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REPORT ON CERTAIN SCIENTIFIC WORK DONE ON THE CEYLON PEARL BANKS DURING THE YEAR 1911.

With three Plates and three Charts.

CONDUCTED BY THE CEYLON COMPANY OF PEARL FISHERS, LIMITED.

BY

T. SOUTHWELL, A.R.C.Sc. (LOND.), F.L.S., F.Z.S.,

Deputy Director of Fisheries for Bengal,

Late Scientific Adviser to the Ceylon Company of Pearl Fishers, Limited, and Inspector of Pearl Banks,

AND

LIEUTENANT J. C. KERKHAM, R.N.R.,

Superintendent of Fisheries.

Colombo:

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Reports from the Ceylon Marine Biological Laboratory.

PART VI.] **Nos. 20 to 22.** [VOL. I.

SUMMARY OF CONTENTS.

INTRODUCTION.

I.—HISTORY OF THE LABORATORY.

WITH the publication of this Report (Part VI.) the Ceylon Marine Biological Laboratory ceases to exist. In 1902 Professor Herdman was deputed by the Royal Society, on behalf of the Colonial Government, to investigate the various problems relating to the pearl banks, and especially the reason of the erratic nature of the fisheries. His five voluminous Reports are well known. The Reports from this Laboratory were merely intended to supplement Herdman's Reports.

After Professor Herdman had finished his investigations in Ceylon, Mr. Hornell, who had acted as Assistant to Professor Herdman during his stay in Ceylon, was left to continue the work on the spot. The Ceylon Marine Biological Laboratory was thus founded. Its first headquarters were at Galle, but were subsequently changed to Colombo, although the great bulk of the work has been done out at sea, on board the barque "Rangasamee Porawee." In 1903 Mr. Hornell was appointed Marine Biologist to the Ceylon Government; during his appointment the first two parts of the Reports from this Laboratory were published. In 1905 the pearl banks were leased out to the Ceylon Company of Pearl Fishers, Limited: Mr. Hornell left the service of Government and took up duties as Manager of this Company. The Ceylon Marine Biological Laboratory thus passed from the hands of Government and became controlled and carried on entirely by the Company.

In 1906 I came out to Ceylon as the Scientific Assistant to the Company. Early in 1908 Mr. Hornell left the service of the Company, and I assumed full executive duties. Later in the year Lieutenant J. C. Kerkham, R.N.R., was appointed Superintendent of Fisheries, and the scientific work devolved on me. This arrangement continued up to the end of 1911, and it was during this period that Parts III., IV., V., and VI. Reports were published. It will be noted that Parts I. and II. (which are now out of print) were published whilst the banks were under the control of Government. All the succeeding Reports represent a mere fraction of the work done by the Company. The Laboratory is being closed on account of the fact that the leasing of the banks by the Company has not proved a commercial success.

I assume duties as Deputy Director of Fisheries for Bengal in December, 1911.

2.—Causes which led to the Failure.

It is impossible to give more than a brief outline of a few of the causes which led to the failure Some of the factors are dealt with in Parts IV. and V. of the preceding Reports.

The uncertain nature of the fisheries has been fully recognized for many centuries. Periods of barrenness have always succeeded years of plenty, and the cause was never discovered. Steuart, whose writings contain shrewd observations mixed with spicy romance, remarked in 1843 that the intermittency of the fisheries was the act of God, and beyond the control of man. The investigations conducted by Professor Herdman and by the Company had for their object, amongst other things, the elucidation of this problem. How far the investigations have been successful will be gathered from the Reports.

As we have seen, the banks were leased out in 1905, and two successful fisheries resulted (1906 and 1907). Since then no fisheries have been held, and at the present time the banks are absolutely barren. Even when spat *is* found, it will be four years before it can be fished, excluding the event of its being lost in the meantime through a variety of causes. The Company were granted the lease of the banks for a period of twenty years, and were bound by the agreement to carry out the recommendations which had already been made by Professor Herdman. The yearly rental to be paid was £20,000, and a further smaller sum had to be expended in general scientific work. The working expenses were, of course, additional.

As the average profit on a normal fishery is about £60,000, it follows that in order to make the enterprise successful a good fishery must take place within every three years. The history of the banks abound with instances in which there are blanks of from four to fifty years, but in this connection it is to be noted that up to six years ago only certain paars, such as the Cheval and the Muttuvaratu, were ever inspected. Subsequent events have shown the high probability of oysters having occurred in times past at other places close by these paars, as the entire plateau is potential paar ground. These questionable blank years undoubtedly exaggerate the periods of time when oysters were really absent. In view of these facts the rental paid has been excessive, as history has shown.

