Cheval Paar, Gulf of Manaar, from the oral shield to the posterior end was 3 centims. The diameter of the oral shield was 3 millims., of the posterior shield 2·5 millims. The body between these shields was of rather smaller diameter, and from each shield the skin seemed gradually to grow thinner as it passed towards the centre of the body.

The colour in the spirit specimens was in the main a yellowish-gray, with tinges of a chestnut-brown. In one specimen this colour was very marked around the edge of the oval shield and extended a little way down the body, further on one side than on the other, and then gradually faded out to reappear in a slighter degree on the posterior shield. The same specimen also showed a few irregularly placed and ill-defined blotches of chestnut colour near the centre of the body.

The proboscis was not fully extended in either specimen. It was protruded from the *centre* of the oral shield and extended in one specimen some 3 millims., in the other somewhat less. The proboscis bears anteriorly several rows of chitinized processes obviously homologous with the hooks of other forms. Further back it bears prominent rounded papillæ, which are continuous with those on the anterior shield (fig. 5). This shield, like the posterior one, is separated from the sides of the body by a well marked rim. The papillæ on the anterior shield are uniformly scattered, but on the posterior shield they run in radiating lines from the rim to the thickened and somewhat indented centre. The walls of the body are comparatively smooth, with at best a few low papillæ, and these mostly at the two ends.

I opened one specimen with a longitudinal incision, and the following is an account of the arrangement of the internal organs. Unfortunately the specimen had had its alimentary canal broken, and the contents, consisting of sand and fragments of shell, were all over the place, and much impeded observation.

The longitudinal muscles of the skin are continuous, as in some of the species of *Aspidosiphon*, and the interior of that covering presents a smooth glistening gray surface. The alimentary canal seemed slightly coiled, but it was impossible to determine if there was a spindle muscle or not.

There are four retractor muscles, two ventral and two dorsal; only two, and these are often fused, occur in *Aspidosiphon* (fig. 8). The ventral are far stouter than the dorsal, and arise further back at about the level of the junction of the anterior quarter with the posterior three-quarters of the animal. The dorsal muscles are hardly half so thick as the ventral. They have their origin a little to right and left of the anus and at about the same level, which is some 2 or 3 millims. behind the edge of the oral shield.

At the base of the attachment of the large ventral muscles is a well marked fringe which obviously gives rise to the reproductive cells.

A single pair of nephridia lie one on each side of the anus. Their external openings lie close to the edge of the dorsal shield, and probably just behind it.

The introvert of both specimens was half everted, and I cut sections of one of them. Unfortunately there was a little sand in the interior of the introvert, and some of the sections were much broken. I was, however, able to make out that the number of tentacles is somewhere about twelve to fifteen. Each tentacle is triangular in section, with a well marked ciliated groove continued down into one of the grooves which line the beginning of the œsophagus. The transverse section also shows the three spaces continuous with the body cavity which communicate at the tip, and which by allowing the entrance of the cœlomic fluid extend the tentacle. As far as I could make out, the tentacles arise from a ring and not from a horseshoe, and the mouth is in the centre of the ring.

Behind the bases of the tentacles were little projections of the epidermis bearing thickened, cuticular projections (fig. 10). These morphologically resemble hooks, but no part of the tip is bent over, and the whole structure is something like a blunt spear-head. They are undoubtedly the homologues of the hooks in other unarmed Gephyrea, and in structure they fairly closely resemble the processes called "hooks" in *Sipunculus australis*, the only member of the genus *Sipunculus* which has "hooks." The spear-head projections were apparently arranged in rings, but with the somewhat broken sections, obliquely cut, it was not possible to definitely make out how many rings there were. Figure 10 also shows the very prominent papillæ of the posterior part of the introvert—the outer layer in the figure—the continuous layer of muscles, the nervous system cut twice, and the almost completed fusion of the retractor muscles around the base of the head.

Part of the brain is shown in section in figure 9, which has been cut through the pigmented, concave layer of cells which forms the eye.

Genus: **Centrosiphon**, n. g.

The new genus may be characterized as follows:—Sipunculoids with circular anterior and circular posterior thickened, chitinoid shields; the introvert emerges from the anterior shield in the centre, and is not inclined to one side more than to any other, it is quite central; both shields are separated from the side walls of the cylindrical animal by a prominent ridge; the papillæ are very prominent on the introvert, and on it and the anterior shield they are uniformly scattered, on the posterior shield they are in radiating lines; anteriorly and just behind the mouth are rows of spear-head-shaped chitinized projections obviously homologous with the hooks of other species.

Species: **Centrosiphon herdmani**, n. g. et sp., Plate I., figs. 4, 5, 6, 7, 8, 9 and 10.

With only two specimens at one's disposal, and those of the same species, to attempt to pick out the specific characters partakes of the nature of prophecy, but, judging by other and allied Gephyrea, the following, or some of them, will probably rank as specific characters:—Longitudinal muscles in a continuous sheath; four retractor muscles, of these the ventral are very thick and inserted about a quarter of the animal's length behind the anterior shield, and the dorsal are very slim and inserted one on either side of the anus, a very little way behind the anterior shield; the nephridia are rather dorsal in position and open close to the edge of the dorsal shield; the tentacles are few in number, some twelve or fifteen, and probably surround the mouth as a simple ring; eyes well developed; no calcareous deposits on either shield.

Systematic Position.

Centrosiphon belongs to the same group of Sipunculoids as *Aspidosiphon* and *Cloeosiphon*. All three genera possess a posterior and an anterior shield, the latter being placed but slightly in front of the anus and at the base of the introvert. *Centrosiphon* differs from *Aspidogaster* in that its introvert emerges from the centre of a round shield, quite symmetrically, and in a line corresponding with the long axis of the body. In *Aspidosiphon* the anterior shield is shaped something like a cockle-shell, and the introvert emerges at or near the narrow end and is at an angle with the main axis of the body. *Centrosiphon* differs from *Cloeosiphon* in the absence of the very characteristic calcareous ring round the base of the siphon, with its lozenge-shaped areas, and in the absence of true hooks, though the latter are represented by chitinized prominences. It resembles *Cloeosiphon* in its central proboscis and in its continuous sheath of longitudinal muscles. In *Aspidosiphon* the sheath may or may not be continuous. It differs from both genera in possessing four retractor muscles, and in the fact that its anterior shield forms a flat platform and not a radially or bilaterally symmetrical cone.

Cloeosiphon aspergillum, Quatr.

A single specimen, from Stn. XLIV., West of Pantura, 30 fathoms. This species is common in the Indian Ocean and parts of the Pacific. The "Siboga" took this form at thirteen stations, and in his account of the Gephyrea collected by the Expedition on that vessel, Sluiter records his view that the variety *javanicum* should be dropped.

Physcosoma agassizii, Sel. and de Man.

A single specimen was taken at Stn. LV., South-west of Periya Paar, in the Gulf of Manaar; depth, 11–14 fathoms.

Physcosoma asser, Sel. and de Man.

Three specimens; one from the Pearl Banks off Aripu (Stn. LIV.), and another from the Lagoon, Galle. Since my paper in the 'Fauna and Geography of the Maldive and Laccadive Islands,' this form has been recorded by Sluiter from four of the "Siboga" stations.

Physcosoma scolops, Sel. and de Man.

Three specimens of this genus are described as coming "out of a scarlet-ball sponge (*Axinella tubulata*), Cheval Paar (Stn. IX., 7 fathoms)," and also West of Periya Paar, 12–14 fathoms, in the same sponge. The species is very common all over the Indian Ocean from the Red Sea and the East Coast of Africa to the East Indies.

Sipunculus, sp.

A fragment of a *Sipunculus*, which was insufficient to allow of identification, was taken at Stn. LVI., south of Dutch Modragam Paar; depth, 8–9 fathoms.

ECHIUROIDEA.

Bonellia pumicea, SLUIT.

The only Echiuroid in the collection was a *Bonellia*, from Galle, which I rather doubtfully identify with SLUITER's *Bonellia pumicea* ('Natuurk. Tijdschr. v. Nederl. Ind.,' vol. 50, 1890, p. 111).

EXPLANATION OF PLATE I.

Figs. 1, 2, 3, 11, and 12 are of *Aspidosiphon corallicola*; figs. 4–10, inclusive, are of *Centrosiphon herdmani*.

Fig. 1. Side view of *Aspidosiphon corallicola*, Sluit. × 10. The introvert is extended, but not quite to its full extent.

Fig. 2. View of anus of the same species, with the thickenings of the anterior shield sloping away from it.

Fig. 3. View of head of the same species showing the ring of tentacles.

Fig. 4. Side view of *Centrosiphon herdmani*, n. g. et sp., with the introvert slightly extended from the anterior shield. × 8. The chestnut-coloured patches seen on one of the specimens are well shown here.

Fig. 5. A view of the anterior plate and introvert of the same specimen seen from above. × 8.

Fig. 6. A view of the posterior plate of the same specimen seen from below. × 8.

Fig. 7. A transverse section through one of the papillæ around the base of the head of the same species showing the chitinous thickening. Highly magnified.

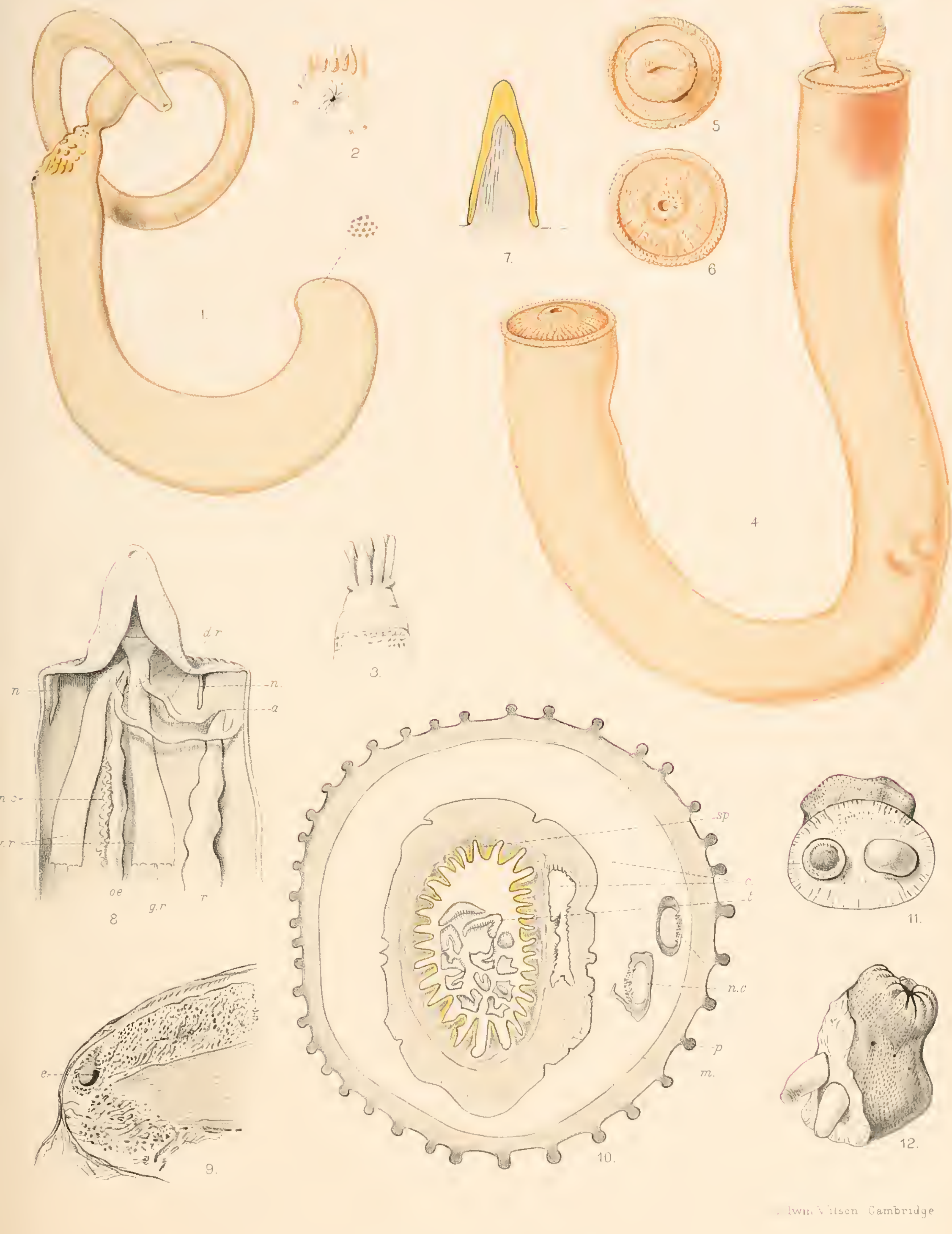
Fig. 8. View of the anterior end of the same species, cut open so as to expose the viscera. × 16 *a.*, position of anus; *d.r.*, the short, slender dorsal retractor muscles; *œ.*, œsophagus; *g.r.*, genital ridge at the base of the ventral retractor muscles; *n.*, nephridia; *n.c.*, ventral nerve cord; *r.*, rectum; *r.r.*, ventral retractor muscles.

Fig. 9. View of a section through the supra-œsophageal ganglion of the same showing *e.*, the eye. Highly magnified.

Fig. 10. Transverse section through the introvert partly retracted, showing the small group of grooved tentacles and the rows of chitinized spines. Highly magnified. *c.*, body-cavity, the isolated portion of this space runs up between the ventral retractors and soon disappears, as the four retractors fuse to form the muscular sheath *m.* round the head; *n.c.* nerve cord, which, owing to the retraction of the introvert, is bent, and thus cut across twice; *p.*, papillæ on the lower part of introvert; *s.p.*, chitinized spines round the base of the head; *t.*, transverse sections of tentacles.

Fig. 11. A *Heteropsammia michelini*, Ed. and H., broken across transversely, showing the head end to the left, and the tail end to the right of an *Aspidosiphon corallicola*, Sluit. × 2.

Fig. 12. Another specimen of the same, fractured longitudinally. The head end of the *Aspidosiphon* is above. The coral shows three pores on its side which communicate with the coiled tube in which the Gephyrean lives.



SIPUNCULIDS FROM CEYLON.

REPORT

ON THE

POLYPLACOPHORA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

E. R. SYKES, B.A., F.L.S.

[WITH ONE PLATE.]

THE large proportion of species described as new in the following pages is not so surprising as it might appear, since we know but little of the fauna of Ceylon, so far as the Chitons are concerned.

The collection includes nine species. Of these, three are identified (one doubtfully) with known forms; five are described as new; and, in one case, that of a single specimen of an *Ischnochiton*, I have thought it wiser to give no specific name.

Callochiton sublævis, n. sp.—Plate I., fig. 3.

Shell in shape, sculpture and girdle pattern similar to *C. lævis* (MONT.). Colour a uniform dark red, the interior of the valves being the same colour. The valves slightly concave in front of the line dividing the lateral and central areas. Valve slits: anterior 14, median 1, posterior 15.

Length, when alive, about 12 millims.

Hab. :—Navakaddua Paar, 7 fathoms, on Coral (one specimen).

The only salient features that I can trace to sever this form from the European *C. lævis* are the median valves having only one slit, the dark red colour inside the valves, and the slight concavity before the line dividing the lateral and central areas.

There is, in the British Museum, a single specimen from the Philippines, bearing the manuscript name of *sublævis*, CARPENTER, which probably belongs to the present species.

Callochiton platessa (Gould) ?

A single specimen, not in very good condition, from the lagoon inside the coral reef at Galle.

Ischnochiton ravanæ, n. sp.—Plate I., fig. 4.

Shell elongate, well elevated. Ground colour white, blotched and marbled with varying colours, black and purple predominating. Sculpture on the lateral areas, well-marked riblets, generally with an angle in the centre of the ribs, pointing towards the girdle; median areas smooth to the eye, but microscopically punctate. Sculpture of the posterior portion of the posterior valve similar to the lateral areas. The anterior valve is marked by slight depressed distant riblets, similar to lines of growth. Interior white, slightly tinted with yellow. Anterior valve with 8, median 1, posterior 15 slits.

Girdle scales broad, flat, thick, strongly striated.

Length, when alive, about 25 millims.

Hab. :—Donnan's Muttuvaratu Paar, 8 fathoms (one specimen).

Ischnochiton herdmani, n. sp.—Plate I., fig. 6.

Shell much elongated, narrow, moderately elevated. Ground colour a greenish-grey with delicate marking of brown, green, yellow, &c.

The sculpture is difficult to describe; the anterior valve and posterior area of the posterior valve are marked by a number of concentric ridges, the edges of these ridges being broken and roughened; the lateral areas of the median valves are similarly sculptured; the anterior portion of the posterior valve and the median areas are marked by a number of crossing lines, which give the appearance of the shell having been stabbed with a broad, blunt dagger; on the jugal tract these lines lengthen out and the stab-marks become finer and much more elongate. Interior white, tinged with pink. Anterior and posterior valves with 9, median with 1 slit.

Girdle wide, with squarish flat, well striated, scales.

Length, when alive, about 40 millims.

Hab. :—The lagoon inside the coral reef at Galle (three specimens).

Related to *I. alatus*, Sby, but more depressed and differing in sculpture.

Ischnochiton ferreus, n. sp.—Plate I., fig. 5.

Shell ovate, eroded and covered with a brown rusty staining, but apparently whitish below. Sculptured on the median valves with about ten radiating riblets on the lateral areas and distant longitudinal riblets on the median areas. The anterior valve and posterior valve (behind the mucro) appear to be sculptured as the lateral areas.

Interior white, stained with brown. Anterior valve with 13, median 1, posterior 13 slits.

Girdle with broad, flat, finely striated scales; some scales do not show the sculpture, but this is, I think, due to erosion.

Length, when alive, about 15 millims.

Hab. :—Trincomalee (one specimen).

Ischnochiton, sp.

A single specimen, from the Gulf of Manaar.

Craspedochiton laqueatus (SBY).—Plate I., fig. 7.

> **Chiton laqueatus**, SBY: 'P. Zool. Soc.,' 1841, p. 104.
>
> ———————— : REEVE, 'Conch. Icon.,' Plate XX., fig. 135.
>
> **Craspedochiton laqueatus**, SBY: SHUTTLEWORTH, 'Bern. Mittheil.,' 1853, p. 67; PILSBRY, 'Man. Conch.,' vol. 14, p. 285.
>
> **Angasia tetrica**, CARPENTER: PILSBRY, 'Man. Conch.,' vol. 14, p. 287.

Hab. :—South of Modragam Paar (Stn. LXIV.), 5 fathoms; and North of the Gulf of Manaar (Stn. LXII.), 7–13 fathoms (several specimens).

I am unable to sever the Philippine shell from the Ceylon form described as *A. tetrica*. The species has a varied generic history, as it forms the type of *Craspedochiton*, SHUTTLEW., *Angasia*, CARPENTER, nec WHITE, and *Phacellozona*, PILSBRY.

A single specimen from "Palk Bay, February, 1902," I refer here with some doubt, as it is slightly more elevate, the posterior valve shows no trace of the radiating lines, and there are other minor differences.

Acanthochites penicillatus (DESH.)—Plate I., fig. 2.

> **Chiton penicillatus**, DESHAYES: 'Moll. Réunion,' p. 41, Plate VI., figs. 8–10.
>
> **Chiton (Acanthochites) penicillatus**, DESH.: MARTENS in MÖBIUS' 'Reise Mauritius,' p. 300.
>
> **Acanthochites penicillatus**, DESH.: PILSBRY, 'Man. Conch.,' vol. 15, p. 15, Plate IV., fig. 84, Plate VIII., figs. 29, 30.

Hab. :—Gulf of Manaar (two specimens).

I identify the Ceylon with the Mauritian shell with a little doubt, as I know the latter only from figures and descriptions.

Tonicia pectinoides, n. sp.—Plate I., fig. 1.

Shell ovate, broad, elevated. Colour, reddish to yellowish-green. Lateral areas well raised. The central areas and anterior portion of the posterior valve are sculptured with longitudinal, broad, flattened riblets, the interstices marked by minute, crossing riblets, somewhat as is frequently seen in the Pectinidæ. Anterior valve, posterior portion of posterior valve, and lateral areas marked with flattened nodules, those on the median valves being fewer in number, irregular in size, and more widely separated. Mucro posterior and much elevated.

Interior white. Median valves with 1, anterior with 8, posterior valve with numerous small slits.

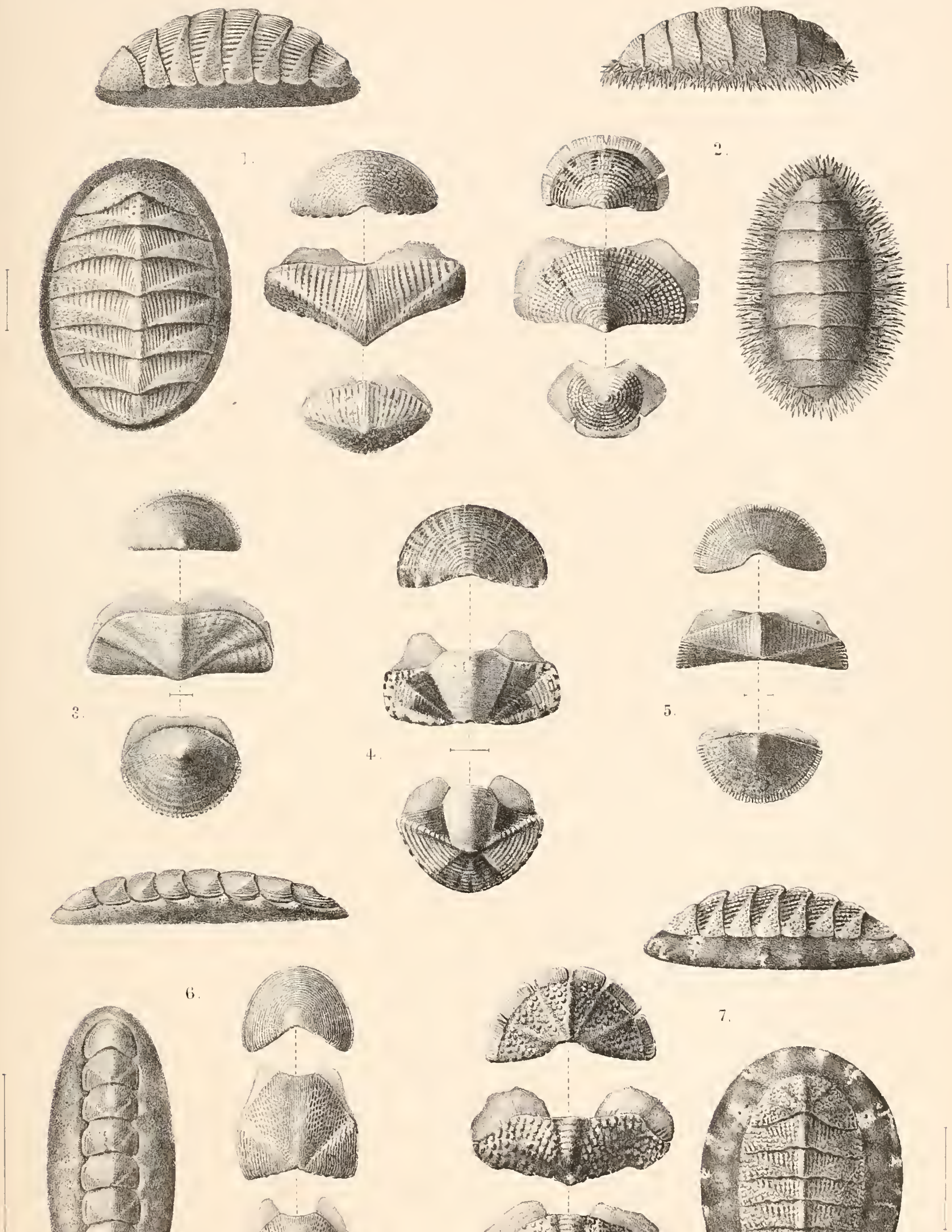
Girdle microscopically setose.

Length, when alive, about 18 millims.

Hab. :—Pearl-banks in the Gulf of Manaar and deep water off Galle (Stn. XL.), 34 fathoms (two specimens).

EXPLANATION OF PLATE I.

Fig. 1. *Tonicia pectinoides*, n. sp.
Fig. 2. *Acanthochites penicillatus* (DESH).
Fig. 3. *Callochiton sublævis*, n. sp.
Fig. 4. *Ischnochiton varanæ*, n. sp.
Fig. 5. *Ischnochiton ferreus*, n. sp.
Fig. 6. *Ischnochiton herdmani*, n. sp.
Fig. 7. *Craspedochiton laqueatus* (SBY).



J Green del. et lith. Mintern Bros imp.

SPECIES OF POLYPLACOPHORA

REPORT

ON THE

HOLOTHURIOIDEA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

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[WITH PLATES I. TO III.]

THE HOLOTHURIANS obtained by Professor HERDMAN during his expedition to Ceylon have proved to be a very interesting and extensive series.

The collection consists of 70 specimens, which are distributed amongst 10 genera and about 30 species. Of these I find that seven are new to science and there are also at least two new varieties. One of the new species requires the formation of a new genus, *Havelockia*, near to *Colochirus* in the Dendrochirotæ.

In the main I have followed the classification and nomenclature adopted by LUDWIG (12).* I have, however, taken JEFFREY BELL'S (16, 17) suggestion with regard to the generic name *Actinopyga*.

The following is a list of the species in the collection :—

Synapta striata, Sluiter.
Synapta beselii, Jäger.
Synapta, sp. (?).
Synapta, sp. (?).
Cucumaria tricolor, Sluiter.
C. turbinata (Hutton).
C. imbricata (Semper).
C. conjungens, Semper.
Thyone fusus, var. *papuensis*, Théel.
Thyone sacellus (Selenka).
Thyone (?) *fusca*, n. sp.
Thyone (?) *hornelli*, n. sp.
Thyone (?) *calcarea*, n. sp.
Phyllophorus cebuensis (Semper).
Actinocucumis donnani, n. sp.
Colochirus quadrangularis, Lesson.
Col. quadrangularis, var. *mollis*, nov.
Col. doliolum (Pallas).

* The numbers in brackets refer to the List of Literature on p. 206.

Colochirus, sp. (?).
Havelockia herdmani, n. gen. & sp.
Actinopyga mauritiana (Quoy and Gaimard).
Actinopyga serratidens, n. sp.
Holothuria kurti, Ludwig.
H. monacaria (Lesson).
H. vagabunda, Selenka.
H. tenuissima, Semper.
H. marmorata (Jäger).
H. atra, Jäger.
H. gallensis, n. sp.
Stichopus chloronotus, Brandt.
St. chloronotus, var. *fuscus*, nov.
St. variegatus, Semper.

In addition to these, the field notes made by Professor HERDMAN and Mr. HORNELL show that they observed two species (or varieties) of *Psolus*, the one black and the other grey, on the East Cheval Paar.

So far as I am aware, this is much the largest collection of Holothurians that has been yet obtained from the seas of Ceylon. Until about twenty years ago no Holothurians had been definitely recorded from that coast. Owing mainly to the work of Drs. PAUL and FRITZ SARASIN, of Mr. EDGAR THURSTON, of Madras, and others, the number on record had lately reached the total of 37 species. Professor HERDMAN'S Holothurian collection, in addition to a number of the forms previously known, contains at least 20 species and distinct varieties which are now recorded from Ceylon for the first time, thus bringing the total number of known species and varieties up to 57, as shown in the following list. The first column gives those species reported by Mr. THURSTON (**19**) from the Gulf of Manaar, the second those described by Professor JEFFREY BELL (**8**), the third shows those collected by Drs. P. and F. SARASIN, chiefly at Trincomalee, and described by Professor LUDWIG (**9**), the fourth those few collected by Professor HAECKEL, and described by Dr. WALTER (**18**), and the fifth column gives those collected by Professor HERDMAN in 1902, and described in the present report.

LIST of Ceylon Holothurians.

Name of Species.	THURSTON.	BELL.	SARASIN.	HAECKEL.	HERDMAN.
Synapta beselii, Jäger		×			×
S. grisea, Semper		×			
S. recta, Semper	×				
S. striata, Sluiter					×
S. sp. (? n. sp.)					×
S. sp. (? n. sp.)					×
Chirodota rufescens, Brandt		×			
Ch. dubia, Semper				×	
Haplodactyla molpadioides, Semper		×			
Hap. australis, Semper	×		×		

List of Ceylon Holothurians—continued.

Name of Species.	Thurston.	Bell.	Sarasin.	Haeckel.	Herdman.
Cucumaria semperi, Bell	×				
C. turbinata (Hutton)					×
C. tricolor, Sluiter					×
C. imbricata (Semper)			×		×
C. conjungens, Semper					×
Thyone sacellus (Selenka)	×				×
Th. fusus, var. *papuensis*, Théel					×
Th. (?) *fusca*, n. sp.					×
Th. (?) *hornelli*, n. sp.					×
Th. (?) *calcarea*, n. sp.					×
Phyllophorus cebuensis (Semper)					×
Actinocucumis typica, Ludwig	×				
Actinocucumis donnani, n. sp.					×
Colochirus quadrangularis, Lesson	×				×
Col. quadrangularis, var. *mollis*, nov.					×
Col. doliolum (Pallas)					×
Col. armatus, Marenzeller		×			
Col. sp. (?)					×
Havelockia herdmani, n. gen. et sp.					×
Actinopyga mauritiana (Q. and G.)		×			×
Act. miliaris, Q. and G.		×	×		
Act. echinites, Jäger			×		
Act. lecanora, Jäger			×		
Act. serratidens, n. sp.					×
Act. sp. (Walter)				×	
Holothuria argus, Jäger		×			
H. atra, Jäger	×	×	×		×
H. cæsarea, Ludwig		×			
H. impatiens, Forskaal		×	×		
H. ondaatjei, Bell		×			
H. marmorata, Jäger	×				×
H. monacaria, Lesson	×		×		×
H. vagabunda, Selenka	×				×
H. scabra, Jäger			×		
H. pulchella, Selenka		×			

List of Ceylon Holothurians—continued.

Name of Species.	Thurston.	Bell.	Sarasin.	Haeckel.	Herdman.
H. spinifera, Théel			×		
H. pardalis, Selenka			×		
H. fusco-cinerea, Jäger			×		
H. edulis, Lesson			×		
H. imitans, Ludwig			×		
H. marenzelleri, Ludwig			×		
H. kurti, Ludwig					×
H. gallensis, n. sp.					×
H. tenuissima, Semper					×
Stichopus variegatus, Semper			×		×
St. chloronotus, Brandt			×		×
St. chloronotus, var. *fuscus*, nov. . . .					×

Geographical Distribution.

An examination of the geographical distribution of the Ceylon Holothurians shows clearly that they are typically Indo-Pacific forms; and that their recorded occurrences form an equatorial belt, ranging from the east coast of Africa to the South Pacific.

It will be seen from the following table that only four of the 53 named species have been found in the North Pacific, namely, *Holothuria fusco-cinerea*, *Colochirus armatus*, *Thyone sacellus* and *Actinocucumis typica;* while the Atlantic fauna is only represented by three species, which occur, two in the Caribbean Sea (*Holothuria atra* and *H. impatiens*) and one at the Cape of Good Hope (*Colochirus doliolum*).

The table shows the recorded distribution of Ceylon Holothurians in the great oceans of the world. The concentration in the right-hand columns, which indicate the Indo-Pacific region, is most marked.

Name of Species.	N. Atlantic.	S. Atlantic.	N. Pacific.	S. Pacific.	Indian Ocean.	E. Indies (Malay Seas).	Australasia.
Synapta beselii, Jäger				×	×	×	
S. grisea, Semper					×	×	×
S. recta, Semper.						×	
S. striata, Sluiter						×	

Name of Species.	N. Atlantic.	S. Atlantic.	N. Pacific.	S. Pacific.	Indian Ocean.	E. Indies (Malay Seas).	Australasia.
Chirodota rufescens, Brandt						×	
Chir. dubia, Semper					×		
Haplodactyla molpadioides, Semper					×	×	
Hap. australis, Semper						×	
Cucumaria semperi, Bell						×	×
C. turbinata (Hutton)					×		×
C. tricolor, Sluiter					×	×	
C. imbricata (Semper)					×	×	
C. conjungens, Semper					×	×	
Thyone sacellus (Selenka)			×		×	×	
Th. fusus, var. *papuensis*, Théel							×
Th. (?) *fusca*, n. sp.					×		
Th. (?) *hornelli*, n. sp.					×		
Th. (?) *calcarea*, n. sp.					×		
Phyllophorus cebuensis (Semper)					×	×	
Actinocucumis typica, Ludwig			×		×		×
Actinocucumis donnani, n. sp.					×		
Colochirus quadrangularis, Lesson					×	×	×
Col. quadrangularis, var. *mollis*, nov.					×		
Colochirus doliolum (Pallas)		×					×
Col. armatus, Marenzeller			×		×		
Havelockia herdmani, n. gen. & sp.					×		
Actinopyga mauritiana (Q. and G.)				×	×	×	
Act. miliaris (Q. and G.)				×	×	×	
Act. echinites, Jäger					×	×	
Act. lecanora, Jäger				×	×	×	
Act. serratidens, n. sp.					×		
Holothuria argus, Jäger				×		×	
H. atra, Jäger	×			×	×	×	
H. caesarea, Ludwig				×			
H. impatiens, Forskaal	×			×	×	×	
H. ondaatjei, Bell					×		
H. marmorata, Jäger				×	×	×	
H. monacaria, Lesson				×	×	×	×

Name of Species.	N. Atlantic.	S. Atlantic.	N. Pacific.	S. Pacific.	Indian Ocean.	E. Indies (Malay Seas).	Australasia.
H. vagabunda, Selenka				×	×	×	
H. scabra, Jäger					×	×	
H. pulchella, Selenka				×	×	×	
H. spinifera, Théel						×	
H. pardalis, Selenka				×	×		
H. fusco-cinerea, Jäger			×	×		×	
H. edulis, Lesson					×	×	
H. imitans, Ludwig				×			
H. marenzelleri, Ludwig					×		
H. kurti, Ludwig					×	×	
H. gallensis, n. sp.					×		
H. tenuissima, Semper				×	×	×	
Stichopus variegatus, Semper					×	×	
St. chloronotus, Brandt				×	×	×	
St. chloronotus, var. *fuscus*, nov.					×		

I wish finally to express my thanks to Professor HERDMAN for allowing me to examine this most interesting collection, as well as for the advice and assistance which he was always willing to give in the solution of points of difficulty.

HOLOTHURIOIDEA.

ORDER: PARACTINOPODA.

FAMILY: SYNAPTIDÆ.

Synapta striata, SLUITER (10)—Plate I., fig. 1.

Eight specimens from the outer part of Yard Cave, Trincomalee (Stn. XXVI.), 2–8 fathoms.

Lengths range from 15 millims. to 85 millims. The smaller specimens are evidently in a contracted condition.

The following is Professor HERDMAN's description taken from the living animal;—

"Living amid sponge branches. Colour, striped lilac on a white ground. The five rays of the body are marked by five narrow white bands. The region between these rays is marked with numerous delicate lilac stripes forming a pattern which is variable in different individuals. The tentacles are used for progression and are flattened for two-thirds of the way from the apex."

There are 13 tentacles present, each having 19 digits. Plate I., fig. 1, shows the flattened extremity of a tentacle, as drawn from the living animal in Professor HERDMAN'S note-book.

There are about 18 Polian vesicles in the specimen dissected, 6 being large and the rest smaller. There is one madreporic canal. The alimentary canal is looped.

The deposits agree with SLUITER'S figures. I have found, however, that some of the anchor plates differ from the usual form in having *smooth* holes. There are also present in the skin numerous miliary granules which are arranged in groups of six or seven, having typically one central granule surrounded by numerous granules in a circle. This species appears to be very closely allied to *S. recta* and *S. indivisa.*

This species is now recorded from Ceylon for the first time.

Distribution :—Java and Ceylon.

[**Synapta beselii**, JÄGER.

A large *Synapta*, measuring 6 feet in length, was found by Mr. HORNELL at Galle. The specimen has not reached me, but the size and description agreed so well with *S. beselii*, already known from Ceylon, that there can be little doubt as to the species.

Distribution :—Indian Ocean, Philippines, South Pacific and East Indies.]

Synapta, sp. (? n. sp.).

This is a fragment from the south west of Palk Bay (Stn. XVIII.), 7 fathoms, in mud. Only the posterior portion of the body remains.

The fragment is 50 millims. long, and the body is evidently in a very contracted condition. All the internal organs are torn away. Still the specimen clearly belongs to a species of *Synapta.*

Deposits :—The anchor plates are in all cases imperfect. The plates are covered with short spines and are perforated by a large number of small holes of various sizes. The anchors are large, and the handle is serrated. So far as I am able to determine, these spicules do not resemble those of any known species, but the incomplete state of the specimen does not permit me to make a definite decision with regard to its identity, nor to describe it more fully.

Synapta, sp. (? n. sp.).

One specimen from Galle. This specimen is in a poor state of preservation, so that I cannot be absolutely certain as to its identity.

There are 12 tentacles, each having 5 digits.

Deposits:—The anchor arms are not always symmetrically placed. They are slightly serrated. The anchor handles are strongly serrated. The anchor plate is perforated irregularly—the arrangement differing in different plates. There are several larger holes with serrated margins, and also several smaller smooth holes. There is no handle to the plate. There are also a number of short rods scattered throughout the skin, having a small hole at each end.

Neither this nor the preceding species can possibly belong to any of the species previously recorded from Ceylon, viz., *S. striata*, *S. recta*, *S. grisea*, and *S. beselii*, and in their spicules they seem to differ from all known species of the genus. Consequently, they probably both of them represent new species, but they are too fragmentary to be described.

ORDER: ACTINOPODA.

FAMILY: DENDROCHIROTÆ.

Cucumaria tricolor, SLUITER (15).

One specimen from near Donnan's Paar (Stn. LX.), Gulf of Manaar, 28 fathoms.

Length of body, 30 millims.

The following is a description of the colour of the living animal as noted by Professor HERDMAN:—"The interambulacra are violet-purple, and the ambulacra appear as light yellow bands, on which are situated pedicels of a deeper yellow." There are also a couple of sketches in the notes which agree with SLUITER's figures and show the characteristic form of body.

The body is curved so that the anus is thrown on to the dorsal surface, thus making the trivium longer than the bivium. The pedicels on the trivium are arranged in three well-defined series, each series being composed of two or three rows. The pedicels on the bivium are not so easily determined, and only on careful examination can an irregular and feebly marked single row of scattered pedicels be distinguished on each side of the dorsum.

The mouth, which is terminal, is surrounded by five very prominent rows of protuberances which terminate the five ambulacra of the body. These prominences, of which there are three in each row, do not appear to be tube feet, but are more probably papillæ. The anus is armed with five teeth, and is surrounded by four papillæ similar to those surrounding the mouth. Gonads are not present.

No deposits were found in the skin.

The calcareous ring is small and consists of ten pieces, without any posterior prolongations. It agrees with SLUITER's drawing.

The only serious difference between SLUITER's description and the above is with regard to the calcareous deposits. The Ceylon specimen has no deposits; but since it has been kept for several months in a solution of formol, it is by no means safe to attach importance to this fact.

There is a slight disagreement in the arrangement of the pedicels. SLUITER's specimen had five well-marked series of pedicels, those on the trivium consisting of five or six rows, and those on the bivium of two or three rows. But the smaller number of pedicels on the Ceylon specimen may be explained by the fact that it is evidently much younger, being only one-fifth the size.

There is also a slight difference of colour. The pedicels of SLUITER's specimen were red; those of the Ceylon specimen were a "deep yellow." This is probably of no importance.

This species is now recorded from Ceylon for the first time. Its known distribution is Aru Islands and Ceylon.

Cucumaria turbinata (HUTTON), Plate I., figs. 2–6.

Labidodesmus turbinata, HUTTON (3), 1878.

One specimen from Gulf of Manaar (Stn. VI.), 6 to 9 fathoms.

HUTTON described this species under the name *Labidodesmus turbinata,* but THÉEL, in his "Challenger" report, places it in the genus *Cucumaria,* with the remark that a re-description of the animal is necessary.

So far as I can ascertain from HUTTON's scanty description, the Ceylon specimen is identical with his New Zealand species, the type specimen of which is now in the British Museum. Professor HERDMAN has kindly examined for me the British Museum specimen, and compared it with my description and drawings of the Ceylon specimen, and was convinced that both belong to the same species. As HUTTON, in his description, said nothing about deposits, Professor F. JEFFREY BELL kindly allowed me to examine a small piece of the skin of the British Museum specimen. I found that there were no deposits present, but since the specimen has been preserved for 25 years, it is by no means safe to conclude that the skin of the living animal was devoid of calcareous spicules. I am now, therefore, able to supply what THÉEL stated was necessary, namely, a re-description of HUTTON's species.

The following is a description of the Ceylon specimen, which I believe to be that species:—

Length, 25 millims. Greatest width, 12 millims.

The colour of the spirit specimen is dark brown on the bivium, and lighter brown on the trivium. The body (Plate I., fig. 6) is widest at the middle, and at the anterior end tapers into a cylindrical neck which is about one-third of the length of the body. At the posterior end the body suddenly contracts and ends in a point at the anus.

The New Zealand specimen ends in a "short pointed tail" at the posterior end. There is no actual process or "tail" in the Ceylon specimen, but it is not inconceivable that during life the animal may have had a short posterior projection which has become retracted. The difference, however, between the British Museum specimen and the Ceylon specimen is, Professor HERDMAN informs me, not now very marked in this respect.

There are five series of pedicels; each series consists of a double row on the "neck," but on the wider portion of the body each series of the trivium consists of about four rows, while each series of the bivium consists of two or three rows. At the posterior end the series are not so well defined, each having only one or two rows of pedicels. There are also one or two pedicels on the interambulacra.

The sucking discs of the pedicels are dark brown or almost black in colour, thus being easily distinguished on the lighter skin.

There are no anal teeth. The tentacles have been cast off.

Deposits:—The spicules (Plate I., figs. 2 to 4) are of one kind and are numerous. Typically they are like a cross having four arms in one plane and with two additional arms arising at right angles to this plane at the junction of the four arms. There are many variations of this, some appearing like a short rod covered with many spines.

The calcareous ring (Plate I., fig. 5) is 5 millims. long and consists of ten pieces. The inter-radials are small and are separate from the radials. The radials are bifurcated posteriorly, and the bifurcations are composed of several small pieces.

There is one stone canal and one Polian vesicle.

The retractor muscles are remarkably long, and are attached to the longitudinal muscles halfway down the body.

Distribution:—New Zealand, Ceylon. Now recorded from the Indian Ocean for the first time.

Cucumaria imbricata (SEMPER).

Ocnus imbricatus, SEMPER (2), 1868. **Ocnus javanicus**, SLUITER, 1880. **Ocnus typicus**, THÉEL (7), 1886.

Ten specimens from (1) Pearl Banks (Stn. LXVI.), Gulf of Manaar, (2) West of Kaltura (Stn. XLIII.), 22 fathoms, and (3) Back Bay, Trincomalee (Stns. XX. and XXI.). Lengths varying from 20 millims. to 50 millims.

Although THÉEL in his "Challenger" report retained the genus *Ocnus*, he expressed some doubts as to its validity. LUDWIG believed that the three forms *O. imbricatus*, *O. javanicus*, and *O. typicus* were identical, and in his Holothurians of BRONN'S "Klassen und Ordnungen des Thierreichs" he placed them all in the genus *Cucumaria*, under the name *C. imbricata*.

Eight of the Ceylon specimens I identified as THÉEL'S species *O. typicus*, and the other two I considered at first to be SLUITER'S species *O. javanicus*. But except for some slight differences in the calcareous ring, in the arrangement of the pedicels, and in the scales and colour of the body, the two forms appear to be very similar. So, on the whole, I now think it best to unite them.

The number of the pedicels on each of the five rows shows some variation, one specimen only having from eight to ten pedicels in each row, whilst those of the *O. javanicus* type have as many as from twenty to twenty-three. The average number, however, in each row is about eighteen. In one specimen the rows of pedicels showed a somewhat irregular arrangement. In the anterior half of the body all of the five rows are in a straight line. At the middle of the body, however, each of the rows makes a deviation and then continues to the posterior end of the body in a straight line. So that the five rows in the posterior half alternate with the five rows in the anterior half of the body.

Another specimen which is very much flattened dorso-ventrally is remarkable in having the pedicels arranged in distinct rows only on the trivium. At a rough glance the bivium appears to be altogether devoid of pedicels, and it is only on a very close examination that a few very small and irregularly scattered pedicels can be distinguished.

The character of the scales is not similar in all the specimens.

It happens that all the individuals which I had identified as *O. typicus* are yellowish-white, in alcohol; and the two others (the *O. javanicus* form) were of a dark brown colour.

The deposits in all the specimens are very similar, and agree with the description of *O. typicus* given by THÉEL.

Distribution :—Hong-Kong, Bay of Bengal, Java, Ceylon.

Cucumaria conjungens (SEMPER) (2).

One specimen from Pearl Banks, Gulf of Manaar. Length, 14 millims.

The specimen agrees very closely with SEMPER'S description, both in the nature of the deposits and the calcareous ring.

Owing to the small size of the specimen, the arrangement of the dorsal pedicels into three rows, as described by SEMPER, is not very clearly marked. The pedicels on the ventral surface are much more numerous than the dorsal pedicels and are irregularly scattered.