For the continuity of fisheries the isolation and protection of breeding stocks is essential. It has often been pointed out that even after a most thorough fishery there are bound to remain a few scattered oysters which escape the vigilance of the divers. This is indeed so, but it has to be remembered that the Ceylon pearl oysters have the sexes separate. They depend for their continuity on their seminal products being wafted together by the movements of the water. Thus, although after a fishery thousands of oysters are left scattered about here and there, it by no means follows that their seminal products come together. A distance of even one yard *may* be fatal. Thus, if the best results are to be obtained, the necessity of leaving and protecting, say, ten compact beds of old oysters of about one acre in extent becomes obvious. During normal fisheries anything from 40 to 80 million oysters may be fished, and the number of oysters required to leave such compact and scattered beds would not be more than 1 to 2 million—an insignificant fraction of the whole. Since these facts were discovered there have been no oysters on the banks, and thus the observation has as yet had no practical fruition. It was to protect such beds as these, if found, that the Company purchased two years ago, at a cost of £3,500, wire netting sufficient to protect an aggregate of one-sixth square mile of oysters. As the pearl banks cover over 700 square miles, and as the cost of netting is prohibitive, to say nothing of the impossibility of dealing on a large scale with netting, it is clear that it could not be used very extensively, and it was never proposed to do more than protect breeding stocks to the extent indicated. Unfortunately the opportunity has never occurred.

The wire netting has been immersed in sea water and its durability tested. It was found to keep intact and effective for a proved period of eighteen months, and thus wire netting would be suitable for protecting spat for this period, after which time protection would not be so necessary.

The principal cause of the failure, however, has been the non-occurrence of a spatfall during the last few years. As no oysters were present on our own banks, it was obvious that if a spatfall did occur it would have to be derived from elsewhere. It has long been believed that young oysters (larvæ) travel over to our banks from Southern India, where a few scattered and unproductive oyster beds occur. The drift bottle experiment described in this Report proves that that is not only quite possible, but that it certainly does happen at times. Blank years on our own banks are due principally to one of two causes, either to the absence of oysters on the Tuticorin banks, or to the failure or sluggishness of the local south-west monsoon current during the critical breeding time, which results in the larvæ failing to reach the plateau, and, dropping into the abyss, being lost for ever.

These facts, however, do not explain why it is that when once the banks *have* oysters on them they should not be more or less independent of exotic spat, but maintain and develop their own. The reason is simple, and is to be found in the rapaciousness of man, whose avarice kills the goose that lays the golden egg, by omitting to leave breeding stocks; also to voracious fish, to whom a bed of oysters is a feeding ground, to be deserted for pastures new only when the supply is exhausted. So thoroughly have the banks been devastated that during the last two and a half years less than half a dozen "shell fish" (molluscs) have been obtained, in spite of the efforts of divers and the use of the trawl and dredge. Thus it is evident that other, and probably all, "shell fish" suffer equally with the pearl oyster, and it is only on account of the commercial importance of the latter that the loss is noted. Now that the banks are depleted of all molluscs, fish of all species are remarkably scanty; but one cannot doubt that, as in past ages, when the banks *do* recover the fish will return. A fuller and more detailed account of the ravages caused by fish will be found in Part IV.

We thus come to agree with Steuart that in some respects the continuity of fisheries is dependent on natural events which are beyond the control of man. But whilst this is so, we can almost escape this catastrophe, and in any case extensively mitigate it, by reserving breeding stocks of old oysters in the way indicated; and, although even thus one could not hope to emulate the luxuriant bounty of Nature, such breeding stocks would at least make the enterprise a successful one commercially.

The importance and significance of trawling, dredging, and transplanting were fully dealt with in Part V. Report, and need not be further considered here.

In the present Report the subject of currents is extensively dealt with. The importance of the surface currents prevalent during the spatting season, and their relation to the natural distribution of oyster larvæ, cannot be exaggerated. Assuming oysters are present on the Tuticorin side, a spatfall on our own banks is certain if the south-west monsoon continues strong at the critical breeding time. If the monsoon is weak or erratic, then the larvæ either drift through Paumben Pass, or drop into the abyss on their way to the pearl banks, depending, of course, on the topographical position of the larvæ when the fluctuations of the monsoon begin. It is very noteworthy that the facts which have been obtained fully and naturally explain why our banks usually retain their own spat as well as receive exotic deposits, whilst the Tuticorin banks and those banks still under Government control are not only destined to lose their own spat, but are situated in such a way that exotic falls of spat thereon are almost physically impossible. These facts are amply borne out in the history of the areas concerned.

Considerable misapprehension has existed during past years in relation to currents in general over the banks. If a bed of oysters has disappeared, the cause has been attributed to currents, no other explanation being obvious. Not only so, but the distinction between a top and a bottom current has not been appreciated. A strong drift may be present on the surface of the water, which is not felt at the bottom. Our experience, extending as it does over five years, has furnished no indication whatever of a bottom current, even though we have had access to the diving dress as well as the information afforded by skin divers. We are of opinion that bottom currents do not exist, and that the loss of beds of oysters in past years was probably never due to this cause, nor to silting over by sand.

Having thus outlined in merest detail some of the circumstances which have led to the failure of the enterprise, it would be well to now consider what ought, in our opinion, to be done in the future.

3. The desirability of forming a Government Marine Department.

The pearl fisheries represent the oldest, and probably the largest, source of revenue to the Government that is, and its extensive nature fully warrants the attempt being made to make the banks as lucrative and successful as possible. What is required in Ceylon is a Government Marine Department, with a special staff of two or three suitably trained men, whose *only* duty would be to fully investigate and enhance the marine resources of the Island. The primary work would be a continuation of the scientific research initiated on the pearl banks. During the south-west monsoon, when operations are impossible on the pearl banks, there would be the investigation of the Placuna fisheries on the sheltered side at Tamblegam, or the investigation of the fresh-water fisheries. In addition to these, chanks are fairly plentiful on muddy ground, and this industry could be made profitable. Finally, fish trawling investigations could be carried on, and this industry placed on a scientific basis. It would be impossible to do this work without a special staff. A Marine Department could be run for from £2,000 to £3,000 per annum successfully, and if a single pearl fishery resulted *once* in from twenty to thirty years, the Department would have paid for itself, to say nothing of the other industries. Other fisheries over and above the one named would represent clear profit. One has only to turn to the Madras Presidency, and many other places elsewhere, to find that even the minor marine industries are placed on a proper and lucrative footing. Ceylon is unique in this respect in possessing the finest pearl fishery in the world, and this fact itself is sufficient reason why a special department should be established. What Peradeniya has done for agriculture in Ceylon—for tea, rubber, coconuts, &c.—can be done by a Marine Department with the pearl fishery and other marine industries.

The difficulties with the fisheries here when under Government control have almost always been that the various officials *pro tem.* were merely casually deputed to reap the harvest of the sea, and had no time nor business to seek to enhance its value, or to ensure its continuity.

There are instances on record, and not far remote, when by the merest chance Government conducted huge fisheries which might easily have been lost. We have no doubt whatever that these incidents have been numerous in the past, but there is necessarily no record to show. Instances are more numerous still in which beds of oysters two, three, four, and even five years old were discovered for the first time. If the inspections had been carried out with that thoroughness which so large a source of revenue warrants, these oysters would have been discovered before they were three months old. It is also equally clear that if beds have frequently been found of this age, other beds have never been found at all. The discovery of a bed of oysters two, three, four, or five years old indicates that the necessity of an extensive survey of the pearl bank area has not been thoroughly appreciated. No inspection is either satisfactory or adequate which does not every year systematically and fully cover the entire plateau; and so long as inspections are merely confined to a few paars, beds of oysters are bound to be lost. Oysters or spat, when they occur, ought to be discovered at once, and watched and tended with that care which the circumstances demand. The rectangular method of inspection adopted by the Company leaves no part of the ground unexplored. It is described elsewhere.

The pearl bank area is to be regarded as *wholly* potential, and not as consisting of a number of paars. The notoriety of the Cheval and Muttuvaratu Paars as very productive areas is merely incident on their having been more frequently examined. In fact, up to five or six years ago these were practically the only areas inspected. As the recent investigators went further afield, other productive paars were discovered, and there is every reason to believe that oysters flourished thereon occasionally from time immemorial, and were never sought for. As we have already noted, the area under lease covers over 700 square miles: there is still much potential ground not under lease. The entire area covers approximately over 1,200 square miles. The thorough inspection of this area would fully occupy six months. It thus becomes evident that there is employment for two trained and expert men, and I have no doubt in my own mind that the establishment of a Marine Department would not only be a successful venture, but that in a short time it would prove to be one of the principal and most lucrative sources of revenue to the Colony. When the banks revert to Government, it will be pathetic if those rough, ready, and casual methods of inspection and control which have come down to us with the banks themselves, are continued.

4.—General.

The legacy left by the Company to Government consists of the information contained in the various private reports sent in to them, of the four Marine Biological Reports, of a chart of the Cheval Paar drawn up from a recent survey, and of a large new nautical and biological chart of the entire plateau under lease, the latter having taken practically five years to prepare. In addition to these, the positions of various trigonometrical and other stations have been verified and the structures repaired. Beacons have been erected on various reefs, and although these are not permanent structures, they will survive for many years. Hatchery and nursery tanks are fitted up complete at Marichchukaddi. A survey of Dutch Bay has been made and a chart published, and this information has conclusively shown the unsuitability of this place as a seaboard nursery. The general experimental work carried on by the Company at enormous expense has been of so extensive a nature, and so conclusive in its results, that it need not be repeated. The faunistic and other specimens collected during five years, including the tow net catches extending over four years, have been sent to the Government Museum, Colombo. These are some of the benefits other than purely pecuniary ones which have been derived by Government from the Company.

I take the liberty of referring here to the introduction of X-ray photography to oyster culture (?) in Ceylon, as considerable misunderstanding exists on this point.