The body tapers at both ends, being more pointed at the posterior end.

This is recorded from Ceylon for the first time.

Distribution :—Bay of Manilla, Ceylon.

Thyone fusus (MÜLLER), var. **papuensis,** THÉEL (7)—Plate I., figs. 7, 8.

Two specimens from the Gulf of Manaar (Stn. IV.), 6–9 fathoms.

Lengths, 25 millims. and 22 millims.

The body is pointed at both ends. The pedicels are scattered all over the body, but show an arrangement into longitudinal series not only on the ambulacra but also on the interambulacra. This arrangement is somewhat obscure in some parts of the body.

The calcareous ring is, comparatively, of very large size, being 11 millims. long in the smaller specimen. The posterior prolongations are composed of several smaller pieces.

The deposits consist of tables which are very thinly scattered. They have four large central holes and also four smaller peripheral holes. In the larger of the two specimens the tables are imperfect, the circumference being broken at several places (Plate I., fig. 8). Whatever may have been the cause of this breaking up, there is no doubt they were originally similar to those of the smaller specimen (fig. 7), which agree with Théel's figure.

There is no doubt that these specimens agree more closely with Théel's variety, *papuensis*, than with the species. *Thyone fusus* is a northern form, and Théel's variety was obtained by the "Challenger" Expedition in Torres Straits. It is now recorded from Ceylon for the first time.

Thyone sacellus (Selenka)—Plate I., figs. 9, 10.

Stolus sacella, Sel. (1), 1867. **Thyone rigida**, Semper (2), 1868. **Stereoderma Murrayi**, Bell (4), 1883.

Two specimens from five miles off Negombo (Stn. I.), 12–20 fathoms, January 31, 1902. Lengths, 75 millims. and 50 millims.

Colour in spirit—light yellow with irregular brown spots.

The skin is hard and rigid. The tentacles are retracted.

The pedicels are irregularly scattered over the body. They are very small and numerous, showing an arrangement in three double rows on the trivium. These rows are not continued to the extremities, but are confined to the middle of the body.

The calcareous ring is typical of the species.

Deposits:—These consist of four-holed plates having on each side a half ring arising from the centre of the plate at right angles (fig. 9). In addition to these I find numerous plates having more than four holes and having short spines on the surface (fig. 10).

These specimens are evidently the same as Bell's *Stereoderma murrayi*, which is now included in Selenka's species, *Thyone sacellus*.

Distribution:—Kurachee, East Coast of Africa, Torres Straits, Japan, and Ceylon.

Thyone (?) **fusca**, n. sp.—Plate I., figs. 11–13.

One specimen from Back Bay, Trincomalee (Stn. XXI.), 8–12 fathoms; 18 millims. long and 10 millims. broad.

The colour of the spirit specimen is brown. The pedicels are the same colour as the general integument.

There are no tentacles present in the preserved specimen.

The pedicels are irregularly scattered all over the body, being slightly more crowded on the ventral surface than on the dorsal. There are no papillæ present.

The calcareous ring is small, being only 4 millims. long. It is composed of ten separate pieces. The radials are notched anteriorly and bifurcated posteriorly. Each posterior prolongation is composed of about four small pieces. The inter-radials are simple (fig. 11).

There is one stone canal and one Polian vesicle. There are no gonads present in this specimen and the alimentary canal is eviscerated. Both the right and the left branches of the respiratory tree are well developed. There are no anal teeth.

Deposits :—These are very scarce, and imperfectly formed. This leads me to believe that the animal may have been preserved originally in formol, but I have no record of this. The deposits are small plates having many holes, and probably slightly hollow (figs. 12 and 13). These are very rare. The pedicels have well-developed terminal plates.

Owing to the tentacles being absent, I am unable to assign the specimen to its genus with certainty, although it is, in all probability, a *Thyone*.

Thyone (?) hornelli, n. sp.—Plate I., figs. 14–16.

One specimen from the lagoon inside the Reef, Galle.

Length, 50 millims. ; breadth, 20 millims.

It is broader at the anterior end, and is slightly narrower at the posterior end.

The colour of the formol specimen is light brown, spotted irregularly with small black marks. The sucking discs of the pedicels in some parts of the body are of a rusty-red colour, and in other parts they are the same colour as the general integument. Beneath the brown epidermis the skin is of a very light violet hue.

The pedicels, which are large, numerous and well formed, are irregularly distributed over the body, showing no arrangement into rows. There are no papillæ.

The tentacles are absent, and there are no anal teeth.

The calcareous ring is composed of five radial pieces and five inter-radials, which are, however, not clearly separated from one another. The radials are notched anteriorly and are bifurcated posteriorly, the posterior prolongations being composed of several smaller pieces. The calcareous ring is fairly massive, being 15 millims. long (fig. 14). There is one Polian vesicle and one stone canal.

The gonads are attached to the dorsal mesentery in one bunch.

The right and left branches of the respiratory tree are large, and both extend to the anterior end of the body.

The internal organs and mesenteries are coloured a light violet, like the skin.

The longitudinal muscle bands are very well developed.

Deposits :—The spicules are very thinly scattered, and consist of small perforated plates having a spiny surface (figs. 15 and 16). Since the animal has been preserved in formol, it is doubtful whether this was originally the exact shape of the deposits.

I cannot be quite certain as to the genus of this form since the tentacles are not present, but it is probably a *Thyone*.

Thyone (?) calcarea, n. sp.—Plate I., figs. 17–20.

One specimen from Cod Bay, Trincomalee (Stn. XXVII.), 6 fathoms.

Length, 20 millims.

The colour in spirit is yellowish-white.

The tentacles are not present.

The pedicels are small and numerous, and are the same colour as the skin. They are scattered all over the body, and are more numerous on the ventral surface than the dorsal. They form a double row on the five ambulacra, but only at the central portion of the body. Those on the three rows of the trivium are longer and more distinct than those of the two rows of the bivium.

There are five small calcareous teeth. The integument is thin but fairly hard.

The animal has a remarkably large calcareous ring, which is half the length of the body. It consists of ten pieces, the five radials having posterior bifurcations which are made up of a number of small pieces. Both radials and inter-radials are notched anteriorly. The inter-radial pieces of the ring are not all of the same length (fig. 17).

There is one Polian vesicle, 4 millims. long, and one madreporite. The gonads are attached to the dorsal mesentery. The alimentary canal is much convoluted.

Deposits:—The spicules are numerous and overlapping. They consist of tables only. These are irregular in shape, mostly triangular or polygonal, and have from five to a dozen holes. The spire consists of two upright rods which join at the top and terminate in one or two blunt points (figs. 18–20).

As in the two previous species, the genus of this form, although probably *Thyone*, cannot be decided with certainty because of the absence of the tentacles.

Phyllophorus cebuensis (Semper)—Plate II., figs. 22–24.

Thyonidium cebuense, Semper (2), 1868. See also Théel (7).

One specimen from Gulf of Manaar (Stn. II.), 8–9 fathoms (see Note, p. 205).

Length, 22 millims., and breadth, 13 millims.

Colour in spirit:—Brown epidermis covering a white skin.

The mouth is slightly dorsal, so that the trivium is a little longer than the bivium.

In the middle of the body the pedicels are irregularly scattered, being more numerous on the trivium than on the bivium. At each end of the body, however, the pedicels are arranged in five double rows.

There are five small anal teeth.

The calcareous ring agrees with Semper's description. Each of the radials has four anterior processes, and also two posterior prolongations, each of which is made up of four small pieces. The inter-radials are simple (fig. 24).

Deposits:—Numerous tables of one kind only. Each table has a central hole surrounded by about eight slightly smaller holes. The spire is tall and massive, and consists of four upright rods, the adjacent ones being connected by four or five bars.

The top of the spire is hemispherical and is covered by numerous spines (figs. 22 and 23).

The Ceylon specimen agrees very closely with SEMPER's description. Unfortunately that author does not give any satisfactory account or figures of the spicules. THÉEL found amongst the "Challenger" Holothurians one which he believed to be identical with SEMPER's species. The deposits in the "Challenger" specimen were of two* kinds and differed considerably from those of the Ceylon specimen (see THÉEL (7)). Seeing that there is this difference in the deposits, the "Challenger" specimen and the Ceylon specimen cannot be identical. And yet the Ceylon specimen agrees very closely with SEMPER's original description. On the other hand, THÉEL expresses some doubt as to the identity of the "Challenger" specimen with SEMPER's species. Consequently I feel justified in assigning the Ceylon specimen to SEMPER's species; and I suggest that the "Challenger" specimen be placed as a variety of the species, which might be named var. *théeli.*

Distribution :—Philippines, Ceylon.

Actinocucumis donnani, n. sp.—Plate II., figs. 25–30.

One specimen, from deep water off Galle (Stn. XLI.).

It is 15 millims. long, and 9 millims. broad at the widest portion of the body.

The colour of the spirit specimen is white.

The body is in a contracted condition, so that the exact arrangement of the pedicels is not very easy to determine. There appear to be, however, five series of pedicels, each series consisting of four or five fairly straight rows. The dorsal rows are more irregular than the ventral ones. Owing to the width of each of the five series, the interambulacral spaces are very narrow. The pedicels have well-developed sucking discs, and in the preserved specimen are very short and distinctly cylindrical. Amongst the pedicels of both the dorsal and ventral surface there are scattered a few papillæ, which are easily distinguished from the pedicels, because of their greater length, their shape, and their delicate appearance.

There are no anal teeth.

Deposits :—These are very thinly scattered, and consist of small oval perforated plates (figs. 26–28). In the pedicels there are numerous small slightly branched bodies similar to those described by THÉEL as "incomplete rosettes" (figs. 29 and 30). The pedicels have well-developed terminal plates.

The calcareous ring is comparatively large, being 8 millims. long. Each of the five radials is composed of two separate pieces, both of which are prolonged posteriorly. The inter-radials are five in number. They do not extend so far anteriorly as the radials, neither have they any posterior prolongations. The radials and inter-radials are made up of a number of small pieces (fig. 25).

* SEMPER's species evidently had only one kind of table.

There is one large Polian vesicle, 4 millims. long, and a single stone canal.

The gonads are present only on the right side of the dorsal mesentery.

Although the tentacles are not present, I have decided to place this specimen in the genus *Actinocucumis*, because of the arrangement of the pedicels, and also because of the presence of papillæ.

Colochirus quadrangularis, Lesson.

Colochirus cœruleus, Semper (2), 1868. See also Théel (7).

Four specimens from South of Adam's Bridge (Stn. LIV.).

Lengths, 75 millims., 60 millims., 30 millims., and 40 millims.

These specimens agree well with Théel's description.

Colour in spirit :—Yellow and dark brown, with a very faint tinge of violet.

Distribution :—Philippines, E. Africa, Australia, E. Indies, Ceylon.

Colochirus quadrangularis, var. **mollis**, nov.—Plate II., fig. 21.

One specimen from South of Thanni-Kodi, Adam's Bridge (Stn. LIV.), 8½ fathoms. Length 100 millims.

This differs from *Colochirus quadrangularis* in the texture of the body wall. Instead of being very hard, thick, and rough, as in *Col. quadrangularis*, the skin is soft, thin, and comparatively smooth.

Although this specimen is larger than any of those of *Col. quadrangularis* in the collection, yet the papillæ at the four angles of the body are much smaller comparatively.

The colour of the animal also differs from that of the Ceylon specimens of *Col. quadrangularis*. The following is the account of the colour of the living animal, as noted by Professor Herdman :—

"Colour of body a uniform orange, slightly mottled with a paler tint. The crown of tentacles are mottled yellow on a dark brown ground. The region between the five valves at the base of the tentacles is white." Plate II., fig. 21, is from a drawing in Professor Herdman's notes showing the living animal with tentacles expanded.

I think it advisable to call this specimen a new variety of *Col. quadrangularis*, with which it agrees in other characters.

Colochirus doliolum (Pallas).

Actinia doliolum, Pallas, 1766. **Colochirus australis**, Ludwig (9), 1875. Also Théel (7).

Two specimens from South of Adam's Bridge (Stn. LIV.).

Lengths, 20 millims. and 8 millims.

The larger of these specimens agrees very closely with the descriptions of this species, both in the form of the body and also in the nature of the deposits.

The smaller specimen is evidently of the same species, although its small size and its contracted condition prevent me from verifying all the characters in detail.

This species is new to the Ceylon fauna.

Distribution :—Australia, Ceylon.

Colochirus, sp. (?).

Navakaddua Paar (Stn. LXVIII.), 8–18½ fathoms.

This specimen, which is only 7 millims. long, is too small to identify with any certainty. The general external form of the body, together with the nature of the deposits, leads to the conclusion that it is a *Colochirus*.

The body is quadrangular, having the pedicels on the trivium arranged in three double rows. The body tapers at the posterior end.

Deposits :—These consist of reticulate cups, knobbed buttons, and very large perforated plates.

The specimen is evidently young, but does not obviously fall into any of the other species. It is perhaps nearest to *C. doliolum*, but differs in the tapering posterior extremity.

Havelockia herdmani, n. gen. et sp.—Plate II., figs. 31–35.

One specimen from South of Adam's Bridge (Stn. LIV.), 4–40 fathoms.

Length 45 millims. and greatest breadth 17 millims.

The colour of the spirit specimen is brown with a dark streak of violet along the middle of each side.

The body is indistinctly quadrangular, but pentagonal at each end. The mouth is surrounded by five valves and there are five smaller valves around the anus.

The ambulacral appendages consist of pedicels and papillæ. The pedicels are confined to the ventral surface. They are arranged in three series traversing the entire length of the ventral surface from the mouth to the anus. The central series consists of about eight rows of pedicels, and the other two series are not quite so broad. There are also a few scattered pedicels on the ventral interambulacra. The papillæ are absent on the ventral surface, but are scattered irregularly over the remaining three sides, being most thinly scattered along the middle of the sides (fig. 31). The anus is devoid of calcareous teeth.

The tentacles are not present. They have evidently been thrown off.

Deposits :—These consist entirely of numerous tables, which are of two kinds :—

(1) Those scattered throughout the skin generally.—These are small tables, generally having four large holes and four smaller peripheral holes (fig. 32). The number of the holes, however, varies. The spire is made up of two rods which unite at the top and give off generally four short projections (fig. 33).

(2) Tables in the papillæ.—These are much larger than those of the general integument, and are not regular in shape (fig. 34). They have a similar spire to the smaller tables.

The calcareous ring is not very large, being 8 millims. long and 8 millims. broad. It consists of ten pieces. The five radials are slightly notched anteriorly and are bifurcated posteriorly. The posterior prolongations are composed of a number of smaller pieces. The five inter-radials have no posterior prolongations and are pointed anteriorly. Retractor muscles are present (fig. 35).

There is one Polian vesicle, and no stone canal can be seen. The gonads are present in two bunches—one on each side of the dorsal mesentery. The right respiratory tree is larger than the left. There are no Cuvierian organs.

The presence of posterior prolongations to the calcareous ring, together with the possession of retractors, prove that this form is a Dendrochirote, although the tentacles are absent.

It possesses a certain external resemblance to the genus *Colochirus* in the general shape of the body; in the arrangement of the pedicels in three rows on the ventral surface, and of the papillæ on the dorsal surface; and also in the presence of the five valves around the mouth.

But there is no doubt that the species is *not* a *Colochirus*, because:—

(1) The pedicels extend the *entire* length of the ventral surface (in *Colochirus* they are absent at both ends).

(2) The deposits, which consist entirely of tables, are different from those of the genus *Colochirus*.

(3) The calcareous ring has posterior prolongations.

Neither does this species agree with any other genus of the Dendrochirotæ, so that I feel compelled to form for it a new genus which may be defined as follows:—

Havelockia,* n. gen.

The body is indistinctly quadrangular, and the mouth and anus are each surrounded by five valves. The ambulacral appendages consist of (1) pedicels, arranged in three series on the ventral surface, each series extending from the mouth to the anus, and consisting of several rows of pedicels; (2) papillæ, which are scattered irregularly over the bivium.

The deposits consist entirely of tables. Each table has a spire consisting of two rods, which are surmounted by three or four short blunt projections.

The calcareous ring has posterior radial bifurcations.

* Named after the SS. "Lady Havelock," from which Professor HERDMAN worked during the greater part of his expedition in the seas round Ceylon.

FAMILY: ASPIDOCHIROTÆ.

Actinopyga mauritiana (QUOY and GAIMARD).

Holothuria mauritiana, Q. & G., 1833. **Mülleria varians**, SELENKA, 1867. **Mülleria mauritiana**, SEMPER, 1868. See also THÉEL (7).

One specimen from the lagoon inside the Reef, Galle. Length, 140 millims.

The specimen possesses most of the characters of the species. There are, however, no white rings around the dorsal papillæ.

On the ventral surface there is a well-marked white symmetrical patch which is quite distinct from the brown dorsal surface.

In THÉEL'S description this marked difference in colouring is not emphasised, and he leads one to believe that the brown on the dorsal surface is *gradually* changed for the lighter colour of the ventral surface. It is interesting to note that the specimens of this species, which Professor HERDMAN kindly examined for me, with Professor JEFFREY BELL, in the British Museum, showed transitions between those described by THÉEL and the striking condition seen in the Ceylon specimen. So that it is evident that the nature of the colouring of the ventral surface, with relation to its distinctness from that of the dorsal surface, is susceptible of considerable variation in the species.

The pedicels of the ventral surface are capable of great extension, and have white sucking discs. The white integument of the ventral surface is closely covered with small but conspicuous pores, suggesting the singular appearance of a white colony of the Compound Ascidian *Leptoclinum*.

Distribution:—Indian Ocean from E. Africa to East Indies; Funafuti, in the central Pacific.

Actinopyga serratidens, n. sp.—Plate III., figs. 36–41.

One specimen from the lagoon inside the Reef, Galle. Length, 180 millims.

Colour of spirit specimen is brownish-black.

The tentacles are partly retracted, so that it is difficult to ascertain their exact number. There are, however, 20 tentacular ampullæ, so that there will also be 20 tentacles. The colour of the tentacles is dark brown.

The mouth is ventral, and is surrounded by a distinct brim formed by a folding of the integument. The anus is surrounded by five distinctly serrated teeth, each tooth being 3 millims. in length.

The pedicels are irregularly scattered over the ventral surface, showing no arrangement in rows. They are distinctly cylindrical with well-developed sucking discs. The dorsal surface is covered with papillæ, which are more slender than the pedicels. They appear, in many cases, to have small rudimentary terminal discs, so that it is difficult to distinguish them from true pedicels. Both pedicels and papillæ are of the same colour as the general integument, so that they are not very conspicuous.

The specimen has a typical Aspidochirote calcareous ring.

There is one large Polian vesicle, 30 millims. long, and there are about eight stone canals attached to the dorsal mesentery.

The right respiratory tree is much larger than the left. This form also possesses Cuvierian organs.

The general body wall is very thick, about 5 millims. This is probably, to a certain extent, due to contraction.

Deposits :—Not very thickly scattered. They consist typically of a short straight rod with dichotomising ends (figs. 36–38). Sometimes the spicules are dumb-bell shaped or bone-shaped (figs. 39–41). The pedicels have no supporting rods, nor spicules of any kind, except a terminal plate. The character from which I have taken the specific name, viz., the serration of the anal teeth, is a very distinct one, and would serve alone to distinguish the species.

Holothuria kurti, Ludwig.—Plate III.; figs. 42–45.

H. lamperti, Sluiter, 1889 (**10**), (**15**).

One specimen from Pearl Banks, Gulf of Manaar (Stn. LXVI.); three specimens from south of Adam's Bridge (Stn LIV.), 4 to 40 fathoms.

The lengths of the specimens vary from 25 millims. to 40 millims. The specimens agree with Sluiter's description.

Deposits :—The spicules agree in the main with Sluiter's description. There are two kinds of table—round tables and cross-shaped tables, each kind being surmounted by a comparatively tall tower ending in numerous teeth. The size of the tables varies very much. In the papillæ there are also knobbed "buttons," having six or seven pairs of holes as figured by Sluiter. In some of the specimens there are also some smooth buttons scattered about in the skin, having six or seven pairs of holes.

So far as I can determine, the cross-shaped tables are derived from the round tables by pieces having become broken or dissolved away; so that there is really only originally the one kind of table, the cross-shaped form being only a stage in the dissolution of the round form. I found all stages between the two extremes (see figs. 42–45). Consequently, in a young specimen, we should expect the round form to predominate, and as the animal grows bigger, the cross-shaped form of table would increase in number.

This species is now recorded from Ceylon for the first time.

Distribution :—Java, Ceylon.

Holothuria monacaria (Lesson).

Psolus monacaria, Lesson, 1830. See also Théel (7).

One specimen from Aripu reef (March 18th); and one specimen from northern part of Gulf of Manaar (Stn. LIV.), 4 to 40 fathoms.

Lengths, 75 millims. and 38 millims.

The colour in alcohol is brown, with yellow rings around the papillæ. The pedicels are light brown. The tentacles are yellow.

There are papillæ on the dorsal surface, and pedicels on the ventral surface. At the anterior third of the body the papillæ are arranged in five distinct longitudinal rows. In the posterior two-thirds they are more irregular. The pedicels are also arranged in five more or less irregular rows on the anterior third of the ventral surface, and they are more irregularly scattered over the remaining two-thirds.

The mouth is surrounded by a crown of small papillæ.

Deposits:—These agree with those figured by Théel. Although the Ceylon specimens differ in the arrangement of the pedicels and papillæ from Théel's description of *H. monacaria*, yet I think there is no doubt as to their identity with that species.

Distribution:—Indian Ocean, E. Indies, Australia, Pacific Islands.

Holothuria vagabunda, Selenka.

Stichopus (sub-genus **Gymnochirota**) **leucospilota**, Brandt, 1835. See also Selenka (1), Semper (2), Théel (7).

One specimen from the lagoon inside the Reef, Galle. Length, 180 millims.

This specimen agrees with the descriptions of the species.

Distribution:—E. Africa, Indian Ocean, E. Indies, Hong Kong, Pacific Islands.

Holothuria tenuissima, Semper (2). See also Théel (7).

Two specimens from the lagoon inside the Reef, Galle; one specimen from off Negombo (Stn. I.). Also elsewhere in Gulf of Manaar (Stn. IX.), 7 fathoms.

Lengths of two specimens, which were in a very contracted condition, 130 millims. Length of other specimen, 80 millims.

The specimens agree with the descriptions of the species.

The pedicels, which are scattered irregularly all over the body, are more numerous on the ventral surface. The anus is slightly pentagonal, with a group of papillæ at each angle.

The smallest of the specimens is evidently a young form, but it agrees with the larger specimens in most respects. Its body wall is very thin, doubtless owing to its immature condition. There is also a small circular area around the mouth—about 15 millims. in diameter—where the skin is much thinner and devoid of pedicels.

These specimens also agree with the descriptions of *H. vitiensis*, *H. kœllikeri*, and *H. clemens*, and it is very probable, as THÉEL suggests, that they all belong to one and the same species, which is susceptible of great variation.

Distribution :—Indo-Pacific region.

Holothuria marmorata (JÄGER).

Bohadschia marmorata, JÄGER, 1833. See also THÉEL (7).

One specimen from the lagoon inside the Reef, Galle. The species was also, Professor HERDMAN'S notes show, found at Trincomalee. Length, 240 millims.

Colour in alcohol.—The ventral surface is a dark brown with a violet tinge. The dorsal surface is lighter, especially at the posterior end. The colour on the dorsal surface is not uniform, but there is not the striped appearance that is typical of the species.

The pedicels are scattered all over the body, the skin being considerably darker at the base of each pedicel.

The anus is pentagonal and is surrounded by five groups of papillæ, each group consisting of five papillæ.

The deposits are typical.

This specimen is very similar in most respects to *H. tenuissima*. It differs slightly from the latter in the nature of the deposits, the spicules not dichotomising to such an extent but having rather the appearance of perforated granules. The papillæ around the anus also are more prominent than in *H. tenuissima*. Nevertheless, in spite of these differences, it is highly probable, as THÉEL suggests, that *H. marmorata*, *H. tenuissima*, together with other allied forms are only, at the most, varieties of the one species.

Distribution :—Indo-Pacific region generally.

Holothuria atra, JÄGER.

H. (sub-genus **Microthele**) **affinis**, BRANDT, 1835. See also THÉEL (7).

There are seven specimens, most of them being very much contracted. This species was found at various localities round Ceylon—in the Gulf of Manaar, at Trincomalee, and at Galle.

The colour in alcohol is dark brown on the dorsal surface and lighter on the ventral. Professor HERDMAN'S notes state that at least some of the specimens when alive were quite black above, but of a pink colour below.

The dorsal papillæ are smaller than the ventral pedicels.

The deposits are typical. The discs of the tables are smooth and have no peripheral perforations.

The gonads are absent in all specimens. Cuvierian organs also are not present in any of the specimens, so that it is highly probable that this species does not possess Cuvierian organs.

In all the specimens the spicules are similar in density and form.

Although the tentacles are retracted in most of the specimens, there appear to be 20 tentacular ampullæ in each specimen.

In every specimen the left respiratory tree is much larger than the right, the former extending to the extreme anterior end of the body.

Appended is a table showing some of the variations noticed in the seven specimens examined :—

Locality.	Length.	Greatest breadth.	Polian vesicles.		Stone canals.	Longest tentacular ampullæ.
			Number.	Greatest length.		
	millims.	millims.		millims.		millims.
Pearl Banks, off Aripu .	125	23	4	22	19	25
Trincomalee	155	38	—	—	17	15
Off Periya Paar	185	34	1	14	11	15
Reef Galle	155	34	5	12	12	14
Off Galle	105	28	2	18	9	10
G. of Manaar.	75	30	1	15	27	7
S.W. Cheval Paar . . .	135	35	1	9	13	14

Holothuria gallensis, n. sp.—Plate III., figs. 46–50.

Three specimens from the lagoon inside the Reef, Galle.*

Lengths, 230 millims., 150 millims., and 70 millims.

The tentacles are not present in any of the specimens; but there are 20 tentacular ampullæ, so that although the tentacles themselves are absent, we may safely conclude that the animal had 20 tentacles.

The body is divided into a distinct dorsal and ventral surface. The dorsal surface is black and is crossed by numerous conspicuous transverse yellow streaks (Plate III., fig. 46). The pattern, however, varies somewhat in different specimens, the yellow streaks in the smallest not being very evident. On the ventral surface the colour is light yellow, mottled all over with small dark grey patches.

Ambulacral appendages :—On the dorsal surface there are small papillæ, which are very thinly scattered and inconspicuous. The appendages on the ventral surface are much more numerous, and are easily distinguished because each one is generally situated in the centre of a dark grey patch. These appendages, which are mostly retracted, are evidently true pedicels. They have only a small terminal plate, and they are strengthened by spicules similar to those found in the general integument.

* This species was, evidently, from Professor HERDMAN'S notes, also found in China Bay, Trincomalee.

The mouth is ventral, and is surrounded by a small brim of papillæ. There are no anal teeth.

Deposits consist of two kinds :—

(1.) Closely packed tables having, in the older specimens, a large central hole and about eight smaller peripheral holes. This is surmounted by a spire having four upright bars. There is one tier of horizontal bars. The spire terminates in a round top having numerous spines (figs. 47 and 49).

(2.) Knobbed "buttons," having generally three pairs of holes (fig. 48).

The tables in the smallest specimen are much better developed than in the older specimens. The buttons in the youngest animal have about five pairs of holes, whilst those in the older specimens invariably have only three (see figs. 49 and 50). These facts incidentally bear out MITSUKURI'S (14) statement with regard to the changes in growth of spicules.

The calcareous ring is simple, like that of a typical Aspidochirote.

There are two long Polian vesicles in the specimen dissected. No stone canals are seen.

It is noteworthy that although this species has never been previously described, it is evidently a fairly common form on the Ceylon coast. It is one of the species used as "Trepang," and has apparently not been distinguished from some of the other large species of *Holothuria*. Possibly, on account of its mottled appearance, it has been confused with *H. marmorata*, from which, however, it differs in many respects. The yellow transverse stripes (see Plate III., fig. 46) on the dorsal surface and the mottling on the ventral are very characteristic.

Stichopus chloronotus, BRANDT.

St. cylindricus, HAACKE, 1880. See also THÉEL (7).

One specimen from East Cheval paar, $5\frac{1}{2}$ fathoms. Length, 140 millims.

This specimen agrees very closely with THÉEL'S description. There are, however, only 19 tentacles in the Ceylon specimen.

There are four longitudinal series of protuberances on the dorsum, the two dorsal series being double, while the two ventral series have a more or less zig-zag arrangement.

The pedicels are irregularly distributed over the ventral surface. Professor HERDMAN'S notes state that the body was of a dark green colour when alive.

Distribution :—Pacific Islands, Indian Ocean from E. Africa to Malay Peninsula.

Stichopus chloronotus, var. fuscus, nov.

Three specimens from Pearl Banks, Gulf of Manaar (Stn. LVIII.), 9–26 fathoms. Lengths, 170 millims., 200 millims., and 110 millims.

The mouth is surrounded by a crown of papillæ.

The number of tentacles is different in each specimen. There are 18 in the largest, 14 in the next, and 16 in the smallest. In the two latter it is highly probable that some tentacles are retracted.

There are four irregular rows of protuberances—one row along each side of the body. In this it differs from *Stichopus chloronotus*, which has two *double* rows on the dorsal surface. The pedicels are irregularly scattered on the ventral surface, showing a slight indication of forming three rows.

The deposits agree with those of *Stichopus chloronotus*, except that the C-shaped deposits are very rare indeed.

These two spirit specimens are very much darker in colour than the spirit specimen of *St. chloronotus*, the former being a dark chocolate-brown.

I consider that the differences between these specimens and *St. chloronotus* justify the formation of a new variety.

Stichopus variegatus, Semper.

St. naso, Haacke, 1880. See Semper (2), Théel (7).

Two specimens from S.W. of Periya Paar (Stn. LV.), 11–24 fathoms.

Lengths, 85 millims. and 75 millims.

The specimens are very much contracted and in a poor state of preservation.

The tentacles in one specimen are dark brown and in the other yellow. I am unable to count them owing to their poor state of preservation, but in other respects the specimens agree with Semper's description.

The pedicels are arranged in three series on the ventral surface, each series having about four rows.

Distribution :—Indo-Pacific, Mauritius, E. Indies, Ceylon.

Note.—While this Report was in the press another specimen (from Gulf of Manaar, February, 1902) was found which is nearly related to *Phyllophorus cebuensis*, but may be distinct, as it differs in the deposits, having additional rosette-shaped buttons.

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(6.) Lampert.—'Archipel der Philippinen. Die Seewalzen,' 1885.

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EXPLANATION OF PLATES.

List of Reference Letters.

a., anus; *ant.*, anterior end; *dors. p.*, dorsal papillæ; *i.*, inter-radial; *m.*, mouth; *p.b.*, pedicels of the bivium; *p.p.*, posterior prolongations of radials; *p.t.*, pedicels of the trivium; *r.*, radial; *s.*, spire of table.

PLATE I.

Fig. 1. Tentacles of *Synapta striata*, Sluiter, from life.
Fig. 2–4. Spicules of *Cucumaria turbinata* (Hutton).
Fig. 5. Calcareous ring of same.
Fig. 6. Side view of *C. turbinata*; three times natural size.
Fig. 7. Top view of a complete table of *Thyone fusus*, var. *papuensis*, Théel.
Fig. 8. Top view of an incomplete table of same.
Fig. 9–10. Spicules of *Thyone sacellus* (Selenka).
Fig. 11. Calcareous ring of *Thyone* (?) *fusca*, n. sp.
Fig. 12–13. Spicules of same.
Fig. 14. Calcareous ring of *Thyone* (?) *hornelli*, n. sp.
Fig. 15–16. Spicules of same.
Fig. 17. Calcareous ring of *Thyone* (?) *calcarea*, n. sp.
Fig. 18–20. Spicules of same. (Fig. 19 is side view of table.)

PLATE II.

Fig. 21. *Colochirus quadrangularis*, var. *mollis*, nov.; natural size, from life.
Fig. 22. Side view of spicule of *Phyllophorus cebuense* (Semper).
Fig. 23. Underneath view of same.
Fig. 24. Calcareous ring of *Phyllophorus cebuense.*
Fig. 25. Calcareous ring of *Actinocucumis donnani*, n. sp.
Fig. 26–28. Spicules in general integument of same.
Fig. 29–30. Spicules of tube feet of same.
Fig. 31. Side view of *Havelockia herdmani*, n. gen. et sp.; twice natural size.
Fig. 32. Top view of "table" in the general integument of same.
Fig. 33. Side view of "table" in the general integument of same.
Fig. 34. Top view of "table" of the papillæ of same.
Fig. 35. Calcareous ring of *Havelockia herdmani.*

PLATE III.

Fig. 36–38. Small dichotomising rods of *Actinopyga serratidens*, n. sp.

Fig. 39–41. Bone-shaped spicules of same.

Fig. 42–45. Showing transformation from a round "table" to a cross-shaped "table" in *Holothuria kurti*, Ludwig.

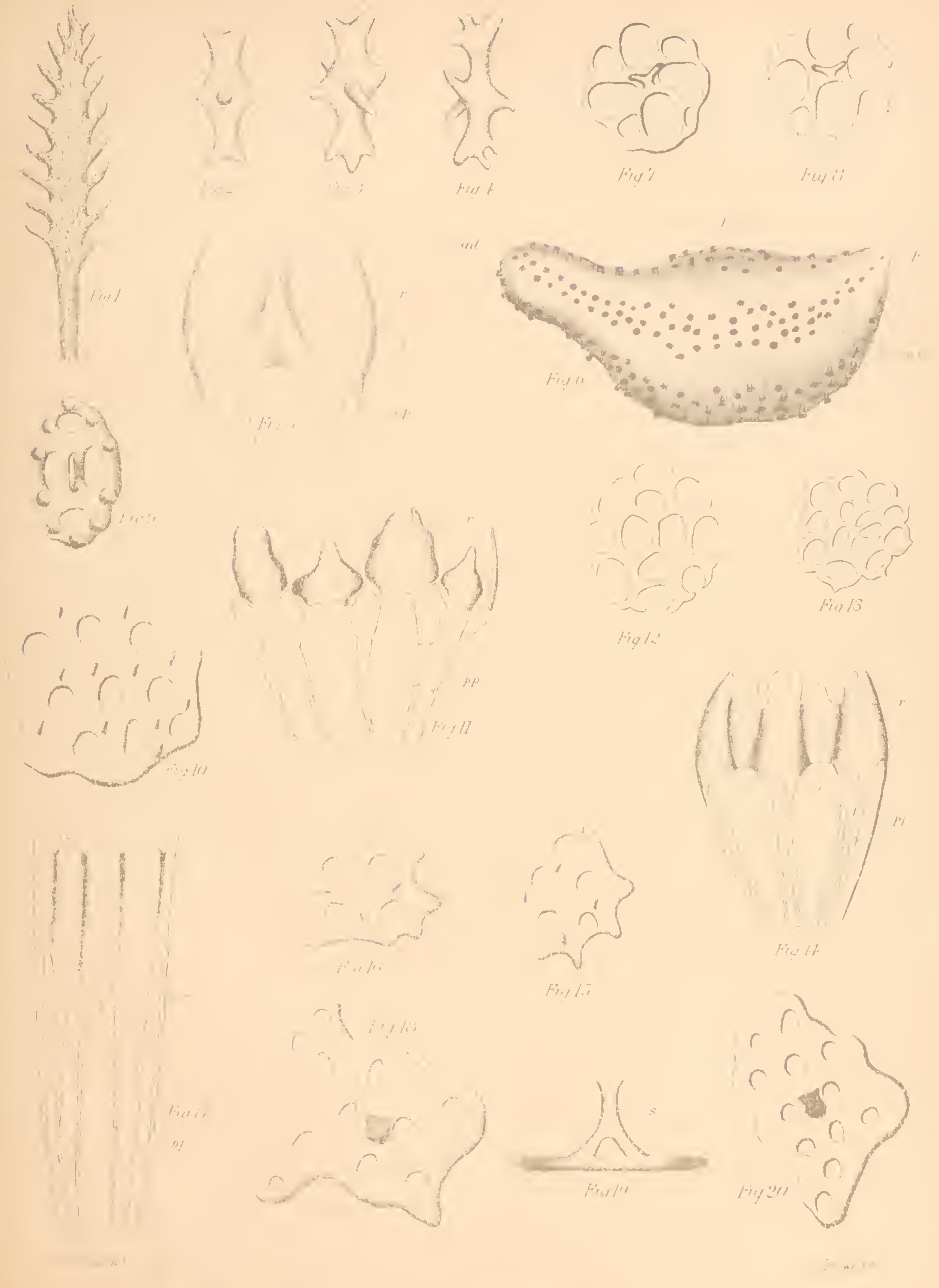
Fig. 46. *Holothuria gallensis*, n. sp., dorsal surface; natural size.

Fig. 47. Side view of "table" of *Holothuria gallensis*, n. sp.

Fig. 48. "Knobbed button" of same.

Fig. 49. Underneath view of "table" in older specimen of *H. gallensis*.

Fig. 50. View of "table" in younger specimen of *H. gallensis*.



[illegible] Figs 7, 8, Thyone fusus var. [illegible]
[illegible] Figs. 14-16, Thyone [illegible]
[illegible] Thyone calcarea

J. Pearson del [illegible]

Fig. 21, Colochirus quadrangularis, var. mollis. Figs. 22–24, Phyllophorus [illegible]
Figs. 25–30, Actinocucumis donnani. Figs. 31–35, Havelockia [illegible]

FIGS. 36-41, ACTINOPYGA SERRATIDENS. FIGS. 42-45, HOLOTHURIA KURTI. FIGS. 46-50, HOLOTHURIA GALLENSIS

REPORT

ON THE

CEPHALOCHORDA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

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[WITH ONE PLATE.]

INTRODUCTION.

THE collection of Acraniates made by Professor HERDMAN during his recent expedition to Ceylon was kindly placed in my hands for examination during my year of post-graduate research work at University College, Liverpool. I here wish to express my thanks to Professor HERDMAN for giving me the opportunity of examining this most interesting series, and also for the ever-willing and kindly help which he has given me in the discussion of literature and other difficulties. The collection was a most interesting one, and comprised in all 98 specimens, 92 obtained by dredging and 6 taken in the surface tow-net. They were collected for the most part in the shallower waters round Ceylon between February 1st and April 1st, 1902; and as the specimens belong to no fewer than seven usually recognised species, they serve to indicate the richness of the Acraniate fauna of the Ceylon seas.

The previous knowledge of the Cephalochorda of the Ceylon coast is very scanty. ANDREWS (3),* in Appendix I. to his paper on *Asymmetron*, notes *Branchiostoma lanceolatum* as doubtfully known to him from Ceylon. In Appendix II. to the same paper, in which the Lancelets of the Smithsonian Museum are enumerated, bottle 34,003 is labelled—"Amphioxus sp., 5 soft specimens from Ceylon." Miss KIRKALDY (6) examined these specimens later and found that four belonged to a new species, which she named *A. cingalense*. The other one she placed provisionally and doubtfully in

* The numbers in brackets refer to the List of Literature cited on p. 226.

the species *B. belcheri*. Thus, at most, three species, represented by six specimens, were then known from Ceylon; and during the course of Miss KIRKALDY'S work she received four more specimens from Ceylon which proved to be *A. cingalense*.

The present collection, therefore, is by far the largest yet made known from Ceylon. The species include—*Branchiostoma lanceolatum*, *B. lanceolatum*, var. *belcheri*, *Asymmetron* (*Heteropleuron*) *cingalense*, *Asymmetron* (*Heteropleuron*) *cultellum*, *Branchiostoma* (*Dolichorhynchus*) *indicum*, *Branchiostoma pelagicum* (the six tow-net specimens), and *B. californiense* (?).

The specimens were preserved, some in alcohol and others in formol, and the latter were in a most excellent state of preservation, being rendered slightly transparent, while the exact outlines and shapes of the fins were splendidly maintained. The spirit specimens were not nearly so good, so far as regards the external appearance, although better in some respects for histological examination.

The group Cephalochorda has a single family, Branchiostomatidæ, containing two genera, *Branchiostoma* and *Asymmetron*. In discussing the Ceylon species, I shall follow the classification and nomenclature given in my recent paper published by the Liverpool Biological Society (**10**).

GENUS I.—BRANCHIOSTOMA, COSTA.

Metapleural folds end symmetrically just behind the anus, separated by the ventral fin; gonads disposed in two lateral series; ventral fin with fin chambers which may or may not have fin rays; oral cirri when present have sense-papillæ; atrial chamber prolonged behind the atriopore in a single (right) cæcum.

Branchiostoma lanceolatum (PALLAS)—Plate I., figs. 1, 2.

Limax lanceolatus, PALLAS, 1776.

Branchiostoma lubricum, COSTA, 1834 and 1843.

Amphioxus lanceolatus, YARRELL, 1836, and others.

Branchiostoma lanceolatum, GRAY, 1851, and others.

This species, which has only before been doubtfully recorded from Ceylon (ANDREWS (**3**)), was represented by ten specimens in the collection.

They were from the following localities:—

(1.) Galle (Stn. XXXV.), February 14th, 7 fathoms. Two specimens.
(2.) Ten miles North of Cheval Paar (Stn. LIII.), March 6th, 7½ fathoms. Three specimens.
(3.) Periya Paar Kerrai (Stn. LIII.), March 4th, 7½ fathoms. One specimen.
(4.) Off Watering Point, Galle (Stn. XXXVIII.), February 17th, 9 fathoms. Four specimens.

The various measurements of these ten specimens will be found in Table I. at the end of the report. The greatest length recorded is 41 millims. and the least 26 millims., the average for the ten being 34·5 millims., considerably lower than KIRKALDY'S average figures (6).

Of the ten, four were males and two females, the males being of greater average length, while the sex of the remaining four could not be determined. These latter were those found off Watering Point, Galle, and one of them had a double row of exceedingly minute gonads as if just developing, while the other three had none whatever. This possibly gives us a clue to the spawning time of the species in tropical seas. It will be noticed from Table I. (p. 222) that these four and the two first males from Galle were caught at least a fortnight before the other specimens, and their gonads were in various stages of development. Those caught 14 to 20 days later had larger and almost mature gonads, in spite of the fact that one at least was considerably smaller than those caught at the earlier date. This would give us the middle of March to the beginning of April as the probable spawning time of these Ceylon specimens of *B. lanceolatum*.

In those specimens in which gonads were present they formed a double series of pouches, generally equal in number on the two sides. The average number present was 23 on each side, rather below KIRKALDY'S average (6). The Galle specimens, preserved in formol, are of a pink tint and almost transparent; the rest, which are in spirit, vary in colour from fawn to a deep orange and are much more opaque.

The number of myotomes varied between 59–61, not a great range; but the arrangement of the somites varied considerably, as Table I. shows. The preatrioporal myotomes ranged from 35 to 37, the average being 36. This is rather more than KIRKALDY'S figures show, but ANDREWS (3) records several with 37 and one with 38 preatrioporal myotomes. The preanal myotomes varied between 11 and 14, the average being 13. Nos. III. and V. on Table I. show only 11 preanal myotomes. This is the lowest number recorded for the species, but repeated countings have confirmed the figure. This is one more instance of the great variability in the arrangement of the myotomes within a given total. The postanal myotomes vary between 11 and 13, the usual figures for the species.

The fins of these specimens agree closely with KIRKALDY'S figures, especially the caudal fin (fig. 1), which is remarkably constant throughout.

The ventral fin has a double series of fin rays, in fin chambers, extending its whole length. The ventral fin chambers are prolonged postanally for a considerable length (fig. 1), and in II., Table I., there certainly is a postanal extension of the fin rays—in spite of LANKESTER'S and BENHAM'S statements to the contrary. The fin rays appear to be better developed both in the dorsal and ventral fins in the older specimens.

The relation of the anterior ends of the notochord and dorsal fin is in all cases as KIRKALDY figures it, *i.e.* the dorsal fin ends conterminously with the myotomes, while the notochord is prolonged further forwards a little way. The nervous system, however, does not always project beyond the dorsal fin, as in one or two of the

Ceylon specimens they ended together. The "Räderorgan" is well developed in these specimens, and has a median dorsal lobe and five or six large lateral lobes on each side. In one specimen examined one of the lateral lobes was branched.

No. IV., Table I., showed an unusual dark oval patch anterior to the dorsal fin and just dorsal to the notochord (fig. 2). No structure could be made out, but when cleared up in clove oil the dark patch was found to have a ventral extension on the left side. Unfortunately the specimen had not been preserved specially for histological work, and so the sections that were made showed no additional structure, the only appearance being a large patch dorsally and to the left side of the notochord, which stained deeply with hæmatoxylin.

Branchiostoma lanceolatum, var. **belcheri**, GRAY.—Plate I., fig. 3.

> **Branchiostoma belcheri**, GRAY, 1847, and others.
>
> **Amphioxus belcheri**, KIRKALDY.

This variety, which is usually regarded as a distinct species, formed the greater part of the collection, being a total of 58 specimens out of 98. It has only been previously recorded from the neighbourhood of Ceylon by THURSTON* in 1890, who mentions the species being dredged 30 miles south of Madras in 1887–88; in fact it has been found but sparingly anywhere before. This large collection, therefore, has offered opportunity for a closer examination of this form, which, I think, has shown that we cannot any longer regard it as specifically distinct from *B. lanceolatum*. This matter is dealt with in detail in my recent paper in the 'Transactions of the Liverpool Biological Society,' where I have given tables compiled from the observations of different workers, showing how the characters of the one form fade gradually into those of the other.