Some years ago an X-ray plant was laid down by Mr. John I. Solomon in the vicinity of the pearl banks. The object was to X-ray oysters, to separate those containing pearls, and to put these back again into the sea for the pearls to grow. It is to be remembered that the Company only fish old oysters. It would seem a far cheaper way (even if less dignified) to proceed in the usual way in the determination of the pearl yield rather than to X-ray the oysters. If the oysters have pearls, they will not grow appreciably bigger during the short span of life which remains to the oyster. If pearls are not present, then these expensive operations are wasted. Even if young oysters are being dealt with, the X-rays will not manufacture or initiate pearl formation, and thus the operations appear useless and extravagant. When one considers that young oysters, when they *do* occur, are found in the quantity of at least half a million per acre, and that the maximum that can be X-rayed per minute is about sixty, the impossibility of the proceeding as a commercial undertaking is evident; and even if the oysters could all be X-rayed in one second, there seems to be no object in attempting it.

In Japan an extensive and successful industry is carried on in pearl culture. Small leaden images of the Buddha and other nuclei are inserted between the mantle and the shell, and these, setting up local irritation, in course of time become partially covered with pearly matter. After they have grown sufficiently large they are removed, and the basal part of this concretion (which has grown to the shell) is carved out of the shell. These artificial pearls are always used for mounting, the basal face being hidden in the mount.

Since probably not ·01 per cent. of the larvæ inhabiting the tissues of the pearl oyster ever become the nuclei of pearls, it would appear likely that future science will concentrate on so treating the oysters that a large percentage of these larvæ will form pearls, as it appears very probable that only such larvæ which for some unaccountable reason die in the tissues, and thus set up local irritation, form pearls. If this is found possible in future years, pearl fishing will be revolutionized.

Consequent on the entire absence of oysters on the Company's banks, numerous suggestions have been received from time to time advising the stocking of the banks with oysters from elsewhere—Mergui, Torres Straits, Persian Gulf, &c. Needless to add, all these suggestions have been passed by. It has taken ten years to collect what little we know of our own oyster. Apart from the expense and probable impossibility of successfully transplanting these exotic oysters over long distances to our banks, we have no reason to believe it would occupy a less time, if transplanting was successful, to acquire the knowledge concerning them that we possess about the pearl oyster. Mother-of-pearl oysters have totally different habits, and if success is doubtful with them in their own natural surroundings, it would obviously be more so here. The Mergui oyster lives in 20 fathoms on a muddy bottom, over which a 7-knot current flows, and where there is a rise and fall of 15 feet of water. Our banks are rocky, covered with only an average of 8 fathoms, and bottom currents are absent. The futility of transplanting such oysters is obvious.

The Ceylon pearl banks do not require supplementing with exotic oysters. Given a spatfall, only thorough inspection, care, and normal foresight in isolating breeding stocks, &c., are required to make the banks perennially productive. A spatfall is almost certain to take place at an early date, and to our successors will be given the opportunity of reaping where we have sown.

In conclusion, I beg to express my indebtedness to the Ceylon Government for kindly publishing these results; my thanks are also due to my wife, for correcting proofs and for really serious and extensive help in many other ways.

T. SOUTHWELL.

At Sea, Cheval Paar,
Ceylon, November 18, 1911.

No. 20.

CURRENTS ON THE CEYLON PEARL BANKS. SUPERFICIAL AND DEEP.

By T. SOUTHWELL, A.R.C.Sc. (Lond.), F.L.S., F.Z.S., and Lieut. J. C. KERKHAM, R.N.R.

With three Charts.

The interest attaching to currents on the pearl banks lies almost wholly in the relation they bear to the oyster, for it is commonly believed that beds of spat or adult oysters have from time to time been entirely swept away by the agency of bottom currents. It is important, in the first place, to note that the oyster is stationary, and almost defenceless against the vast majority of its natural enemies. Fish of various species devour them omnivorously. Subtle and fatal diseases attack them. A variety of other animals compete with them for food, and often grow on their shells, as if to purposely arrest and accommodate such food as the gentle undulations of the bottom layer of water may bring near by.

The outstanding character of the oyster (*Margaritifera vulgaris*) is its sedentary habits, and the power it possesses of holding on to rock and other solid objects in such a way as to remain securely attached. This condition is essential to the oyster's welfare, and so strong and powerful is this attachment that it is only with difficulty that divers are able during fishery times to dislodge them from their anchorage. The attachment is made by means of a beard or byssus, similar to that occurring in the ordinary English mussel (*Mytilus edulis*). A very considerable percentage of oysters lose their byssus in being pulled away from their attachment. This structure can, however, be replaced in a very short time, and if necessary many times in succession.

In dealing with currents on the Ceylon pearl banks, it is essential, in the first place, to carefully distinguish between surface and bottom currents, for they bear different relations to the oyster. Therefore, in order to understand these relationships better, we will deal with each separately.

I.—Surface Currents during the North-east Monsoon.

Investigations of the surface currents have been carried on intermittently during the last four years, but only during the north-east monsoon. The observations on the south-west monsoon have only been carried out during two seasons, viz., 1908 and 1910. The results during the latter monsoon were in every sense satisfactory. The percentage returns were high (51·5 per cent.), and the results of each year's work were similar. In 1910 alone 565 bottles were released at different stations during the south-west monsoon, of which 291 were returned; whilst in 1908 only 80 bottles were released, and 47 returned. The results from many bottles liberated during the north-east monsoons of the last four years have had to be discarded, owing to the fact that the management of these drift bottles changed hands, and the results of the first two years' work were useless, as the necessary data was not obtainable. This paper, therefore, embodies the result of two years' work during each monsoon, viz., those of 1908 and 1909 during the north-east monsoon, and those of 1908 and 1910 during the south-west monsoon. Full statistics are given at the end of the paper.

Apart from the drift bottle experiments, our knowledge and experience has been further extensively supplemented by the observations made by commanders of coasting vessels, some of whom have had many years' experience.

These investigations were carried out on the west side of the Island (between Galle and Adam's Bridge), where, of course, the pearl banks lie, and also on the Indian side, and in the Gulf of Mannar generally. It is necessary at the outset to understand that the pearl bank area of the Ceylon coast consists of a shallow water plateau, shelving out from the beach to about the 12-fathom line, and then rapidly deepening to several hundred fathoms. The overfall ranges from 1 to 18 miles from the beach. The bottom consists of alternations of sand and limey rock, which latter is derived from decayed coral re-organized into an exceedingly hard substance by the cementing growths of *Nullipore* and *Polyzoa*. At most places the rock is only covered by less than four inches of sand, and is often quite bare.

These details have been obtained as a result of continued dredging and trawling operations, combined with the extensive work of skin diving and also dress diving.

Practically parallel to the shore, which runs approximately north and south, there is a more or less continuous, fringing, coral reef, exposed at places during low water. The rise and fall of tide is limited to a few inches only. Towards the north of the plateau the submerged continuation of Karativu Island runs in a northerly direction for about 10 miles as a narrow sandy shoal, and terminates very abruptly. Reference to the appended chart will indicate the topographical relations of the mainland. To the north the pearl banks under lease lie in a *cul-de-sac*. The only exit to the gulf is Palk's Strait, whilst Southern India forms the western boundary. The influence of these varied factors on the surface current will, however, be dealt with later.

It is obvious that during the north-east monsoon the surface current over the entire plateau has a different trend to that existing during the south-west monsoon, so that in order to fully elucidate and understand the true condition of affairs we will deal with each monsoon separately.

(*a*) *North-east Monsoon.*

This monsoon commences about the beginning of November and extends until about the end of May. It is the fine weather season, as the wind is from the land. During November, December, and January strong northerly winds prevail during the day, usually becoming almost easterly at or during the night. In February these strong winds gradually die down.

During March and April dead (*Trichodesmium*) calms prevail about midday. An hour or more later a gentle breeze springs up from the west, and as it strengthens it veers to the north, and by nightfall is due east from the land, where it continues during the night, shifting again to the south in the morning hours and gradually dying away at daybreak.

These conditions have been noted during a great number of years, and although the sequence of these daily changes of the wind is occasionally broken, they still remain a very noticeable feature about this time. During the fishery season the westerly afternoon wind enables the fleet to sail ashore, whilst the early morning easterly winds waft them back again to the fishing grounds after they have disposed of their oysters.

In May these rhythmic winds are almost entirely broken up, and are succeeded by calm mornings and exceedingly squally afternoons, characterized by heavy rains with lightning and thunder. This condition marks the approach of the south-west monsoon.

In thus considering the currents prevalent during the north-east monsoon, it will be noticed from the chart that the pearl bank area under lease lies in a *cul-de-sac*, where it is entirely protected by the mainland and the line of fringing reefs.

The banks south of Tallaivillu Point are swept by an oceanic current, which, running north, is deflected at this point to the west and on to the Indian coast.

North of Tallaivillu Point, however, it may be said that there are no true surface currents, except far out at sea. What surface currents exist on the plateau are transient and temporary, and vary even during the day with the direction of the wind, by which they are controlled and to which they entirely owe their existence. This area lies securely under the lee of the land, and is further protected by the line of fringing reefs previously mentioned. The situation of the banks renders them immune from oceanic currents, and bottles liberated on this area took one of two courses. If liberated well inshore, they were drifted south as far as Dutch Bay by the prevailing northerly wind. If liberated a little further west to the overfalls or beyond, they eventually drifted over towards Cape Comorin, being first blown south by the prevailing wind, and eventually they became involved in the oceanic current named, which runs along the west Ceylon coast in a northerly direction as far north as Tallaivillu Point, and then takes a westerly direction to the Indian coast towards Tuticorin, from whence it runs south, and, rounding Cape Comorin, has been traced as far north as Calicut. The current thus sweeping west runs out into the Indian Ocean, where it is lost, but it is exceedingly interesting to note that we have had a bottle returned from the Maldive Islands. This current, as it sweeps round Cape Comorin, still runs in a westerly direction, although owing to the configuration of the land offsets from the main current have been traced as far north as Calicut. From the above it will be gathered that bottles liberated along the Indian side and the Ceylon side (except on the inshore areas under lease) have usually been lost. The percentage recovered is small (16·76 per cent.), and such bottles consist entirely of (*a*) those liberated inshore on the areas under lease, which merely drifted south on to the beach by the prevailing north wind, these form the bulk of those returned; (*b*) those which were liberated further out at sea, west of the above area, which first drifted south with the prevailing northerly wind, and eventually becoming involved in the westerly current, drifted over to the Tuticorin side; while (*c*) those which were liberated to the south became directly involved in the westerly oceanic current named and were carried up the east coast of India. As we have seen, however, the vast majority (83·24 per cent.) were lost, being carried away into the Indian Ocean by the oceanic current.