The Ceylon specimens were found in the following localities:—

(1.) Ten miles north of Cheval Paar, June 3rd, 1902, $7\frac{1}{2}$ fathoms. Seven specimens.

(2.) Outside Karativo Paar (Stn. LVIII.), March 10th, 10 fathoms. Two specimens.

(3.) Off Karkopani (Stn. IV.), February 2nd, 8 fathoms. Two specimens.

(4.) Off Mutwal Island (Stn. LXVII.), March 19th, 14 fathoms. Three specimens.

(5.) Periya Paar Kerrai (Stn. L.), $7\frac{1}{2}$ fathoms, sand, March 4th. Four specimens.

(6.) Off Chilaw Paar (Stn. LXIX.), 10 fathoms, March 20th. Six specimens.

(7.) West Cheval Paar (Stn. LXV.), March 18th, $7\frac{1}{2}$ fathoms. Nine specimens.

(8.) Near Periya Paar (Stn. LXII.), March 13th, in Foraminiferal sand, 11 fathoms. Eleven specimens.

(9.) South-west of Cheval Paar (Stn. XLIX.), March 1st, $8\frac{1}{2}$ fathoms. Fourteen specimens.

* Madras Government Museum, Bulletin No. 1, p. 26.

The colour of these specimens varied somewhat. Those found outside Karativo Paar and off Mutwal Island were a deep orange colour; those found near Periya Paar and south-west of Cheval Paar were pure white, while those from west of Cheval Paar, on March 18th, were of a purplish-pink colour.

The measurements of these specimens are recorded in Table II., pp. 223, 224.

In length they vary considerably, from 25 millims. to 56 millims., the average being 41·5 millims. One specimen, XXIV., Table II., was much damaged, all the postanal and one half of the part between the anus and atriopore being missing. The remainder measured, however, 53 millims., giving us 70 millims. as the probable length of the whole animal—quite a giant amongst Acraniates.

Out of the 58 specimens, 28 were females, and only 10 were proved to be males; the sex of 20 could not be determined owing to the absence of gonads.

The size of the animal appears to bear a relation to the period of sexual maturity, which is contrary to what FORSTER-COOPER (8) found for *Asymmetron lucayanum*. Here it is the largest that have well-developed gonads and the smallest that are immature. All the immature ones were under 36 millims. in length. This would show that at a length of about 40 millims. the form *B. belcheri* becomes adult. All these specimens, it may be noted, were caught at about the same time of the year and in much the same locality, and there can be no question of some being taken at the spawning season and others not. It must be that the larger ones only were adult and the others immature. In the spirit specimens the gonads could not, in all cases, be counted, owing to the opacity of the metapleural folds, but in the formol-preserved specimens they were determined with ease.

In all the specimens counted, except one, the gonads of the right side were more numerous than those of the left, the average being 25 right to 23 left. The lowest number was 15 (some had evidently been already shed), and the highest was 30.

A few specimens had peculiar gonads. No. XX., Table II., had unusually small gonads, though itself a large specimen; while No. XXVI., Table II., showed a curious arrangement, some of the gonads being quite small and alternating with large mature ones. Late in March and early in April seems to be about the spawning time of this variety in the Gulf of Manaar.

The variation in the myotomes is striking, not so much in the total number as in the distribution. The total myotomes ranged from 63 to 66, 64 being the average. The commonest formula was 38, 17, 9, which agrees closely with KIRKALDY's figures (6), and differs considerably from GÜNTHER's (1). The number of preatrioporal myotomes varied from 36 to 39, by far the greater number, 34 out of 58, having 38. The number of preanal myotomes varied from 16 to 18, 17 being the average; while the postanal myotomes numbered 8 to 10, 9 being the commonest number.

From these figures it will be seen that *B. belcheri* from Ceylon agrees closely with those from Australia examined by KIRKALDY (6), and the two are undoubtedly the same species, and not distinct forms as Miss KIRKALDY suggested.

The fins of *B. belcheri* are fairly constant (fig. 3) and agree with KIRKALDY'S figure, except that she figures the rostral fin proportionately rather small. In ours it is well developed, rather long, and more pointed than her figure shows. In some specimens it is so well developed as to suggest a transition from *B. lanceolatus* to *B. indicus*. The ventral fin has fin chambers and a double series of ventral fin rays.

The extent of development of fin rays appears to vary with the age of the animal.

In the smallest specimens no ventral or dorsal fin rays are present. In those a little larger, dorsal fin rays appear, the ventral ones being still undeveloped; while in those a little larger again, both series are seen.

The fin chambers are not prolonged postanally. The nervous system and the dorsal fin end conterminously, while the notochord is prolonged a little way in front of both.

A fæcal pellet adhering to the anus of No. LIII., Table II., on examination was found to be rich in skeletons of diatoms, which gives an indication of the food.

The intertentacular membrane between the oral cirri of *B. belcheri* is low, and the sensory-papillæ are very large and prominent.

The "Räderorgan" is exceptionally well developed, there being a large median dorsal lobe and six lateral lobes on each side. The liver is exceptionally large and extends for three-quarters of the length of the pharynx on the right side.

Branchiostoma pelagicum, GÜNTHER (1889).—Plate I., fig. 16.

The six specimens taken in the tow-net were found to be poorly preserved, and being also extremely small, their identification is a matter of some difficulty. I think, however, that there can be little doubt that they are *B. pelagicum*, GÜNTHER (2).

Of the six, one was taken in a coarse tow-net in the Indian Ocean, to the south-east of Sokotra, about halfway between Perim and the Maldives, on January 16th, 1902; while the other five were taken with a fine net on January 20th, 1902, in the Indian Ocean, after passing Minikoy Atoll, and therefore between the Maldives and the Gulf of Manaar. There is therefore no doubt as to their all being truly pelagic forms.

The largest measured 8·5 millims., the smallest 4·5 millims., the average for the six being 6 millims. The greatest breadth of the largest specimen was 1 millim. All six are undoubtedly the same species, and agree in detail as far as can be made out.

The notochord extends from the extreme tip of the snout to the end of the tail, projecting some little way beyond the myotomes.

The nervous system stops short of the end of the notochord at both extremities. The eye spot is very large and conspicuous, far larger in proportion to the size of the animal than in the other species. This, in itself, is suggestive of a pelagic life. All along the nerve cord, at regular intervals, occur groups of five or six large pigment spots (fig. 16). This is a character noted in GÜNTHER'S *B. pelagicum*.

The number of myotomes (as nearly as could be determined from the imperfect preservation) was 65. GÜNTHER'S *B. pelagicum* had 67; while one specimen described by FORSTER-COOPER (8) had 60. This specimen was 21 millims. long, twice as long as GÜNTHER'S.

There was no trace of oral cirri to be seen, nor did FORSTER-COOPER find any in his specimen (8). This then appears to be a true character of the species, and not to be due to any imperfection in preservation. It is, moreover, what might be expected. The oral cirri probably have, as one of their functions, to direct currents of water into the oral hood and so to the mouth and alimentary canal. This is absolutely necessary in an animal which leads a sedentary life. But a pelagic form, by virtue of its mode of life and motion through the water, would cause currents in the right direction, and thus the oral cirri would be rendered unnecessary.

No gonads could be observed in any of the six specimens. They were probably immature. In none were the dorsal, ventral, or caudal fins preserved sufficiently well to indicate, in any way, their shape and size. One specimen had traces of a caudal fin which indicated that it was very well developed.

On the whole, it may be said that in general shape, size, number of myotomes, absence of oral cirri, large size of eye-spot, and pigment spots on the nerve cord, our specimens agree with GÜNTHER'S *B. pelagicum*, and it seems quite safe to refer them to this species.

Branchiostoma indicum (WILLEY).—Plate I., figs. 11–13.

Dolichorhynchus indicus, WILLEY, 1901.

Two specimens, one from Galle (Stn. XXXVI.), in $4\frac{3}{4}$ fathoms, and the other taken off Watering Point (Stn. XXXVIII.) in the same locality, in 9 fathoms, I am disposed to refer to this species, although the absence of some details in WILLEY'S description and the lack of figures render the identification a little uncertain.

Both my specimens have long and well-marked preoral lobes, but the proportional length of the lobes does not appear to be quite as great as in WILLEY'S specimens (fig. 11). Moreover, the preoral lobes of the Ceylon specimens do not appear bent as WILLEY'S figures show; but it may well be that the bending was due to some accident or injury, and that the lobes are not bent in life.

One of our specimens measures 17 millims., and the other 36 millims. The latter is a male, and has 29 right gonads and 25 left. The smaller one has no gonads and is evidently immature. The larger one has a myotome formula of 43, 14, 13—total, 70; while the smaller one has 41, 14, 14—total, 69. Both these formulæ agree closely with WILLEY'S description.

The dorsal fin is low and ends conterminously with the myotomes. Its outline in the large specimens is interrupted by a peculiar wavy break (fig. 12), possibly due to an injury and subsequent healing up. The notochord extends a long way in front of the dorsal fin. The nervous system is overlapped by the dorsal fin, while in WILLEY'S description the arrangement is the reverse of that.

The posterior extension of the notochord past the myotomes is not very great. The ventral fin has fin chambers which are also extended postanally, as in *B. lanceolatum* and *Asymmetron hectori*. In the latter species the chambers extend postanally to the antepenultimate myotome, while here they extend only five myotomes posterior to the anus. The ventral fin rays are double, and are not extended postanally as in *A. hectori*. WILLEY did not notice the postanal extension of the fin chambers in his specimens. Only the larger specimen here has ventral fin rays, showing again what was noticed under *B. lanceolatum*, var. *belcheri*, that it is only in the larger specimens that the ventral fin rays are well developed.

The caudal fin is here well marked off from the dorsal and ventral fins, there being a well marked supra- and infra-caudal lobe in both specimens (figs. 11 and 13). There are about 35 to 40 oral cirri of the usual type, bearing sense-papillæ. On the whole it seems fairly certain that these two specimens belong to the species *Branchiostoma indicum*. The distribution also favours this conclusion, for the Orissa Coast of India, where the species was found, is not far north of Ceylon.

Branchiostoma californiense (?), J. G. COOPER.—Plate I., figs. 14, 15.

(?) **B. capense**, GILCHRIST.

There is one specimen, No. V., Table IV., in the collection the identity of which is a little uncertain. I refer it, with some little hesitation, to *Branchiostoma californiense*, J. COOPER. In another paper (**10**) I have expressed doubt as to the distinctness of *B. californiense* and *B. capense*. Since then Professor HERDMAN has received from Dr. GILCHRIST eight well-preserved specimens of his *B. capense*, and has placed them in my hands for examination. In these I find no trace of an eye-spot. The specimens range from 51 to 63 millims. in length, and the number of myotomes from 74 to 76. The formula varies within 46 to 48, 18 or 19, 9 or 10—47, 19, 9 being the most frequent form. There are 35 pairs of gonads. This formula is so close to that of *B. californiense*, and the two agree so well in proportions and characters of the head, that notwithstanding the absence of an eye-spot I should hesitate to consider the Cape form distinct until further specimens of the Californian species have been examined.

The Ceylon specimen was taken in the Cheval district (Stn. XI.), at 6 fathoms, on February 4th, and was 42 millims. long. It had no gonads and was evidently immature. Its myotome formula was 40, 20, 12—total, 72.

The rostral fin is separated from the dorsal fin by a shallow notch. The dorsal fin is low, and has a series of fin rays. The caudal fin is very slightly marked off from the ventral and dorsal fins and has its infra-caudal lobe slightly the larger and deeper. The ventral fin is very long indeed, and has a series of double fin rays running its whole length. Neither the ventral fin rays nor chambers are prolonged postanally. The metapleura have a symmetrical termination, thus determining the genus to which the specimen belongs.

The oral cirri are long, and number about 30. They bear well-marked sense-papillæ. The "Räderorgan" is of the usual type, and has a median dorsal lobe and two or three lateral lobes on each side.

The notochord projects far in front of the anterior end of the myotomes and projects posteriorly a little way beyond the last myotome. The dorsal fin ends conterminously with the myotomes. The nervous system projects anteriorly beyond the dorsal fin. A well-marked eye-spot is present.

From the above description it will be noticed that this specimen agrees with *B. californiense* in all particulars except in the arrangement of the myotomes.

The total number of myotomes is the same in both, but the preatrioporal part is shorter, and the postanal portion longer in ours than in *B. californiense*. The geographical distribution may, at first sight, be supposed to be against this identification, for the species is only recorded from San Diego Bay, California, and it is certainly a noteworthy fact that it should turn up at the other extreme end of the Indo-Pacific region. But it is not more remarkable than the case of *Asymmetron lucayanum*, which was first found in the Atlantic and then in the Pacific Ocean.

Our specimen differs from *B. capense*, as described by GILCHRIST (**9**), in the number and arrangement of the myotomes and in the presence of an eye-spot, which is absent in *B. capense*. But variation has not yet been much studied in *B. capense*, and possibly the full range of the myotomes is not known. It may be, therefore, that this specimen, and those named *B. capense*, are only variations of *B. californiense*, similar to those shown for other species in the tables at the end of this report.

The habitat of *B. capense* (Cape Colony) bridges the gap between California and Ceylon, and it may be added that other species of Acraniates known from the Maldive Archipelago have been found also at Zanzibar.

It will be seen, therefore, that our Ceylon specimen differs but very slightly from either *B. californiense* or *B. capense*. Both these forms are still comparatively little known, and a re-examination of both is highly desirable, and would probably confirm the view I have ventured to express, that these two species are not really distinct. I believe I am justified in referring this specimen provisionally to *B. californiense*.

GENUS II.—ASYMMETRON, ANDREWS.

Left metapleuron stops just behind the anus, the right is continuous with the median ventral fin; gonads disposed in a single (right) series; oral cirri with or without sense-papillæ; intra-buccal tentacles 10 to 16; ventral fin with or without fin chambers or rays; post-atrioporal cæca 1 to 2 in number.

Asymmetron cingalense (KIRKALDY).—Plate I., figs. 4–7.

Heteropleuron cingalense, KIRKALDY, 1895.

This species was represented by nineteen specimens found sporadically, like *B. lanceolatum*, var. *belcheri*, in Foraminiferal sand in the Gulf of Manaar.

The colour of this species had practically the same range as the others—deep orange, purplish-pink, and pale fawn tints being found. The dimensions of the specimens are recorded in Table III. The total length varied from 20 to 36 millims., the average being 26·5 millims.

The specimens were found in the following localities:—

(1.) Half a mile East of Dutch Modragam Paar (Stn. LVI.), March 10th, 8 fathoms. Two specimens.
(2.) South of Adam's Bridge (Stn. LIV.), March 8th, 8 fathoms. One specimen.
(3.) Off Karkopani (Stn. IV.), February 2nd, 8 fathoms. One specimen.
(4.) Between the Cheval Paars (Stn. XLVIII.), March 4th, $7\frac{1}{2}$ fathoms. One specimen.
(5.) South-west of Cheval Paar (Stn. XLIX.), March 1st, 8 fathoms. Two specimens.
(6.) West of Periya Paar (Stn. XVII.), February 4th, 11 fathoms. Eight specimens.
(7.) West of Periya Paar (Stn. LXI.), March 12th, 12 fathoms. Four specimens.

Although so small compared with the specimens of the form *B. belcheri*, nearly all were sexually mature—thus showing that the average length of the adult *A. cingalense* is much smaller than that of the adult *B. belcheri*.

Of the nineteen specimens, ten were males and seven were females, while the sex of two could not be determined. The number of gonads varied from 18 to 26, always on the right side, the average being 24.

The total number of myotomes varied between 61 and 64, 63 being the average and most frequent number. The most common myotome formula was 39, 16, 8, which occurred 10 times out of 19 specimens. The preatrioporal myotomes varied between 37–39, the preanal between 15 and 17, and the postanal between 6 and 8. This species thus has a comparatively short postanal portion.

The variation in the total number of the myotomes and in their arrangement is less in this species than in any other species of the group. The fins are fairly constant throughout the specimens (figs. 4 and 6), and agree well with KIRKALDY's figures (**6**). The dorsal fin is deeper anteriorly than in the rest of its extent, recalling in a lesser degree the condition of *A. cultellum* (PETERS). It has fin chambers with single fin rays. The dorsal fin in all cases overlaps the nervous system. The ventral fin is very shallow and has fin chambers with double fin rays which are very small and difficult to see. The ventral fin chambers are not prolonged postanally.

In only one of the 19 specimens is the relation of the dorsal fin to the anterior end of the notochord as figured by KIRKALDY. In that figure the anterior end of the notochord is but a little way in front of the anterior end of the dorsal fin. This is seen in but one of the Ceylon specimens, No. X., Table III. (see fig. 5). In the remaining 18 (fig. 6) the anterior end of the dorsal fin is much further behind the anterior end of the notochord. The relation of these two structures to one another is evidently susceptible of some variation. This receives support from what we know in another species. In *Asymmetron lucayanum*, from the Maldive Archipelago, FORSTER-COOPER (8) has figured the dorsal fin and notochord as ending almost conterminously at the anterior end, while in ANDREWS' original figure (3) and in KIRKALDY'S figure (6) of that species the anterior end of the notochord is far in front of that of the dorsal fin.

In one or two specimens I was able to count the oral cirri. They vary from 26 to 32 in number. The intertentacular membrane between the oral cirri of this species is much deeper than is seen in *B lanceolatum*, var. *belcheri*, and extends from one-third to half the way up. The sensory-papillæ, on the other hand, are much less marked. In one preparation of the oral cirri of this species one cirrus was seen to be branched about one-third of the way up, and the branch was about half as long as the cirrus.

In No. XIII., Table III., a curious structure (fig. 7) was noticed in the dorsal fin just behind the level of the mouth. At this place a break in the fin occurs. A slit runs downwards and backwards for about the length of 2 myotomes. The slit is lined throughout by the epithelium that covers the rest of the body. Posterior to the slit, and continuous with it, is a darker stretch of tissue which looks like a closure of a former extension of the slit. Sections do not show much more, but the structure seems to be confined to the dorsal fin. The nervous system, notochord, and other neighbouring organs are quite unaffected. It is probably the result of some accident arresting the growth of the fin at this spot during its development.

Asymmetron cultellum (PETERS).—Plate I., figs. 8–10.

Epigonichthys cultellus, PETERS, 1876; GILL, 1895; WILLEY, 1901.

Branchiostoma cultellum, GÜNTHER, 1884; and WILLEY, 1894.

Heteropleuron cultellum, KIRKALDY, 1895.

Only two specimens of this interesting species were present in the collection, one from near the coral reefs off Vangali (Stn. LII.), March 5th, in 3 fathoms, and the other from the East Cheval (Stn. XI.), February 4th, in 6 fathoms. They were both quite small, one measuring 23 millims. and the other 25 millims. Both had well-developed gonads, one being a male (the smaller of the two), and the other a female.

It is evident, therefore, that this species, like *A. cingalense*, is a small one as compared with *B. lanceolatum* and its variety *belcheri*.

The male had 17 gonads and the female 20 gonads, both on the right side. The myotome formula for the male specimen was 35, 12, 7—total, 54; while that of the female was 35, 12, 8—total, 55. There is, therefore, quite a close agreement between the two.

The best distinguishing feature of this species is the dorsal fin, which is so markedly swollen at its anterior end. This feature alone is usually quite a sufficient indication of the species (fig. 8). In *A. cingalense* the dorsal fin is slightly swollen at its anterior end. This condition is somewhat more emphasised in *A. maldivense*, a new species lately described by FORSTER-COOPER, from the Maldives (8). This new species seems to bear a remarkable resemblance to the specimens of *A. cultellum*, from Ceylon. The resemblance in the shape of the fins in particular is striking. In both the Ceylon specimens of *A. cultellum* the fin rays are absent from the ventral fin chambers.

The female specimen is well preserved and shows the notochord to be distinctly knobbed, one of the chief characters of the species (fig. 8). The male specimen is not so well preserved and does not show this knobbed notochord. In both specimens the dorsal fin overlaps the nervous system, and the notochord is prolonged in front of the dorsal fin rather more than KIRKALDY shows (figs. 8 and 9). The caudal fin also differs somewhat from KIRKALDY's figures, for while in the latter it is deeper and well marked off from the rest of the fins, in the Ceylon specimens the dorsal and ventral fins fade insensibly into the caudal fin, as shown in *A. maldivense* (8).

I have been able to confirm KIRKALDY in finding sensory-papillæ on the oral cirri of this species. WILLEY (4) had previously stated that the cirri were smooth. The papillæ were distinctly present in the female specimen from Ceylon.

CONCLUSIONS.

The whole collection has proved of very great interest in many ways. Although no new species are recorded, the fact that seven species (including var. *belcheri*) of the group occur round Ceylon, indicates the great wealth of the Acraniate fauna of these waters.

Four species are recorded from this neighbourhood for the first time—*Branchiostoma pelagicum*, *B. californiense*, *B. indicum*, and *Asymmetron cultellum*; while our knowledge of the geographical distribution of nearly all the species has been extended by this collection.

As regards the habitat of the animals, we have some indication in this collection that they live commonly in a clean coarse sand, made up, at least to some extent, of the shells of the large Foraminifera *Orbitolites* and *Heterostegina*.

The depths at which the specimens were taken range from 3 to 14 fathoms, in all cases comparatively shallow water.

The food of these tropical forms appears to consist largely of diatoms, especially of forms found growing over zoophytes, corals, shells, and other submarine objects. In nearly all, the alimentary canal was seen to contain the skeletons of such forms, and fæcal pellets showed the same.

The tables at the end of the report show how extremely variable the species of the group are, and the more extended our knowledge of this group becomes, the less distinctly do the species appear to be separated. The spawning time of the group in tropical seas appears to be the latter half of March, rather earlier in the year than in more temperate seas.

B. lanceolatum is recorded from the Indian Ocean for the first time. It appears to be a cosmopolitan species, being by far the most widely distributed of all the species. The tropical forms differ but slightly from their Mediterranean relations.

The variety (as I consider it) *B. belcheri* is the predominant form in these waters, and constitutes 60 per cent. of the present collection.

A. cingalense, as might be expected, is also well represented in the collection.

The fact that only two specimens of *A. cultellum* were found, suggests that Ceylon may be nearly at the limit of its distribution, and that it becomes more numerous as we approach Australia.

The re-discovery of *B. indicum* is interesting, and extends somewhat its known distribution.

Perhaps the most interesting specimens of the collection were those I have referred to *B. pelagicum*, and it is to be regretted that their state of preservation did not admit of a more complete study of their anatomy, which would probably show points of interest. The collection demonstrated, however, definitely, that this species is truly pelagic.

The most surprising find is *B. californiense*, which, though showing some slight variation, is in most respects the same as its American relations.

Finally, this tropical part of the Indian Ocean seems to be either the home of this group, or is exceedingly well populated, as no less than eight out of the eleven well characterised species have now been recorded from the seas around Ceylon, as follows:—

Branchiostoma lanceolatum	Ceylon	(HERDMAN), (ANDREWS ?)
Ditto, var. *belcheri*	Ceylon	(HERDMAN),
	Singapore	(BEDFORD).
Branchiostoma indicum	Orissa Coast of India	(WILLEY),
	Ceylon	(HERDMAN)
Branchiostoma pelagicum	Indian Ocean	(GARDINER)
	Gulf of Manaar	(HERDMAN)

Branchiostoma californiense (?)	Gulf of Manaar	(HERDMAN).
Asymmetron cingalense . . .	Ceylon	(KIRKALDY), (HERDMAN).
Asymmetron maldivense . . .	Maldives and Zanzibar . .	(GARDINER).
Asymmetron cultellum . . .	Ceylon	(HERDMAN).
Asymmetron lucayanum . . .	Maldives	(GARDINER),
	Zanzibar	(CROSSLAND).

The following tables give the numerical details in regard to every specimen in the collection :—

TABLE I.—*Branchiostoma lanceolatum* (10 specimens).

Locality.	Serial number.	Length.	Sex.	Number of gonads.	Myotome formula. Pre-atrial.	Pre-anal.	Post-anal.	Total.
		millims.						
(1.) Galle, 7 fathoms	I.	40	m.	21 R. 21 L.	37	12	11	60
	II.	36	m.	21 R. 21 L.	37	13	11	61
(2.) 10 miles North of Cheval Paar, 7½ fathoms . . .	III.	41	m.	not determined	36	11	13	60
	IV.	36	f.	24 R. 24 L.	35	14	12	61
	V.	26	f.	22 R. 22 L.	37	11	11	59
(3.) Periya Paar Kerrai, 7½ fathoms	VI.	35	m.	24 R. 24 L.	36	13	12	61
(4.) Off Watering Point, Galle, 9 fathoms . . .	VII.	33	—	gonads small	35	14	12	61
	VIII.	35	—	none	37	12	12	61
	IX.	30	—	,,	36	13	11	60
	X.	31·5	—	,,	36	12	12	60
Mean	—	34·35	4 m. 2 f.	22·4 R. 22·4 L.	36·2	12·5	11·7	60·1
Mode	—	—	—	—	36	13	12	61
Range	—	16	—	4	3	4	3	3

TABLE II.—*B. lanceolatum*, var. *belcheri* (58 specimens).

Locality.	Serial number.	Length.	Sex.	Number of gonads.	Myotome formula. Pre-atrial.	Pre-anal.	Post-anal.	Total.
		millims.						
(1.) 10 miles North of Cheval Paar, 7½ fathoms . . .	I.	52	f.	—	37	18	9	64
	II.	48	f.	—	37	17	9	63
	III.	52	f.	—	37	18	9	64
	IV.	56	f.	—	37	18	9	64
	V.	50	m.	—	37	17	9	63
	VI.	46	f.	—	38	18	8	64
	VII.	32	f. immature	—	38	17	9	64
(2.) Off Karativo Paar, 10 fathoms . .	VIII.	46	f.	—	38	17	10	65
	IX.	40	m.	—	38	17	9	64
(3.) Off Karkopani, 8 fathoms . . .	X.	49	m.	20 R. 20 L.	38	17	8	63
	XI.	39	none	—	39	17	8	64
(4.) Off Mutwal Island, 14 fathoms . .	XII.	43	f.	—	39	17	10	66
	XIII.	42	f.	—	39	17	damaged.	
	XIV.	27	—	immature	38	16	10	64
(5.) Periya Paar Kerrai, 7½ fathoms.	XV.	54	f.	26 R. 26 L.	38	17	9	64
	XVI.	52	f.	27 R. 25 L.	37	17	9	63
	XVII.	55	f.	24 R. 26 L.	38	18	8	64
	XVIII.	48	m.	29 R. 26 L.	37	17	9	63
(6.) Off Chilaw Paar, 10 fathoms . .	XIX.	50	f.	24 R. 24 L.	38	17	9	64
	XX.	53	m.	21 R. 19 L.	38	17	9	64
	XXI.	42	—	none	38	16	10	64
	XXII.	43	f.	23 R. 20 L.	37	17	9	63
	XXIII.	35	—	none	38	17	9	64
	XXIV.	53	f.	28 R. 26 L.	38	—	damaged.	
(7.) West Cheval Paar, 7½ fathoms . .	XXV.	55	f.	25 R. 25 L.	38	17	9	64
	XXVI.	48	f.	27 R. 25 L.	37	16	10	63
	XXVII.	52	f.	30 R. 27 L.	38	17	10	65
	XXVIII.	49	f.	(?) R. 15 L.	37	17	9	63
	XXIX.	48	f.	27 R. 24 L.	38	17	9	64
	XXX.	52	f.	27 R. 23 L.	38	17	9	64
	XXXI.	52	f.	25 R. 25 L.	38	17	9	64
	XXXII.	46	m.	30 R. 27 L.	38	17	9	64
	XXXIII.	27	—	none	37	17	9	63
(8.) Near Periya Paar, 11 fathoms . .	XXXIV.	32	—	,,	38	17	9	64
	XXXV.	35	—	,,	39	17	9	65
	XXXVI.	33	—	,,	38	18	9	65
	XXXVII.	28	—	,,	38	17	9	64
	XXXVIII.	30	—	,,	37	17	9	63
	XXXIX.	28	—	,,	38	17	8	63
	XL.	26	—	,,	38	18	9	65
	XLI.	26	—	,,	39	17	9	65
	XLII.	26	—	,,	38	17	9	64
	XLIII.	28	—	,,	39	17	9	65
	XLIV.	32	—	,,	39	17	9	65

TABLE II.—*B. lanceolatum*, var. *belcheri* (58 specimens)—continued.

Locality.	Serial number.	Length.	Sex.	Number of gonads.	Myotome formula. Pre-atrial.	Pre-anal.	Post-anal.	Total.
		millims.						
(9.) South-west of Cheval Paar, 8½ fathoms	XLV.	47	m.	not counted	37	17	9	63
	XLVI.	54	f.	,,	38	18	8	64
	XLVII.	40	m.	,,	39	17	8	64
	XLVIII.	43	f.	,,	39	17	8	64
	XLIX.	43	m.	,,	38	17	9	64
	L.	45	f.	,,	38	17	10	65
	LI.	49	f.	,,	38	17	8	63
	LII.	33	—	,,	38	17	9	64
	LIII.	25	—	,,	36	18	9	63
	LIV.	27	—	,,	39	17	8	64
	LV.	29	—	,,	38	17	9	64
	LVI.	35	f.	,,	38	—	damaged.	
	LVII.	44	m.	,,	38	17	9	64
	LVIII.	46	f.	,,	38	17	9	64
Mean	—	41·64	28 f. 10 m.	—	37·9	17·4	9	64·3
Mode	—	—	—	—	38	17	9	64
Range	—	32	—	—	3	3	3	4

TABLE IV.—I., II., *Asymmetron cultellum*; III., IV., *Branchiostoma indicum*; V., *B. californiense* (?).

Locality.	Serial number.	Length, millims.	Sex.	Number of gonads.	Myotome formula. Pre-atrial.	Pre-anal.	Post-anal.	Total.
Coral Reefs off Van-gali, 3 fathoms	I.	23	m.	17 R.	35	12	7	54
East Cheval Paar, 6 fathoms	II.	25	f.	20 R.	35	12	8	55
Galle, 4¾ fathoms	III.	36	m.	25 L. 29 R.	43	14	13	70
Off Watering Point, Galle, 9 fathoms	IV.	17	—	none	41	14	14	69
Cheval Paar, 6 fathoms	V.	42	—	none	40	20	12	72

Table III.—*Asymmetron cingalense* (19 specimens).

Locality.	Serial number.	Length.	Sex.	Number of gonads.	Myotome formula. Pre-atrial.	Pre-anal.	Post-anal.	Total.
		millims.						
(1.) Half mile East of Dutch Modragam, 8 fathoms.	I.	30	f.	22 R.	39	16	8	63
	II.	31	f.	25 R.	39	15	8	62
(2.) South of Adam's Bridge, 8 fathoms . . .	III.	32·5	m.	26 R.	39	16	9	64
(3.) Off Karkopani, 8 fathoms . . .	IV.	36	f.	25 R.	39	17	6	62
(4.) Cheval Paar, 7½ fathoms . . .	V.	25	m.	23 R.	37	16	9	62
(5.) South-west of Cheval Paar, 8 fathoms . . .	VI.	25	m.	22 R.	39	16	9	64
	VII.	29	f.	uncertain	37	17	7	61
(6.) West of Periya Paar, 11 fathoms	VIII.	31·5	m.	18 R.	39	17	8	64
	IX.	30	m.	23 R.	39	16	8	63
	X.	31	m.	23 R.	39	16	8	63
	XI.	23	f.	24 R.	39	16	8	63
	XII.	24	m.	22 R.	39	16	8	63
	XIII.	24	f.	25 R.	39	16	8	63
	XIV.	23	m.	23 R.	39	16	8	63
	XV.	20	m.	18 R.	39	16	8	63
(7.) West of Periya Paar, 12 fathoms	XVI.	21	—	24 R.	39	16	8	63
	XVII.	25	f.	24 R.	39	16	8	63
	XVIII.	22	m.	21 R.	39	16	8	63
	XIX.	23	—	22 R.	39	16	8	63
Mean	—	26·5	7 f. 10 m.	21·6 R.	38·8	16·1	8	63·7
Mode	—	—	—	—	39	16	8	63
Range	—	17	—	9	3	3	4	4

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EXPLANATION OF PLATE.

Fig. 1. Caudal fin of *Branchiostoma lanceolatum.* All the Ceylon specimens conform more or less to this type.

Fig. 2. Head of No. IV., Table I., *B. lanceolatum*, to show the dark patch anterior to the dorsal fin and dorsal to the notochord.

Fig. 3. Caudal fin of *B. lanceolatum*, var. *belcheri.* Very uniform throughout the Ceylon specimens.

Fig. 4. Caudal fin of *Asymmetron cingalense.*

Fig. 5. Anterior end of No. X., Table III., *A. cingalense*, the only one in which relation of notochord to dorsal fin anteriorly is the same as in Kirkaldy's figure.

Fig. 6. The general arrangement of the anterior end of the Ceylon specimens of *A. cingalense.*

Fig. 7. Anterior end of No. XIII., Table III., *A. cingalense*, to show peculiar structure in the dorsal fin.

Fig. 8. Female *A. cultellum.*

Fig. 9. Anterior end of male *A. cultellum.* Notochord not definitely clubbed.

Fig. 10. Caudal fin of male *A. cultellum.*

Fig. 11. *B. indicum.*

Fig. 12. Anterior end of large *B. indicum.*

Fig. 13. Caudal fin of large *B. indicum.*

Fig. 14. Anterior end of *B. californiense* (?).

Fig. 15. Posterior end of *B. californiense* (?).

Fig. 16. *B. pelagicum.*

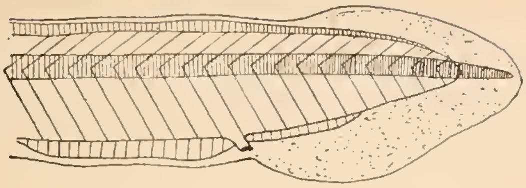

Fig 1

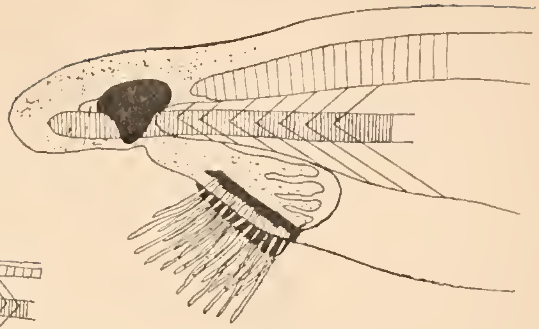

Fig 2

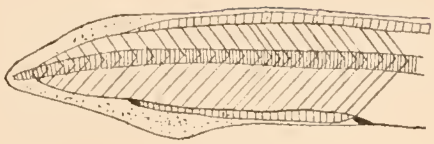

Fig 3

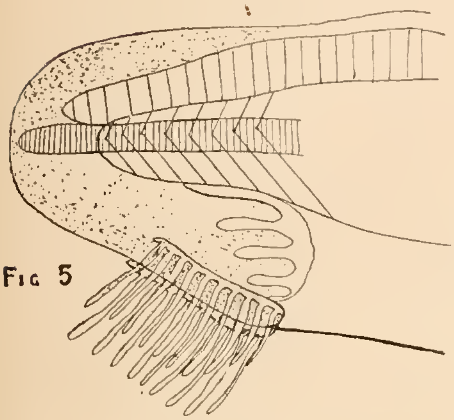

Fig 5

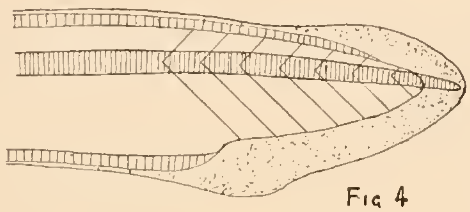

Fig 4

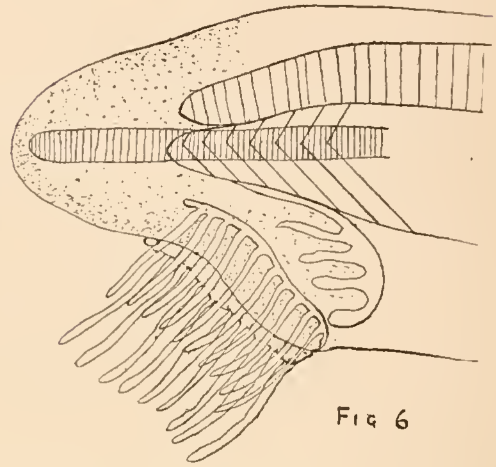

Fig 6

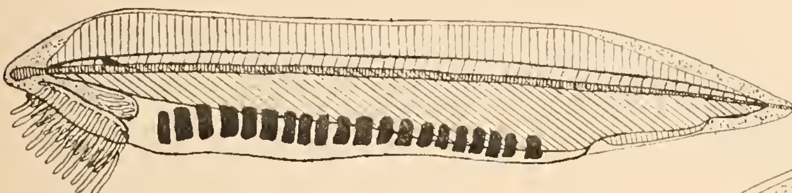

Fig 8

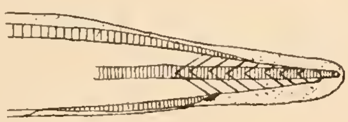

Fig 10

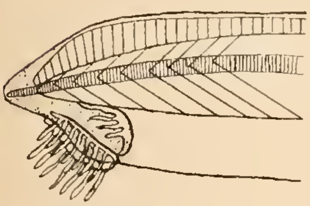

Fig 9

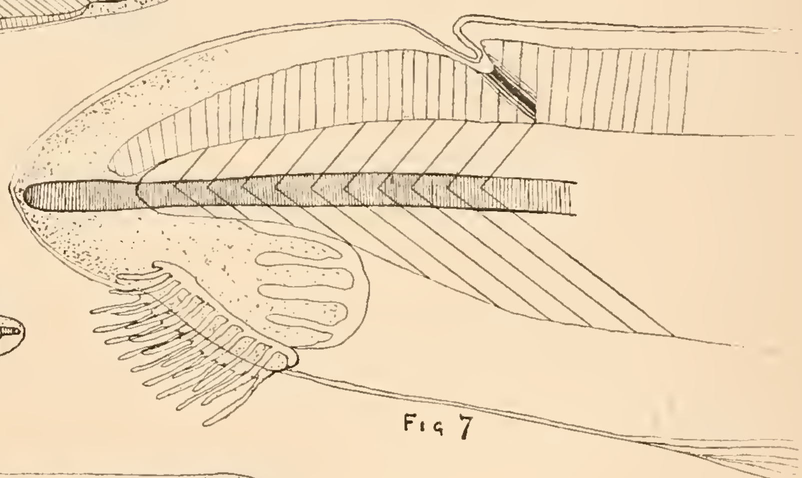

Fig 7

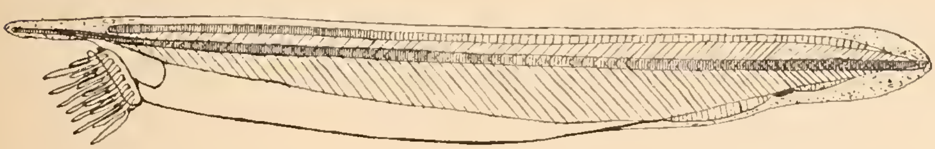

Fig 11

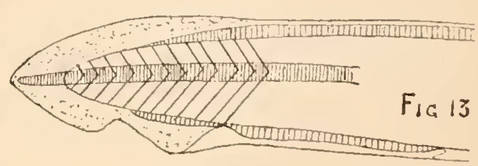

Fig 13

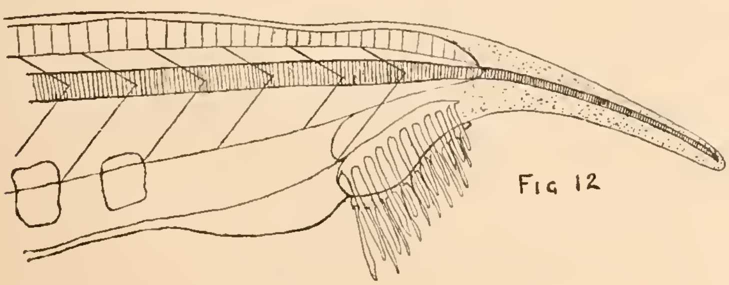

Fig 12

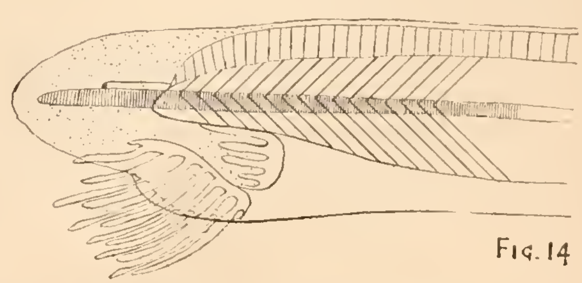

Fig. 14

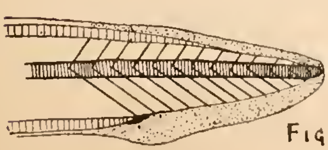

Fig. 15

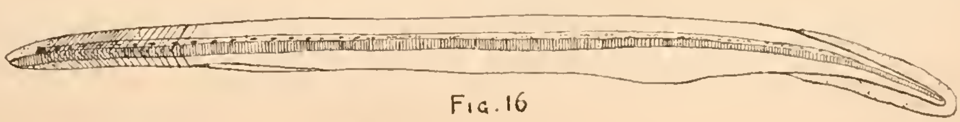

Fig. 16

REPORT

ON THE

COPEPODA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

ISAAC C. THOMPSON, F.L.S., AND ANDREW SCOTT, A.L.S.

[WITH PLATES I. TO XX.]

THE COPEPODA contained in the collections brought home by Professor HERDMAN may be conveniently divided into four sections, viz. :—(1) those obtained during the voyages out and home; (2) those collected by the tow-net around the Island of Ceylon; (3) those obtained by examination of washings from dredged material (Ascidians, Sponges, Corals, Pearl Oysters, &c.); and (4) the parasitic species found attached to fishes. The collection was contained in 122 bottles, each bottle representing a gathering from one of the stations shown in the appended list. The free-swimming species naturally form by far the largest part of the collection, although they do not contain most of the novelties. Some of the gatherings were preserved in formol, and others in alcohol. Out of the total number, those marked 1 to 41 were collected on the voyages to Ceylon and home, and most of the others during Professor HERDMAN's three months' work round Ceylon, while some have been sent since by Mr. HORNELL as the result of his further work. Professor HERDMAN's method of collecting material from a fast steamer has already been described in the 'Transactions of the Liverpool Biological Society.' The water containing the material enters the ship some feet below the surface and is pumped into the tank from which baths, &c., are supplied. On this occasion he was fortunate enough to have the entire use of one of the bath-rooms, a tow-net being fixed to the tap so that sea-water was running through it day and night. By this means it is practicable to collect material from the whole of the route traversed, and mostly in good condition.

This collection of Copepoda has proved to be exceedingly rich and varied, containing as it does no less than 283 species, of which 76 are new to science, while at least ten new genera are required. The list of new forms is as follows :—

Ridgewayia typica, n. gen. & sp.
Centropages tenuiremis, n. sp.
C. dorsispinatus, n. sp.
Pontella danæ, var. *ceylonica*, nov.
Labidocera pectinata, n. sp.
L. kroyeri, var. *stylifera*, nov.
,, var. *gallensis*, nov.
Pontellopsis herdmani, n. sp.
Sunaristes inopinata, n. sp.
S. longipes, n. sp.
S. curticaudata, n. sp.
Tegastes imthurni, n. sp.
T. donnani, n. sp.
T. twynami, n. sp.
T. chalmersi, n. sp.
Stenhelia brevicornis, n. sp.
S. gracilicaudata, n. sp.
S. longicornis, n. sp.
S. perplexa, n. sp.
S. dentipes, n. sp.
S. minuta, n. sp.
S. knoxi, n. sp.
Parastenhelia hornelli, n. gen. & sp.
P. similis, n. sp.
Ameira minor, n. sp.
A. tenuipes, n. sp.
Ceylonia aculeata, n. gen. & sp.
Laophonte hirsuta, n. sp.
Laophontella typica, n. gen. & sp.
Tetragoniceps dubia, n. sp.
T. minor, n. sp.
Dactylophusia dentata, n. sp.
D. havelocki, n. sp.
D. hirsuta, n. sp.
D. ceylonica, n. sp.
D. hamiltoni, n. sp.
D. robusta, n. sp.
D. laticaudata, n. sp.
D. æmula, n. sp.
D. platysoma, n. sp.
Peltidium ovale, n. sp.
P. angulatum, n. sp.
P. speciosum, n. sp.
P. serratum, n. sp.
P. perplexum, n. sp.
Porcellidium brevicaudatum, n. sp.
P. acuticaudatum, n. sp.
P. ravanæ, n. sp.
Pseudanthessius maximus, n. sp.
P. chelifer, n. sp.
P. concinnus, n. sp.
Lichomolgus gracilis, n. sp.
L. ieversi, n. sp.
L. lankensis, n. sp.
L. buddhensis, n. sp.
L. simplex, n. sp.
L. elegans, n. sp.
L. robustus, n. sp.
L. gigas, n. sp.
L. dentipes, n. sp.
Paralichomolgus curticaudatus n. gen. & sp.
P. longicaudatus, n. sp.
Hermannella robusta, n. sp.
H. serendibica, n. sp.
Hersiliodes leggii, n. sp.
H. tamilensis, n. sp.
H. dubia, n. sp.
Asterocheres manaarensis, n. sp.
A. major, n. sp.
A. minor, n. sp.
Asteropontius typicus, n. gen. & sp.
A. attenuatus, n. sp.
Collocheres giesbrechti, n. sp.
Lepeopsyllus typicus, n. gen. & sp.
L. ovalis, n. sp.
Doropontius denticornis, n. gen. & sp.
Cletopontius serratus, n. gen. & sp.
Stephopontius typicus, n. gen. & sp.
Chondracanthus cynoglottidis, n. sp.

The large majority of these new species were found in the gatherings from the pearl banks in the Gulf of Manaar, where Professor HERDMAN and Mr. HORNELL were working for some weeks. The dissection and drawing of so many new forms has involved a vast amount of close labour and diligent research, and Mr. THOMPSON must here be allowed to state that this portion of the work, and indeed the chief part of the laborious examination of the material, was undertaken and has been skilfully carried out by Mr. ANDREW SCOTT, whose previous experience of this group of animals makes his co-operation invaluable.

The species, known and new, from the collection represent the families as follows :—

Calanidæ	44 species.	Oncæidæ	8 species.
Centropagidæ	29 ,,	Corycæidæ	29 ,,
Pseudocyclopidæ	1 ,,	Lichomolgidæ	13 ,,
Candaciidæ	10 ,,	Asterocheridæ	18 ,,
Pontellidæ	31 ,,	Ergasilidæ	2 ,,
Cyclopidæ	8 ,,	Caligidæ	4 ,,
Ascidicolidæ	3 ,,	Chondracanthidæ	2 ,,
Harpacticidæ	78 ,,	Lernæopodidæ	3 ,,

LIST OF COLLECTING STATIONS.

I. Voyage Out (Stations 1 to 24).

1. English Channel to Gibraltar . . . . (36 species) Dec. 28–31, 1901.
2. Gibraltar to Marseilles . . . . (25 ,,) Jan. 2, 1902.
3. Marseilles to Messina . . . . (38 ,,) ,, 5

ERRATUM.

For *Dactylophusia* read *Dactylopusia* throughout Report on Copepoda.

16. ,, ,, ,, (coarse net) . . . . . ([illegible] ,,) ,, [illegible]
17. ,, ,, ,, (fine net) . . . . . (41 ,,) ,, 17
18. ,, ,, ,, (coarse net) . . . . (39 ,,) ,, 17
19. ,, ,, ,, (mostly fine net) . . . (36 ,,) ,, 18
20. ,, ,, ,, (coarse net) . . . . (35 ,,) ,, 18
21. ,, ,, off Minikoi (coarse net) . . . . (56 ,,) ,, 19
22. ,, ,, ,, (fine net) . . . . . (56 ,,) ,, 19
23. ,, ,, Maldives to G. of Manaar (coarse net) (40 ,,) ,, 20
24. ,, ,, ,, ,, ,, (fine net) (42 ,,) ,, 20

as it does no less than 283 species, of which 76 are new to science, while at least ten new genera are required. The list of new forms is as follows :—

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S. perplexa, n. sp.
S. dentipes, n. sp.
S. minuta, n. sp.

D. robusta, n. sp.
D. laticaudata, n. sp.
D. æmula, n. sp.
D. platysoma, n. sp.

Peltidium ovale, n. sp.
P. angulatum, n. sp.
P. speciosum, n. sp.
P. serratum, n. sp.
P. perplexum, n. sp.
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P. acuticaudatum, n. sp.
P. ravanæ, n. sp.
Pseudanthessius maximus, n. sp.
P. chelifer, n. sp.
P. concinnus, n. sp.
Lichomolgus gracilis, n. sp.
L. ieversi, n. sp.
L. lankensis, n. sp.
L. buddhensis, n. sp.
L. simplex, n. sp.
L. elegans, n. sp.
L. robustus, n. sp.
L. gigas, n. sp.
L. dentipes, n. sp.

[illegible], n. gen. & sp.
Cletopontius serratus, n. gen. & sp.
Stephopontius typicus, n. gen. & sp.
Chondracanthus cynoglottidis, n. sp.

The large majority of these new species were found in the gatherings from the pearl banks in the Gulf of Manaar, where Professor HERDMAN and Mr. HORNELL were working for some weeks. The dissection and drawing of so many new forms has involved a vast amount of close labour and diligent research, and Mr. THOMPSON must here be allowed to state that this portion of the work, and indeed the chief part of the laborious examination of the material, was undertaken and has been skilfully carried out by Mr. ANDREW SCOTT, whose previous experience of this group of animals makes his co-operation invaluable.

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Candaciidæ	10	,,	Asterocheridæ	18	,,
Pontellidæ	31	,,	Ergasilidæ	2	,,
Cyclopidæ	8	,,	Caligidæ	4	,,
Ascidicolidæ	3	,,	Chondracanthidæ	2	,,
Harpacticidæ	78	,,	Lernæopodidæ	3	,,

LIST OF COLLECTING STATIONS.

I. Voyage Out (Stations 1 to 24).

1.	English Channel to Gibraltar	(36 species)	Dec.	28–31, 1901.
2.	Gibraltar to Marseilles	(25 ,,)	Jan.	2, 1902.
3.	Marseilles to Messina	(38 ,,)	,,	5
4.	Messina to Port Said	(38 ,,)	,,	8
5.	Port Said to Suez	(31 ,,)	,,	9
6.	Gulf of Suez	(28 ,,)	,,	10
7.	South end of Gulf of Suez to 300 miles south	(44 ,,)	,,	11
8.	Red Sea	(43 ,,)	,,	12
9.	South end of Red Sea (coarse net)	(37 ,,)	,,	13
10.	,, ,, (fine net)	(45 ,,)	,,	13
11.	Perim to 200 miles into Indian Ocean (fine net)	(43 ,,)	,,	14
12.	,, ,, ,, (coarse net)	(33 ,,)	,,	14
13.	Indian Ocean, south of Socotra (fine net)	(53 ,,)	,,	15
14.	,, ,, ,, ,, (coarse net)	(53 ,,)	,,	15
15.	,, ,, going east (fine net)	(59 ,,)	,,	16
16.	,, ,, ,, (coarse net)	(47 ,,)	,,	16
17.	,, ,, ,, (fine net)	(41 ,,)	,,	17
18.	,, ,, ,, (coarse net)	(39 ,,)	,,	17
19.	,, ,, ,, (mostly fine net)	(36 ,,)	,,	18
20.	,, ,, ,, (coarse net)	(35 ,,)	,,	18
21.	,, ,, off Minikoi (coarse net)	(56 ,,)	,,	19
22.	,, ,, ,, (fine net)	(56 ,,)	,,	19
23.	,, ,, Maldives to G. of Manaar (coarse net)	(40 ,,)	,,	20
24.	,, ,, ,, ,, ,, (fine net)	(42 ,,)	,,	20

II. Voyage Back (Stations 25 to 41).

25.	Colombo to Minikoi (return voyage)	(17 species)	April	8–9, 1902.
26.	Minikoi onwards to west	(41 ,,)	,,	9–10
27.	Indian Ocean, further west	(41 ,,)	,,	10–11
28.	,, ,, ,,	(36 ,,)	,,	11–12
29.	,, ,, ,,	(40 ,,)	,,	12–13
30.	,, ,, ,,	(33 ,,)	,,	13–14
31.	South of Aden to Red Sea	(27 ,,)	,,	14–15
32.	Red Sea	(33 ,,)	,,	15–16
33.	,,	(22 ,,)	,,	16–17
34.	,,	(26 ,,)	,,	17–18
35.	Gulf of Suez and Suez Canal	(21 ,,)	,,	18–19
36.	Suez Canal (12 hours)	(12 ,,)	,,	19
37.	Port Said, Mediterranean onwards	(23 ,,)	,,	20–21
38.	South of Crete (air 63° F., sea 63·5° F.)	(20 ,,)	,,	21–22
39.	Crete to Messina	(16 ,,)	,,	22–23
40.	Messina to Sardinia	(6 ,,)	,,	23–24
41.	Strait of Bonifacio to Marseilles	(9 ,,)	,,	24

III. Round Ceylon.

42.	Four hauls off Negombo (Station I.*)	(11 species)	Jan.	31, 1902.
43.	Off Chilaw (Station III.)	(25 ,,)	Feb.	1
44.	Chilaw Paar (Station V.)	(18 ,,)	,,	2
45.	Off Kalpentyn Island—night and early morning	(11 ,,)	,,	2–3
46.	Muttuvaratu Paar, 11.30 A.M.	(18 ,,)	,,	3
47.	Cheval and Periya paars	(29 ,,)	,,	4
48.	Pamban Pass, 8 A.M.	(18 ,,)	,,	5
49.	Palk Bay (Station XVIII.)	(6 ,,)	,,	6
50.	Back Bay, Trincomalee (Station XX.)	(8 ,,)	,,	7
51.	,, &c., Trincomalee	(9 ,,)	,,	8
52.	Surface, 5 miles east of Arugam Bay	(26 ,,)	,,	12
53.	Galle, after dark, 9 P.M.	(11 ,,)	,,	14
54.	,, ,, 8 P.M.	(9 ,,)	,,	15
55.	,, surface outside bay, daylight	(36 ,,)	,,	17
56.	Off Pantura, south of Colombo	(26 ,,)	,,	19
57.	North of Karativo, Kodramallai Point	(22 ,,)	,,	25
58.	$2\frac{3}{4}$ miles S.S.W. of Chilavaturi, bottom 15 fathoms	(14 ,,)	,,	26
59.	To south of Cheval Paar	(41 ,,)	,,	26
60.	Modragam Paar	(19 ,,)	March	1

* Stations with roman numerals, in brackets, are the dredging stations (see "Narrative," p. 17).

61.	Off south bar, Manaar, surface.	(10 species)	March	3, 1902.
62.	Off Manaar Island	(12 ,,)	,,	3
63.	Cheval Paar	(35 ,,)	,,	4
64.	,, ,, ...	(21 ,,)	,,	4
65.	North of East Cheval Paar (Station LII.) . . .	(28 ,,)	,,	5
66.	10 miles N. of Cheval, bottom net, 7 fms. (Sta. LIII.)	(22 ,,)	,,	6
67.	South of Adam's Bridge, 12 fathoms.	(15 ,,)	,,	7
68.	,, ,, ,, surface	(23 ,,)	,,	7
69.	,, ,, ,, ,, ...	(22 ,,)	,,	8
70.	Dutch Modragam Paar, surface	(17 ,,)	,,	10
71.	Karativo Paar, 6 to 10 fathoms	(23 ,,)	,,	10
72.	Donnan's Muttuvaratu Paar, 8 fathoms . . .	(28 ,,)	,,	11
73.	West of Periya Paar, deep net	(15 ,,)	,,	13
74.	Vankali Paar, 9 fathoms (phosphorescent) . . .	(15 ,,)	,,	13
75.	South-east of Modragam	(10 ,,)	,,	17
76.	Off Mutwal Island	(12 ,,)	,,	19
77.	Chilaw Paar (Station LXIX.)	(12 ,,)	,,	20
78.	Donnan's Muttuvaratu Paar	(35 ,,)	,,	29
79.	Mudalaikuli Paar	(21 ,,)	,,	30
80.	Talaivillu Paar, all day	(22 ,,)	April	1
81.	Navakaddu Paar	(11 ,,)	,,	2
82.	Galle	(5 ,,)	June	5
83.	,, Bay	(4 ,,)	,,	14
84.	,, Harbour	(7 ,,)	July	3
85.	,, 9 A.M.	(3 ,,)	,,	7
86.	,, Harbour	(8 ,,)	,,	12
87.	,, ,, ...	(16 ,,)	,,	15
88.	,, ,, 8 A.M.	(3 ,,)	,,	20
89.	,, ,, 9 A.M.	(2 ,,)	,,	31
90.	,, ...	(6 ,,)	August	1
91.	,, 5 P.M.	(1 ,,)	,,	8
92.	Pearl banks, washed from Medusæ	(11 ,,)	(no date)	
93.	Galle, 3 P.M.	(4 ,,)	August	12
94.	South-east Cheval Paar, at anchor	(15 ,,)	Nov.	11
95.	East Cheval Paar, centre	(2 ,,)	,,	6
96.	,, ,, ...	(9 ,,)	,,	7
97.	,, ,, ...	(3 ,,)	,,	8
98.	Periya Paar Kerrai, daylight	(10 ,,)	,,	9
99.	,, ,, night	(9 ,,)	,,	9
100.	West Cheval	(12 ,,)	,,	10
101.	,, ,, ...	(8 ,,)	,,	11

102.	Periya Paar, night	(9 species)	Nov.	13, 1902.
103.	South-west Cheval	(2 ,,)	,,	14
104.	Kondatchi Paar	(5 ,,)	,,	17
105.	Muttuvaratu Paar	(4 ,,)	,,	19
106.	,, pearl oyster washings	(46 ,,)	,,	19
107.	Cheval Paar	(8 ,,)	Feb. & Mar., 1902.	
108.	Pearl banks, washings from dredged débris.	(6 ,,)	,,	
109.	Washings from young pearl oysters	(3 ,,)	,,	
110.	,, ,, deep water dredgings, Pt. de Galle	(3 ,,)	,,	
111.	General washings of dredged Invertebrates	(41 ,,)	,,	
112.	Washings from dredgings, G. of Manaar sponges.	(13 ,,)	,,	
113.	Tow-net off Marichchukaddi	(11 ,,)	Feb.	1, 1903.
114.	Modragam Paar, surface	(15 ,,)	,,	2
115.	Karativo, shoal buoy	(14 ,,)	,,	2
116.	South-east Cheval Paar, surface	(12 ,,)	,,	4–5
117.	East Cheval, surface	(8 ,,)	,,	7
118.	Cheval Paar	(14 ,,)	,,	9
119.	,, ,,	(only young *Calanus vulgaris*)	March	10
120.	,, ,,	,, ,, ,, ,,	,,	20
121.	East Cheval Paar	(5 species)	April	18
122.	Washings from Cheval Paar pearl oysters	(1 ,,)	,,	

Distribution of Species.

The Numbers refer to the Stations in the preceding List.

Calanus helgolandicus, 1, 2, 3, 37, 38, 41.

,, gracilis, 4, 21, 22, 38.

,, minor, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 24, 31, 34, 38, 39, 41, 43, 46, 47, 48, 49, 69, 78, 81, 92.

,, pauper, 3, 4, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 19, 21, 22, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 42, 43, 47, 49, 51, 52, 54, 55, 56, 60, 62, 63, 64, 65, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 79, 80, 94, 96, 98, 99, 102, 113.

,, darwini, 5, 9, 10, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 54, 68, 74, 80, 103.

,, vulgaris, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 42, 44, 45, 46, 47, 49, 50, 52, 53, 55, 56, 57, 59, 60, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 92, 94, 100, 101, 102, 104, 116, 117, 118, 119, 120.

Euchæta marina, 1, 2, 3, 4, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32, 50, 55, 56, 57, 71, 74, 78, 94, 99.

,, spinosa, 2, 3, 30.

,, acuta, 3, 4.

,, concinna, 9, 10, 34, 100, 102, 104, 105.

,, barbata, 28, 29.

Scolecithrix danæ, 12, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 74, 77.

,, bradyi, 3, 14, 15, 21. 22, 23.

,, chelipes, 34.

,, auropecten, 8.

,, tenuipes, 8.

Ridgewayia typica, n. gen. & sp., 106.

Phænna spinifera, 1, 9, 20.

Centropages chierchiæ, 1, 2, 21, 22, 64.

,, typicus, 2, 3, 37.

,, violaceus, 3, 7, 13, 16, 18, 37, 38, 40, 41, 52, 59.

,, furcatus, 6, 9, 10, 11, 13, 14, 15, 16, 24, 26, 27, 31, 32, 34, 35, 46, 48, 55, 56, 59, 63, 64, 65, 66, 68, 69, 74, 78, 115.

,, elongatus, 7, 15, 21, 22, 24, 27, 30, 34.

,, gracilis, 7, 10, 16, 17, 18, 22, 26, 28, 29, 30, 34, 35, 55, 56.

,, kroyeri, 13, 14.

,, calaninus, 15, 17, 18, 19, 20, 21, 26, 27, 56, 59, 72.

,, orsini, 30, 46, 59, 64, 65, 70, 71, 76, 78, 79, 80.

,, tenuiremis, n. sp., 13, 43, 47, 53, 54, 56, 59, 60, 63, 64, 65, 69, 70, 71, 79, 94, 96, 98, 99, 101, 107.

,, dorsispinatus, n. sp., 75.

Isias clavipes, 1.

Pseudodiaptomus salinus, 5, 6, 7, 35, 36, 37.

,, serricaudatus, 11, 13, 15, 43, 53, 54, 55, 57, 58, 59, 61, 70, 71, 72, 79, 80, 91, 92, 107, 113.

,, aurivillii, 47, 48, 59, 60, 65, 66, 69, 80.

Temoropia mayumbæensis, 6, 7.

Temora longicornis, 1, 4.

,, discaudata, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 42, 43, 45, 47, 48, 52, 55, 56, 57, 59, 60, 61, 63, 64, 65, 66, 68, 69, 70, 71, 73, 74, 75, 76, 98, 99, 100, 101, 114, 116, 118.

,, stylifera, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 43, 52.

,, turbinata, 43, 59, 64, 73, 82.

Metridia lucens, 1, 2, 3, 4, 5.

Pleuromamma gracilis, 1, 2, 3, 4, 11, 12, 13, 14, 15, 16, 21, 22, 23, 24, 26, 27, 28, 29, 30, 32, 33, 34, 35, 39.

Pleuromamma xiphias, 1.
,, abdominalis, 3, 4, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 32, 33, 34, 35.
Lucicutia flavicornis, 1, 2, 3, 4, 5, 7, 8, 13, 15, 21, 22, 23, 26, 27, 28, 29, 30, 37, 38, 39, 78.
Heterorhabdus spinifrons, 3, 11, 13, 14, 16, 21, 22.
,, papilliger, 12.
,, abyssalis, 12.
,, clausi, 27.
Pseudocyclops obtusatus, 15, 108, 122.
Candacia armata, 1.
,, simplex, 3, 9, 10, 11, 13, 14, 16, 23, 32, 55, 59, 63, 64, 94, 98, 99, 100, 101, 102.
,, bispinosa, 3, 9, 37.
,, bradyi, 7, 9, 10, 11, 13, 15, 20, 24.
,, truncata, 7, 8, 13, 14, 16, 17, 20, 21, 22, 23, 24, 26, 29, 33, 34, 55, 56, 100, 117.
,, catula, 7, 8, 13, 15, 16, 21, 22, 26, 27, 29, 32, 34, 55, 56, 59, 77, 78.
,, longimana, 9, 10, 11.
,, æthiopica, 9, 13, 14, 16, 17, 18, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 72.
,, curta, 9, 10, 11, 14, 56, 99.
,, pachydactyla, 14, 16, 17, 20, 21, 22, 23, 30, 56, 72, 74.
Calanopia elliptica, 5, 7, 9, 10, 11, 12, 13, 14, 21, 22, 23, 24, 32, 35, 36, 37, 43, 47, 48, 49, 52, 54, 55, 57, 58, 59, 64, 67, 68, 69, 72, 75, 77, 79, 102, 114, 116.
,, minor, 7, 9, 10, 14, 15, 22, 23, 24, 26, 32, 35, 36, 42, 43, 47, 48, 59, 64, 66, 70, 78, 79, 92, 94, 96.
,, aurivillii, 82, 83, 85, 90, 114, 115, 118, 121.
Labidocera acuta, 5, 9, 10, 11, 12, 13, 14, 15, 20, 21, 23, 26, 31, 32, 45, 46, 47, 48, 49, 52, 55, 57, 59, 60, 61, 63, 64, 65, 66, 69, 73, 74, 75, 76, 102, 103, 113, 116, 117.
,, minuta, 9, 12, 13, 14, 15, 16, 31, 33, 43, 46, 47, 48, 55, 59, 68, 71, 73, 98, 99, 100.
,, detruncata, 17, 19, 20, 21, 26, 27, 50.
,, pavo, 46, 50, 51, 53, 54, 55, 57, 58, 59, 60, 61, 65, 93, 98.
,, kroyeri, 45, 46, 57, 65, 98, 99, 100, 101, 102, 103, 117.
,, ,, var. stylifera, 72, 75, 76, 77, 93.
,, ,, var. gallensis, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58.
,, pectinata, n. sp., 48.
Pontella danæ, var. ceylonica, 46, 57, 60, 63, 65.

Botryllophilus ruber, from Sponges, Ceylon.
Sunaristes paguri, 111.
,, inopinata, n. sp., 111.
,, longipes, n. sp., 111.
,, curticaudata, n. sp., 111.
Longipedia coronata, 35, 36, 38.
,, minor, 113.
Canuella perplexa, 5.
Ectinosoma atlanticum, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 39, 40, 41, 42, 43, 45, 46, 47, 51, 52, 54, 56, 57, 58, 60, 61, 64, 65, 66, 67, 68, 69, 71, 72, 73, 78, 79, 80, 81, 92, 113, 115.
,, roseum, 2, 5, 6, 7, 8, 10, 11, 13, 14, 15, 17, 18, 19, 21, 22, 23, 24, 25, 26, 28, 29, 30, 31, 32, 33, 34, 35, 37, 42, 43, 45, 46, 48, 52, 53, 54, 56, 57, 58, 60, 61, 62, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 78, 79, 80, 81, 92, 114, 115.
,, normani, 106, 111.
,, propinquum, 106, 111.
Setella gracilis, 3, 6, 7, 8, 11, 13, 14, 15, 16, 18, 19, 21, 22, 23, 24, 25, 27, 30, 31, 33, 34, 35, 37, 38, 43, 47, 51, 52, 55, 56, 59, 62, 64, 66, 71, 72, 73, 78, 79, 80, 81, 115, 116, 118.
Miracia efferata, 19, 22, 24, 26.
,, minor, 1, 13, 15.
Euterpina acutifrons, 1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, 15, 18, 25, 29, 32, 35, 36, 39, 45, 46, 47, 48, 51, 52, 53, 56, 57, 58, 59, 60, 61, 63, 64, 66, 67, 68, 69, 73, 78, 80, 92, 113, 115, 116, 117, 118.
Tachidius littoralis, 6.
Clytemnestra scutellata, 11, 12, 13, 14, 15, 18, 19, 21, 22, 24, 56, 62, 118.
,, rostrata, 15, 16, 27, 28, 30, 31, 33, 37, 78.
Tegastes sphærica, 5.
,, nigrans, 106.
,, imthurni, n. sp., 106.
,, donnani, n. sp., 106.
,, twynami, n. sp., 106.
,, chalmersi, n. sp., 106.
Stenhelia brevicornis, n. sp., 106.
,, gracilicaudata, n. sp., 106.
,, longicornis, n. sp., 106.
,, perplexa, n. sp., 106.
,, dentipes, n. sp., 106.

Pseudanthessius maximus, n. sp., 86.
,, chelifer, n. sp., 108, 111.
,, concinnus, n. sp., 108.
,, liber, 111.
Lichomolgus minor, 5, 109, 111, 113.
,, gracilis, n. sp., 111.
,, ieversi, n. sp., 106, 111.
,, lankensis, n. sp., 111.
,, buddhensis, n. sp., 111.
,, simplex, n. sp., 112.
,, elegans, n. sp., 111.
,, robustus, n. sp., 111.
,, gigas, n. sp., 111.
,, dentipes, n. sp., 111.
Paralichomolgus curticaudatus, n. gen. & sp., 111.
,, longicaudatus, n. sp., 111.
Hermannella arenicola, 106, 109, 111.
,, robusta, n. sp., 111.
,, serendibica, n. sp., 112.
Hersiliodes leggii, n. sp., 112.
,, tamilensis, n. sp., 106.
,, dubia, n. sp., 5.
Oncea venusta, 1, 2, 3, 4, 7, 8, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 34, 35, 36, 37, 38, 52, 55, 56, 66, 68, 71, 72, 73, 74, 80.
,, media, 1, 2, 3, 6, 7, 12, 13, 14, 17, 19, 20, 21, 79, 114, 115, 116, 118.
,, subtilis, 1, 3, 4.
,, minuta, 1, 2, 3, 4, 6, 7, 10, 14, 15, 16, 17, 19, 25, 26, 28, 29, 31, 32, 34, 35, 38, 39, 42, 43, 50, 55, 63, 65, 78, 92.
,, mediterranea, 1, 4, 5, 7, 8, 9. 10, 11, 12, 13, 16. 18, 22, 23, 24, 37, 78, 80.
,, notopus, 5.
,, conifera, 13, 15.
Lubbockia squillimana, 6, 8, 10, 28, 32.
Corycæus venustus, 1, 2, 3, 4, 5, 6, 8, 10, 11, 12, 14, 15, 16, 19, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 42, 46, 47, 48, 50, 55, 56, 59, 60, 62, 64, 65, 66, 67, 69, 72, 78, 81.
,, rostratus, 2, 4, 38, 39, 40.
,, danæ, 3, 8, 10, 11, 13, 14, 15, 16, 17, 18, 19, 22, 23, 24, 26, 27, 31, 52, 55, 64, 65, 67.
,, furcifer, 3, 4, 17, 19, 55, 62, 73, 76, 77.
,, flaccus, 3, 4, 15, 37, 38, 39, 41.

Corycæus elongatus, 3, 7, 8, 22.
,, speciosus, 4, 5, 8, 9, 10, 11, 13, 14, 15, 16, 19, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32, 42, 55, 59, 68, 78.
,, lubbockii, 4, 11, 37, 39, 43, 47, 56, 64.
,, carinatus, 4, 7, 19, 22, 59.
,, ovalis, 4, 10, 11, 13, 14, 16, 21, 23, 24, 26, 29.
,, obtusus, 5, 8, 9, 10, 11, 13, 14, 15, 18, 19, 21, 22, 23, 24, 26, 27, 28, 30, 32, 38, 42, 43, 45, 46, 47, 48, 50, 51, 52, 53, 55, 56, 57, 58, 59, 60, 61, 64, 65, 66, 67, 68, 72, 73, 78, 79, 80, 114, 115, 118, 121.
,, gibbulus, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 43, 52, 55, 56, 57, 65, 69, 70, 71, 72, 78, 80, 81.
,, longistilis, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 69.
,, concinnus, 13, 15, 16, 17, 18, 20, 22, 25, 26, 27, 28, 29, 30, 52, 55, 59, 71, 72.
,, gracilicaudatus, 13, 14, 15, 18, 19, 21, 22, 25, 26, 27, 28, 29, 32, 33, 34, 52, 58, 71, 73.
,, robustus, 15.
,, tenuis, 15, 42, 65.
,, longicaudis, 78.
Copilia mirabilis, 7, 8, 9, 10, 15, 16, 17, 19, 20, 25, 94.
Sapphirina ovatolanceolata, 3, 4, 8, 9, 10, 13, 14, 15, 17, 19, 20, 29, 117.
,, gastrica, 9, 11.
,, ovalis, 12, 67.
,, nigromaculata, 14, 15, 21, 22, 23, 29, 59, 115
,, metallina, 17.
,, salpæ, 18, 101.
,, auronitens, 21.
,, bicuspidata, 23.
,, intestinata, 25.
,, sinuicauda, 74.
Asterocheres stimulans, 111, 112.
,, dentatus, 111, 112.
,, minutus, 111, 112.
,, manaarensis, n. sp., 112.
,, major, n. sp., 110.
,, minor, n. sp., 112.
Asteropontius typicus, n. gen. & sp., 112.
,, attenuatus, n. sp., 111.
Collocheres giesbrechti, n. sp., 111.

Scottocheres elongatus, 111.
,, longifurca, 111.
Lepeopsyllus typicus, n. gen. & sp., 106.
,, ovalis, n. sp., 111.
Doropontius denticornis, n. gen. & sp., 111.
Cletopontius serratus, n. gen. & sp., 111.
Stephopontius typicus, n. gen. & sp., 111.
Bradypontius siphonatus, 111.
Artotrogus orbicularis, 111.
Bomolochus scomberesocis.
,, unicirrus.
Caligus dakari.
,, diaphanus.
,, benedeni.
Lepeophtheirus thompsoni.
Chondracanthus cornutus.
,, cynoglottidis, n. sp.
Brachiella thynni.
,, merluccii.
Anchorella uncinata.

Fish Parasites.

COPEPODA.

Family: CALANIDÆ.

Calanus helgolandicus (Claus).

One of the commonest northern species. Taken at 6 stations in this collection, but not further south than the Mediterranean.

Calanus gracilis, Dana.

Less common than the preceding species, occurring at 4 stations, but similar in distribution.

Calanus minor (Claus).

Common throughout the route traversed, from the Mediterranean to the Indian Ocean, occurring at 33 stations.

Calanus pauper, Giesbr.

Taken at 58 stations; distribution similar to that of the last species.

Calanus darwini (Lubbock).

Less plentiful than the two preceding species, occurring at 27 stations, from the Red Sea southwards through the Indian Ocean.

Calanus vulgaris (DANA).

The most generally distributed of any species throughout the route traversed, occurring at 70 stations, from the Red Sea southwards.

Calanus robustior, GIESBR.

Only once taken, at Station 21, off Minikoi, in the Indian Ocean; previously known from the Atlantic and Pacific Oceans.

Eucalanus attenuatus (DANA).

Occurred plentifully at 18 stations, from the Red Sea southwards through the Indian Ocean to Ceylon.

Eucalanus pileatus, GIESBR.

Taken at 4 stations only, twice in the Red Sea and twice in the Indian Ocean, which adds to its hitherto known distribution in the Atlantic and Pacific.

Eucalanus crassus, GIESBR.

Occurred once in the Red Sea and at 4 stations round Ceylon; previously reported from the Indian Ocean.

Eucalanus subcrassus, GIESBR.

Occurred at 27 stations; twice in the Red Sea, and throughout the Indian Ocean.

Eucalanus subtenuis, GIESBR.

A few specimens were found from 9 stations, all in the sea round Ceylon.

Eucalanus monachus, GIESBR.

A rare species hitherto known only from the Mediterranean. Specimens were found, off Ceylon, at 2 stations, thus extending its known range to the Indian Ocean.

Rhincalanus cornutus (DANA).

Reported from 10 stations, all in the Indian Ocean. Previously known from the Mediterranean, the Atlantic, and the Pacific.

Rhincalanus nasutus, GIESBR.

Similar in distribution to the last species. Occurred at 8 stations in the collection.

Mecynocera clausi, I. C. THOMPSON.

Found at 27 stations, extending from the Red Sea throughout the Indian Ocean, the latter being an addition to its hitherto known distribution.

Paracalanus parvus (CLAUS).

One of the most widely distributed species throughout the regions traversed. Occurred at 65 stations, extending from the British coasts to the Ceylon pearl banks.

Paracalanus crassirostris, F. DAHL.

Found at 16 stations, all in the sea round Ceylon; not previously known from the Indian Ocean.

Metacalanus aurivillii, CLEVE—Plate II., figs. 18 to 20.

Occurred at 27 stations, all in the sea round Ceylon; previously known only from the Malay Archipelago. We show the female abdomen and the male and female fifth natatory legs of this species, as they are not represented in sufficient detail by CLEVE.

Acrocalanus gibber, GIESBR.

Found sparingly at 4 stations, from the Gulf of Suez and Indian Ocean.

Acrocalanus longicornis, GIESBR.

A much commoner species than the preceding, occurred at 33 stations, extending from the Red Sea throughout the Indian Ocean and around Ceylon.

Acrocalanus gracilis, GIESBR.

Occurred at 9 stations; general distribution similar to that of the two preceding species.

Acrocalanus monachus, GIESBR.

A few specimens of this rarer form were found at 2 stations between Minikoi and Sokotra. Previously known from the Pacific and Indian Oceans.

Calocalanus pavo (DANA).

This beautiful species, easily recognised by its elegant plumose furcal setæ, although rarely found perfect, has a wide range throughout the Atlantic, Pacific and Indian Oceans, and occurred at 33 stations, extending from Gibraltar through the Mediterranean, Red Sea, Indian Ocean, and around Ceylon.

Calocalanus plumulosus (CLAUS).

Similar in distribution to the last species, but less common. It occurred at 12 stations.

Clausocalanus furcatus (BRADY).

Well distributed throughout the entire traverse, occurring at 47 stations.

Clausocalanus arcuicornis (DANA).

Rarer than the preceding species, but similarly distributed. It occurred at 20 stations.

Pseudocalanus elongatus (BOECK).

One of the commonest British species; occurred at 6 stations, extending as far south as the Gulf of Suez.

Ætideus armatus, BRADY.

A species widely distributed throughout the Atlantic, Pacific and Indian Oceans, but only taken at 3 stations in this collection, from the Mediterranean to the Gulf of Suez.

Undeuchæta minor, GIESBR.

Occurred off Gibraltar, and at 2 stations in the Indian Ocean; the latter are additions to its hitherto known range.

Euchirella rostrata (CLAUS).

Occurred twice in the Indian Ocean.

Euchirella messinensis (CLAUS).

Only once taken, off Minikoi, west of Ceylon, thus considerably extending its southern range; the Mediterranean and the Gulf of Gascony being the only previous records.

Euchæta marina (PRESTAND.).

A common ocean species; occurred at 36 stations, extending throughout the entire traverse.

Euchæta spinosa, GIESBR.

Found very sparingly off Gibraltar and in the Mediterranean, and again off Ceylon; not previously reported from the Indian Ocean.

Euchæta acuta, GIESBR.

Taken at 2 Mediterranean stations, between Messina and Port Said.

Euchæta concinna, DANA.

Occurred at 3 stations in the Red Sea and at 4 stations round Ceylon.

Euchæta barbata, BRADY.

Occurred at 2 stations in the Indian Ocean near Ceylon. Known previously only from the Atlantic.

Scolecithrix danæ (LUBBOCK).

Taken at 18 stations in the Indian Ocean and round Ceylon.

Scolecithrix bradyi, GIESBR.

Occurred once in the Mediterranean, and at 6 stations in the Indian Ocean, the latter being an addition to its known range.

Scolecithrix chelipes, GIESBR.

Taken only at one station, in the Red Sea, its only known habitat.

Scolecithrix auropecten, GIESBR.

A rare species—was found in the Red Sea, an addition to its known range in the Mediterranean and Atlantic.

Scolecithrix tenuipes, T. SCOTT.

Like the preceding species, this was found in the Red Sea, its only previously known habitat being the Gulf of Guinea.

Ridgewayia, n. gen.

Body cyclopoid in form, 6 cephalothoracic segments well defined. Abdomen 4-jointed, anterior antennæ 25-jointed. Posterior antennæ 2-branched, the outer branch consisting of 2 joints, the inner branch of many joints and longer than the outer. Mouth organs very similar to those of *Calanus* and *Temora*.

Outer and inner branches of 1st to 4th natatory legs all 3-jointed. Outer branch of 5th pair 3-jointed; inner branch 2-jointed.

The male of the one species occupying this genus being unknown, it is not easy to fix with certainty the exact systematic position. In the anterior and posterior antennæ, as well as in the mouth organs of the female, it closely resembles the Calaninæ. In the segmentation of the first 4 pairs of natatory legs it agrees with *Calanus*, but not in the 5th pair. On the whole we think that the position of the genus should be amongst the Calanidæ. At the suggestion of Professor HERDMAN we have named this genus in honour of Sir WEST RIDGEWAY, who was Governor of Ceylon when the pearl oyster investigation was carried on.

Ridgewayia typica, n. sp.—Plate I., figs. 1 to 13.

Length, female 0·85 millim.; male unknown.

Cephalothorax 6-jointed, the cephalic segment equal in length to the four following combined. The 5th thoracic segment has a strong hook pointing downwards on its ventral surface. Rostrum short, broad and pointed. Abdomen 4-jointed, the genital segment very wide and equal in length to the following two united; it bears a similar hook to that of the last thoracic segment on its right side posteriorly. Furcal rami about twice as long as broad, each bearing 4 long terminal setæ.

Anterior antennæ 25-jointed, nearly equalling in length the cephalothorax. The proportional lengths of the joints are as follows:—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.
15.	20.	7.	7.	7.	7.	7.	7.	7.	7.	7.	7.	8.	8.	8.	9.	8.	8.	8.	7.	7.	11.	17.	21.	20.

Posterior antennæ 2-branched, the outer branch consisting of 2 joints, the inner of 8, the 2 basal and the apical joints being each about double the length of the intermediate ones. Mandible broad with 9 or 10 small teeth, palp 2-branched, one branch having 2, the other 4 joints. Maxilla well developed, inner branch composed of 2 large setiferous digits. First and second maxillipeds similar to those of the Calanidæ.

Natatory legs 1 to 4 with outer and inner branches all 3-jointed, the lateral and terminal spines destitute of serrations and hairs. The inner branch of 5th pair is 2-jointed; the outer branch 3-jointed, bearing lanceolate spines with serrated edges; the 3rd joint is attached to the centre of the 2nd joint.

Two specimens, both females, were found in the Muttuvaratu pearl-oyster washings.

This, the only known representative of the genus *Ridgewayia*, is easily recognised by the inner branch of the posterior antennæ, by the hooks on the last thoracic and genital segments, and by the 5th pair of natatory legs.

Phænna spinifera, CLAUS.

Occurred at 3 stations, near Gibraltar, in the Red Sea, and in the Indian Ocean.

FAMILY: CENTROPAGIDÆ.

Centropages chierchiæ, GIESBR.

Occurred at 5 stations, near Gibraltar, in the Indian Ocean, and about the Cheval Paar and other pearl banks, Ceylon. Not previously reported from the Indian Ocean.

Centropages typicus, KRÖYER.

A well-known northern species, common around the British coasts. Occurred at 3 stations in the Mediterranean.

Centropages violaceus, CLAUS.

Found at 11 stations, extending from the Mediterranean to the Red Sea, and throughout the Indian Ocean.

Centropages furcatus (DANA).

One of the commoner species of this genus. Occurred at 29 stations, from the Red Sea throughout the Indian Ocean.

Centropages elongatus, GIESBR.

Found at 8 stations, from the Gulf of Suez throughout the Indian Ocean.

Centropages gracilis (DANA).

Occurred at 14 stations, the range being much the same as that of the preceding species.

Centropages kroyeri, GIESBR.

Found twice in the northern Indian Ocean, in the vicinity of Socotra. The western Mediterranean appears to be its only previously known habitat.

Centropages calaninus (DANA).

Occurred at 11 stations in the Indian Ocean.

Centropages orsini, GIESBR.

This, like the preceding species, occurs at 11 stations, all in the Indian Ocean.

Centropages tenuiremis, n. sp.—Plate I., figs. 14 to 18.

Length, female 2·0 millims.; male 1·8 millims.

Body somewhat angular, widest anteriorly, slightly tapering to last segment of thorax, which is terminated by long outwardly extended lateral acute projections. Anterior antennæ of female 24-jointed, the proportional lengths being as follows:—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.
3.	4.	2.	2.	3.	3.	2.	3.	3.	4.	4.	5.	6.	7.	8.	8.	8.	8.	7.	5.	5.	5.	5.	5.

Male right antenna 24-jointed; joints 13 to 17 are considerably thickened; a geniculation occurs between the 18th and 19th joints.

Abdomen of female 4-jointed, of male 5-jointed, the last one very small.

Furcal ramus sub-linear, the length about three times the width. Terminal caudal setæ in the female have the basal portion thickened.

The basal joint of the right 5th natatory leg in the female is acutely produced on the inner side and bears three rows of minute teeth. The 5th legs in the male are in general similar to those of *C. typicus*, as are the other appendages not alluded to.

Large numbers of specimens, both male and female, were found at 21 stations round Ceylon.

The acute lateral terminal thoracic spines, the 5th natatory legs in the female, and the abdomen and furcal rami are the distinguishing features of this species.

Centropages dorsispinatus, n. sp.—Plate I., figs. 19 to 25.

Length, female 1·37 millims.; male 1·24 millims.

Cephalothorax ovate, the posterior segment having a rounded acute terminal projection. Rostrum short, broad and triangular. A remarkable curved beak-like hook adorns the median dorsal line of the posterior edge of the cephalic segment. Anterior antennæ of the female 24-jointed, the proportional lengths being as follows:—

1.	2.	3.	4.	5	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.
3.	5.	1.	1.	1.	1.	1.	1.	2.	2.	3.	3.	5.	5.	5.	6.	6.	6.	6.	5.	4.	3.	3.	4.

The 2nd, 5th, 10th and 11th joints bear spinous projections. Male right anterior antennæ 23-jointed, with a geniculation between the 18th and 19th joints.

Abdomen of female 4-jointed; of male 5-jointed, the last joint very small. Furcal rami slightly curved inwards, about twice as long as the width. Fifth natatory legs attenuated; the second joint of right leg in female has a long plain projecting spine on inner side. The chela of the male right natatory leg is clothed with short hair on the outer side.

The other appendages are similar to those of *C. typicus*. A number of specimens, male and female, were taken in Palk Straits, Ceylon.

The species is easily distinguished by the median dorsal cephalic hook, and by the 5th pair of natatory legs and the abdomen and furcal rami.

Isias clavipes, Boeck.

This British species was only taken once, in the first gathering. It ranges to the Mediterranean and Atlantic Ocean.

Pseudodiaptomus salinus, Giesbr.—Plate II., figs. 21 to 23.

Occurred at 3 stations in the Gulf of Suez and at 3 stations in the Indian Ocean, its only previous record being from the Red Sea.

Giesbrecht's specimen was a female, the male remaining unknown until now; we have the satisfaction to record it from the same stations at which the females were found. The male measures 1·25 millims., and its characters are shown by figs. 22 and 23, on Plate II. The female also measures 1·25 millims., and its fifth pair of legs are shown at fig. 21, Plate II.

Pseudodiaptomus serricaudatus (T. Scott).

Occurred at 20 stations throughout the Indian Ocean and about Ceylon.

Pseudodiaptomus aurivillii, Cleve—Plate II., figs. 24 to 26.

Found at 8 stations in the Indian Ocean. Fortunately the specimens include the male hitherto unknown. The female measures 1·2 millims. and the male ·93 millim. The characteristic appendages of both sexes are shown by figs. 24 to 26, on Plate II.

Temoropia mayumbæensis, T. Scott.

Two records for this rare species were added in the Gulf of Suez. The Gulf of Guinea is its only previously known habitat.

Temora longicornis (Müller).

This common British species was found at 2 stations, from the English Channel to the Mediterranean.

Temora discaudata, Giesbr.

One of the most widely distributed species throughout the regions traversed.

Occurred at 60 stations, from the Mediterranean southwards, throughout the Indian Ocean, and round Ceylon.

Temora stylifera (DANA).

Occurred at 16 stations, from the Red Sea southwards, through the Indian Ocean, and about Ceylon.

Temora turbinata (DANA).

Occurred first in the Gulf of Manaar, and at 4 other stations about the Ceylon Pearl Banks. Has been previously reported from the Pacific, New Zealand, and the Gulf of Guinea, but not from the Indian Ocean.

Metridia lucens, BOECK.

Fairly common, from the English Channel, through the Mediterranean, and as far as the Gulf of Suez, but not further south.

Both the latter localities are an extension of its known range of distribution.

Pleuromamma gracilis, CLAUS.

Occurred at 24 stations, from the English Channel onwards to the Indian Ocean, and in the open sea around Ceylon.

Pleuromamma xiphias, GIESBR.

This was taken in the first gathering only, probably near Gibraltar.

Its previously known range includes the Atlantic, Pacific and Indian Oceans.

Pleuromamma abdominalis (LUBBOCK).

Found at 28 stations, from the Mediterranean to the Indian Ocean, as far as Ceylon.

Lucicutia flavicornis (CLAUS).

Occurred at 21 stations, extending from the English Channel to the Indian Ocean, as far as Ceylon.

Heterorhabdus spinifrons (CLAUS).

Found once in the Mediterranean and again at 4 stations in the Indian Ocean and twice off Minikoi, near Ceylon.

Heterorhabdus papilliger (CLAUS).

Heterorhabdus abyssalis (GIESBR.).

Heterorhabdus clausi (GIESBR.).

The above three species were each taken once only. The two former between Perim and 200 miles into the Indian Ocean—the latter near Minikoi. Each record is an addition to the known distribution of the species.

Family: PSEUDOCYCLOPIDÆ.

Pseudocyclops obtusatus, Brady and Robertson.

A few specimens only were obtained in the northern Indian Ocean and about the pearl banks and Cheval Paar, Ceylon.

The British coast appears to be the only previously recorded habitat.

Family: CANDACIIDÆ.

Candacia armata (Boeck).

Taken only in the first gathering, between the English Channel and Gibraltar. It is probable that the tropical records of this species, long known as *C. pectinata*, Brady, refer to other Candacias, as more than one species is included in the figures of *C. pectinata* in the Report on the "Challenger" Copepoda, but none of them are identical with Boeck's *C. armata*.

Candacia simplex (Giesbr.).

Occurred at 19 stations, from the Mediterranean onwards through the Indian Ocean and at several of the Ceylon stations. Not before recorded from the Indian Ocean.

Candacia bispinosa (Claus).

Found on three occasions in the Mediterranean and the Red Sea. Previously reported from the Indian Ocean.