It is to be noted that during this monsoon a steady flow of water passes through the Paumben Pass, from the north to the south side, and has been noted by such steamers as regularly pass through. This current of water, however, passes out into the Gulf of Mannar and is never felt on the area under lease, which lies to the extreme north-east of the gulf.

The pass through the Mannar Channel may be altogether neglected. During the south-west monsoon this channel becomes silted up. With the advent of the north-east monsoon the water collecting to the north and north-east of Mannar island quickly scours out the channel, but the effect of this is only felt for a few days on the area under lease. After the channel is clear no further current is noticed. A reference to the chart will show how insignificant and temporary the effect of this channel is.

Over the area under lease then, occurring as it does in such a secluded position, away and protected from all disturbing oceanic influences, the essential conditions for a calm sea (save such as is caused by wind, and therefore temporary in character) prevail. On this section of the plateau alone 300 drift bottles have been liberated. Of these, 57, or only 19 per cent., were returned. We have in the above been referring purely to the northern head of the gulf.

South of Tallaivillu Point, however, an entirely different set of conditions prevail. Here, as we have seen, a very decided current runs along the coast in a northerly direction, and in the face of the north-east monsoon. This current is known to exist throughout the entire monsoon, and is reckoned with and allowed for by local vessels. Its origin is a little obscure, but its occurrence is beyond possible doubt. Its rate averages 0·3 knot per hour. It appears to rise as an offshoot from the current produced on the east side of the Island during the north-east monsoon, which, running in a general southerly direction, flows into the open sea to the south-west of Ceylon. A branch from this volume of water rounds the south end of Ceylon, and runs north along the West Ceylon coast. This current on reaching Tallaivillu Point takes a due westerly course towards Tuticorin in South-east India. From there it runs south, and rounding Cape Comorin flows north along the west coast of India, and has been traced as far as Alleppe and Calicut, although the main current passes west and is lost in the Indian Ocean. This current continues through January and February, and ceases as the strength of the monsoon declines in March. During April and May there is no current noticeable, and this condition continues until the south-west monsoon sets in. The explanation of these facts may be difficult, but the presence of the current under consideration is unquestionable, for not only have drift bottles liberated in the vicinities concerned been recovered on the Indian side and in the Maldive Islands, but, as before noted, commanders of vessels traversing this tract are perfectly familiar with its direction and have helped the writers considerably.

It is interesting to further find that Steuart in his "Notes on Ceylon" (1843) points out that "ships leaving Bombay in the height of the north-east monsoon, to load cotton at Tuticorin, after passing Cape Comorin find the southern current so strong as to induce them to stretch across the Gulf of Mannar, and beat up the western coast of Ceylon until they can steer for their destined port, and this they accomplish against what is called in Ceylon 'a long shore wind.'"

This old-time observation fully amplifies our statement of the prevalent currents, and falls in line absolutely with our own observations.

To summarize, then, on the west coast of Ceylon the surface disturbance falls into two sharply defined sets, each set being strictly limited to a particular area, as under :—

(1) North of Tallaivillu Point (which comprises the pearl bank area under lease) the conditions of entire protection from oceanic currents and from the north-east monsoon exist on the inshore areas. Such disturbances as there are are purely local, varying, and intermittent, and are entirely due to the wind, which is invariably from the north over the plateau. This surface drift running south finds a ready exit in Portugal and Dutch Bay, and the changes taking place in the latter backwater may in some measure be due to the presence of this surface drift.

Further out at sea, and to the west of the plateau, northerly winds still prevail, and consequently there is a definite surface drift, which runs south for some distance. Eventually this drift joins the current running north (in the opposite direction) along the West Ceylon coast, and from about Tallaivillu Point runs west. Some bottles liberated about this vicinity have been recovered on the East Indian coast. The majority, however, were lost. In some cases a few rounded Cape Comorin, and were recovered on the West Indian coast as far north as Calicut, but the main current passes west into the Indian Ocean, and the bottles were consequently lost. One alone was returned from the Maldive Islands.

(2) South of Tallaivillu Point a definite current runs from the south of the Island in a northerly direction at an average rate of 0·3 knot per hour, and in the face of the north-east monsoon. This current is deflected about Tallaivillu Point, and from there takes a westerly course towards the Indian coast, and then, turning south, rounds Cape Comorin, and has been traced north along the west coast of India as far as Calicut. But the main current runs west into the Indian Ocean.

It is certain that the secluded and sheltered position of the pearl bank area under lease as distinct from the pearl bank area still under Government control, and which latter lies south of Tallaivillu Point, owes its larger degree of productivity to the incidence of its protected position. It is also evident, *a priori*, that such surface disturbance as does exist there is not sufficient to affect oysters whose natural habitat is in from 5 to 10 fathoms of water.