Candacia bradyi, A. Scott.

Occurred at 8 stations, extending from the Gulf of Suez into the Indian Ocean.

Mr. Scott's previous record was from Aden. It is probable that some of the previous records of *C. pectinata* from tropical seas are really this species.

Candacia truncata (Dana).

Occurred at 18 stations, from the Gulf of Suez onwards through the Indian Ocean to Ceylon.

Candacia catula (Giesbr.).

Occurred at 17 stations, the range being similar to that of the preceding species.

Candacia longimana (Claus).

Obtained at 3 stations only, from the south of the Red Sea and from Perim into the Indian Ocean.

Candacia æthiopica (Dana).

Range of this species is similar to that of *C. catula*; obtained at 17 stations.

Candacia curta (Dana).

Of similar range to the last species, but less plentiful; was found at 6 stations.

Candacia pachydactyla (Dana).

Obtained at 11 stations in the Indian Ocean and round Ceylon.

Family: PONTELLIDÆ.

Calanopia elliptica (Dana).

Taken between Port Said and Suez and then fairly continuously through the Indian Ocean and round Ceylon. Occurred at 37 stations.

Calanopia minor, A. Scott.

Of similar range to *C. elliptica*—occurred 25 times.

Calanopia aurivillii, Cleve.

Obtained at 4 stations in the vicinity of Galle and at 4 on the pearl banks. Cleve's specimens were from the Malay Archipelago.

Labidocera acuta (Dana).

Common from Port Said throughout the Indian Ocean and round Ceylon—occurred at 39 stations.

Labidocera minuta, Giesbr.

Occurred first at the southern end of the Gulf of Suez and then at 20 stations throughout the Indian Ocean and round Ceylon.

Labidocera detruncata (Dana).

Occurred at 7 stations in the Indian Ocean, and also found at Back Bay, Trincomalee.

Labidocera pavo, Giesbr.

Obtained at 14 Ceylon stations. Known previously only from the Red Sea.

Labidocera kroyeri (Brady).

Similar in distribution to last species: obtained at 11 Ceylon stations.

Labidocera kroyeri (Brady), var. **gallensis**, nov.—Plate II., figs. 6, 7.

Male differs from *L. kroyeri* in several particulars. The posterior thoracic segment in this variety is rounded at base, and has a trifid projection on the left side instead of a bifid one as in *L. kroyeri*. The 1st abdominal segment has a long narrow spine on its right basal corner. The end of basal portion of the claspers in the 5th natatory legs is very short and the chela more spinous than that of *L. kroyeri*. In other respects there is a close similarity between the species and this variety.

Taken in surface tow-nettings from Galle Harbour and elsewhere, Ceylon.

Labidocera kroyeri (BRADY), var. **stylifera**, nov.—Plate II., figs. 8, 9.

Male differs from *L. kroyeri* like the variety *gallensis* in the last thoracic segment and in the 5th natatory legs. The basal portion of the latter is produced into a long rod-like projection. Several specimens were taken at different stations round Ceylon.

Labidocera pectinata, n. sp.—Plate II., figs. 10 to 14.

Length, female, 2·1 millims. Male unknown.

Cephalothorax 5-jointed, robust in centre, slightly tapering towards each end, the terminal segment having strong lateral spinous projections. Rostrum short, bifid at apex. Anterior antennæ 23-jointed, in length about equal to the cephalothorax.

The relative lengths of the joints are as follows :—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.
6.	16.	2.	2.	2.	4.	4.	6.	5.	5.	8.	10.	10.	12.	16.	14.	16.	16.	10.	10.	10.	9.	9.

Posterior antennæ and mouth organs and 1st to 4th pairs of natatory legs as in the other members of this genus. Abdomen 3-jointed, about one-third as long as the cephalothorax ; the right basal extremity of the genital segment is produced into two curved spines ; the middle joint bears a knobbed protuberance. The furcal rami are slightly asymmetrical, the right one being nearly half as large again as the left ; the inner side of each is lined with fine hairs ; each furca terminating in five short setæ. Fifth natatory legs, each composed of two 1-jointed branches, asymmetrical, the inner branches being differently denticulated ; both branches of the left leg are larger than those of the right. The characters of the abdomen and 5th natatory legs are unlike those of any other species known to us.

Four specimens, all females, were taken in Palk Straits, Ceylon.

Pontella fera, DANA.

Found at 3 stations, viz., twice off Minikoi, Indian Ocean, and at Vankali Paar, Ceylon.

Pontella securifer, BRADY.

Taken off Minikoi, Indian Ocean, and at 10 stations round Ceylon.

Pontella princeps, DANA.

Was found once only, at Chilaw Paar, Ceylon.

Pontella tenuiremis, GIESBR.

Was found once only, in Palk Strait, Ceylon. GIESBRECHT'S specimen was from the Pacific Ocean.

Pontella danæ, var. **ceylonica**, nov.—Plate II., figs. 1 to 5.

Length, female 3·4 millims.

Cephalothorax of nearly the same width throughout, in this respect differing from

P. danæ, which tapers gradually from the second to the posterior thoracic segment. Rostrum nearly straight, length about double the width, and has bifid apex. Fifth natatory legs asymmetrical, the left having outer and inner branches larger than the right branches; the outer one has a large and small spine on the outer side.

First joint of abdomen somewhat globular, whereas that of *P. danæ* is more quadrate. A number of specimens, all females, were found at 5 stations around Ceylon. The 5th natatory legs and the shape of the abdomen serve to distinguish the variety from *P. danæ*, Giesbrecht.

Pontellina plumata, Dana.

Occurred at 17 stations, south of Gulf of Suez, in the Indian Ocean, and round Ceylon.

Pontellopsis armata (Giesbr.).

Occurred first between the Maldives and the Gulf of Manaar, and then at 9 Ceylon stations. Previously known from the Pacific and Indian Oceans.

Pontellopsis krameri (Giesbr.).

Occurred at 4 Red Sea stations. Giesbrecht's specimens were also from the Red Sea. The species has been recorded from Fortescue Strait by A. Scott.

Pontellopsis regalis, Dana.

The only specimen of this species was taken in the Mediterranean, near Messina.

Pontellopsis strenua (Dana).

Found only at Cheval and Periya paars, Ceylon.

Pontellopsis perspicax (Dana).

Like the last species, this was only taken on the Cheval and Periya paars.

Pontellopsis herdmani, n. sp.—Plate II., figs. 15 to 17.

Length, female 1·9 millims.; male unknown.

Cephalothorax about twice as long as its breadth, having 5 segments, the posterior segment terminating on each side with a triangular acuminated spine. Rostrum long, narrow, and bifid. Anterior antennæ 16-jointed, the relative lengths of the joints being as follows: $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.\ 7.\ 8.\ 9.\ 10.\ 11.\ 12.\ 13.\ 14.\ 15.\ 16.}{6.\ 7.\ 5.\ 8.\ 3.\ 5.\ 3.\ 5.\ 5.\ \ 6.\ \ 9.\ \ 6.\ \ 6.\ \ 7.\ \ 6.\ \ 6.}$

Posterior antennæ, mouth organs and 1 to 4 pairs of natatory legs as in the other species of *Pontellopsis*. Abdomen about half the length of the cephalothorax, composed of 2 joints, the first being about double the size of the second and having 2 thorn-like projections on the right side. Furcal rami twice as long as broad, with fine hairs on the inner surface and each terminating in 5 short non-plumose setæ.

Fifth pair of natatory legs each 2-branched; each branch composed of one bifid joint, the outer branches each having 3 small spines on outer edge. A few females were found in Galle Harbour and also off Karativo Island in the Gulf of Manaar.

The abdomen and 5th natatory legs distinguish this from any other described form. We have peculiar pleasure in naming it after Professor HERDMAN.

Acartia clausi, GIESBR.

A common British species. Occurred at the first 4 stations as far as the Gulf of Suez, and once off Ceylon at the south end of the Cheval Paar.

Acartia longiremis, LILLJ.

Taken at 9 stations, from the English Channel to the Mediterranean off Messina.

Acartia dubia, T. SCOTT.

Found in the Suez Canal and in the Red Sea.

Acartia erythræa, GIESBR.

Well distributed throughout the traverse, occurring at 53 stations, from the Gulf of Suez, throughout the Indian Ocean, and around Ceylon.

Acartia centrura, GIESBR.

Occurred in Gulf of Suez and the Red Sea, and at 6 stations round Ceylon. Previously reported from the Red Sea and Atlantic Ocean.

Acartia negligens, DANA.

Obtained at 38 stations, from Gulf of Suez onwards through the Indian Ocean, and common around Ceylon.

Tortanus gracilis (BRADY).

One record only from about the Gulf of Suez. BRADY records the species from the Philippine Islands.

Tortanus forcipatus (GIESBR.).

Occurred at 3 Ceylon stations only, viz., off Kalpentyn Island, Cheval and Periya paars, and off Pantura, south of Colombo. GIESBRECHT's specimens were from Amoy, China.

FAMILY: CYCLOPIDÆ.

Thorellia brunnea, BOECK.

Found in washings from sponges, Gulf of Manaar.

Oithona plumifera, BAIRD.

A common species, recorded from 40 stations almost continuously throughout the seas traversed.

Oithona similis, CLAUS.

Commencing at the Gulf of Suez, this species occurred at 38 stations; similar in distribution to *O. plumifera.*

Oithona minuta, T. SCOTT.

This species, first recorded from the Gulf of Guinea, appears to be abundant throughout the Indian Ocean and round Ceylon, occurring at 35 stations.

Oithona rigida, GIESBR.

Occurred in the Red Sea, about Minikoi, and at 18 stations around Ceylon.

Oithona spinifrons, BOECK.

This common British species, closely allied to *O. similis*, occurred in the earlier gatherings, and in the Red Sea and Northern Indian Ocean, to Ceylon.

Oithona nana, GIESBR.

Occurred at 3 stations on the Pearl banks, Ceylon.

Oithona setigera, DANA.

Taken on 4 occasions in the Mediterranean and once in the Suez Canal.

FAMILY: ASCIDICOLIDÆ.

Doropygus normani, BRADY.

A few specimens were taken from the branchial sac of a species of *Cynthia* found at the Aripu reef, Gulf of Manaar.

Doropygus pulex, THORELL.

Found attached to the branchial sac of a species of *Molgula*, from the Cheval and Periya paars, Ceylon.

Botryllophilus ruber, HESSE.

Found in washings from sponges, Gulf of Manaar.

FAMILY: HARPACTICIDÆ.

Sunaristes paguri, HESSE.

A few specimens were found in the general washings from Ceylon Invertebrates.

Sunaristes inopinata, n. sp.—Plate III., figs. 1 to 8.

Length, male 1·3 millims.; female 1·5 millims.

Body resembling *S. paguri*, but all the segments broader in proportion to length. Anterior antennæ of female 6-jointed, densely covered on the upper side with plumose setæ and bearing two long club-like appendages, possibly olfactory.

The relative lengths of the joints are as follows : $\frac{1.\ 2.\ 3.\ 4.\ 5.\ \ 6.}{11.\ 7.\ 7.\ 5.\ 4.\ 15.}$

Anterior antennæ of male short and broad, terminating in a curved hook.

Posterior antennæ and mouth organs as in *S. paguri*. Both branches of 1st to 4th pairs of natatory legs 3-jointed, most of the joints having small bundles of fine hairs on the surface or at the sides. Fifth pair as in *S. paguri*.

Abdomen about the same length as the cephalothorax, composed of joints of which the genital segment is the larger one. Furcal rami twice as long as the breadth, tapering to the apex, and each having a stout spine on inner margin. Several specimens were found in the general washings from Ceylon Invertebrates.

Sunaristes longipes, n. sp.—Plate III., figs. 9 to 11.

Length, female 1·5 millims.; male unknown.

Similar in build to the last species but more robust. Anterior antennæ 6-jointed and similar to *S. inopinata*, except in proportional lengths of joints, which are as follows : $\frac{1.\ 2.\ 3.\ 4.\ 5.\ \ 6.}{15.\ 7.\ 3.\ 5.\ 3.\ 19.}$

Abdomen short and robust, about equal in length to the first 3 thoracic segments. First 2 joints are coalescent, the 4th and especially the 5th very small. Furcal rami long and tapering, the length 3 times that of the breadth; each has a spine on both sides. Mouth organs as in *Longipedia*, *Canuella* and *Sunaristes*. Other organs as in last species, with the exception of 4th pair of natatory legs, which (fig. 10) are very narrow, the inner branch being nearly double the length of the outer one.

The length of the furcal rami and the elongated 4th pair of natatory legs serve to distinguish this species from others of the genus. One specimen only, a female, was found in the general washings from Ceylon Invertebrates.

Sunaristes curticaudata, n. sp.—Plate III., figs. 12 to 17.

Length, female, 1·6 millims. Male unknown.

First segment of cephalothorax equal in length to that of the four following segments combined, and much broader. Abdomen 4-jointed, about three-fourths of the length of the cephalothorax. Anterior antennæ 4-jointed, all adorned with plumose setæ, the second joint having also two spines. The proportionate lengths are as follows : $\frac{1.\ \ 2.\ 3.\ 4.}{12.\ 16.\ 5.\ 7.}$

Mouth organs as in *Longipedia*, *Canuella* and *Sunaristes*.

Other organs similar to those of *S. paguri*, with the exception of the inner branch of the 4th natatory legs, which in this species is 2-jointed (fig. 16). Caudal segments short, their length not much exceeding the width; the anterior inner corner of each is marked off by a dividing line. One specimen only was found in the general washings of Ceylon Invertebrates.

The form of the furcal rami is sufficiently diagnostic to distinguish this from other species of the genus. The fact that this species has the inner branch of the fourth pair of legs only 2-jointed may, sometime, necessitate its removal to a new genus.

Longipedia coronata, CLAUS.

Occurred at 2 stations in the Mediterranean and once in the Suez Canal. Usually a littoral species. Found also in washings from Sponges, Gulf of Manaar.

Longipedia minor, T. SCOTT.

A few specimens of this form were obtained in the tow-net off Marichchukaddy.

Canuella perplexa, T. and A. SCOTT.

One specimen was taken between Port Said and Suez.

Ectinosoma atlanticum (BRADY and ROBERTSON).

The most abundant species throughout the collection. Occurred at 66 stations, from the Mediterranean throughout the Red Sea and Indian Ocean and all around Ceylon.

Ectinosoma roseum, DANA.

Hardly less common than *E. atlanticum*. Fifty-nine stations, similarly distributed.

Ectinosoma normani, T. and A. SCOTT.

Ectinosoma propinquum, T. and A. SCOTT.

Both species found in washings from young pearl oysters and in the general washings from Ceylon Invertebrates.

Setella gracilis, DANA.

Occurred at 44 stations fairly continuously, from the Mediterranean to Ceylon.

Miracia efferata, DANA.

Was obtained in the Indian Ocean, twice off Minikoi, and between the Maldives and the Gulf of Manaar.

Miracia minor, T. SCOTT.

Was taken off Gibraltar, and was also found at 2 stations in the northern Indian Ocean. SCOTT'S specimens were taken in the Gulf of Guinea.

Euterpina acutifrons (Dana).

Well distributed throughout the traverse, occurring at 48 stations, from the Mediterranean to Ceylon.

Tachidius littoralis, Poppe.

One specimen was taken in the Gulf of Suez.

Clytemnestra scutellata, Dana.

Occurred at 10 Indian Ocean stations, and 3 round Ceylon, viz., off Pantura to the south of Colombo, at Cheval Paar and west of Periya Paar, Gulf of Manaar.

Clytemnestra rostrata (Brady).

Found at 8 stations, from the Mediterranean, Gulf of Suez, Red Sea, and the Indian Ocean, and once at Ceylon, near the Muttuvaratu Paar.

Tegastes sphærica (Claus).

One specimen of this littoral species was taken between Port Said and Suez.

Tegastes nigrans (T. and A. Scott).

A number of specimens were found in washings from Muttuvaratu pearl oysters.

Tegastes imthurni, n. sp.—Plate IV., figs. 1 to 9.

Length, female 0·6 millim. to 0·45 millim.; male unknown.

Cephalothorax composed of 6 segments; the first broadly falciform, and extending ventrally to double the width of the other segments.

Abdomen 4-jointed, the first extending ventrally into a long projection, truncated at end. A large rounded hook from the centre of the 1st segment projects over the posterior ends of the other segments.

Anterior antennæ 6-jointed, the relative lengths being: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.}{25.\ 18.\ 9.\ 4.\ 4.\ 4.}$

Posterior antennæ and mouth organs, with the exception of the 2nd maxillipeds, as in *T. sphærica*. In this species the inner concave edge of the chelate hand, instead of being pectinated, has a small funnel-shaped expansion, the upper circular edge being clothed with fine hairs. The inner projecting corner of the hand has, on the upper edge, about 10 short spines arranged in a pectinate manner.

The 1st pair of natatory legs are similar to *T. sphærica*. The 2nd, 3rd, and 4th pairs differ considerably from that species, however, and also from the generic description in Brady's Monograph of British Copepoda. In the 2nd and 3rd pairs of *T. imthurni*, and also in *T. donnani*, and in *T. twynami*, the inner branches are composed of 3 joints, while the outer branches have only 2 joints. The 4th pair has the outer branch 3-jointed, and has only 2 joints in the inner branch. The basal joint of the inner branch of this pair is a wide foliaceous expansion with thickened edges. The 5th pair in this and the following 3 species are also different from the type of the genus, and instead of being 2-jointed, are composed of 1 joint only, which, however, is obviously built up of 2 coalesced joints. Fig. 2 represents a smaller form, not differing in details of structure, except in the absence of hook from abdomen.

Several specimens were found in the washings from the Muttuvaratu pearl oysters.

At Professor HERDMAN'S suggestion we dedicate this new species to Mr. E. F. IM THURN, the Lieutenant-Governor of Ceylon at the time of the investigations.

Tegastes donnani, n. sp.—Plate IV., figs. 10 to 12.

Length, female, 0·37 millim.; male unknown.

In appearance and structure this species very nearly resembles *T. imthurni*, the 7-jointed anterior antennæ and the 5th natatory legs being the only important points of difference.

Proportionate lengths of antennary joints: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{26.\ 26.\ 12.\ 22.\ 4.\ 8.\ 7.}$

Four specimens, all females, were found in the Muttuvaratu pearl oyster washings. We name this species after Captain J. DONNAN, C.M.G., formerly Inspector of the Ceylon Pearl Fisheries.

Tegastes twynami, n. sp.—Plate IV., figs. 13 to 16.

Length, female 0·54 millim.; male unknown.

This species also resembles *T. imthurni* in detail, with the exception of the anterior antennæ, the hand of the 2nd maxillipeds, and the 5th natatory legs. The anterior antennæ are only 6-jointed, the proportionate lengths of the joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.}{13.\ 13.\ 10.\ 8.\ 5.\ 5.}$

The inner concave edge of the hand in 2nd maxilliped is strongly pectinated and has a round funnel-shaped protuberance with ciliated edge similar to that of *T. imthurni*; the terminal falcate claw is very stout. Fifth pair of natatory legs like those of *T. donnani*, but larger. Two specimens, both females, were found in the washings from the Muttuvaratu pearl oysters.

The cuticle in the foregoing species is covered with minute circular dots, these are also found on the basal joint of the fourth pair of legs, on the fifth pair and in a lesser degree on the chela of the posterior maxillipeds.

We name this species in honour of Sir WILLIAM TWYNAM, who has long been connected with the Ceylon Pearl Fisheries.

Tegastes chalmersi, n. sp.—Plate IV., figs. 17 to 22.

Length, female, 0·3 millim.; male unknown.

A much smaller form than any of the three preceding. Cephalothorax 5-jointed; length and breadth of 1st joint about equal.

Abdomen 3-jointed, the 1st joint being produced as in the other species of the genus, but different from them in having 4 large denticulations on its outer surface.

Anterior antennæ 7-jointed, the proportionate lengths of the joints being as follows : $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.\ 7.}{14.\ 10.\ 6.\ 4.\ 4.\ 4.\ 5.}$

The 2nd maxillipeds differ considerably from those of any of the preceding species. The middle joint is long and narrow, arcuate on one side and flat on the other, with short setæ on one-half of the flat side. The terminal spine is shaped like a scythe and about $\frac{3}{4}$ the length of the middle joint. Natatory legs as in *T. imthurni*, excepting 4th and 5th pairs. In the 4th pair the outer and inner branches are both 3-jointed, and the basal joint of the inner branch is not foliaceous. The 5th legs are less angular than those of the other species, the surface being covered with rows of convolute markings.

Two specimens, both females, were found in the Muttuvaratu pearl oyster washings. The anterior antennæ, the 2nd maxillipeds, and the 4th natatory legs readily distinguish this species from the others of the genus.

This species is named after Dr. A. J. CHALMERS, formerly a Liverpool Student of Science, now Registrar and Professor in the Medical College, Colombo.

Stenhelia brevicornis, n. sp.—Plate V., figs. 1 to 9.

Length, female, 0·9 millim. ; male unknown.

Cephalothorax narrow, 5-jointed. Anterior antennæ short, 8-jointed, the relative lengths of the joints being as follows : $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.\ 7.\ 8.}{18.\ 12.\ 10.\ 8.\ 3.\ 4.\ 6.\ 12.}$ Most of the joints are shorter than the breadth and bear numerous setæ. The 4th joint is produced on upper side, terminating in a long filament.

Posterior antennæ, mouth organs, and 1st to 4th pairs of natatory legs as in *S. ima*. The basal joint of 5th pair is large and triangular, bearing 6 marginal and apical setæ, two of them plumose ; second joint long and narrow, tapering towards apex and bearing six setæ, the apical one much longer than the marginal ones. Abdomen 5-jointed ; the posterior margin of the 1st joint has a dorsal hook, the margins of the other joints being fringed with fine hairs. Furcal rami about 3 times as long as broad.

Two specimens only, both females, were found in the Muttuvaratu pearl oyster washings. The short, broad-jointed anterior antennæ, the outer joint of the 5th natatory legs, and the long furcal rami are the chief distinguishing features of this species.

Stenhelia gracilicaudata, n. sp.—Plate V., figs. 10 to 15.

Length, female, 0·67 millim. ; male unknown.

Cephalothorax 5-jointed, very robust. Anterior antennæ 8-jointed, the proportional lengths of the joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ 5.\ 6.\ 7.\ \ 8.}{14.\ 20.\ 10.\ 11.\ 4.\ 5.\ 3.\ 10.}$ They are well clothed with setæ on the upper side. The 4th joint is produced and terminates in a long narrow filament.

Posterior antennæ and mouth organs as in *S. brevicornis.* Natatory legs in general similar to those of *S. brevicornis*, but the 1st pair differs therefrom in the respective lengths of its joints; the 5th pair is less triangular, the second joint being ovate. Abdomen 5-jointed, about the same length as the cephalothorax, but only half the width, and non-setiferous on posterior edges. Furcal rami about 4 times as long as broad.

One specimen only, a female, was found in the Muttuvaratu pearl oyster washings.

The chief distinguishing features are the anterior antennæ, the 1st and 5th natatory legs, and the long narrow furcal rami.

Stenhelia longicornis, n. sp.—Plate V., figs. 16 to 22.

Length, female, 0·8 millim.; male, 0·6 millim.

Cephalothorax similar to that of *S. brevicornis.* Anterior antennæ 8-jointed, long and narrow, the proportional lengths being: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ 5.\ 6.\ 7.\ 8.}{15.\ 24.\ 12.\ 11.\ 3.\ 4.\ 5.\ 7.}$ The 4th joint terminates in a long narrow filament; the setæ of the various joints as in *S. gracilicaudata.*

Posterior antennæ and mouth organs and 2nd to 4th pairs of natatory legs as in *S. brevicornis.* The 1st pair of legs agrees in form with *S. gracilicaudata*, as also does the 5th pair in the female, with the exception of the spines of the inner joint, which in this species are shorter, more numerous, and mostly plumose. The outer joint has a pellucid circle near the outer edge. Fig. 21 shows the inner branch of the 2nd pair in the male, and fig. 22 the 5th leg of the male, which is much smaller than that of the female.

Abdomen short and broad, the 4th joint having a short tooth on lower edge. The furcal rami are very small, about half as long as broad. A few specimens of each sex were found in the Muttuvaratu pearl oyster washings. The long narrow anterior antennæ, the 5th natatory legs, and the small furcal rami are the distinguishing characters of this species.

Stenhelia perplexa, n. sp.—Plate VI., figs. 1 to 7.

Length, female, 0·6 millim.; male unknown.

Cephalothorax much resembles *S. brevicornis.* Anterior antennæ 8-jointed, the proportional lengths of joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ 5.\ 6.\ 7.\ 8.}{15.\ 17.\ 12.\ 10.\ 3.\ 4.\ 4.\ 8.}$

Posterior antennæ and mouth organs, with the exception of 2nd maxillipeds (fig. 3), as in *S. brevicornis.* Natatory legs all more or less similar to those of *S. longicornis.*

Abdomen broad, the joints mostly quadrate, posterior margins devoid of setæ. Furcal rami short and broad, produced downwards on inner edges; terminal setæ as in *S. longicornis*.

Several females were found in the washings from Muttuvaratu pearl oysters.

This species in many of its characters resembles other members of the genus, without agreeing with any one in all respects. The jointing of the anterior antennæ and the long 2nd maxillipeds are its chief distinguishing features.

Stenhelia dentipes, n. sp.—Plate VI., figs. 8 to 14.

Length, female, 0·56 millim.; male unknown.

Cephalothorax somewhat angular anteriorly, with long narrow pointed rostrum.

The antennæ in the only specimen found were missing, with the exception of the four basal joints on one side. Mouth organs as in *S. brevicornis*, with the exception of 2nd maxillipeds, the middle joint of which is broadly ovate, and the claw curved and slender.

The inner branch of the 1st pair of natatory legs is double the length of the outer branch; 2nd to 4th pairs as in *S. brevicornis*. Inner branch of 5th pair elongated, terminating in a short dagger-like spine; second joint long and gradually narrowing, ending in a small elegant foot-shaped protuberance having 2 apical and 5 lateral setæ. In this respect it somewhat resembles *S. blanchardi*, T. and A. SCOTT. Abdomen similar to *S. perplexa*; furcal rami twice as long as the width.

Found with the other members of the genus here described in the Muttuvaratu pearl-oyster washings. It can be readily distinguished by its 5th pair of natatory legs.

Stenhelia knoxi, n. sp.—Plate X., figs. 15 to 18.

Length, female 0·67 millim.; male unknown.

Cephalothorax and abdomen each with 5 segments. Anterior antennæ very stout 6-jointed, the proportional lengths being as follows: $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.}{12.\ 6.\ 3.\ 14.\ 8.\ 17.}$

Both branches of 1st to 4th pairs of natatory legs 3-jointed; outer branch of 1st pair has long, strong, lateral and terminal spines; 2nd joint of 5th pair ovate.

Three specimens, all females, were found in the Muttuvaratu pearl oyster washings.

We name this species after ROBERT KNOX, who escaped from the King of Kandy to the coast, at the pearl banks, in 1679.

Although the anterior antennæ are only 6-jointed instead of 8, in all other respects the characters agree with those of *Stenhelia*, so we have thought it best to include this species in that genus.

Stenhelia minuta, n. sp.—Plate VI., figs. 21 to 24.

Length, female, 0·5 millim.; male unknown.

This minute species bears a close resemblance to *S. brevicornis*, both in general form and in its mouth organs, posterior antennæ, and 2nd, 3rd, and 4th pairs of natatory legs. Anterior antennæ 8-jointed, the proportional length of the joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.\ \ 8.}{10.\ 12.\ 6.\ 10.\ 2.\ 3.\ 4.\ 6.}$

In its 1st pair of natatory legs it resembles *S. longicornis*, the 5th pair being similar to those of *S. gracilicaudata*.

One specimen only, a female, was found in the Muttuvaratu pearl oyster washings. Its minute size, the jointing of the anterior antennæ, and the 1st and 5th natatory legs constituted its chief features.

Parastenhelia, n. gen.

Anterior antennæ 9-jointed. Inner branch of posterior antennæ 3-jointed. Mandible palp with 2 branches each 1-jointed. Second maxilliped like a grasping hand. First pair of natatory legs has outer branch 3-jointed, inner branch 2-jointed. Inner branches of 2nd, 3rd, and 4th pairs all 3-jointed. Fifth pair foliaceous and 2-jointed. Abdomen in both sexes 5-jointed.

The characters which distinguish this genus from *Stenhelia* are the 9-jointed antennæ and the 2-jointed inner branch in 1st pair of natatory legs.

Parastenhelia hornelli, n. sp.—Plate VII., figs. 1 to 10.

Length, female 1 millim.; male 0·77 millim.

In general appearance, and in the jointing of cephalothorax and abdomen, this species much resembles the members of the genus *Stenhelia*.

Anterior antennæ of female 9-jointed, the proportional lengths of the joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.\ \ 8.\ \ 9.}{21.\ 20.\ 15.\ 12.\ 8.\ 11.\ 4.\ 3.\ 12.}$

The upper surface is plentifully clothed with long setæ. Inner branch of posterior antennæ 3-jointed, the 2 apical joints bearing several plumose spines.

Basal joint of mandible large, with lateral warty protuberance, and 3 rounded teeth at apex. Palp is of pyriform shape, having 3 plumose spines at apex, and laterally has 2 branches, each composed of 1 joint bearing several setæ. Second maxilliped is a grasping hand with ovate middle joint, terminating in a stout claw.

Inner branch of 1st pair of natatory legs 2-jointed, the 1st joint being $1\frac{1}{2}$ times the length of the entire 3-jointed outer branch; terminal joint very small.

Inner branches of 2nd, 3rd, and 4th pairs all 3-jointed in both sexes. Fifth pair foliaceous; basal joint triangular and bearing plumose spines. Second joint in female very long, wide at base and tapering towards apex, the edges having fine hairs, and the apex 6 spines, mostly plumose. Outer branch of male 5th pair half the size of the female and distinctly divided into 3 joints bearing spines, mostly plumose.

Several males and females were found in the washings from young pearl oysters, also in the general washings of dredged material, in deep water off Point de Galle, and in the Muttuvaratu pearl oyster washings. We have pleasure in dedicating this new form to our friend Mr. JAMES HORNELL, who worked with Professor HERDMAN in Ceylon.

The 9-jointed anterior antennæ and the 2-jointed inner branch of 1st pair natatory legs clearly separate this species from the genus *Stenhelia*, with which it in most other points agrees. These characters, together with the 3-jointed inner branch of 2nd pair of natatory legs in the male, as well as the remarkable 5th pair in both sexes, served to distinguish this species from any other genus known to us.

Parastenhelia similis, n. sp.—Plate X., figs. 8 to 14.

Length, female 1 millim.; male unknown.

Has a general resemblance to *P. hornelli*, but differs therefrom in the length of joints of anterior antennæ, in the 2nd maxillipeds, and in the 2nd branch of 5th natatory legs. Anterior antennæ 9-jointed, the proportional lengths of the joints being as follows: $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.\ 7.\ 8.\ 9.}{10.\ 9.\ 8.\ 7.\ 5.\ 5.\ 4.\ 2.\ 5.}$

Hand of 2nd maxillipeds gracefully curved; the apical claw long and stout. Inner joint of 5th pair of natatory legs long and wide; laterally lined with fine hairs; the terminal spines plumose. Furcal rami about twice as broad as long. Two specimens, both females, were found in the Muttuvaratu pearl oyster washings.

Ameira minor, n. sp.—Plate V., figs. 23 to 29.

Length, female 0·46 millim.; male unknown.

Cephalothorax narrow, 5-jointed. Anterior antennæ 8-jointed, the proportional lengths of the joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ 4.\ 5.\ 6.\ 7.\ 8.}{5.\ 20\ \ 12.\ 8.\ 4.\ 5.\ 3.\ 5.}$

The 4th joint terminates with a long narrow filament. Posterior antennæ similar to those of *A. longipes*. Mouth organs as in *A. longiremis*.

Natatory legs, 1st to 4th pairs, somewhat similar to those of *A. longipes*. The 5th pair much resemble those of *A. tenuicornis*.

Abdomen 5-jointed, the posterior edges of all the joints lined with minute hairs. Furcal rami subquadrate, each terminating in 2 thick and 3 thin setæ.

A considerable number of females only were found in the Muttuvaratu pearl-oyster washings. This is a very small species bearing a strong resemblance to the genus *Stenhelia*, but distinctly differing from members of that genus in having the inner branch of the posterior antennæ 1-jointed.

Ameira tenuipes, n. sp.—Plate VI., figs. 15 to 20.

Length, female 0·53 millim.; male unknown.

Cephalothorax 5-jointed. Rostrum short and wedge-shaped. Anterior antennæ profusely setose, 8-jointed, the proportional lengths of the joints being as follows:

$\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.\ \ 8.}{20.\ 21.\ 12.\ 8.\ 6.\ 6.\ 3.\ 5.}$ The 4th joint terminates with a long filament. The inner branch of posterior antennæ is 2-jointed, the 2nd joint being very small.

Mouth organs and 2nd, 3rd, and 4th pairs of natatory legs as in *A. minor*. First joint of inner branch of 1st pair of legs as long as entire 3-jointed outer branch; 3rd inner joint long and narrow.

Basal joint of 5th pair of legs triangular, bearing 2 short plumose setæ and 3 plain ones. Outer joint long and narrow, 4 times as long as broad; fringed on both sides with fine hairs, and having 4 terminal setæ and 1 lateral.

One specimen only, a female, was found in the Muttuvaratu pearl oyster washings. Although the inner branch of the posterior antennæ is 2-jointed, we have thought it best to include this species in the genus *Ameira*, with which it agrees in all other particulars. The 1st and 5th natatory legs readily distinguish it from other species.

Ceylonia, n. gen.

Cephalothorax and abdomen each 5-jointed. Anterior antennæ 7-jointed. Inner branch of posterior antennæ 1-jointed. Mandible palp with one small branch. Second maxilliped non-prehensile. Inner branches of 1st to 4th pairs of natatory legs all 2-jointed; outer branches 3-jointed; 5th pair foliaceous.

The genus *Ceylonia* is nearly related to *Mesochra*, and might have been incorporated therewith but for the structural difference in the 1st pair of natatory legs and in the maxillipeds.

Ceylonia aculeata, n. sp.—Plate VII., figs. 11 to 23.

Length, female 1·2 millim; male 1 millim.

Body robust throughout; cephalothorax and abdomen each 5-jointed, the first two abdominal joints imperfectly divided. Rostrum short and blunt.

Anterior antennæ short and stout, thickly setiferous, 7-jointed, a long thick filament protruding from the apex of 4th joint. The proportional lengths of the joints are as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{16.\ 12.\ 16.\ 9.\ 3.\ 6.\ 11.}$

Outer branch of posterior antennæ 2-jointed, the outer edge and apex of 2nd joint lined with 6 stout spines; inner branch composed of one joint with 2 apical spines.

Biting part of mandible consists of 3 large teeth; palp with small branch, spinous at apex. First maxilliped has terminal claw and two 1-jointed branches with apical plumose setæ. Second maxilliped wedge-shaped, non-prehensile, but with small curved rudimentary claw.

Inner branches of 1st to 4th natatory legs 2-jointed; outer branches 3-jointed. Inner branches of 1st pair only $\frac{2}{3}$ the length of outer branch, both bearing strong spines; a remarkable rod-like projection with hirsute termination extends from the centre of 1st joint of inner branch. The middle joint of outer branch of male

3rd pair of legs bears a long stout aculeate spine. Fifth pair of legs foliaceous; outer joint in female roundly ovate, both clothed with long spinous setæ. In the male 5th pair the joints are coalescent and terminate in dagger-shaped spines and plumose setæ. Furcal rami about $1\frac{1}{2}$ times as long as broad, each bearing a long thick terminal spine and short setæ.

Several females and 2 males were obtained from young pearl oyster washings, and from deep water off Point de Galle. The anterior and posterior antennæ, the mouth organs and the 1st and 5th pairs of natatory legs are clear distinguishing characters of this species.

Laophonte serrata, Claus.

Laophonte inornata, A. Scott.

Both of the above were taken at Cheval Paar, and were also found in general washings of Invertebrates from the pearl oyster beds.

Laophonte hirsuta, n. sp.—Plate VIII., figs. 1 to 8.

Length, female 0·5 millim.; male unknown.

Lateral edges of cephalothorax and abdomen fringed with minute hairs, giving the animal a hirsute appearance. First cephalic segment quadrately shield-shaped, produced postero-laterally, and equalling in size the rest of the cephalothorax and abdomen.

Anterior antennæ 6-jointed, the proportional lengths of the joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.}{13.\ 14.\ 14.\ 4.\ 3.\ 10.}$ The upper side is clothed throughout with short setæ, the protuberance of the 4th joint leading to a long narrow filament.

Posterior antennæ and mouth organs, with the exception of mandible, as in *L. horrida*. Mandible elongated and narrow, the palp being long and slender. Inner branch of 1st pair natatory legs remarkably robust, terminating in a very small joint and a short stout curved claw. Outer branch 2-jointed, the 2 joints not half the length of the 1st inner joint. The outer branch in 2nd, 3rd and 4th pairs is 3-jointed, the inner 2-jointed. The 5th pair have small basal joints and a long narrow second joint armed with plumose setæ. Furcal rami small, subquadrate.

Eleven specimens, all females, were obtained from the Muttuvaratu pearl oyster washings and the general washings of dredged Invertebrates.

The 1st and 5th natatory legs are sufficiently diagnostic of this species.

Laophontella, n. gen.

Body somewhat pyriform, the cephalic segment nearly half the animal's entire length. Anterior antennæ 5-jointed. Posterior antennæ and mouth organs appear to be as in *Laophontodes*. The 1st, 2nd, and 3rd pairs of natatory legs have both inner and outer branches 2-jointed, 4th pair with outer branch 3-jointed, and inner branch with 1 joint only; 5th pair 2-jointed, foliaceous.

Laophontella differs from both *Laophonte* and *Pseudolaophonte* in the absence of claws in the 1st natatory leg; from *Laophontodes* in the inner branch of 4th pair being only 1-jointed.

With only one specimen, however (a female), to judge from, the generic characters may in the future require some revision.

Laophontella typica, n. sp.—Plate VIII., figs. 9 to 16.

Length, female, 0·5 millim.; male unknown.

Cephalic segment long and tumid; produced posteriorly into long acute spines.

Lateral edges of abdomen more or less notched. Anterior antennæ nearly half as broad as long, 5-jointed, profusely setiferous, the proportional lengths of the joints being as follows: $\frac{1.\ 2.\ 3.\ 4.\ 5.}{16.\ 8.\ 5.\ 3.\ 4.}$ The 1st joint has two claw-like spines, and the 3rd joint another, of larger size.

Mouth organs similar to those of *Laophontodes*. Branches of 1st pair of natatory legs of equal length; outer branch 3-jointed, as are the outer branches of 2nd, 3rd, and 4th pairs; inner branch 2-jointed, the 1st joint being double the length of the 2nd, both branches terminating in long setæ. Inner branch of 2nd and 3rd legs 2-jointed, and of the 4th 1-jointed, all armed with strong spines. Basal joint of 5th pair small and spinous; outer joint small, bearing 7 spines. One specimen only, a female, was found in the Muttuvaratu pearl oyster washings. The stout rugged anterior antennæ, the notched abdominal segments, and the inner branches of the swimming feet clearly distinguish this species from other genera.

Cletodes linearis (Claus).

Taken in the Suez Canal, and also in various washings of Invertebrates from the Gulf of Manaar.

Tetragoniceps dubia, n. sp.—Plate VIII., figs. 17 to 22.

Length, female, 0·9 millim.; male unknown.

Cephalothorax 5-jointed, the cephalic segment equalling in length the following three combined, and considerably stouter. Rostrum short and blunt. Anterior antennæ 8-jointed, the 1st joint non-setose, but projecting posteriorly into a beak-shaped protuberance. The other joints very setose, the 4th bearing a long narrow filament. The proportional lengths of the joints are $\frac{1.\ \ 2.\ 3.\ 4.\ 5.\ 6.\ 7.\ 8.}{37.\ 14.\ 9.\ 6.\ 4.\ 5.\ 5.\ 9.}$

Posterior antennæ and mouth organs generally like those of *T. malleolata*. Inner branches of 1st to 4th pairs of natatory legs 2-jointed, the outer branches 3-jointed. Fifth legs 1-jointed, with partial segmentation, and having 10 setæ. A pyramidal spine projects from the surface. Furcal rami about twice as long as broad.

One specimen only, and that possibly an immature one, was found in the Muttuvaratu pearl oyster washings. It is nearly related to *T. malleolata*, with which we were at first disposed to place it. The 5th feet are, however, very different from, and the furca much shorter than in that species, so that it seems necessary to separate the present form.

Tetragoniceps minor, n. sp.—Plate VIII., figs. 23 to 28.

Length, female, 0·5 millim.; male unknown.

Closely related to *T. bradyi*; differing, however, from that species in the jointing of the anterior antennæ, and in the long narrow furcal rami. Anterior antennæ 8-jointed, the proportional lengths being as follows: $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.\ 7.\ 8.}{40.\ 14.\ 8.\ 7.\ 4.\ 3.\ 6.\ 8.}$ A long beak-like hook projects from the 2nd joint, by which it differs from *T. consimilis*.

The posterior antennæ, the mouth organs, and the 5 pairs of natatory legs are much the same as those of *T. bradyi*.

One specimen only was found in Muttuvaratu pearl oyster washings. The beaked 2nd joint of the anterior antennæ sufficiently distinguishes it from others of the genus.

Dactylophusia tisboides (Claus).

This littoral species was taken between Port Said and Suez.

Dactylophusia latipes (T. Scott).

Taken sparingly on the Ceylon pearl banks. Only previous record is Gulf of Guinea.

Dactylophusia dentata, n. sp.—Plate IX., figs. 1 to 10.

Length, female 1·2 millim.; male 0·83 millim.

Cephalothorax robust; cephalic segment about as long as the rest of the thoracic segments combined. Third and fourth segments have remarkably sharp dorsal teeth; abdomen narrow, little more than one-third the length of the cephalothorax; lateral margins of genital segment produced into a large blunt tooth. Anterior antennæ 8-jointed, the proportional lengths being as follows: $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.\ 7.\ 8.}{10.\ 11.\ 8.\ 9.\ 3.\ 4.\ 3.\ 4.}$

The prolonged apex of joint 4 bears a long broad filament. Inner branch of posterior antennæ 2-jointed. Mandible palp 2-branched, the primary branch having long terminal setæ. Second maxilliped has an angular hand and terminal claw of about the same length. Both branches of 1st pair of natatory legs 3-jointed; the basal inner joint half as long again as the entire outer branch; the other joints very small.

In the male the 2nd joint of inner branch of 2nd pair is produced into a long pointed dagger-like spine, broad at base. Fifth pair of female 2-jointed, foliaceous, the inner joint ovate; those of the male similar but smaller. Furcal rami subquadrate, about twice as long as broad, a thick chitinous band lining the inner edges.

Ten males and 5 females were found in the Muttuvaratu pearl oyster washings. The dentated thoracic and 1st abdominal segments, the 2nd maxillipeds, the male 2nd natatory legs, and the furcal rami clearly distinguish this species.

Dactylophusia havelocki, n. sp.—Plate IX., figs. 11 to 18.

Length, female 1 millim.; male unknown.

Anterior antennæ short, 8-jointed, the joints short, length and breadth of each nearly equal. Fourth joint bears a long narrow filament, and the proportional lengths of the joints are: $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.\ 7.\ 8.}{9.\ 8.\ 5.\ 6.\ 3.\ 4.\ 2.\ 6.}$

Mandible palp 2-branched, secondary branch small, distinctly 2-jointed. Hand of 2nd maxilliped rounded on one side, flat on the other; claw slender. Natatory legs similar to *D. dentata;* the inner branch of the 5th pair however is nearly quadrate instead of ovate. Furcal rami nearly twice as broad as long; basal portion of apical spines thick and jointed.

A few specimens, all females, were found in the Muttuvaratu pearl oyster washings. The short anterior antennæ and furca, coupled with the shape of the mandible palp, and the inner joint of the 5th natatory legs, characterize this species.

Dactylophusia hirsuta, n. sp.—Plate IX., figs. 19 to 24.

Length, female 1·2 millim.; male unknown.

All the segments of the abdomen covered with rows of fine short hairs. Anterior antennæ 9-jointed, the 4th joint bearing a long filament.

The proportional lengths of the joints are as follows: $\frac{1.\ \ 2.\ 3.\ \ 4.\ 5.\ 6.\ 7.\ 8.\ 9.}{14.\ 14.\ 7.\ 10.\ 3.\ 5.\ 4.\ 3.\ 9.}$

Basal joint of 2nd maxilliped has a row of small hairs near apex, and three terminal plumose setæ; hand small; the claw 2-jointed, long and narrow.

Inner branch of 1st pair of natatory legs as in *D. dentata*, but with shorter terminal spines; 5th pair not unlike those of *D. dentata*, but the length and armature of the setæ are distinctly different, and each joint has a pellucid patch on its surface. Furcal rami very short and hirsute.

Three specimens, all females, were found in the Muttuvaratu pearl oyster washings. The 9-jointed anterior antennæ, the hirsute abdomen, 2nd maxillipeds and furca, and the 5th pair of natatory legs serve to distinguish this species.

Dactylophusia ceylonica, n. sp.—Plate IX., figs. 25 to 32.

Length, female 1·3 millim.; male 0·96.

Posterior dorsal edges of thoracic and abdominal segments have each a row of fine hairs. Anterior antennæ 8-jointed, the proportional lengths of the joints being as follows : $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.\ 7.\ 8.}{11.\ 11.\ 5.\ 8.\ 3.\ 5.\ 2.\ 6.}$ The 4th joint bears a long thin filament.

First pair of natatory legs of female same as in *D. hirsuta ;* the inner branch in male has a remarkably long stout spine equalling in length the 1st joint, projecting from the 2nd basal joint. The 2-jointed inner branch of 2nd pair in male has 3 thick more or less curved spines at apex of 2nd joint. Outer joint of 5th pair in female about equal in size to the 1st joint. In the male both joints are exceedingly small.

Eighteen females and 13 males were found in the Muttuvaratu pearl oyster washings. The chief distinguishing characters of this species are the inner joints of 1st and 2nd male natatory legs, and the 5th pair in the female.

Dactylophusia hamiltoni, n. sp.—Plate X., figs. 1 to 7.

Length, female 1·1 millim. ; male unknown.

Cephalothorax and abdomen each with 5 segments.

Anterior antennæ 8-jointed, the proportional lengths of the joints being as follows : $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.\ 7.\ 8.}{12.\ 12.\ 10.\ 11.\ 3.\ 6.\ 4.\ 7.}$

A long filament springs from the prolongation of the 4th joint. Outer branch of posterior antennæ 3-jointed, a 2-jointed inner branch springing from the basal joint. Second maxillipeds large ; the apical claw strong, blunt at end. Inner joint of 5th pair of natatory legs subquadrate, about twice as long as broad. Abdomen long and slender ; furcal rami quadrate, about twice as long as broad.

One specimen only, a female, was found in the Muttuvaratu pearl oyster washings. The form of the 2nd maxillipeds, and 5th pair of natatory legs, and the abdomen, are characteristic of this species, which we name after Colonel Hamilton, a former inspector of the pearl banks.

Dactylophusia robusta, n. sp.—Plate X., figs. 19 to 24.

Length, female 0·64 millim. ; male unknown.

A small but moderately robust species with a very tumid cephalothoracic segment. Anterior antennæ 8-jointed. Joints long and narrow, with the exception of the 5th, which is very small ; the proportional lengths are : $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.\ 7.\ 8.}{14.\ 24.\ 12.\ 20.\ 4.\ 10.\ 7.\ 12.}$

Posterior antennæ, mandible, and maxilla similar to those of *D. gracilicaudata ;* 2nd maxillipeds have the palm straight and the lower side rounded. Outer branches of the 1st natatory legs much shorter than the inner branches. The middle joint of the outer branches longer than either the basal or apical joints ; 2nd, 3rd, and 4th legs resemble those of *D. tisboides.* The 5th pair have a large primary joint and a moderately long and narrow secondary joint. The primary joint is furnished with 5 setæ, and the secondary with 6 setæ. Abdomen 4-jointed, about half as long as the combined lengths of the cephalic and thoracic portions. Furcal rami small, longer than broad.

A few specimens were found in the washings from the Muttuvaratu pearl oysters.

D. robusta differs from other species in the structure of the anterior antennæ, and the 1st and 5th natatory legs.

Dactylophusia laticaudata, n. sp.—Plate XI., figs. 1 to 8.

Length, female 0·6 millim.; male unknown.

A small flat species of a yellow colour, resembling in general appearance *D. flava*. When only recently preserved, the 1st, 2nd, and 3rd thoracic segments present a band of deep brown madder colour; this band eventually disappears in spirit-specimens, and only the general colour remains. Anterior antennæ 6-jointed, short and robust; the proportional lengths are: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.}{13.\ 12.\ 9.\ 8.\ 5.\ 4.}$

Secondary branch of posterior antennæ 2-jointed; basal joint very short; 2nd joint long. Mandible as in *D. tisboides;* palp with 2 nearly equal branches. The lower branch is furnished with 2 strong spines situated in the middle of the external margin. Maxilla and 1st maxilliped resembling those of *D. tisboides*. Second maxilliped long and narrow, both surfaces slightly rounded; terminal claw very strong. Outer branch of 1st natatory legs 3-jointed, very short; inner branch has a long and very wide 1st joint and one small terminal joint; 2nd, 3rd, and 4th legs resembling in general those of the genus; the terminal spines have ring-like markings. The 5th legs have the primary joint large and foliaceous, much longer than broad, with 5 short, stout terminal spines; secondary joint small with 2 strong spines on the outer margin, 2 terminal ringed spines and 1 small spine on the inner distal margin. Abdomen 4-jointed, very wide. Furcal rami small and tumid.

Several specimens of this curious species were found in the Muttuvaratu pearl oyster washings.

Dactylophusia æmula, n. sp.—Plate XI., figs. 9 to 12.

Length, female 0·4 millim.; male unknown.

In general appearance very like *D. laticaudata,* but smaller and less robust. The colouring is the same as in that species.

Anterior antennæ narrow, 7-jointed. The proportional lengths of the joints are as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{13.\ 12.\ 10.\ 11.\ 4.\ 3.\ 6.}$

Posterior antennæ, mandible and palp, maxilla and maxilliped as in *D. laticaudata.* The 1st to 4th natatory legs resemble those of *D. laticaudata,* except that the basal joint of the inner branch of the 1st is less tumid. The 5th legs in this species also have the primary joint large and foliaceous, but proportionally broader than long, and the terminal spines are shorter and less tumid; secondary joint small. Marginal spines, with the exception of the inner sub-terminal one which is very strong, short and slender. Abdomen less tumid than in *D. laticaudata.*

Several specimens, all females, from the same locality as the foregoing species, from which it is distinguished by the structure and proportional lengths of the joints of the anterior antennæ, and by the 1st and 5th legs. The two foregoing species differ in the structure of their appendages, especially in the 1st legs, which have the inner branch only 2-jointed, from the general type of *Dactylophusia*, and may some time require a separate genus.

Dactylophusia platysoma, n. sp.—Plate XI., figs. 13 to 18.

Length, female 0·62 millim.; male unknown.

In general appearance more like a *Porcellidium* than a *Dactylophusia*, and it is only when the appendages are examined that it becomes clear that it is not a *Porcellidium;* neither can it be said to be a typical *Dactylophusia*, though provisionally referred to that genus. Anterior antenna moderately long and slender, 9-jointed; the proportional lengths are : $\frac{1.\ \ 2.\ \ 3.\ 4.\ 5.\ 6.\ 7.\ 8.\ 9.}{13.\ 18.\ 10.\ 9.\ 4.\ 5.\ 2.\ 2.\ 4.}$

Posterior antennæ, mandible and palp, maxilla and 1st maxillipeds nearly as in *D. tisboides;* 2nd maxillipeds elongate, with a strong terminal claw. First natatory legs resembling those of *D. tisboides;* 2nd, 3rd and 4th though generally like those of *Dactylophusia*, are more slender than the corresponding legs of any member of the genus known to us. The 5th feet have the primary joint large and foliaceous. The extremity of the joint is fringed with fine hairs, amongst which are 3 prominent setæ; secondary joint not distinctly separated from the primary one, with rounded margins and furnished with 6 apical setæ. Abdomen very flat, 4-jointed, furcal rami short.

Six females were found in the washings from the Muttuvaratu pearl oysters.

Thalestris mysis, CLAUS.

Found in the Gulf of Suez and again at Cheval Paar, Ceylon.

Pseudothalestris imbricata, BRADY—Plate XI., figs. 19 to 24.

This species was described from a single specimen (a male) in the Report on the "Challenger" Copepoda by Professor BRADY. No further specimens seem to have been discovered until now. In the present collection a single female was found in washings from the Muttuvaratu pearl oysters, which from its general resemblance in structural detail we have concluded is the female of *P. imbricata.*

Length, female 0·65 millim.

In general agreement with the recently described species of this genus, it is more like a small *Westwoodia* than a *Thalestris.* The outer branches of the 1st natatory legs are very small and distinctly 2-jointed. Anterior antennæ 6-jointed; proportional lengths as follows : $\frac{1.\ \ 2.\ \ 2.\ 4.\ 5.\ 6.}{9.\ 12.\ 21.\ 4.\ 7.\ 7.}$

Posterior antennæ, mandible, maxilla and maxillipeds similar to those figured by BRADY. Natatory legs 1 to 4 also similar. The 5th legs have a large primary joint and a small secondary joint each furnished with a number of hairs.

Furcal rami extremely short, much broader than long.

Harpacticus chelifer (MÜLLER).

A common littoral British species. It occurred only once, in a tow-net gathering from Marichchukaddi, Ceylon.

Peltidium ovale, n. sp.—Plate XIII., figs. 1 to 6.

Length, female 1·6 millim.; male unknown.

Body ovate, cephalothorax and abdomen not clearly separated. Anterior antennæ short, 6-jointed, the proportional lengths of joints being as follows : $\frac{1.\ \ 2.\ \ 3.\ 4.\ 5.\ 6.}{13.\ 16.\ 10.\ 6.\ 2.\ 6.}$ Most of the joints are densely setiferous, the 3rd and 4th also bearing a long filament.

Posterior antennæ and mouth organs as in *P. purpureum*. Outer branch of 1st pair of natatory legs 2-jointed, with marginal hairs on both sides; inner branch 3-jointed, half as long again as the outer, the middle joint about twice the length of the 1st, and the 3rd joint very small, having at the apex two narrow curved claws. In the 2nd, 3rd, and 4th pair, both branches are 3-jointed, the outer branch armed on outer side with lateral aculeate plumose spines; the inner side and inner branch both bearing plumose setæ. The 5th pair of legs 2-jointed, the basal joint very small and produced on each side; the outer joint long and stout, with terminal aculeate spines.

Three females only were found in the Muttuvaratu pearl oyster washings and in the general washings of Invertebrates. This and the 4 following species all clearly agree with PHILIPPI's original description of the genus except as to the anterior antennæ, which he gives as 9-jointed, whereas our 5 new species are 6- and 7-jointed. Seeing that PHILIPPI knew of only one species, *P. purpureum*, we think the generic character should be altered to read—6- to 9-jointed, to admit these new forms.

The rounded forehead and the 5th pair of natatory legs sufficiently distinguish this species from the others.

Peltidium angulatum, n. sp.—Plate XIII., figs. 7 to 11.

Length, 1·2 millim.; male unknown.

Body angular, with large anterior protuberance or rostrum. Anterior antennæ 7-jointed, the proportional lengths being as follows : $\frac{1.\ \ 2.\ 3.\ 4.\ 5.\ 6.\ 7.}{16.\ 14.\ 9.\ 6.\ 2.\ 2.\ 5.}$

First pair of natatory legs shorter and stouter than those of *P. ovale*; the basal joint of outer branch bears 2 small elongated processes in place of spines. Basal joint of 5th pair produced on one side into a long linear projection with apical spine; outer joint elongated, narrowing towards apex, armed with strong plain and plumose spines. Two specimens, both females, were found in the Muttuvaratu pearl oyster washings. It differs from *P. ovale* in the anterior antennæ, the 5th pair of legs, and particularly in the arrangement of the chitinous bands or reticulations of the carapace.

Peltidium speciosum, n. sp.—Plate XIII., figs. 12 to 17.

Length, female 1·1 millim.; male unknown.

Body resembles *P. angulatum* in shape, but is differently reticulated, the chitinous bands being thicker. Anterior antennæ stout, 7-jointed, the filaments and setæ as in the two previous species; the proportional sizes are: $\frac{1.\ \ 2.\ \ 3.\ 4.\ 5.\ 6.\ 7.}{22.\ 22.\ 14.\ 6.\ 3.\ 3.\ 6.}$

First pair of natatory legs very robust. In other respects they and the other pairs agree with *P. angulatum.* Fig. 17 represents a smaller form with thinner bands.

A number of specimens, all females, were found in the Muttuvaratu pearl oyster washings. The jointing of the anterior antennæ, and the robustness of the 1st pair of natatory legs, serve to distinguish this species.

Peltidium serratum, n. sp.—Plate XIII., figs. 18 to 22.

Length, female 1·6 millim.; male unknown.

Body robust, rostrum broad, with 4 indentations on anterior surface; margins of all the cephalothoracic segments serrated. Anterior antennæ 6-jointed, the proportional lengths of the joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ 4.\ 5.\ 6.}{20.\ 20.\ 14.\ 4.\ 4.\ 7.}$

Outer branch of 1st pair of natatory legs robust. Fifth pair foliaceous, 1-jointed, with a long spear-shaped plumose apical spine and several lateral spines, some of them plumose; anteriorly drawn out into a curved protuberance with terminal spine representing a rudimentary basal joint.

Three specimens, all females, were found in the bottom tow-net at Chilavaturai, Ceylon. The character of the reticulation on the carapace and the remarkable 5th natatory legs clearly distinguish this species from others.

Peltidium perplexum, n. sp.—Plate XIII., figs. 23 to 27.

Length, female 1·1 millim.; male unknown.

Body and character of reticulation resemble *P. speciosum.* Anterior antennæ 7-jointed, the proportional lengths of joints being as follows: $\frac{1.\ \ 2.\ 3.\ 4.\ 5.\ 6.\ 7.}{23.\ 16.\ 9.\ 6.\ 4.\ 3.\ 7.}$

Natatory legs similar to those of *P. angulatum.*

Two specimens, both females, were found in the Muttuvaratu pearl oyster washings.

This differs from other species chiefly in the proportional lengths of joints of anterior antennæ. CLEVE has formed a genus *Reticulina* for the species *R. aurivillii*, which is certainly a *Peltidium*, but it is not sufficiently well figured to enable us to compare it with any of the foregoing species.

Ilyopsyllus affinis, T. SCOTT.

Appeared once between Port Said and Suez, and again in the Gulf of Manaar, also at Kodramallai, north of Karativo, and $2\frac{3}{4}$ miles south-south-west of Chilavaturai.

Porcellidium fimbriatum, CLAUS—Plate XII., figs. 1 to 10.

Length, female 0·7 millim.

Anterior antennæ 6-jointed; proportional lengths of joints: $\dfrac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.}{12.\ 13.\ 10.\ 6.\ 5.\ 2.}$

A few specimens, all females, of this species, which appear to be identical with CLAUS' *P. fimbriatum*, were found in the washings from the Muttuvaratu pearl oysters. The chief points that distinguish this species from the others are the 5th feet, the abdomen, and the furcal rami.

Porcellidium brevicaudatum, n. sp.—Plate XII., figs. 11 to 14.

Length, female 0·67 millim.

Anterior antennæ 6-jointed, as follows: $\dfrac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.}{13.\ 17.\ 12.\ 8.\ 4.\ 2.}$

This species is easily distinguished from the others by its smooth carapace and ciliated margins, the large 5th feet, the short abdomen, and the furcal rami.

Six specimens, all females, were obtained from the Muttuvaratu pearl oyster washings and from the general washings of Ceylon Invertebrates.

Porcellidium acuticaudatum, n. sp.—Plate XII., figs. 15 to 18.

Length, female 0·6 millim.

Anterior antennæ 6-jointed; proportional lengths as follows: $\dfrac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.}{11.\ 11.\ 8.\ 6.\ 4.\ 3.}$

The chief features of this species are its moderately large 5th feet with rounded apex, the small abdomen produced laterally on each side, and the acutely pointed apex of the furcal rami.

Three females of this distinct species were found in the washings from the Muttuvaratu pearl oysters.

Porcellidium ravanæ, n. sp.—Plate XII., figs. 19 to 22.

Length, female 0·6 millim.

Anterior antennæ 6-jointed; proportional lengths as follows: $\dfrac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.}{10.\ 18.\ 13.\ 8.\ 5.\ 3.}$

The distinguishing characters of this *Porcellidium* are the moderately wide 5th feet, which taper off to an acute point, the small abdomen, the posterior angles of which are not so much prolonged as in *P. acuticaudatum*, and the obliquely rounded external margin of the furcal rami. Three females of this species were found in the washings from the Muttuvaratu pearl oysters.

Idya furcata (BAIRD).

A common British littoral species. Occurred at 7 stations from the English Channel through the Mediterranean and Gulf of Suez to the Red Sea.

Idya longicornis, T. SCOTT.

Found in the general washings from Ceylon Invertebrates. Previously known only from British waters.

Pseudanthessius gracilis, CLAUS—Plate XIV., figs. 19 to 23.

One specimen was found in the general washings of the Ceylon Invertebrata obtained about the pearl banks. We give some additional figures of this species.

Pseudanthessius maximus, n. sp.—Plate XIV., figs. 1 to 11.

Length, female 3·5 millims. ; male 2·7 millims.

Cephalothorax 6-jointed, the lateral spaces between the joints giving it a coarsely pinnatifid appearance. Abdomen of female 4-jointed, male 5-jointed, the 1st segment in the male being much longer and wider than any of the others.

Anterior antennæ 7-jointed, each joint bearing several short spinous setæ, and the proportional lengths being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{15.\ 32.\ 7.\ \ 9.\ \ 9.\ \ 7.\ \ 6.}$

Posterior antennæ 4-jointed, the 3rd joint much the smallest; the 4th bears a stout blunt hooked spine. Mandible is produced apically into a long recurved spine with toothed edges, also a smaller toothed spine, and toothed edge. The palp is short, armed with three apical spines and a lateral one. First maxilliped has a stout basal joint, with an outer joint extended into 2 curved hairy spines. Second maxilliped of female has an oval middle joint terminating in a short claw; that of the male is a strong grasping hand, the terminal claw long and stout.

First pair of natatory legs has both branches 3-jointed, the outer one armed with serrated lanceolate spines; both branches have numerous plumose setæ. Fourth pair 2-branched; the outer one 3-jointed, armed with short ovate serrated spines, the inner branch consists of 1 long joint gradually widening to the apex; the lateral posterior edges are produced into spines, between which are 2 terminal plumose setæ. The 5th pair consist each of a long curved joint with 3 terminal plumose spines. Furcal rami about 3 times as long as broad, slightly tapering to apex.

Several males and females were taken by surface tow-net in Galle harbour.

This species is easily distinguished by its large size, by the mandible and posterior antennæ, and by the 4th and 5th pair of natatory legs.

Pseudanthessius chelifer, n. sp.—Plate XIV., figs. 12 to 18.

Length, female 1 millim.; male unknown.

Cephalothorax 6-jointed, ovate. Abdomen 4-jointed, the 1st joint swollen and rounded anteriorly, narrowing to base. Anterior antennæ 7-jointed, the proportional lengths of the joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{16.\ 24.\ 8.\ 21.\ 16.\ 12.\ 12.}$

Posterior antennæ 3-jointed, the apical joint having 3 long terminal spines and a long broad curved terminal claw dentated on upper side. Mandible small, anteriorly extended into a serrated spine; palp large, having 3 terminal spines. The 1st maxilliped narrow, ending in a denticulate spine and a smaller lateral spine. The 2nd maxilliped consists of a long narrow curved joint having 2 small lateral spines and 3 terminal spines. Inner branch of 4th pair of natatory legs consists of one small narrow joint with terminal spine. Furcal rami about 3 times as long as broad.

Several specimens, all females, were found about the pearl banks. A very distinct species, readily recognized by its posterior antennæ, the 2nd maxilliped and the 4th pair of natatory legs.

Pseudanthessius concinnus, n.sp.—Plate XIV., figs. 24 to 30.

Length, female 0·85 millim.; male unknown.

Cephalothorax ovate, similar to *P. gracilis*, but considerably smaller. Abdomen 5-jointed. Anterior antennæ 7-jointed, the proportional lengths of the joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{10.\ 24.\ 8.\ 16.\ 16.\ 12.\ 7.}$

Posterior antennæ nearly as in *P. gracilis*. Mandibles consist of a curved joint, tumid in centre, with narrow, blunt termination. First maxilliped 1-jointed, long, narrow towards apex, with strong lateral and terminal spines. Second maxilliped 2-jointed, the first joint rather longer than broad; terminal joint very small with 2 strong apical spines. Both branches of 1st pair of natatory legs 3-jointed; inner branch of 4th pair 1-jointed with truncate base terminating in large serrated lanceolate spine and one plain spine; outer branch 3-jointed, having serrated lanceolate spines. Furcal rami long and narrow.

One specimen only, a female, was found in the general washings from Ceylon Invertebrata.

The mouth organs, the inner branch of 4th pair of natatory legs and the furcal rami are the distinguishing features of this species.

Pseudanthessius liber (Brady and Robertson).

Found amongst the general washings of Invertebrates from the pearl oyster beds.

Lichomolgus minor, A. Scott.

Found at 2 stations only, and far apart, viz., between Port Said and Suez, and amongst the washings of young pearl oysters, Ceylon.

Lichomolgus gracilis, n. sp.—Plate XV., figs. 1 to 9.

Length, male 0·7 millim.; female 1 millim.

Cephalothorax (female) ovate, 6-jointed, abdomen 3-jointed, the 1st considerably longer and wider than the combined succeeding 2 joints. First joint of male abdomen quadrate; more than 4 times the size of the 2nd joint.

Anterior antennæ (female) 7-jointed, the proportional lengths of the joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{17.\ \ 25.\ \ 9.\ \ 11.\ \ 12.\ \ 7.\ \ 5.}$

Posterior antennæ 3-jointed, the apical joint terminating in a strong curved claw, and having 3 small lateral spines. Mandible has an angular quadrate base, and is pectinated along upper edge; palp short, with 3 spines.

First maxilliped has outer joint triangular, sharp and wedge-shaped, and has a serrated curved lateral spine arising from centre; outer joint of 2nd maxilliped (female) very small, with stout apical spines; in the male it is a grasping hand with long curved claw. Inner branch of 4th pair of natatory legs 2-jointed. Furcal rami divergent, about 4 times as long as broad.

Several males and females were found in the general washings of dredged Invertebrates. The mouth organs, posterior antennæ, and furcal rami sufficiently distinguish this species.

Lichomolgus ieversi, n. sp.—Plate XV., figs. 10 to 17.

Length, male 0·96; female 1·06.

Cephalothorax 6-jointed; cephalic segment subquadrate; abdomen 4-jointed, the genital segment smaller than in the other species of the genus. Anterior antennæ 7-jointed, the proportional lengths of the joints as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{16.\ \ 25.\ \ 8.\ \ 17.\ \ 17.\ \ 12.\ \ 5.}$

Posterior antennæ 3-jointed; the middle joint small; apical joint longer than the combined 1st and 2nd; with four terminal curved spines, two of which are moderately stout. Mandibles long and narrow, coming to a fine point, edges hairy. Terminal joint of 1st maxilliped drawn out, forming a fine ciliated stylet; there is also one lateral spine; 2nd maxilliped (female) 3-jointed, with very short terminal spine; 2nd maxilliped of male forms a chelate hand with very long rounded claw. Inner branch of 4th pair of natatory legs 2-jointed, the outer branch equals 3 of the inner and has truncated apex; outer branch has 5 lanceolate spines. Furcal rami very long and nearly parallel.

About 20 females and 4 males were found in the Muttuvaratu pearl oyster washings and in the Invertebrata washings. The mouth organs, antennal joints, and the furca are the chief distinguishing features of this species, which is named in honour of Mr. R. W. Ievers, Government Agent of the Northern Province of Ceylon, where the pearl banks are situated.

Lichomolgus buddhensis, n. sp.—Plate XV., figs. 18 to 24.

Length, female 1 millim. ; male unknown.

Cephalothorax broadly ovate, about 4 times as long as the abdomen, which is 3-jointed; the genital segment being about 4 times the size of the 2 combined succeeding joints; it is much swollen in the middle. Anterior antennæ 7-jointed, the proportional lengths of the joints being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{17.\ 31.\ 7.\ 15.\ 14.\ 13.\ 10.}$

Mandible and palp short. Maxillipeds and natatory legs similar to *P. ieversi.* Furca quadrate, very small.

Several specimens, all females, were found in the general washings of dredged Invertebrates. The very short abdomen and furca are quite characteristic of this species—named in honour of the celebrated home of Buddhism from which it came.

Lichomolgus lankensis, n. sp.—Plate XV., figs. 25, 26.

Length, female 1·0 millim. ; male unknown.

Cephalothorax ovate. Abdomen 3-jointed; genital segment about as long as the combined two succeeding joints and furca. Anterior antennæ 7-jointed, the proportional lengths being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{22.\ 29.\ 10.\ 14.\ 10.\ 7.\ 5.}$

Posterior antennæ, mouth organs, and natatory legs as in *L. gracilis.*

Three specimens, all females, were found in the general washings of dredged Invertebrates. Its general form, and the comparative shortness of the anterior antennæ and furca, distinguish this species from others of the genus.

Lichomolgus simplex, n. sp.—Plate XV., figs. 27 to 34.

Length, female 0·88 millim. ; male 0·8 millim.

Cephalothorax 6-jointed, abdomen (female) 4-jointed, male abdomen 5-jointed, genital segment double in size that of the female; anterior antennæ 6-jointed, the proportional lengths being as follows: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.}{13.\ 22.\ 8.\ 22.\ 18.\ 18.}$

Posterior antennæ 3-jointed, the middle one very short; terminal joint 3 times the length of the second, with 2 apical spines. Mandible constricted in centre; outer portion somewhat quadrate, with ciliated edges bearing 2 small corner filaments and a plumose spine. Maxillipeds similar to *L. buddhensis*, but stouter. Natatory legs as in *L. gracilis.*

Furcal rami about 3 times as long as broad. A few specimens of each sex were found in the washings from sponges dredged in the Gulf of Manaar. The general shape of the animal and of the abdomen and furca and the jointing of the anterior antennæ serve to distinguish this species.

Lichomolgus elegans, n. sp.—Plate XVI., figs. 8 to 13.

Length, female 1·5 millim.; male unknown.

Cephalothorax 6-jointed. Abdomen 4-jointed, the genital segment being longer than the 3 succeeding joints combined, and having a wedge-shaped notch near the centre on each side. Anterior antennæ 7-jointed, the proportional lengths being as follows: $\dfrac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{11.\ 32.\ 4.\ 11.\ 9.\ 7.\ 4.}$

Posterior antennæ 3-jointed, the first joint rather longer and nearly double the width of each of the succeeding joints. The third joint bears a strong apical claw. Maxillipeds resemble *L. buddhensis*, but are stouter. Inner branch of 4th pair of natatory legs 2-jointed, the outer joint being about double the length of the inner. Furcal rami very short, about as broad as long.

One specimen only, a female, was found in the general washings from dredged Invertebrates. The notched abdominal genital segment is the most striking characteristic of this species.

Lichomolgus robustus, n. sp.—Plate XVI., figs. 14 to 20.

Length, female 1·1 millim.; male unknown.

Cephalothorax robust, ovate, 6-jointed. Abdomen 4-jointed; the genital segment about as long as the combined 2 succeeding joints. Anterior antennæ 7-jointed, the proportional lengths being as follows: $\dfrac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{15.\ 32.\ 5.\ 11.\ 8.\ 8.\ 5.}$

Posterior antennæ similar to *L. simplex*, but more robust. Mandible stylet serrated on outer edge. Maxillipeds and natatory legs like *L. buddhensis*. Furca about half as long again as broad.

One specimen only, a female, was found in the general washings from dredged Invertebrata. In many points there is a great resemblance between this species and *L. buddhensis;* but in the jointing of the cephalothorax, and more particularly of the abdomen, and in the small size of the 5th natatory legs in this species, the difference is so considerable that we are justified in separating them.

Lichomolgus gigas, n. sp.—Plate XVI., figs. 21 to 26.

Length, female 2 millims.; male 1·4 millims.

Cephalothorax ovate, 6-jointed. Abdomen, female 4-jointed; male 5-jointed. Anterior antennæ long and slender, 7-jointed; the proportional lengths being as follows: $\dfrac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{12.\ 32.\ 4.\ 16.\ 12.\ 9.\ 7.}$

Posterior antennæ, mouth organs, and natatory legs and furca nearly resemble *L. simplex*.

One of each sex were found in the general washings of dredged Invertebrata.

The large size and the jointing of the slender anterior antennæ sufficiently distinguish this species.

Lichomolgus dentipes, n. sp.—Plate XVI., figs. 27 to 30.

Length, female 0·86 millim.; male unknown.

Cephalothorax broadly ovate, the cephalic segment equal in size to the combined 5 following; the edges of the 3rd and 4th segments are finely serrated. The 5th segment is very small, with sharply-pointed lateral terminations.

Abdomen very short and stout, hardly $\frac{1}{5}$th the length of cephalothorax; genital segment as long as the combined 2 following and double the width; 4th joint the same as 1st. Furcal rami equal in length and breadth.

Anterior antennæ 7-jointed, the proportional lengths being: $\frac{1.\ \ 2.\ 3.\ 4.\ 5.\ 6.\ 7.}{11.\ 26.\ 3.\ 7.\ 4.\ 3.\ 2.}$

Mouth organs as in *Paralichomolgus*. Inner branch of 4th natatory legs 2-jointed, both joints straight and very narrow. The 5th pair have each a large tooth projecting from inner side anteriorly.

Of this very striking species one specimen only, a female, was found in the general washings of dredged Invertebrata. It is easily recognisable by its serrated thoracic edges and by the 4th and 5th natatory legs—the tooth on the latter gives the specific name.

Paralichomolgus, n. gen.

Female; body composed of 10 segments; cephalothorax rotund or ovate; 5-jointed; genital segment much larger than the others, being the 1st and 2nd segments united.

Anterior antennæ 8-jointed. Posterior antennæ, mouth organs, and natatory legs as in *Lichomolgus*. The difference between this genus and *Lichomolgus* consists in the lateral prolongations of the body segments and in the jointing of the anterior antennæ.

Paralichomolgus curticaudatus, n. sp.—Plate XVI., figs. 1 to 7.

Length, female 1·2 millims.; male unknown.

Cephalothorax ovate, 5-jointed; the posterior edges of segments 2 to 4 being pointed. Abdomen very short, about $\frac{1}{5}$th the length of the cephalothorax; genital segment wider than its length and having on each side posteriorly a rounded lobe; the other joints very small. Furcal rami very small, almost half spheres. Anterior antennæ 8-jointed, the proportional lengths being as follows: $\frac{1.\ \ 2.\ 3.\ 4.\ \ 5.\ 6.\ 7.\ 8.}{12.\ 35.\ 3.\ 8.\ 13.\ 8.\ 4.\ 3.}$

Posterior antennæ 3-jointed; the 1st and 2nd joints sub-equal; the 3rd as long as the combined 1st and 2nd; terminal claw thick, and obtuse at apex. Mandible and palp as in *Lichomolgus buddhensis*. Maxillipeds similar to *Lichomolgus ieversi*, except that the joints of the 2nd are nearly double the width of the latter. Natatory legs also similar to those of latter species; the 2 joints of inner branch of the 4th pair, however, being equal in length to the 3-jointed outer branch.

Two specimens, both females, were found in the general washings from the dredged Invertebrata. The short abdomen, the wide joints of 2nd maxillipeds, and the jointing of inner branch of 4th pair of natatory legs readily distinguish this species.

Paralichomolgus longicaudatus, n. sp.—Plate XX., figs. 6 to 8.

Length, female 1·1 millims. ; male unknown.

Body sub-rotund ; 1st to 3rd joints of cephalothorax are pointed posteriorly and with a tooth on each lateral edge of 2nd and 3rd ; 4th joint very small. Abdomen about $\frac{1}{4}$ the length of cephalothorax ; genital segment large and tumid ; the rest 3 times broader than long. Furcal rami square, very short, with long terminal setæ.

Anterior antennæ 8-jointed, the proportional lengths being: $\frac{1.\ \ 2.\ 3.\ 4.\ \ 5.\ 6.\ 7.\ 8.}{16.\ 28.\ 2.\ 9.\ 12.\ 8.\ 4.\ 3.}$

Posterior antennæ, mandible, maxillipeds, and first 3 pairs and 5th pair of natatory legs as in *P. curticaudatus*. The 2-jointed inner branch of 4th pair natatory legs springs from middle of long basal joint at right angles ; the 3 joints of outer branch being also at right angles to basal joint.

One specimen only, a female, was found in the general washings from dredged Invertebrata. The general appearance and the 4th pair of natatory legs clearly distinguish this species from the last described.

Hermannella arenicola, Brady.

Found in the general washings of dredged Invertebrata from the pearl banks.

Hermannella robusta, n. sp.—Plate XVII., figs. 1 to 8.

Length of female 1·1 millims. ; male unknown.

A very robust species with comparatively short abdomen. Anterior antennæ 7-jointed ; proportional lengths of joints : $\frac{1.\ \ 2.\ 3.\ \ 4.\ 5.\ 6.\ 7.}{16.\ 35.\ 5.\ 16.\ 8.\ 6.\ 4.}$

The posterior antenna has a short stout hook-like spine arising from the 3rd joint. Mandible and maxillipeds have a general resemblance to the corresponding organs in *Lichomolgus*. Both branches of 1st to 4th natatory legs are 3-jointed. The 5th legs are rudimentary. Abdomen with 4 segments ; genital segment large and tumid, 4th joint longer than the 3rd ; furcal rami about twice as long as broad, and slightly longer than the last abdominal segment.

This species is easily recognised by the robust body and short abdomen, which is less than a fourth of the length of the body, and by the short furca. Three females were found in the washings from Ceylon Invertebrates.

Hermannella serendibica, n. sp.—Plate XVII., figs. 9 to 11.

Length of female, 1·16 millims. ; male unknown.

In general appearance more attenuated than *H. robusta*. Anterior antennæ 7-jointed ; proportional length of joints : $\frac{1.\ \ 2.\ 3.\ \ 4.\ 5.\ 6.\ 7.}{8.\ 26.\ 6.\ 12.\ 9.\ 6.\ 4.}$

Posterior antennæ, mandible, maxillipeds and natatory legs similar to those of *H. robusta*. The 5th feet are more developed than in the previous species. Abdomen 4-jointed, rather less than half the length of the body. Genital segment large, much wider posteriorly than in front; 2nd, 3rd and 4th joints subequal in length and each about as long as broad. Furcal rami long and narrow, about 5 times longer than broad and equal to the combined lengths of the 3rd and 4th joints of the abdomen. Three females were found in washings from Gulf of Manaar sponges. This *Hermannella* is easily identified by its attenuated form, long abdomen, with the peculiar swelling of the genital segment, and long furca.

Hersiliodes leggii, n. sp.—Plate XVII., figs. 12 to 21.

Length of male 1·5 millims.; female unknown.

Anterior antennæ 7-jointed; the proportional lengths are: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{11.\ 14.\ 7.\ 20.\ 13.\ 9.\ 12.}$

Posterior antenna 4-jointed, similar to that of other *Hersiliodes*. Mandible strong, with a well-developed biting part. Maxilla more developed than in *Lichomolgus*, and bearing a number of strong apical setæ. The first maxilliped has the terminal joint strongly toothed and also furnished with a setiferous digit. The second maxilliped well developed, in general appearance resembling that of other species of the genus.

Both branches of 1st to 4th natatory legs are 3-jointed. Fifth legs foliaceous, subquadrangular in shape, rather longer than broad, and furnished with 3 dagger-like spines and 1 seta. Abdomen 5-jointed, fully half as long as the body. Furcal rami short, about as broad as long.

One specimen in washings from Gulf of Manaar sponges. This species, which we name after Captain LEGGE, at present Inspector of the pearl banks, is easily recognised from any other member of the genus by the proportional lengths of the joints of the anterior antennæ and by the quadrangular 5th legs.

Hersiliodes tamilensis, n. sp.—Plate XVII., figs. 22 to 25.

Length, female 1·3 millims.; male unknown. In general appearance resembling the previous species. Anterior antennæ 7-jointed; proportional lengths of the joints: $\frac{1.\ \ 2.\ \ 3.\ \ 4.\ \ 5.\ \ 6.\ \ 7.}{10.\ 10.\ 5.\ 15.\ 10.\ 7.\ 11.}$

Posterior antennæ, mandible, maxilla, and 1st maxillipeds nearly as in *H. leggii*. Terminal joint of 2nd maxilliped armed with 2 moderately strong spines and 2 small setæ. Natatory legs 1 to 4 somewhat similar to those of *H. leggii*. Fifth legs long and narrow, about 3 times longer than broad, and armed with 3 dagger-like spines and 1 seta.

Abdomen 5-jointed, fully half as long as the body. Genital segment long and broad, widest near the middle; 2nd joint quadrangular in shape, about half as long as the genital segment; 3rd, 4th, and 5th joints shorter than broad, and in combined length equal to the 2nd joint. Furcal rami short and wide, about as broad as long.

In washings from Muttuvaratu pearl oysters.

The proportional lengths of the joints of the anterior antennæ, and the long and narrow 5th feet, distinguish this species from any of the others.

Hersiliodes dubia, n. sp.—Plate III., figs. 18 to 27.

Length, male 1·8 millims. ; female unknown.

Cephalothorax quadrate in form, composed of 5 segments. Anterior antennæ 6-jointed, and all clothed with non-plumose setæ; the proportional lengths are as follows : $\frac{1.\ 2.\ 3.\ 4.\ 5.\ 6.}{8.\ 6.\ 5.\ 3.\ 4.\ 8.}$

Posterior antennæ 4-jointed, the basal joint equalling in size the 3 following.

Mandible with 2 horizontal plumose projections and 2 plumose setæ. Maxilla with 3 terminal spinous setæ, and 4 on the outer side, 2 of them plumose. First maxilliped 2-jointed, the apical joint terminating in a strong curved claw and a plumose spine on each side. Second maxilliped 2-jointed, the basal one with a rounded papilla ; the hand angularly curved on outer side, terminating in a long rounded claw bluntly rounded at apex, and having on under side 3 spine-like setæ.

First 4 pairs of natatory legs 2-branched, each having 3 joints with the edges mostly clothed with fine hairs. Fifth pair each consist of a quadrate joint with 3 strong spines and a few hairs and setæ at base. Abdomen rather shorter than the cephalothorax, 5-jointed, the genital segment very large, nearly square, and having hooked posterior lateral terminations.

Furcal rami linear, about 4 times as long as broad, with a small spine on each outer side and terminating in 3 setæ of unequal lengths.

One specimen only, a male, was taken in the Suez Canal.

This species agrees, in most particulars, with Canu's *Hersiliodes.* Canu, however, gives 7 joints in the anterior antennæ, although his careful drawing of *H. pelseneeri* shows only 6 joints. It is evident that the species comprising the genus *Hersiliodes* undergo considerable changes in their various ecdyses, and in the absence of an adult female we can only provisionally place our species in this genus.

Family : ONCEIDÆ.

Oncea venusta, Philippi.

Oncea media, Giesbr.

Oncea minuta, Giesbr.

Oncea mediterranea, Claus.

All the above were generally distributed over the entire voyage. *O. media* was found only once about Ceylon, viz., at Mudalaikuli Paar. *O. mediterranea* occurred twice in Ceylon, viz., at Muttuvaratu Paar and at Talaivillu Paar. *O. venusta* was taken at 10 and *O. minuta* at 5 Ceylon stations.

Oncea subtilis, Giesbr.

Oncea notopus, Giesbr.

Oncea conifera, Giesbr.

Three rarer species. *O. subtilis* occurred at 3 Mediterranean stations; *O. notopus* between Port Said and Suez, and *O. conifera* in the Northern Indian Ocean.

Lubbockia squillimana, Claus.

Occurred at 4 stations in the Gulf of Suez and Red Sea, and once off Minikoi.

Family: CORYCÆIDÆ.

Corycæus venustus, Dana.

Eighteen species of the genus *Corycæus* are included in the collection. *C. venustus* was obtained in fair numbers throughout the entire voyage, occurring at 42 stations.

Corycæus rostratus, Claus.

Occurred at 5 Mediterranean stations.

Corycæus danæ, Giesbr.

Taken at 22 stations, from the Mediterranean onwards.

Corycæus furcifer, Claus.

Taken at 2 Mediterranean stations, twice in the Indian Ocean, and at 5 Ceylon stations.

Corycæus flaccus, Giesbr.

Occurred at 7 Mediterranean stations and once in the Indian Ocean.

Corycæus elongatus, Claus.

Taken once in the Mediterranean, twice in the Red Sea and once in the northern Indian Ocean.

Corycæus speciosus, Dana.

Generally distributed throughout the voyage, and taken at 5 Ceylon stations.

Corycæus lubbockii, Giesbr.

Found at 8 stations, in Mediterranean, Indian Ocean and 4 localities round Ceylon.

Corycæus carinatus, Giesbr.

Occurred 5 times, viz., Mediterranean, Gulf of Suez and Indian Ocean, off Minikoi and south of Cheval Paar, Ceylon.

Corycæus ovalis, Claus.

Taken at 11 stations in the Mediterranean, Red Sea and northern Indian Ocean.

Corycæus obtusus, Dana.

Corycæus gibbulus, Giesbr.

Corycæus longistilis, Dana.

Similar in range of distribution, occurring from Suez to Ceylon at 47, 41 and 16 stations respectively. *C. longistilis* however occurred only once about Ceylon, viz., south of Adam's Bridge, the others being generally represented round the island.

Corycæus concinnus, Dana.

First appeared in the Indian Ocean, where it occurred at 13 stations, and at 5 Ceylon localities.

Corycæus gracilicaudatus, Giesbr.

Similar in range to *C. concinnus*, but it first appeared in the Red Sea.

Corycæus robustus, Giesbr.

Taken once only, in the northern Indian Ocean.

Corycæus tenuis, Giesbr.

Occurred at 3 stations, viz., in the northern Indian Ocean, off Negombo, and at the Cheval Paar pearl banks.

Corycæus longicaudis, Dana.

One specimen was found at Muttuvaratu Paar, Ceylon.

Copilia mirabilis, Dana.

Found in the Mediterranean, Gulf of Suez, Red Sea, at 6 stations in the Indian Ocean, and once at Ceylon, south-east of Cheval Paar.

Sapphirina ovatolanceolata, Dana.

Ten species of the genus *Sapphirina* occur in the collection, the majority being represented at only 1 or 2 localities. *S. ovatolanceolata* was the most widely distributed, and occurred at 12 stations, extending from the Mediterranean to the Red Sea and Indian Ocean as far as Minikoi.

Sapphirina gastrica, Giesbr.

Occurred twice, viz., in the Red Sea, and again from Perim into the Indian Ocean.

Sapphirina ovalis, Dana.

One specimen was taken in the Indian Ocean after leaving Perim, and another south of Adam's Bridge, Ceylon.

Sapphirina nigromaculata, CLAUS.

Occurred at 6 Indian Ocean stations, and south of Cheval Paar, Ceylon.

Sapphirina metallina, DANA.

Sapphirina salpæ, CLAUS.

Sapphirina auronitens, CLAUS.

Sapphirina bicuspidata, GIESBR.

Sapphirina intestinata, GIESBR.

Sapphirina sinuicauda, BRADY.

One or two specimens of each of the above were taken in the Indian Ocean, with the exception of *S. sinuicauda*, which was taken at Vankali Paar, Ceylon.

FAMILY: ASTEROCHERIDÆ.

Asterocheres stimulans, GIESBR.

Asterocheres dentatus, GIESBR.

Asterocheres minutus, CLAUS.

Several specimens belonging to each of the above species were obtained in the general washings from Ceylon Invertebrates and also in washings from sponges collected in the Gulf of Manaar.

Asterocheres manaarensis, n. sp.—Plate XIX., figs. 11 to 20.

Length, female 0·78 millim.; male unknown.

Cephalothorax ovate, 6-jointed, the 5th joint very small. Abdomen 3-jointed; genital segment subquadrate, larger than the two following joints together.

Anterior antennæ 20-jointed, the relative lengths of the joints being as follows:—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
12.	3.	2.	2.	2.	2.	2.	3.	2.	5.	7.	7.	7.	7.	8.	9.	13.	4.	7.	4.

The 17th joint has a long filament, the others profusely setose.

Posterior antennæ, maxilla, and maxillipeds similar to *Asteropontius typicus*.

Mandible consists of a long scythe-like spine, without biting teeth, and a 2-jointed palp, the smaller apical joint bearing two terminal plumose setæ.

Both branches of 1st pair of natatory legs 3-jointed; 1st joint of outer branch has a large posterior plumose spine; 3rd and 4th joints of inner branch are toothed on inner side. Inner branch of 4th pair 3-jointed, the apical joint terminating in a large serrated lanceolate spine; the inner side of the joints toothed. The 5th pair each consist of a ciliated oblong joint. Furca short and stout, broader than long. Two specimens, both females, were found in the washings from Gulf of Manaar sponges.

Asterocheres major, n. sp.—Plate XVIII., figs. 21 to 28.

Length, female 1·1 millim.; male 1 millim.

Body nearly circular in outline. Cephalothoracic segment large. Anterior antennæ 20-jointed; proportional lengths of joints :—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
12.	5.	4.	3.	3.	3.	3.	4.	4.	5.	4.	4.	5.	7.	7.	7.	10.	6.	4.	2.

Posterior antennæ, mandible and palp, maxilla, maxilliped, and natatory legs, 1st to 4th, nearly as in other *Asterocheres*. Fifth feet very narrow, about $3\frac{1}{2}$ times longer than broad, furnished with three apical setæ. Abdomen 3-jointed, about $\frac{1}{2}$ the length of the body, joints of moderate length, genital segment slightly longer than the 2nd joint, last joint about $\frac{3}{5}$ the length of the second. Furca very short, about as broad as long, and only $\frac{1}{4}$ the length of the last abdominal joint. The male is slightly smaller than the female, and has the anterior antenna only 17-jointed. The genital segment of the abdomen is slightly longer than the combined lengths of the next 2 joints.