It might be argued that on a shallow water plateau such as exists on the west of the Island no surface current or drift could exist at all which did not affect the bottom on which the oyster lives. There are certainly movements of the water on the bottom, otherwise stagnation would result. But these movements are undulatory. They are vertical, and not horizontal.

The total effect of the surface movements on the area under lease with regard to the oyster is nil. They certainly are not harmful. The relative productivities of the areas (*a*) under lease and (*b*) those still under Government control has a deeper origin. But before attempting to discuss the matter further, we must first understand the nature of the surface currents during the south-west monsoon, for these currents *in toto* have a very real relation with the pearl oyster.

II.—Surface Currents during the South-west Monsoon.

We have already pointed out in Part III. Report of this series that the south-west monsoon on striking Cape Comorin is deflected in such a way that it runs approximately east and reaches the Ceylon coast about Tallaivillu Point, and then runs south.

It will be noted that the current, therefore, runs exactly opposite to the one prevalent in the north-east monsoon, and not only has it a definite course, but a more definite origin. This oceanic current, running as it does in its easterly course from Cape Comorin (and which has been felt as far north as Tuticorin), plays a very prominent and important part in the determination of the currents prevalent in the gulf, for with its fluctuations in strength the whole trend of the flow of water in the entire gulf changes. When the monsoon is weak this oceanic current is scarcely felt, and the south-west monsoon has full play in the gulf, where the current then runs north. When the monsoon is strong and steady, this oceanic current has an easterly course from points between Cape Comorin and Tuticorin, and reaching the Ceylon coast about Tallaivillu Point, turns, and runs south.

These details have been repeatedly corroborated by commanders of local coasting steamers who have had long experience. And during the south-west monsoon of 1910, 565 drift bottles were liberated at various points in order to confirm the above facts. Of these 565 bottles, 291 were returned, giving a percentage return of 51·5 per cent. In this connection it is important to note that with reference to drift bottles liberated in other parts of the world the usual and average percentage return is one-third. or 33 per cent., so that our experiment was very successful.

The south-west monsoon usually commences in June, and we started liberating bottles at definite stations at the end of June, 1910, and continued until September. The following is a summary of the results.

Drift bottles liberated off Cape Comorin and off Colombo late in June, before the monsoon had become severe, were recovered in the vicinity of Paumben, indicating a northerly current on both sides of the gulf (viz., on the west side of Ceylon and the south-east side of India). Early in July, as the monsoon freshened, bottles liberated off Cape Comorin and Tuticorin took an easterly direction, and were recovered along the Ceylon coast, from south of Tallaivillu Point to Galle, and even Dondra Head, including Chilaw, Negombo, and Colombo. Bottles liberated off Colombo were also recovered to the south.

This result clearly indicates that the oceanic current in the full force of the monsoon runs east to the Ceylon coast and then turns south, following the contour of the land. The average rate of this current was found to be 0·5 knot per hour on its eastward course, and 1 knot when running south along the Ceylon coast. The reason for the increase in the speed of the current will be dealt with later.

It is significant that along the Ceylon coast south of Tallaivillu Point the current runs in the teeth of each prevailing monsoon. This current continued to flow until nearly the end of July, during which time the south-west monsoon blew strong and steady. At the end of July the monsoon moderated and fell light, and the current was then observed to reverse and to run north again along the Ceylon coast, and also along the Indian coast from Cape Comorin to Palk's Strait. During this lull, which continued until the middle of August, bottles liberated off Chilaw and Tallaivillu Point on the Ceylon coast were recovered north, at the head of the gulf, in the vicinity of Paumben and Adam's Bridge. Those liberated off Cape Comorin, Tuticorin, and Manapad were also recovered at the same place.

The monsoon strengthened again during the second week in August, and bottles liberated off Cape Comorin and Tuticorin were again picked up off the Ceylon coast as far south as Dondra Head. This recurrence of the oceanic easterly current during strong south-west monsoon conditions was felt at Tuticorin. The current continued steady up to the end of August, when the monsoon again began to abate. During this third lull in the monsoon the current again took a northerly course, running at a rate of 0·3 knot per hour; and bottles liberated off Cape Comorin were again recovered at Paumben, Delft island, near Kayts, also at Point Calimere, 70 miles north of the Paumben Pass, and even at Tranquebar, 120 miles north of the Paumben Pass, both the latter points being on the Indian coast. The explanation of these apparently anomalous results, which admit of perfect co-ordination, is not merely interesting, it is important.

As we shall shortly see, this oceanic current produces different effects on the Ceylon coast, for, as already pointed out, on the banks not under lease and south of Tallaivillu Point the oceanic current runs south when the monsoon is strong, and when weak it runs north with the wind; whilst on the area under lease there is merely a surface drift dependent, as usual, on the wind.

In now attempting to explain the irregularities of the oceanic current and the results relating thereto, we would draw particular attention to the charts appended, without which it will be difficult to follow the text.