A number of specimens in washings from material collected off Point de Galle. This species is easily recognised by its circular body and narrow abdomen.

Asterocheres minor, n. sp.—Plate XVIII., figs. 29 to 31.

Length, female 0·8 millim.; male 0·7 millim.

In general appearance very like *Asterocheres major*, only much smaller.

Anterior antennæ 20-jointed; proportional lengths of joints :—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
10.	3.	3.	3.	2.	2.	2.	3.	4.	4.	3.	3.	4.	4.	5.	6.	8.	4.	5.	2.

Other appendages similar to *A. major*.

The distinguishing characters of this species are the difference in the proportional lengths of the joints of the anterior antennæ, the different proportional lengths of the abdominal joints and the furca, the latter being about $\frac{1}{2}$ the length of the last abdominal joint.

Several specimens in washings from Gulf of Manaar sponges.

Asteropontius, n. gen.

Cephalothorax roundly ovate, 5-jointed, the cephalic segment larger than the combined lengths of the 4 following segments. Anterior antennæ 18–19-jointed. Abdomen 3-jointed.

Outer branch of posterior antennæ 4-jointed, a small 1-jointed branch springing from the 1st joint. Maxilla 2-branched. Mandible long and narrow; palp 1-jointed. Maxillipeds and natatory legs, 1st to 5th, as in *Asterocheres*.

Asteropontius typicus, n. sp.—Plate XIX., figs. 1 to 10.

Length, female 0·96 millim.; male unknown.

Cephalothorax roundly ovate, about twice the length of abdomen; genital segment as long as the other 2 abdominal joints combined; tumid in centre. Furca very short.

Anterior antennæ 19-jointed, all clothed with short setose spines; the 17th carries a long narrow filament. The proportional lengths of the joints are as follows:—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.
12.	4.	3.	3.	3.	3.	3.	4.	3.	5.	7.	7.	7.	7.	7.	8.	9.	4.	6.

Mandible long, narrow, with 5 biting teeth at apex; palp 1-jointed, with long terminal plumose setæ. Maxilla 2-branched, the smaller one half the length and half the width of the larger branch, both bearing long terminal plumose setæ. Maxillipeds and 1st to 5th natatory legs as in *Asterocheres;* basal joint of outer branch of 1st pair has a broad lanceolate spine on apex of outer margin.

Several specimens, all females, were found in the washings from Gulf of Manaar sponges, and in the general washings of Invertebrates. The species bears a general resemblance to *Asterocheres*, but the 19-jointed antennæ and the 1-jointed mandible palp separate it therefrom.

Asteropontius attenuatus, n. sp.—Plate XVIII., figs. 11 to 20.

Length, female 0·92 millim.; male unknown.

Body attenuated, very narrow in front. Cephalothoracic segment triangular in outline, nearly twice as long as the combined lengths of the 1st, 2nd, and 3rd thoracic segments. Anterior antennæ 18-jointed, with a large sensory filament on the end of the 17th joint. Proportional lengths of the joints:—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
11.	4.	2.	2.	2.	2.	2.	3.	7.	4.	7.	7.	7.	8.	8.	10.	12.	10.

Posterior antennæ, mandible, maxilla, maxillipeds, and 1st to 4th natatory legs nearly as in *Asteropontius typicus.* Fifth feet long and very narrow, about 6 times longer than broad, and furnished with 3 apical setæ. Abdomen 3-jointed. Genital segment longer than the combined length of the next 2 joints. Anterior portion tumid. Furcal rami short, about $2\frac{1}{2}$ times as long as broad, and equal to the length of the last abdominal joint.

Two specimens were found in washings from Ceylon Invertebrates.

This species is easily distinguished from *A. typicus* by its attenuate form and the long narrow 5th feet.

Collocheres giesbrechti, n. sp.—Plate XVIII., figs. 1 to 10.

Length, female 0·67 millim.; male unknown.

Body elongate, sub-ovate; cephalothoracic segment with a rounded forehead and about equal to twice the lengths of the 1st to 3rd thoracic segments combined. Anterior antennæ 20-jointed, with a sensory filament on the end of the 18th joint.

Proportional lengths of the joints:—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
12.	3.	3.	3.	3.	3.	4.	3.	4.	3.	4.	7.	5.	7.	7.	8.	8.	9.	5.	9.

Posterior antennæ, mandible and palp, maxilla and maxillipeds and natatory legs nearly as in *C. gracilicauda*. Fifth feet 2-jointed, 2nd joint slightly curved, long and narrow, furnished with 2 sub-apical setæ on the outer margin, one sub-apical seta on the inner margin and one apical seta, on each side of which there is a distinct tooth-like projection of the foot. Abdomen narrow, 4-jointed. Genital segment longer than the combined lengths of the 2nd, 3rd and 4th joints. Furcal rami short and narrow, about $2\frac{1}{2}$ times longer than broad.

Two specimens in the washings from Ceylon Invertebrates.

This species is easily distinguished from the other members of the genus by the lengths of the joints of the anterior antennæ, the shape of the 5th feet and the furca.

We have much pleasure in naming the new *Collocheres* after Dr. GIESBRECHT, whose monograph on the Naples Copepoda belonging to this peculiar family has done much to simplify their study.

Scottocheres elongatus (T. and A. SCOTT).

Scottocheres longifurca, GIESBR.

Both found in washings from Ceylon dredged Invertebrates.

Lepeopsyllus, n. gen.

Body oval, thin and scale-like, composed of 4 segments. Abdomen 3-jointed and completely covered by the last thoracic segment. Furca completely covered or only partly covered by the same segment. The margin of the carapace is thickly lined with papilla-like prolongations, of irregular length, which probably impart strength to this region.

Siphon long, reaching to about the end of the last abdominal joint. Anterior antennæ 13-15-jointed. Outer branch of posterior antennæ 4-jointed; inner branch long and blade-like.

Mandible rudimentary, consisting of a long hair attached to a short slender basal joint; palp 2-jointed, the joints long and of about equal length, the outer one covered with minute hairs. Maxilla consists of 2 separate lobes attached to the ends of a long basal joint. Maxillipeds nearly as in the other Asterocheridæ.

Both branches of 1st to 3rd pairs of natatory legs 3-jointed; outer branch of 4th pair 3-jointed, the inner consisting of a minute knob with one hair; 5th pair each consist of a long curved hairy appendage. Furca divergent, long and narrow.

Lepeopsyllus typicus, n. sp.—Plate XIX., figs. 21 to 29.

Length, female 1·48 millims.; male unknown.

Anterior antennæ 15-jointed, the proportional lengths of the joints being as follows:

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
26.	13.	18.	5.	4.	5.	4.	4.	4.	4.	4.	5.	3.	4.	1.

Joint 12 bears a long fine filament.

The other characters are the same as those of the genus. Furcal rami long and divergent, extending a little beyond the edge of the carapace.

One specimen, a female, was found in the Muttuvaratu pearl oyster washings. This species has a longer and less rounded body than the succeeding one, the only known species for which it could be mistaken. The jointing of the anterior antennæ also serves to distinguish it.

Lepeopsyllus ovalis, n. sp.—Plate XIX., figs. 30 to 33.

Length of female 1·4 millims. ; male unknown.

Carapace more rotund than in *L. typicus* but otherwise very similar. Anterior antennæ 13-jointed, the proportional lengths of the joints being as follows :—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
21.	10.	17.	5.	4.	7.	4.	4.	7.	5.	2.	4.	2.

The other appendages are practically the same as those of *L. typicus*. Furca are entirely covered by the carapace. Two specimens, both females, were found in the general washings from dredged Invertebrates.

Besides the difference in shape of the carapace, the jointing of the anterior antennæ serves to distinguish this species from *L. typicus*.

Doropontius, n. gen.

Body nearly circular ; cephalic and thoracic segments produced laterally into strong points. Abdomen of the female 3-jointed, anterior antennæ 17-jointed. Posterior antennæ as in *Asterocheres manaarensis*. Mandible, maxilla, maxillipeds and 1st–4th pairs of natatory legs as in *Asterocheres*. Fifth pair of natatory legs 2-jointed.

Doropontius denticornis, n. sp.—Plate XX., figs. 1 to 5.

Length, female 0·9 millim. ; male unknown.

The cephalic segment shield-shaped, forming about $\frac{3}{4}$ of the entire animal. Second and 3rd thoracic segments have each an obtuse lateral tooth. Abdomen short ; genital segment about twice as broad as long, laterally excavated to form an upper and a lower tooth, the latter rounded posteriorly. The 2nd and 3rd segments together hardly equal in length to the 1st, and about twice as broad as long. Anterior antenna 17-jointed, the proportional lengths of the joints being as follows :—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
19.	6.	13.	5.	5.	1.	5.	6.	6.	7.	7.	7.	8.	10.	3.	6.	2.

The lower margin of the 4th joint is prolonged into a strong pointed tooth, and the 14th joint bears a long filament. Furcal rami quadrate, rather longer than broad.

A few specimens, all females, were found in washings from Gulf of Manaar sponges and in the general washings of Invertebrates. The pointed cephalic and thoracic segments, the anterior antennæ, and the 3-jointed abdomen are the characters which distinguish this genus and species.

Cletopontius, n. gen.

Body broadly ovate, the cephalic segment forming about $\frac{3}{4}$ of the entire body.

Abdomen 3-jointed. Inner branch of posterior antennæ 2-jointed. Mandible stylet-shaped, palp 1-jointed. Maxilla and maxillipeds as in *Asterocheres*. First, 2nd and 3rd pairs of natatory legs 2-branched, both branches 3-jointed; 4th pair composed of 1 branch only.

The characters of this genus do not agree in all respects with any of the known sub-families of the Asterocheridæ, and a new sub-family may therefore be required for its reception.

Cletopontius serratus, n. sp.—Plate XX., figs. 9 to 18.

Length, female 0·8 millim.; male unknown.

Lateral edges of 1st and 2nd thoracic segments bluntly serrated. Abdomen small, the genital segment being about equal in size to 16 of either of the 2 following joints,

Anterior antenna 18-jointed, the proportional lengths of the joints being as follows:—

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
28.	12.	7.	15.	6.	8.	10.	3.	6.	12.	10.	8.	8.	10.	10.	13.	14	3.

The 4th joint is faintly divided into 3, the 16th joint bears a long filament. Inner branch of posterior antenna 2-jointed; the apical joint less than $\frac{1}{2}$ the length of the basal joint.

The other characters as those of genus, which readily distinguish it. A few specimens, all female, were found in the general washings of dredged Invertebrates.

Bradypontius siphonatus, Giesbr.

Found in washings from Ceylon dredged material.

Artotrogus orbicularis, Boeck.

One specimen was in the general washings from Ceylon dredged Invertebrates.

Stephopontius, n. gen.

Body sub-quadrate, a strongly marked dividing line separating the cephalic segment from the thoracic joints; all have rounded margins.

Abdomen of female composed of 1 joint; that of male 3-jointed. Anterior antenna of female 6-jointed; the male antenna is 2-jointed, the apex forming in conjunction with the extremity of the basal joint what appears to be a strong clasping organ.

Posterior antenna 1-branched. Mandible stylet-shaped; palp 1-jointed. Maxilla represented by a stout plumose spine. Maxillipeds as in *Asterocheres*. First pair of natatory legs each composed of two 1-jointed branches, the outer branch very small; 2nd and 3rd pair 2-branched, both 2-jointed; 4th pair 1-branched, having 2 joints. In 5th pair each consists of a lamella.

Stephopontius typicus, n. sp.—Plate XX., figs. 19 to 31.

Length, female 6·7 millims.; male 8 millims.

Second thoracic segment in female has a terminal lateral appendage on each side; this is absent in male, which has a prolongation of the last thoracic segment on each side of the abdomen. The 1-jointed abdomen in female has a small protuberance on each side at the genital opening. Male abdomen 3-jointed, very small.

Anterior antenna of female 6-jointed, the proportional lengths being as follows:—

1.	2.	3.	4.	5.	6.
13.	16.	8.	8.	7.	16.

The terminal joint bears a long filament.

Posterior antenna 4-jointed, the apical joint bearing a broad spine with wide trifid end. Other characters as in the genus. Furcal rami very small, spherical in male: knob-like in female. A number of specimens, both males and females, of this very striking form were found in the general washings from dredged Invertebrates. Its general appearance, the male anterior antennæ, and the 1st, 2nd and 5th natatory legs prevent its being mistaken for any other known species.

Family: ERGASILIDÆ.

Bomolochus scomberesocis, Kr.

One adult female with 2 larval forms attached to vulva was taken from the gills of *Caranx leptolepis* from Aripu, Ceylon.

Bomolochus unicirrus, Richiardi.

Several specimens, male and female, were found in the gill chambers of *Amphisile scutata*, Linn., from Ceylon.

Family: CALIGIDÆ.

Caligus dakari, Van Beneden.

Several specimens were taken from the mouth of *Arius venosus* caught in Palk Bay, Ceylon.

Caligus diaphanus, Nordmann.

Several were found about the mouth and attached to the dorsal fin of *Therapon puta* from Aripu, Ceylon.

Caligus benedeni, BASSETT-SMITH.

Found attached to the inner surface of operculum of *Sciæna diacanthus* from Palk Strait, Ceylon.

Lepeophtheirus thompsoni, BAIRD.

Found associated with *Caligus dakari* in the mouth of *Arius venosus* from Palk Bay, Ceylon.

FAMILY: CHONDRACANTHIDÆ.

Chondracanthus cornutus, MÜLLER.

One only was taken from the gills of *Cynoglossus oligolepis*, from Ceylon.

Chondracanthus cynoglottidis, n. sp.—Text, fig. 1.

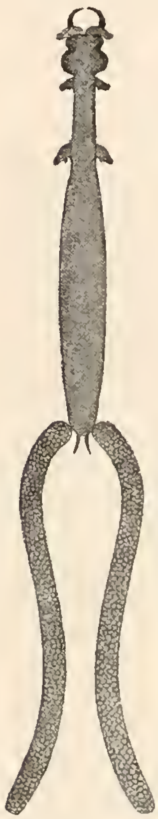

Fig. 1. *Chondracanthus cynoglottidis.*

Length, female 4·65 millims. (excluding ovisacs); male unknown.

Head rounded, 2-lobed, as wide as the widest part of the body. Body constricted for about $\frac{1}{3}$ of its length, when it expands in width, again narrowing towards the posterior end, and terminating in short strong spines. Anterior antennæ unjointed, about 3 times as long as broad. Posterior antennæ consist of 2 gracefully curved spines. Two pairs of lateral prolongations (rudimentary appendages), having on under side of each a small rounded tubercle, spring from the constricted part of the body. A pair of long wide ovisacs, equalling in length the entire animal, are attached to the posterior end.

Specimens were found attached to the nasal cœcum in *Cynoglossus brachyrhynchus* and *C. brevirostris* by Mr. J. JOHNSTONE, who obtained for us this series of 11 fish-parasites while examining the collection of Ceylon fishes in the Zoological Department of Liverpool University.

FAMILY: LERNÆOPODIDÆ.

Brachiella thynni, CUV.

Attached to gills of *Chirocentrus dorab*, from Palk Strait.

Brachiella merluccii, BASSETT-SMITH.

From grooves underneath the head of *Sciæna diacanthus* from Palk Strait.

Anchorella uncinata, MÜLLER.

Found under head in the folds of operculum of *Gazza equulæformis* from Palk Bay.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Ridgewayia typica*, n. gen. et n. sp., female, from left side. × 80.
,, 2. ,, ,, last thoracic segment, from left side. × 160.
,, 3. ,, ,, anterior antenna. × 123.
,, 4. ,, ,, posterior antenna. × 220.
,, 5. ,, ,, mandible and palp. × 220.
,, 6. ,, ,, maxilla. × 220.
,, 7. ,, ,, 1st maxilliped. × 220.
,, 8. ,, ,, 2nd ,, × 220.
,, 9. ,, ,, 1st natatory leg. × 220.
,, 10. ,, ,, 2nd ,, × 220.
,, 11. ,, ,, 4th ,, × 220.
,, 12. ,, ,, 5th ,, × 220.
,, 13. ,, ,, abdomen and furca, from above. × 53.
,, 14. *Centropages tenuiremis*, n. sp., female, from above. × 40.
,, 15. ,, ,, 5th pair of natatory legs, female. × 106.
,, 16. ,, ,, right anterior antenna, male. × 53.
,, 17. ,, ,, 5th pair of natatory legs, male. × 106.
,, 18. ,, ,, abdomen and furca (male), from above. × 53.
,, 19. *Centropages dorsispinatus*, n. sp., female, from above. × 53.
,, 20. ,, ,, cephalic segment, from left side. × 53.
,, 21. ,, ,, basal joints of anterior antennæ, female. × 106.
,, 22. ,, ,, 5th natatory leg, female. × 106.
,, 23. ,, ,, right anterior antenna, male. × 53.
,, 24. ,, ,, 5th pair of natatory legs, male. × 106.
,, 25. ,, ,, abdomen and furca (male), from above. × 53.

PLATE II.

Fig. 1. *Pontella danæ*, var. *ceylonica*, female, from above. × 32.
,, 2. ,, ,, ,, rostrum. × 80.
,, 3. ,, ,, ,, inner branch of 1st natatory leg. × 159.
,, 4. ,, ,, ,, 5th pair of natatory legs. × 80.
,, 5. ,, ,, ,, abdomen and furca. × 53.
,, 6. *Labidocera kroyeri*, var. *gallensis*, male, 5th pair of natatory legs. × 53.
,, 7. ,, ,, ,, last thoracic and 1st abdominal segments. × 53.
,, 8. ,, var. *stylifera*, male, 5th pair of natatory legs. × 53.
,, 9. ,, ,, last thoracic and 1st abdominal segments. × 53.
,, 10. *Labidocera pectinata*, n. sp., female, from above. × 40.
,, 11. ,, ,, ,, rostrum. × 106.
,, 12. ,, ,, ,, inner branch of 1st natatory leg. × 160.
,, 13. ,, ,, ,, 5th pair of natatory legs. × 106.
,, 14. ,, ,, ,, abdomen and furca. × 80.
,, 15. *Pontellopsis herdmani*, n. sp., female, from above. × 40.
,, 16. ,, ,, ,, rostrum. × 80.

Fig. 17. *Pontellopsis herdmani*, n. sp., female, 5th pair of natatory legs. × 106.

,, 18. *Metacalanus aurivillii*, CLEVE, female, 5th pair of natatory legs. × 552.

,, 19. ,, ,, ,, abdomen and furca. × 552.

,, 20. ,, ,, male, 5th pair of natatory legs. × 159.

,, 21. *Pseudodiaptomus salinus*, GIESBR., female, 5th natatory leg. × 159.

,, 22. ,, ,, male, 5th pair of natatory legs. × 159.

,, 23. ,, ,, ,, abdomen and furca. × 159.

,, 24. *Pseudodiaptomus aurivillii*, CLEVE, female, 5th natatory leg. × 159.

,, 25. ,, ,, male, 5th pair of natatory legs. × 159.

,, 26. ,, ,, ,, abdomen and furca. × 159.

PLATE III.

Fig. 1. *Sunaristes inopinata*, n. sp., female, from left side. × 80.

,, 2. ,, ,, ,, anterior antenna. × 156.

,, 3. ,, ,, ,, 1st natatory leg. × 90.

,, 4. ,, ,, ,, 2nd ,, × 120.

,, 5. ,, ,, ,, 4th ,, × 120.

,, 6. ,, ,, ,, last abdominal segment and furca. × 60.

,, 7. ,, ,, male, apical joints of anterior antenna. × 195.

,, 8. ,, ,, female, 5th natatory leg. × 390.

,, 9. *Sunaristes longipes*, n. sp., female, from left side. × 80.

,, 10. ,, ,, ,, 4th natatory leg. × 120.

,, 11. ,, ,, ,, last abdominal segments and furca. × 60.

,, 12. *Sunaristes curticaudata*, n. sp., female, from left side. × 80.

,, 13. ,, ,, ,, anterior antenna. × 111.

,, 14. ,, ,, ,, 2nd natatory leg. × 120.

,, 15. ,, ,, ,, 3rd ,, × 120.

,, 16. ,, ,, ,, 4th ,, × 120.

,, 17. ,, ,, ,, last abdominal segments and furca. × 90.

,, 18. *Hersiliodes dubia*, n. sp., male, from above. × 45.

,, 19. ,, ,, ,, anterior antenna. × 90.

,, 20. ,, ,, ,, posterior antenna. × 180.

,, 21. ,, ,, ,, mandible. × 260.

,, 22. ,, ,, ,, maxilla. × 260.

,, 23. ,, ,, ,, 1st maxilliped. × 260.

,, 24. ,, ,, ,, 2nd ,, × 90

,, 25. ,, ,, ,, 1st natatory leg. × 120.

,, 26. ,, ,, ,, 4th ,, × 120.

,, 27. ,, ,, ,, 5th ,, × 180.

PLATE IV.

Fig. 1. *Tegastes imthurni*, n. sp., female, from right side. × 106.

,, 2. ,, ,, another female, from left side. × 159.

,, 3. ,, ,, female, anterior antenna. × 195.

,, 4. ,, ,, ,, 2nd maxilliped. × 195.

,, 5. ,, ,, ,, 1st natatory leg. × 136.

,, 6. ,, ,, ,, 2nd ,, × 90.

Fig. 7. *Tegastes imthurni*, n. sp., female, 3rd natatory leg. × 60.
,, 8. ,, ,, ,, 4th ,, × 60.
,, 9. ,, ,, ,, 5th ,, × 60.
,, 10. *Tegastes donnani*, n. sp., female, from right side. × 159.
,, 11. ,, ,, ,, anterior antenna. × 390.
,, 12. ,, ,, ,, 5th natatory leg. × 90.
,, 13. *Tegastes tegnani*, n. sp., female, from right side. × 106.
,, 14. ,, ,, ,, anterior antenna. × 60.
,, 15. ,, ,, ,, 2nd maxilliped. × 260.
,, 16. ,, ,, ,, 5th natatory leg. × 181.
,, 17. *Tegastes chalmersi*, n. sp., female, from left side. × 159.
,, 18. ,, ,, ,, anterior antenna. × 781.
,, 19. ,, ,, ,, 2nd maxilliped. × 320.
,, 20. ,, ,, ,, 1st natatory leg. × 500.
,, 21. ,, ,, ,, 4th ,, × 500.
,, 22. ,, ,, ,, 5th ,, × 500.

PLATE V.

Fig. 1. *Stenhelia brevicornis*, n. sp., female, from left side. × 106.
,, 2. ,, ,, ,, anterior antenna. × 368.
,, 3. ,, ,, ,, posterior antenna, inner branch. × 276.
,, 4. ,, ,, ,, mandible and palp. × 276.
,, 5. ,, ,, ,, 2nd maxilliped. × 368.
,, 6. ,, ,, ,, 1st natatory leg. × 276.
,, 7. ,, ,, ,, 4th ,, × 221.
,, 8. ,, ,, ,, 5th ,, × 276.
,, 9. ,, ,, ,, last abdominal segment and furca. × 159.
,, 10. *Stenhelia gracilicaudata*, n. sp., female, from left side. × 159.
,, 11. ,, ,, ,, anterior antenna. × 276.
,, 12. ,, ,, ,, 1st natatory leg. × 276.
,, 13. ,, ,, ,, 4th ,, × 276.
,, 14. ,, ,, ,, 5th ,, × 276.
,, 15. ,, ,, ,, last abdominal segment and furca. × 159.
,, 16. *Stenhelia longicornis*, n. sp., female, from left side. × 106.
,, 17. ,, ,, ,, anterior antenna. × 221.
,, 18. ,, ,, ,, 1st natatory leg. × 221.
,, 19. ,, ,, ,, 5th ,, × 221.
,, 20. ,, ,, ,, last abdominal segment and furca. × 104.
,, 21. ,, ,, male, 2nd natatory leg, inner branch. × 221.
,, 22. ,, ,, ,, 5th ,, ,, × 221.
,, 23. *Ameira minor*, n. sp., female, from left side. × 159.
,, 24. ,, ,, ,, anterior antenna. × 335.
,, 25. ,, ,, ,, posterior antenna, inner branch. × 552.
,, 26. ,, ,, ,, mandible and palp. × 552.
,, 27. ,, ,, ,, 1st natatory leg. × 276.
,, 28. ,, ,, ,, 5th ,, × 335.
,, 29. ,, ,, ,, last abdominal segment and furca. × 335.

PLATE VI.

Fig. 1.	*Stenhelia perplexa*, n. sp., female,	from left side.	× 159.
,, 2.	,, ,, ,,	anterior antenna.	× 390.
,, 3.	,, ,, ,,	2nd maxilliped.	× 530.
,, 4.	,, ,, ,,	1st natatory leg.	× 260.
,, 5.	,, ,, ,,	4th ,,	× 260.
,, 6.	,, ,, ,,	5th ,,	× 260.
,, 7.	,, ,, ,,	last abdominal segment and furca.	× 260.
,, 8.	*Stenhelia dentipes*, n. sp., female,	from left side.	× 159.
,, 9.	,, ,, ,,	basal joints of anterior antenna.	× 260.
,, 10.	,, ,, ,,	2nd maxilliped.	× 781.
,, 11.	,, ,, ,,	1st natatory leg.	× 390.
,, 12.	,, ,, ,,	4th ,,	× 260.
,, 13.	,, ,, ,,	5th ,,	× 390.
,, 14.	,, ,, ,,	last abdominal segment and furca.	
,, 15.	*Ameira tenuipes*, n. sp., female,	from left side.	× 159.
,, 16.	,, ,, ,,	anterior antenna.	× 390.
,, 17.	,, ,, ,,	posterior antenna, inner branch.	× 390.
,, 18.	,, ,, ,,	mandible and palp.	× 390.
,, 19.	,, ,, ,,	1st natatory leg.	× 390.
,, 20.	,, ,, ,,	5th ,,	× 390.
,, 21.	*Stenhelia minuta*, n. sp., female,	from left side.	× 159.
,, 22.	,, ,, ,,	anterior antenna.	× 260.
,, 23.	,, ,, ,,	1st natatory leg.	× 390.
,, 24.	,, ,, ,,	5th ,,	× 390.

PLATE VII.

Fig. 1.	*Parastenhelia hornelli*, n. gen. et sp., female,	from left side.	× 106.
,, 2.	,, ,, ,,	anterior antenna.	× 260.
,, 3.	,, ,, ,,	posterior antenna.	× 260.
,, 4.	,, ,, ,,	mandible and palp.	× 390.
,, 5.	,, ,, ,,	2nd maxilliped.	× 390.
,, 6.	,, ,, ,,	1st natatory leg.	× 260.
,, 7.	,, ,, ,,	4th ,,	× 195.
,, 8.	,, ,, ,,	5th ,,	× 195.
,, 9.	,, ,, male,	2nd ,,	× 260.
,, 10.	,, ,, ,,	5th ,,	× 260.
,, 11.	*Ceylonia aculeata*, n gen. et sp., female,	from left side.	× 106.
,, 12.	,, ,, ,,	anterior antenna.	× 390.
,, 13.	,, ,, ,,	posterior antenna.	× 390.
,, 14.	,, ,, ,,	mandible and palp.	× 390.
,, 15.	,, ,, ,,	maxilla.	× 260.
,, 16.	,, ,, ,,	1st maxilliped.	× 260.
,, 17.	,, ,, ,,	2nd ,,	× 780.
,, 18.	,, ,, ,,	1st natatory leg.	× 260.
,, 19.	,, ,, ,,	4th ,,	× 195.

Fig. 20. *Ceylonia aculeata*, n. gen. et sp., female, 5th natatory leg. × 195.
,, 21. ,, ,, ,, last abdominal segment and furca. × 90.
,, 22. ,, ,, male, 3rd natatory leg. × 195.
,, 23. ,, ,, ,, 5th ,, × 390.

PLATE VIII.

Fig. 1. *Laophonte hirsuta*, n. sp., female, from above. × 106.
,, 2. ,, ,, ,, anterior antenna. × 260.
,, 3. ,, ,, ,, posterior antenna, inner branch. × 395.
,, 4. ,, ,, ,, mandible and palp. × 395.
,, 5. ,, ,, ,, 2nd maxilliped. × 395.
,, 6. ,, ,, ,, 1st natatory leg. × 395.
,, 7. ,, ,, ,, 4th ,, × 395.
,, 8. ,, ,, ,, 5th ,, × 260.
,, 9. *Laophontella typica*, n. gen. et sp., female, from above. × 106.
,, 10. ,, ,, ,, from left side. × 106.
,, 11. ,, ,, ,, anterior antenna. × 395.
,, 12. ,, ,, ,, 2nd maxilliped. × 395.
,, 13. ,, ,, ,, 1st natatory leg. × 260.
,, 14. ,, ,, ,, 2nd ,, × 260.
,, 15. ,, ,, ,, 4th ,, × 260.
,, 16. ,, ,, ,, 5th ,, × 260.
,, 17. *Tetragoniceps dubia*, n. sp., female, from left side. × 106.
,, 18. ,, ,, ,, anterior antenna. × 260.
,, 19. ,, ,, ,, 2nd maxilliped. × 395.
,, 20. ,, ,, ,, 1st natatory leg. × 195.
,, 21. ,, ,, ,, 4th ,, × 195.
,, 22. ,, ,, ,, 5th ,, × 260.
,, 23. *Tetragoniceps minor*, n. sp., female, from left side. × 159.
,, 24. ,, ,, ,, anterior antenna. × 520.
,, 25. ,, ,, ,, 2nd maxilliped. × 780.
,, 26. ,, ,, ,, 1st natatory leg. × 260.
,, 27. ,, ,, ,, 5th ,, × 156.
,, 28. ,, ,, ,, last abdominal segment and furca. × 195.

PLATE IX.

Fig. 1. *Dactylophusia dentata*, n. sp., female, from left side. × 80.
,, 2. ,, ,, ,, anterior antenna. × 221.
,, 3. ,, ,, ,, posterior antenna, inner branch. × 221.
,, 4. ,, ,, ,, mandible palp. × 221.
,, 5. ,, ,, ,, 2nd maxilliped. × 221.
,, 6. ,, ,, ,, 1st natatory leg. × 184.
,, 7. ,, ,, ,, 5th ,, × 221.
,, 8. ,, ,, ,, last abdominal segment and furca. × 221.
,, 9. ,, ,, male, 2nd natatory leg, inner branch. × 221.
,, 10. ,, ,, ,, 5th ,, × 221.

Fig. 11. *Dactylophusia havelocki*, n. sp., female, from left side. × 80.
" 12. " " " anterior antenna. × 159.
" 13. " " " posterior antenna, inner branch. × 260.
" 14. " " " mandible palp. × 260.
" 15. " " " 2nd maxilliped. × 260.
" 16. " " " 1st natatory leg. × 195.
" 17. " " " 5th " × 130.
" 18. " " " last abdominal segment and furca. × 130.
" 19. *Dactylophusia hirsuta*, n. sp., female, from left side. × 80.
" 20. " " " anterior antenna. × 195.
" 21. " " " 2nd maxilliped. × 195.
" 22. " " " 1st natatory leg. × 156.
" 23. " " " 5th " × 156.
" 24 " " " last abdominal segment and furca. × 111.
" 25. *Dactylophusia ceylonica*, n. sp., female, from left side. × 64.
" 26. " " " anterior antenna. × 156.
" 27. " " " 2nd maxilliped. × 156.
" 28. " " " 1st natatory leg. × 156.
" 29. " " " 5th " × 98.
" 30. " " male, 1st " inner branch. × 98.
" 31. " " " 2nd " " × 156.
" 32. " " " 5th " " × 130.

PLATE X.

Fig. 1. *Dactylophusia hamiltoni*, n. sp., female, from left side. × 80.
" 2. " " " anterior antenna. × 120.
" 3. " " " posterior " × 181.
" 4. " " " 2nd maxilliped. × 260.
" 5. " " " 1st natatory leg. × 195.
" 6. " " " 5th " × 195.
" 7. " " " last abdominal segment and furca. × 181.
" 8. *Parastenhelia similis*, n. sp., female, from left side. × 106.
" 9. " " " anterior antenna. × 260.
" 10. " " " 2nd maxilliped. × 390.
" 11. " " " 1st natatory leg. × 260.
" 12. " " " 4th " × 195.
" 13. " " " 5th " × 260.
" 14. " " " last abdominal segments and furca. × 260.
" 15. *Stenhelia knoxi*, n. sp., female, from left side. × 106.
" 16. " " " anterior antenna. × 390.
" 17. " " " 1st natatory leg. × 390.
" 18. " " " 5th " × 195.
" 19. *Dactylophusia robusta*, n. sp., female, from left side. × 159.
" 20. " " " anterior antenna. × 390.
" 21. " " " 2nd maxilliped. × 390.
" 22. " " " 1st natatory leg. × 260.
" 23. " " " 5th " × 260.
" 24. " " " last abdominal segments and furca. × 260.

PLATE XI.

Fig. 1. *Dactylophusia laticaudata*, n. sp., female, from above. × 159.
„ 2. „ „ „ anterior antenna. × 260.
„ 3. „ „ „ posterior antenna, inner branch. × 260.
„ 4. „ „ „ mandible palp. × 260.
„ 5. „ „ „ 2nd maxilliped. × 260.
„ 6. „ „ „ 1st natatory leg. × 260.
„ 7. „ „ „ 4th „ × 260.
„ 8. „ „ „ 5th „ × 260.
„ 9. *Dactylophusia aemula*, n. sp., female, from above. × 159.
„ 10. „ „ „ anterior antenna. × 390.
„ 11. „ „ „ 1st natatory leg. × 260.
„ 12. „ „ „ 5th „ × 260.
„ 13. *Dactylophusia platysoma*, n. sp., female, from above. × 106.
„ 14. „ „ „ anterior antenna. × 390.
„ 15. „ „ „ 2nd maxilliped. × 390.
„ 16. „ „ „ 1st natatory leg. × 260.
„ 17. „ „ „ 4th „ × 260.
„ 18. „ „ „ 5th „ × 195.
„ 19. *Pseudothalestris imbricata*, BRADY, female, from left side. × 159.
„ 20. „ „ „ anterior antenna. × 390.
„ 21. „ „ „ 2nd maxilliped. × 260.
„ 22. „ „ „ 1st natatory leg. × 195.
„ 23. „ „ „ 5th „ × 195.
„ 24. „ „ „ last abdominal segment and furca. × 395.

PLATE XII.

Fig. 1. *Porcellidium fimbriatum*, CLAUS, female, from above. × 106.
„ 2. „ „ „ anterior antenna. × 260.
„ 3. „ „ „ posterior antenna, inner branch. × 260.
„ 4. „ „ „ mandible and palp. × 195.
„ 5. „ „ „ 1st maxilliped. × 396.
„ 6. „ „ „ 2nd „ × 396.
„ 7. „ „ „ 1st natatory leg. × 260.
„ 8. „ „ „ 4th „ × 195.
„ 9. „ „ „ 5th „ × 195.
„ 10. „ „ „ abdomen and furca. × 180.
„ 11. *Porcellidium brevicaudatum*, n. sp., female, from above. × 106.
„ 12. „ „ „ anterior antenna. × 260.
„ 13. „ „ „ 5th natatory leg. × 260.
„ 14. „ „ „ abdomen and furca. × 195.
„ 15. *Porcellidium acuticaudatum*, n. sp., female, from above. × 106.
„ 16. „ „ „ anterior antenna. × 260.
„ 17. „ „ „ 5th natatory leg. × 195.
„ 18. „ „ „ abdomen and furca. × 195.
„ 19. *Porcellidium ravanae*, n. sp., female, from above. × 106.

Fig. 20. *Porcellidium ravana*, n. sp., female, anterior antenna. × 260.
,, 21. ,, ,, ,, 5th natatory leg. × 195.
,, 22. ,, ,, ,, abdomen and furca. × 156.

PLATE XIII.

Fig. 1. *Peltidium ovale*, n. sp., female, from above. × 40.
,, 2. ,, ,, ,, anterior antenna. × 195.
,, 3. ,, ,, ,, 2nd maxilliped. × 95.
,, 4. ,, ,, ,, 1st natatory leg. × 95.
,, 5. ,, ,, ,, 4th ,, × 95.
,, 6. ,, ,, ,, 5th ,, × 95.
,, 7. *Peltidium angulatum*, n. sp., female, from above. × 53.
,, 8. ,, ,, ,, anterior antenna. × 195.
,, 9. ,, ,, ,, 2nd maxilliped. × 95.
,, 10. ,, ,, ,, 1st natatory leg. × 95.
,, 11. ,, ,, ,, 5th ,, × 195.
,, 12. *Peltidium speciosum*, n. sp., female, from above. × 53.
,, 13. ,, ,, ,, anterior antenna. × 195.
,, 14. ,, ,, ,, 2nd maxilliped. × 95.
,, 15. ,, ,, ,, 1st natatory leg. × 120.
,, 16. ,, ,, ,, 5th ,, × 195.
,, 17. ,, ,, ,, a smaller form, with thinner bands. × 64
,, 18. *Peltidium serratum*, n. sp., female, from above. × 40.
,, 19. ,, ,, ,, anterior antenna. × 195.
,, 20. ,, ,, ,, 2nd maxilliped. × 95.
,, 21. ,, ,, ,, 1st natatory leg. × 95.
,, 22. ,, ,, ,, 5th ,, × 95.
,, 23. *Peltidium perplexum*, n. sp., female, from above. × 40.
,, 24. ,, ,, ,, anterior antenna. × 156.
,, 25 ,, ,, ,, 2nd maxilliped. × 95.
,, 26. ,, ,, ,, 1st natatory leg. × 95.
,, 27. ,, ,, ,, 5th ,, × 195.

PLATE XIV.

Fig. 1. *Pseudanthessius maximus*, n. sp., female, from above. × 27.
,, 2. ,, ,, ,, anterior antenna. × 90.
,, 3. ,, ,, ,, posterior antenna. × 90.
,, 4. ,, ,, ,, mandible and palp. × 156.
,, 5. ,, ,, ,, 1st maxilliped. × 120.
,, 6. ,, ,, ,, 2nd ,, × 90.
,, 7. ,, ,, ,, 1st natatory leg. × 60.
,, 8. ,, ,, ,, 4th ,, × 90.
,, 9. ,, ,, ,, 5th ,, × 90.
,, 10. ,, ,, male, 2nd maxilliped. × 90.
,, 11. ,, ,, ,, abdomen and furca. × 30.
,, 12. *Pseudanthessius chelifer*, n. sp., female, from above. × 80.
,, 13. ,, ,, ,, anterior antenna. × 260.

Fig. 14. *Pseudanthessius chelifer*, n. sp., female, posterior antenna. × 156.
,, 15. ,, ,, ,, mandible and palp. × 260.
,, 16. ,, ,, ,, 1st maxilliped. × 260.
,, 17. ,, ,, ,, 2nd ,, × 260.
,, 18. ,, ,, ,, 4th natatory leg. × 156.
,, 19. *Pseudanthessius gracilis*, CLAUS, female, from above. × 80.
,, 20. ,, ,, ,, anterior antenna. × 260.
,, 21. ,, ,, ,, posterior ,, × 195.
,, 22. ,, ,, ,, 2nd maxilliped. × 180.
,, 23. ,, ,, ,, 4th natatory leg. × 195.
,, 24. *Pseudanthessius concinnus*, n. sp., female, from above. × 80.
,, 25. ,, ,, ,, anterior antenna. × 260.
,, 26. ,, ,, ,, mandible. × 260.
,, 27. ,, ,, ,, 1st maxilliped. × 395.
,, 28. ,, ,, ,, 2nd ,, × 395.
,, 29. ,, ,, ,, 1st natatory leg. × 195.
,, 30. ,, ,, ,, 4th ,, × 195.

PLATE XV.

Fig. 1. *Lichomolgus gracilis*, n. sp., female, from above. × 80.
,, 2. ,, ,, ,, anterior antenna. × 260.
,, 3. ,, ,, ,, posterior antenna. × 260.
,, 4. ,, ,, ,, mandible and palp. × 395.
,, 5. ,, ,, ,, 1st maxilliped. × 395.
,, 6. ,, ,, ,, 2nd ,, × 260.
,, 7. ,, ,, ,, 4th natatory leg. × 156.
,, 8. ,, ,, male, 2nd maxilliped. × 181.
,, 9. ,, ,, ,, abdomen and furca. × 90.
,, 10. *Lichomolgus ieversi*, n. sp., female, from above. × 80.
,, 11. ,, ,, ,, anterior antenna. × 260.
,, 12. ,, ,, ,, posterior antenna. × 260.
,, 13. ,, ,, ,, mandible. × 395.
,, 14. ,, ,, ,, 1st maxilliped. × 260.
,, 15. ,, ,, ,, 2nd ,, × 260.
,, 16. ,, ,, ,, 4th natatory leg. × 156.
,, 17. ,, ,, male, 2nd maxilliped. × 180.
,, 18. *Lichomolgus buddhensis*, n. sp., female, from above. × 80.
,, 19. ,, ,, ,, anterior antenna. × 156.
,, 20. ,, ,, ,, posterior antenna. × 78.
,, 21. ,, ,, ,, mandible and palp. × 260.
,, 22. ,, ,, ,, 1st maxilliped. × 260.
,, 23. ,, ,, ,, 2nd ,, × 195.
,, 24. ,, ,, ,, 4th natatory leg. × 156.
,, 25. *Lichomolgus lankensis*, n. sp., female, from above. × 80.
,, 26. ,, ,, ,, anterior antenna. × 260.
,, 27. *Lichomolgus simplex*, n. sp., female, from above. × 80.
,, 28. ,, ,, ,, anterior antenna × 260.
,, 29. ,, ,, ,, posterior antenna. × 195.

Fig. 30. *Lichomolgus simplex*, n. sp., female, mandible. × 260.
,, 31. ,, ,, ,, 1st maxilliped. × 260.
,, 32. ,, ,, ,, 2nd ,, × 260.
,, 33. ,, ,, ,, 4th natatory leg. × 195.
,, 34. ,, ,, male, abdomen and furca. × 90.

PLATE XVI.

Fig. 1. *Paralichomolgus curticaudatus*, n. gen. et sp., female, from above. × 80.
,, 2. ,, ,, ,, anterior antenna. × 195.
,, 3. ,, ,, ,, posterior antenna. × 90.
,, 4. ,, ,, ,, mandible and palp. × 260.
,, 5. ,, ,, ,, 1st maxilliped. × 260.
,, 6. ,, ,, ,, 2nd ,, × 260.
,, 7. ,, ,, ,, 4th natatory leg. × 195.
,, 8. *Lichomolgus elegans*, n. sp., female, from above. × 53.
,, 9. ,, ,, ,, anterior antenna. × 130.
,, 10. ,, ,, ,, posterior antenna. × 120.
,, 11. ,, ,, ,, 1st maxilliped. × 195.
,, 12. ,, ,, ,, 2nd ,, × 195.
,, 13. ,, ,, ,, 4th natatory leg, inner branch. × 90.
,, 14. *Lichomolgus robustus*, n. sp., female, from above. × 80.
,, 15. ,, ,, ,, anterior antenna. × 156.
,, 16. ,, ,, ,, posterior antenna. × 156.
,, 17. ,, ,, ,, mandible. × 260.
,, 18. ,, ,, ,, 1st maxilliped. × 260.
,, 19. ,, ,, ,, 2nd ,, × 260.
,, 20. ,, ,, ,, 4th natatory leg. × 195.
,, 21. *Lichomolgus gigas*, n. sp., female, from above. × 53.
,, 22. ,, ,, ,, anterior antenna. × 98.
,, 23. ,, ,, ,, posterior antenna. × 90.
,, 24. ,, ,, ,, 1st maxilliped. × 260.
,, 25. ,, ,, ,, 4th natatory leg. × 60.
,, 26. ,, ,, male, abdomen and furca. × 45.
,, 27. *Lichomolgus dentipes*, n. sp., female, from above. × 80.
,, 28. ,, ,, ,, anterior antenna. × 98.
,, 29. ,, ,, ,, 4th natatory leg. × 195.
,, 30. ,, ,, ,, 5th ,, × 156.

PLATE XVII.

Fig. 1. *Hermannella robusta*, n. sp., female, from above. × 80.
,, 2. ,, ,, ,, anterior antenna. × 130.
,, 3. ,, ,, ,, posterior antenna. × 156.
,, 4. ,, ,, ,, mandible. × 195.
,, 5. ,, ,, ,, 1st maxilliped. × 195.
,, 6. ,, ,, ,, 2nd ,, × 195.
,, 7. ,, ,, ,, 1st natatory leg. × 156.
,, 8. ,, ,, ,, 4th ,, × 156.

Fig. 9. *Hermannella serendibica*, n. sp., female, from above. × 80.
„ 10. „ „ „ anterior antenna. × 130.
„ 11. „ „ „ posterior antenna. × 156.
„ 12. *Hersiliodes leggii*, n. sp., male, from above. × 54.
„ 13. „ „ „ anterior antenna. × 120.
„ 14. „ „ „ posterior antenna. × 90.
„ 15. „ „ „ mandible. × 260.
„ 16. „ „ „ maxilla. × 195.
„ 17. „ „ „ 1st maxilliped. × 195.
„ 18. „ „ „ 2nd „ × 130.
„ 19. „ „ „ 1st natatory leg. × 90.
„ 20. „ „ „ 4th „ × 130.
„ 21. „ „ „ 5th „ × 111.
„ 22. *Hersiliodes tamilensis*, n. sp., female, from above. × 66.
„ 23. „ „ „ anterior antenna. × 120.
„ 24. „ „ „ 2nd maxilliped. × 120.
„ 25. „ „ „ 5th natatory leg. × 156.

PLATE XVIII.

Fig. 1. *Collocheres giesbrechti*, n. sp., female, from above. × 159.
„ 2. „ „ „ anterior antenna. × 260.
„ 3. „ „ „ posterior antenna. × 260.
„ 4. „ „ „ mandible and palp. × 390.
„ 5. „ „ „ maxilla. × 260.
„ 6. „ „ „ 1st maxilliped. × 390.
„ 7. „ „ „ 2nd „ × 260.
„ 8. „ „ „ 1st natatory leg. × 260.
„ 9. „ „ „ 4th „ × 260.
„ 10. „ „ „ 5th „ × 395.
„ 11. *Asteropontius attenuatus*, n. gen. et sp., female, from above. × 106.
„ 12. „ „ „ anterior antenna. × 195.
„ 13. „ „ „ posterior antenna. × 156.
„ 14. „ „ „ mandible and palp. × 156.
„ 15. „ „ „ maxilla. × 156.
„ 16. „ „ „ 1st maxilliped. × 260.
„ 17. „ „ „ 2nd „ × 260.
„ 18. „ „ „ 1st natatory leg. × 195.
„ 19. „ „ „ 4th „ × 195.
„ 20. „ „ „ 5th „ × 260.
„ 21. *Asterocheres major*, n. sp., female, from above. × 80.
„ 22. „ „ „ anterior antenna. × 156.
„ 23. „ „ „ posterior antenna. × 195.
„ 24. „ „ „ mandible and palp. × 195.
„ 25. „ „ „ maxilla. × 195.
„ 26. „ „ „ 4th natatory leg. × 120.
„ 27. „ „ „ 5th „ × 130.
„ 27*a*. „ „ male, anterior antenna. × 156.
„ 28. „ „ „ abdomen and furca. × 80.

Fig. 29. *Asterocheres minor*, n. sp., female, from above. × 80.
,, 30. ,, ,, ,, anterior antenna. × 195.
,, 31. ,, ,, male, abdomen and furca. × 80.

PLATE XIX.

Fig. 1. *Asteropontius typicus*, n. sp., female, from above. × 80.
,, 2. ,, ,, ,, anterior antenna. × 195.
,, 3. ,, ,, ,, posterior antenna. × 195.
,, 4. ,, ,, ,, mandible and palp. × 195.
,, 5. ,, ,, ,, maxilla. × 390.
,, 6. ,, ,, ,, 1st maxilliped. × 195.
,, 7. ,, ,, ,, 2nd ,, × 195.
,, 8. ,, ,, ,, 1st natatory leg. × 195.
,, 9. ,, ,, ,, 4th ,, × 195.
,, 10. ,, ,, ,, 5th ,, × 195.
,, 11. *Asterocheres manaarensis*, n. sp., female, from above. × 106.
,, 12. ,, ,, ,, anterior antenna. × 195.
,, 13. ,, ,, ,, posterior ,, × 195.
,, 14. ,, ,, ,, mandible and palp. × 195.
,, 15. ,, ,, ,, maxilla. × 195.
,, 16. ,, ,, ,, 1st maxilliped. × 195.
,, 17. ,, ,, ,, 2nd ,, × 195.
,, 18. ,, ,, ,, 1st natatory leg. × 195.
,, 19. ,, ,, ,, 4th ,, inner branch. × 195.
,, 20. ,, ,, ,, 5th ,, × 195.
,, 21. *Lepeopsyllus typicus*, n. gen. et sp., female, from above. × 53.
,, 22. ,, ,, ,, anterior antenna. × 195.
,, 23. ,, ,, ,, posterior ,, × 156.
,, 24. ,, ,, ,, mandible and palp. × 156.
,, 25. ,, ,, ,, maxilla. × 260.
,, 26. ,, ,, ,, 1st maxilliped. × 90.
,, 27. ,, ,, ,, 2nd ,, × 90.
,, 28. ,, ,, ,, 1st natatory leg. × 111.
,, 29. ,, ,, ,, 4th ,, × 111.
,, 30. *Lepeopsyllus ovalis*, n. sp., female, from above. × 53.
,, 31. ,, ,, ,, anterior antenna. × 195.
,, 32. ,, ,, ,, 4th natatory leg. × 111.
,, 33. ,, ,, ,, 5th ,, × 195.

PLATE XX.

Fig. 1. *Doropontius denticornis*, n. gen. et sp., female, from above. × 80.
,, 2. ,, ,, ,, anterior antenna. × 195.
,, 3. ,, ,, ,, 1st maxilliped. × 90.
,, 4. ,, ,, ,, 2nd ,, × 90.
,, 5. ,, ,, ,, 1st natatory leg. × 195.
,, 6. *Paralichomolgus longicaudatus*, n. sp., female, from above. × 106.
,, 7. ,, ,, ,, anterior antenna. × 195.
,, 8. ,, ,, ,, 4th natatory leg. × 195.

Fig. 9.	*Cletopontius serratus*, n. gen. et sp.,	female,	from above.		× 80.
„ 10.	„	„	„	anterior antenna.	× 260.
„ 11.	„	„	„	posterior antenna.	× 260.
„ 12.	„	„	„	mandible and palp.	× 195.
„ 13.	„	„	„	maxilla.	× 195.
„ 14.	„	„	„	1st maxilliped.	× 195.
„ 15.	„	„	„	1st natatory leg.	× 195.
„ 16.	„	„	„	3rd „	× 195.
„ 17.	„	„	„	4th „	× 390.
„ 18.	„	„	„	5th „	× 260.
„ 19.	*Stephopontius typicus*, n. gen. et sp.,	female,	from above.		× 80.
„ 20.	„	„	male	„	× 80.
„ 21.	„	„	female,	anterior antenna.	× 520.
„ 22.	„	„	male	„	× 195.
„ 23.	„	„	female,	posterior antenna.	× 260.
„ 24.	„	„	„	mandible and palp.	× 260.
„ 25.	„	„	„	maxilla.	× 395.
„ 26.	„	„	„	1st maxilliped.	× 195.
„ 27.	„	„	„	2nd „	× 195.
„ 28.	„	„	„	1st natatory leg.	× 395.
„ 29.	„	„	„	2nd „	× 260.
„ 30.	„	„	„	4th „	× 260.
„ 31.	„	„	„	5th „	× 156.

It is with deep sorrow that I have to record the sudden death of my friend and fellow-worker, the senior author of this Report, just as his last sheets were passing through the press, and too late for any change to be made elsewhere in this volume. Mr. Isaac Thompson's many scientific friends, who have known and appreciated his work on the Copepoda, will share the feelings of regret which Mr. Andrew Scott, the joint-author, and I desire to express that this Report should have proved to be his last piece of scientific work.

W. A. H.

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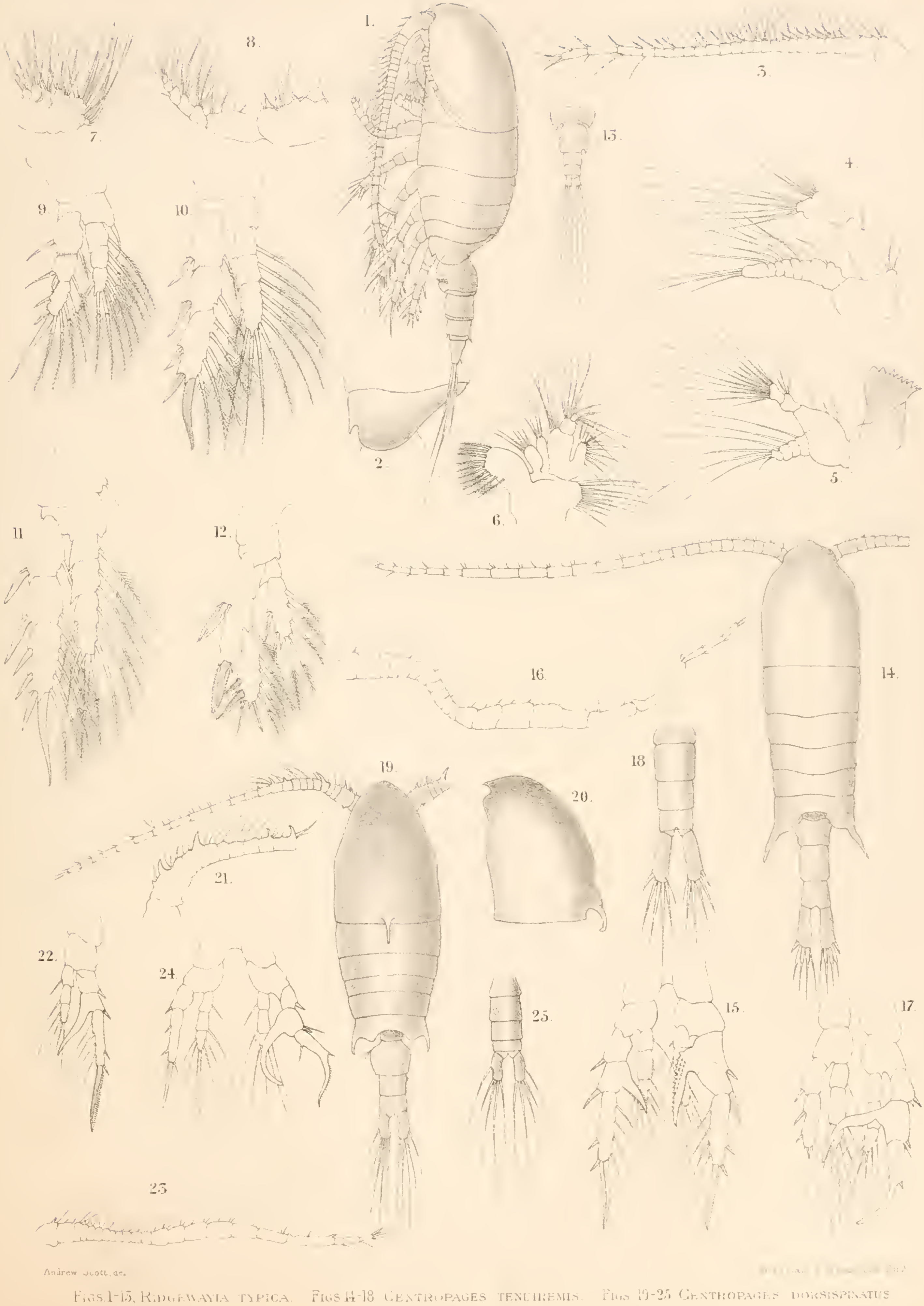

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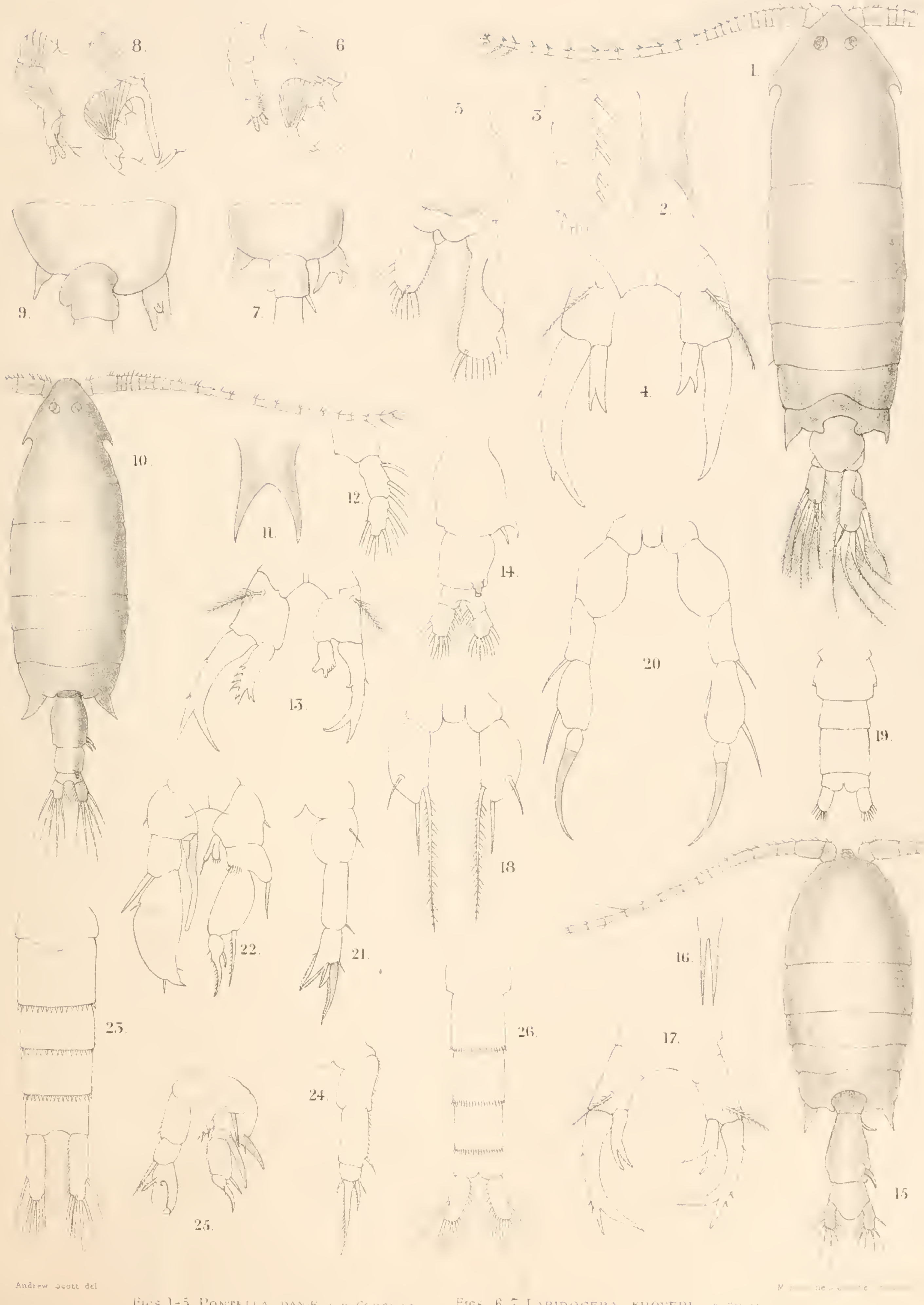
Figs. 1-13, Ridgewayia typica. Figs 14-18 Centropages tenuiremis. Figs 19-25 Centropages dorsispinatus



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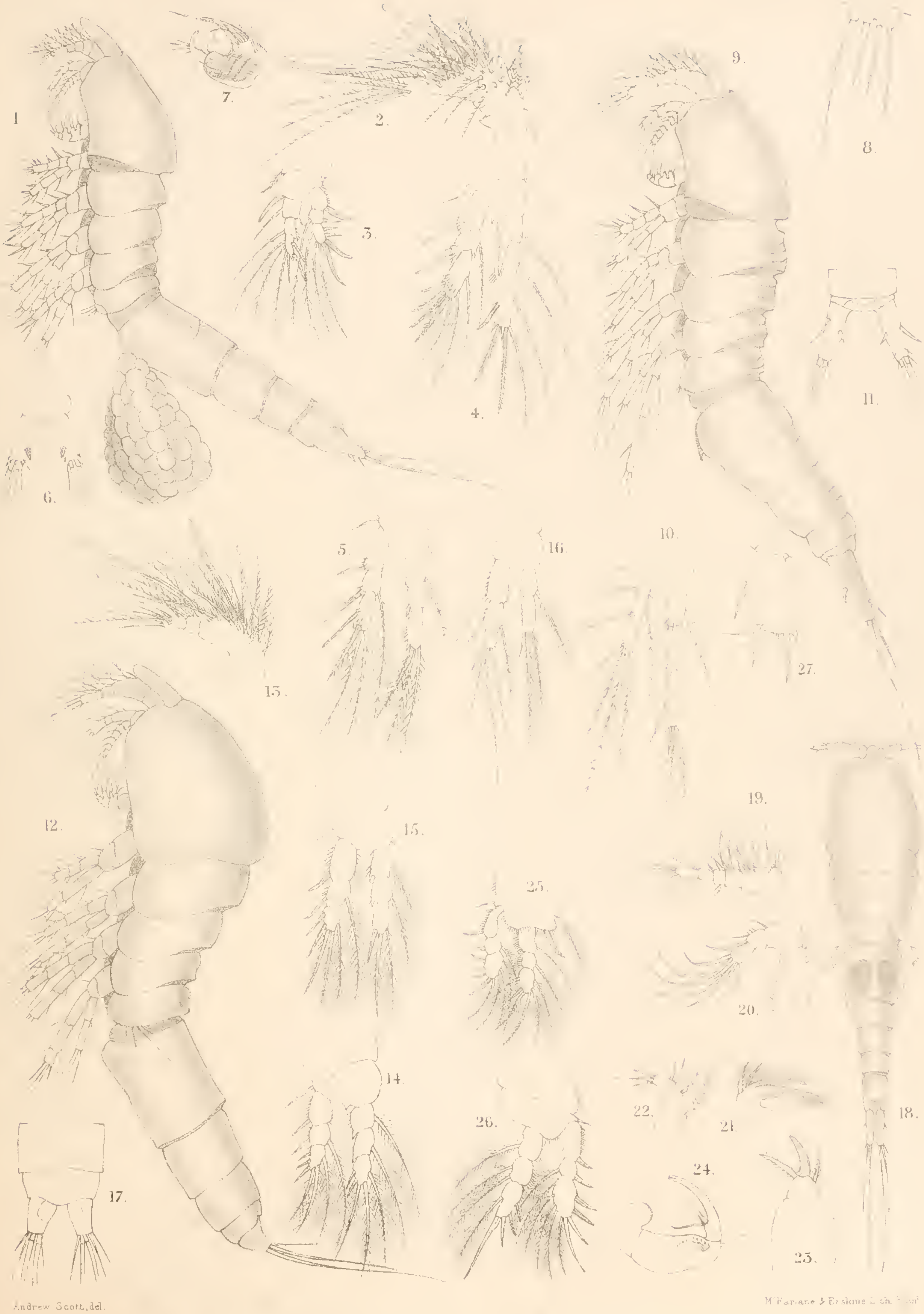
Figs 1-5 Pontella danæ, var Ceylonica Figs. 6 7. Labidocera kroyeri var Gallensis
Figs 8.9. Labidocera kroyeri, var. Stylifera. Figs. 10-14, Labidocera pectinata Figs 15-17. Pontellopsis herdmani
Figs. 18-20. Metacalanus aurivillii, Cleve. Figs 21-23 Pseudodiaptomus salinus, Giesb Figs 24-26 Pseudodiaptomus aurivillii Cleve



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FIGS 1-8, SUNARISTES INOPINATA FIGS 9-11, SUNARISTES LONGIPES
FIGS 12-17, SUNARISTES CURTICAUDATA FIGS. 18-27, HERSILIODES DUBIA

Figs. 1-9, Tegastes imthurni. Figs. 10-12, Tegastes donnani.
Figs. 13-16, Tegastes twynami. Figs. 17-22, Tegastes chalmersi.

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Figs 1-9, Stenhelia brevicornis. Figs. 10-15 Stenhelia gracilicaudata

Figs 16-22, Stenhelia longicornis Figs. 23-29, Ameira minor

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Figs 1-7, Stenhelia perplexa. Figs. 8-14, Stenhelia dentipes.
Figs. 15-20, Ameira tenuipes. Figs 21-24, Stenhelia minuta.

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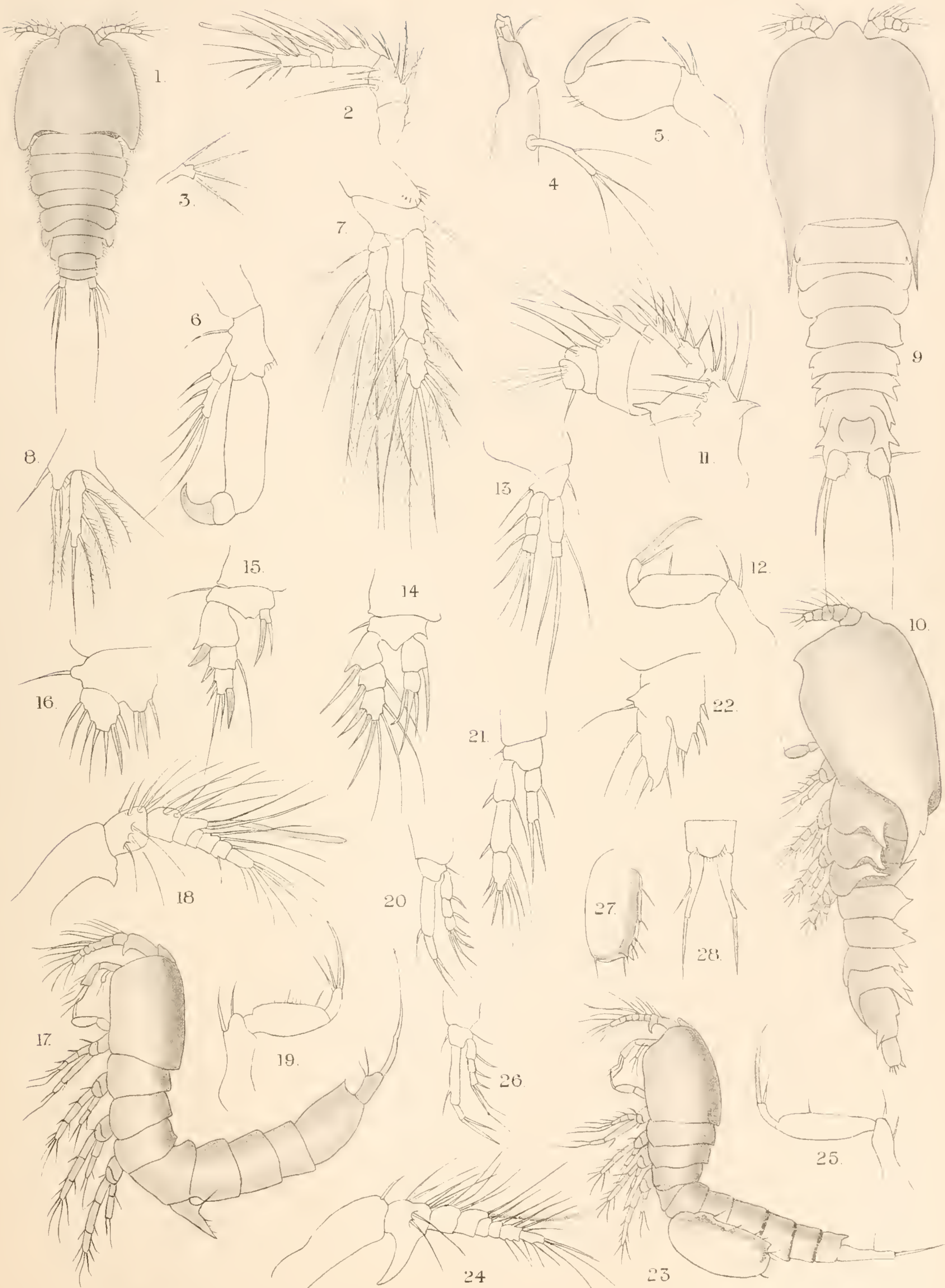
Figs 1-10. Parastenhelia hornelli   Figs. 11-23. Ceylonia aculeata.



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FIGS 1-8, LAOPHONTE HIRSUTA. FIGS 9-16, LAOPHONTELLA TYPICA

FIGS 17-22, TETRAGONICEPS DUBIA FIGS 23-28, TETRAGONICEPS MINOR.

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FIGS 1-10, DACTYLOPHUSIA DENTATA
FIGS 11-18, DACTYLOPHUSIA HAVELOCKI
FIGS. 19-24, DACTYLOPHUSIA HIRSUTA
FIGS 25-32, DACTYLOPHUSIA CEYLONICA

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Figs 1-7, Dactylophusia hamiltoni. Figs. 8-14, Parastenhelia similis
Figs 15-18, Stenhelia knoxi. Figs. 19-24, Dactylophusia robusta

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Figs 1-8, Dactylophusia laticaudata
Figs.13-18 Dactylophusia platysoma.

Figs 9-12 Dactylophusia æmula.
Figs.19-24, Pseudothalestris imbricata, Brady.

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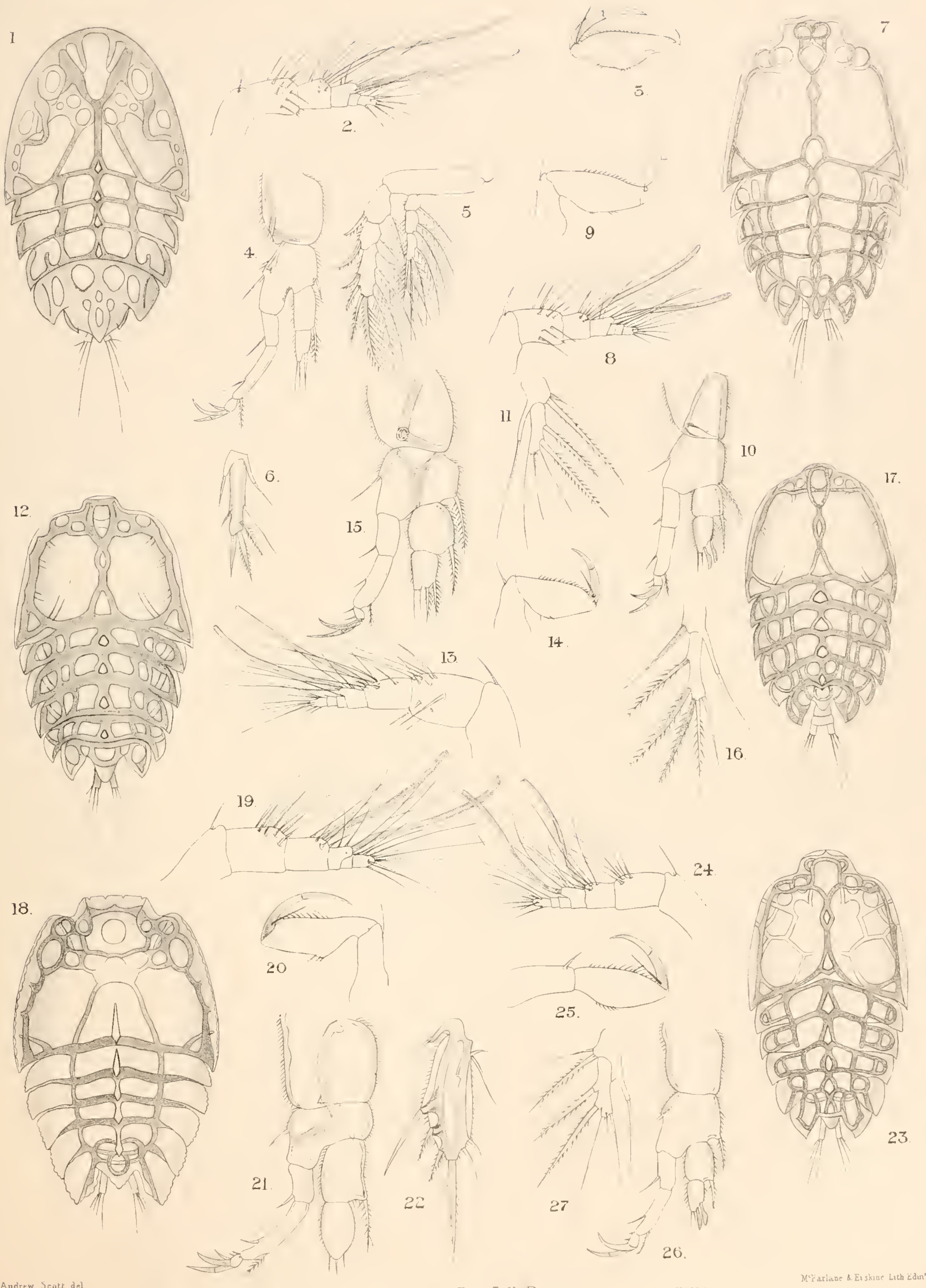
Figs. 1-10, Porcellidium fimbriatum, Claus. Figs. 11-14, Porcellidium brevicaudatum.
Figs. 15-18, Porcellidium acuticaudatum. Figs. 19-22, Porcellidium ravanæ.



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Figs 1-6, Peltidium ovale Figs 7-11, Peltidium angulatum
Figs 12-17, Peltidium speciosum Figs 18-22, Peltidium serratum Figs. 23-27, Peltidium perplexum.

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Figs. 1-11, Pseudanthessius maximus. Figs. 12-18, Pseudanthessius chelifer.
Figs. 19-23, Pseudanthessius gracilis, Claus. Figs 24-30, Pseudanthessius concinnus.

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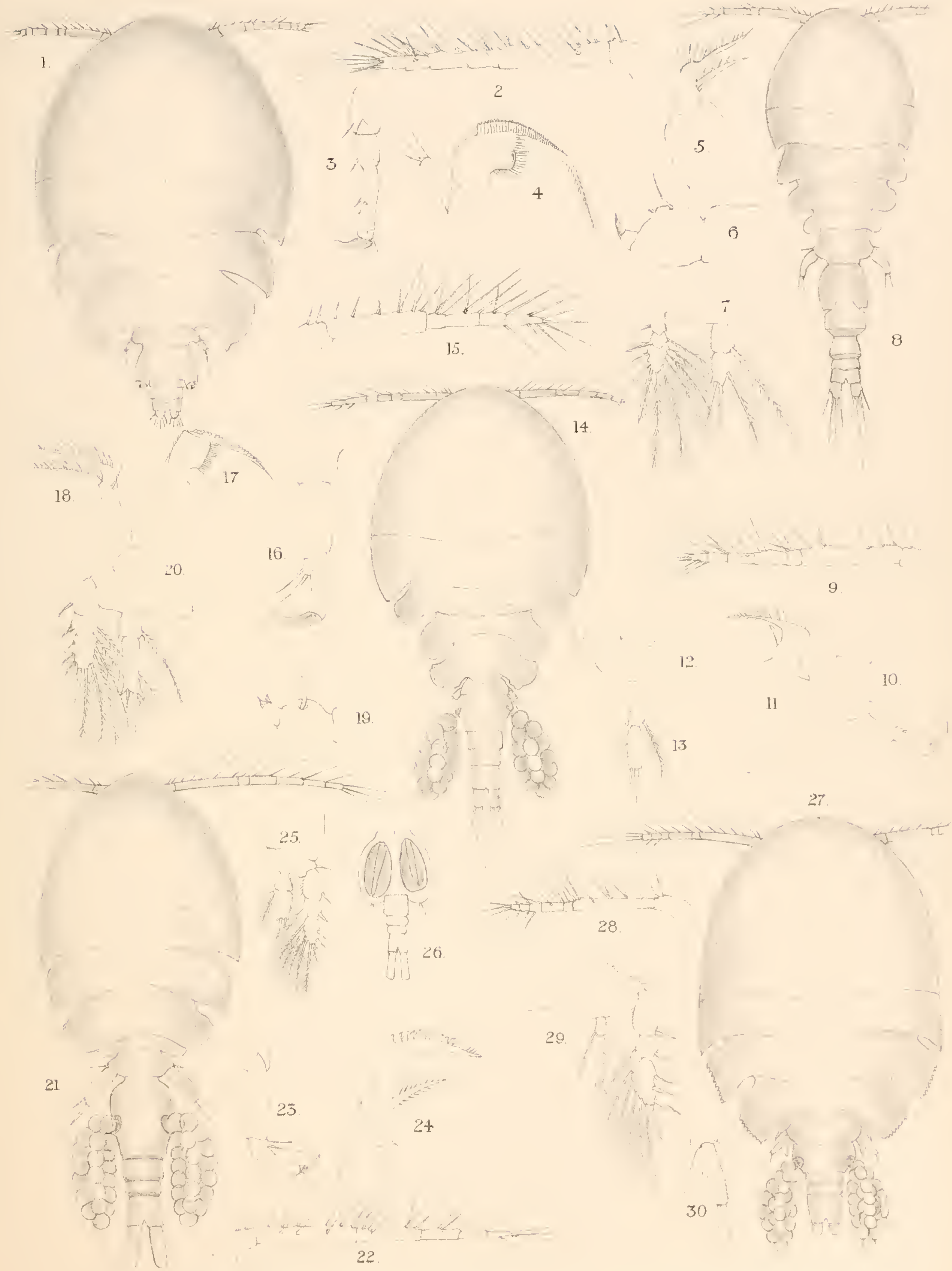
Figs 1-9 Lichomolgus gracilis. Figs. 10-17, Lichomolgus ieversi.
Figs. 18-24, Lichomolgus buddhensis. Figs. 25, 26, Lichomolgus lankensis. Figs. 27-34, Lichomolgus simplex.



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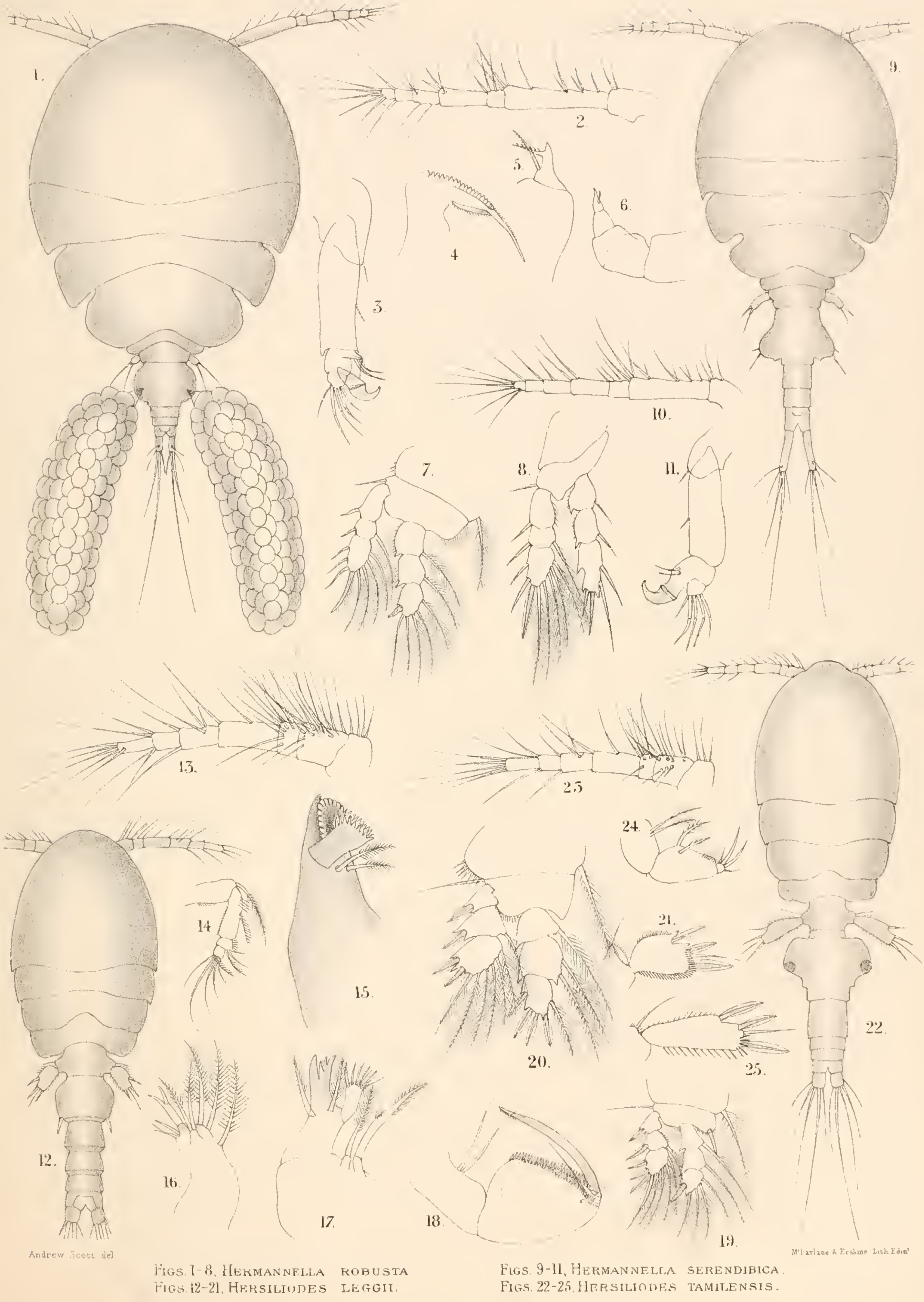
Figs 1-7, Paralichomolgus curticaudatus. Figs. 8-13, Lichomolgus elegans.
Figs. 14-20, Lichomolgus robustus Figs. 21-26 Lichomolgus gigas Figs 27-30 Lichomolgus dentipes



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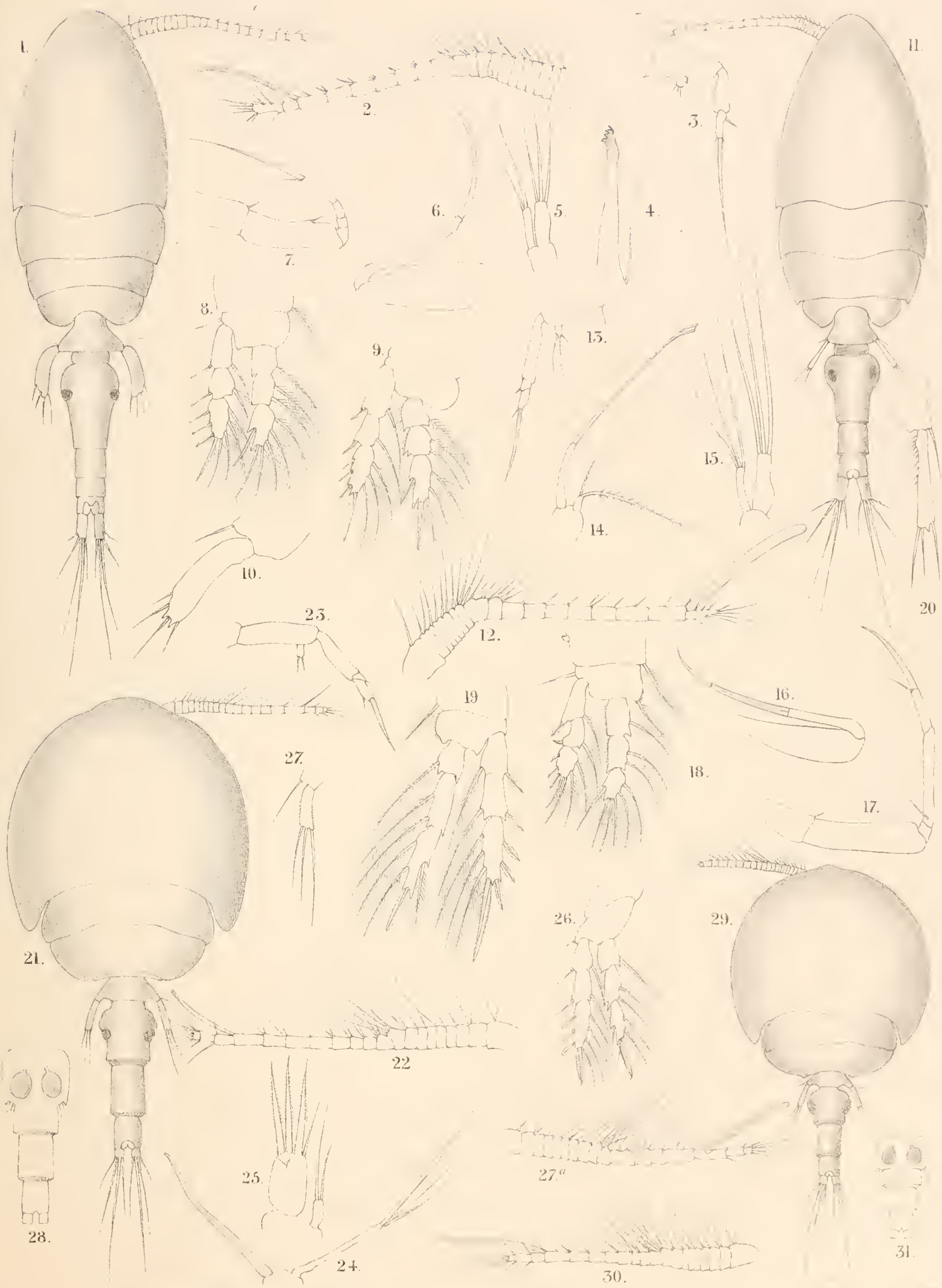
FIGS. 1-8, HERMANNELLA ROBUSTA. FIGS. 9-11, HERMANNELLA SERENDIBICA.
FIGS. 12-21, HERSILIODES LEGGII. FIGS. 22-25, HERSILIODES TAMILENSIS.



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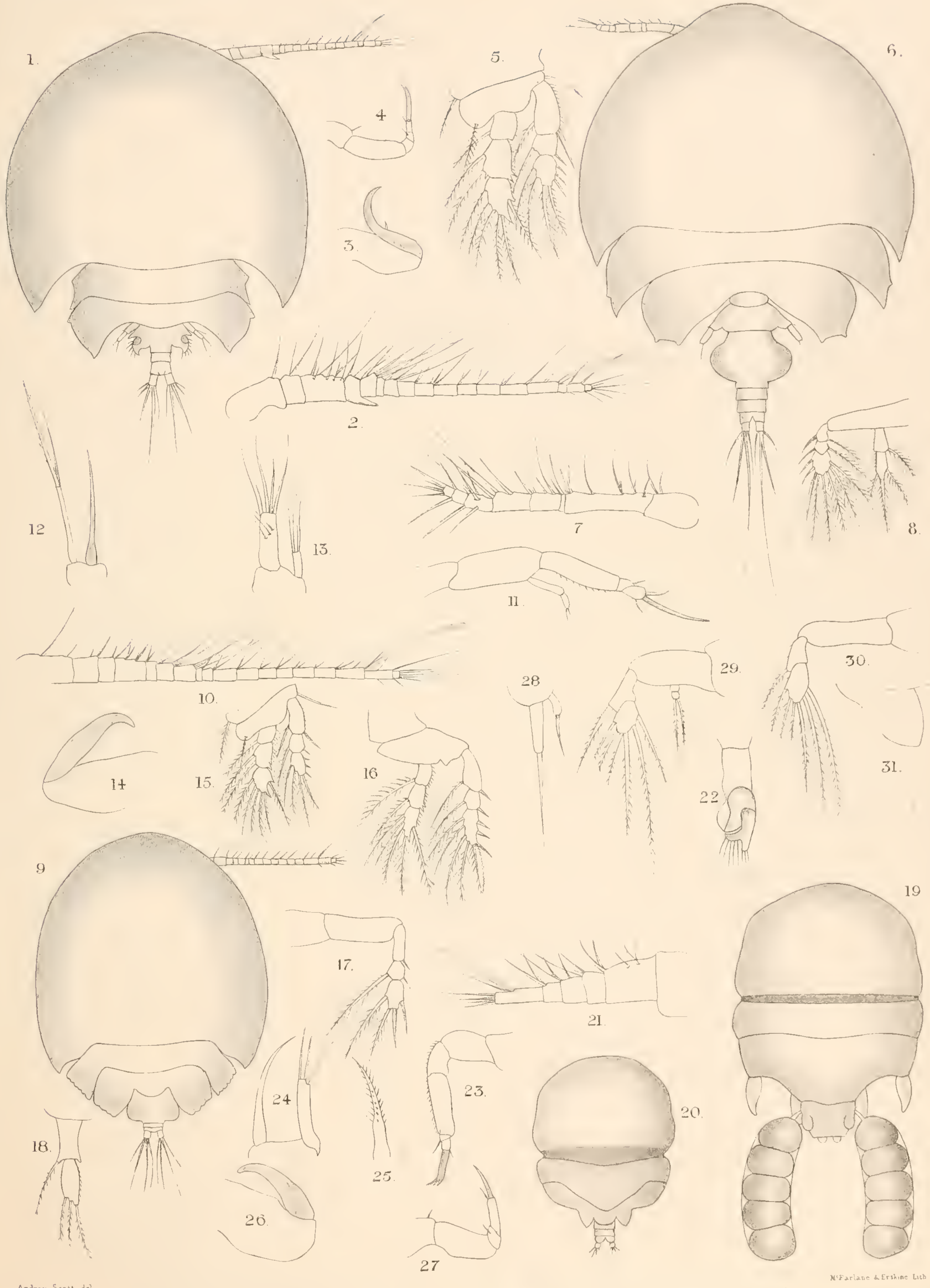
FIGS. 1-10, COLLOCHERES GIESBRECHTI. FIGS 11-20, ASTEROPONTIUS ATTENUATUS.
FIGS 21-28, ASTEROCHERES MAJOR. FIGS. 29-31, ASTEROCHERES MINOR.

Figs. 1-10, Asteropontius typicus. Figs. 11-20, Asterocheres manaarensis.
Figs. 21-29, Lepeopsyllus typicus. Figs 30-33, Lepeopsyllus ovalis.



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Figs. 1-5, Doropontius denticornis.
Figs. 9-18, Cletopontius serratus.
Figs. 6-8, Paralichomolgus longicaudatus.
Figs. 19-31, Stephopontius typicus.

1076