The presence of an oceanic current from the west during the south-west monsoon is a well-established fact. During a weak or moderate monsoon this current never penetrates the gulf at all. It is only when strong and continued south-west conditions prevail that the oceanic current becomes as it were pushed up into the gulf by the continued effects of strong wind and south-west sea.

We have already seen that unless the monsoon is very strong there is a northerly current at the head of the gulf, particularly on the Indian side. This northerly current, aided by the wind, finds an exit through the Paumben Pass, through which a steady current runs to the north during this monsoon. This current through the pass represents the normal flow of water consequent on the monsoon effects in the gulf. When the monsoon is not particularly strong, the oceanic current does not penetrate the gulf, and the Paumben Pass under those conditions provides a sufficient exit for the volume of water which is continually being blown into the gulf during the south-west conditions. Consequently the northerly current is felt on the Indian side and on the Ceylon side south of Tallaivillu Point. We would here point out that the Mannar Channel and the passes through Adam's Bridge become silted up during the south-west monsoon. It will be seen that the banks under lease are situated in such a position that they are protected from this northerly current. What " current " there is on this area is due purely to the wind.

We, therefore, find that bottles liberated off Cape Comorin during a moderate monsoon find their way through the Paumben Pass, and have even been recovered as far north as Cape Calimere and Tranquebar; whilst bottles liberated off the Ceylon coast north of Tallaivillu Point merely drifted ashore with the wind north of the point where they were liberated. Bottles liberated south of Tallaivillu Point also merely drifted ashore during a light or moderate monsoon, and were recovered north of where they were liberated. These conditions are, of course, what one would naturally expect from the lie of the land.

During a strong south-west monsoon, however, the currents run quite differently. Then, owing to the force of the monsoon, the oceanic current partly penetrates the gulf, and the water at the head of the gulf becomes piled up. During a strong monsoon the sea level at the head of the gulf is 9 inches above the normal. The exit through the Paumben Pass is insufficient to carry away the volume of water which collects in the gulf. The stronger and more continued the monsoon, the further into the gulf does the oceanic current penetrate, and the larger the head or cushion of water formed there. This current is purely oceanic, and penetrating the gulf takes an approximately east and east-south-easterly course, and reaches the Ceylon coast south of Tallaivillu Point. It is here joined by a volume of water, which represents an overflow from the head or cushion of water which has become piled up in the gulf, due to the penetration of the oceanic current. So that there are two exits for the water which becomes piled up at the extreme north of the gulf during strong monsoon conditions. There is the Paumben Pass and the south-eastern extremity near Tallaivillu Point, at which latter point the oceanic current turns south. The drain of water at this latter place, together with the Paumben Pass, provide exits (without producing currents) for the volume of water which has collected north of where the oceanic current has penetrated the gulf. These exits are merely escapes for the water which has accumulated above its normal level and is therefore under pressure.

The rate of the oceanic current as it sweeps eastward is 0·5 knot per hour. South of Tallaivillu Point, where it is joined by water which helps to drain away the " head " of water referred to in the gulf, it obtains a speed of 1 knot per hour.

Bottles liberated in the height of the monsoon off Cape Comorin and off Tuticorin were recovered at points along the Ceylon coast from Tallaivillu Point as far south as Dondra Head; whilst those liberated off the Ceylon coast south of Tallaivillu Point were recovered south of where they were liberated, and those liberated north of Tallaivillu Point were recovered to the north, having been merely driven ashore with the wind.

When the oceanic current penetrates the gulf, it becomes evident that the northern current ceases to exist, for it is obstructed by the oceanic current. Those forces (wind and sea) which normally produce the northerly set are expended in pushing the oceanic current into the gulf. North of this point of penetration the surface movements in the gulf are purely due to wind, which near the Indian coast blows from the west, whilst further out at sea the wind becomes south-west.

It is important to note that during the south-west conditions a strong westerly wind is continually blowing with some force over Southern India, and is persistently recorded at Tuticorin. The oceanic current is thus assisted considerably in its easterly course by the prevailing wind.

We thus see that the surface currents during the south-west monsoon have two phases, and it will be well to here summarize them :—

(1) A light or moderate monsoon, when the currents run northerly towards the Paumben Pass, both along the Indian coast and along the Ceylon coast south of Tallaivillu Point (only), where the water finds an exit.

(2) A phase of strong monsoon, when the oceanic currênt penetrates the gulf, and the water at the head of the gulf consequently becomes piled up as a cushion. The oceanic current, aided by the westerly wind which prevails over Southern India, takes an easterly course, and eventually reaches the Ceylon coast about Tallaivillu Point. It is here joined by an overflow of water from the head of the gulf and then runs south on the Ceylon coast. This penetration of the oceanic current into the gulf destroys the northerly set towards the head of the gulf, for the forces which normally produce this northerly current have been expended in pushing the oceanic current north. The drift over the volume of water north of where the oceanic current penetrates is solely due to the prevailing winds; whilst at Paumben Pass and Tallaivillu Point there are exits for the water therefrom, which, being above the normal level owing to the penetration of the oceanic current, is under pressure.

In the table given at the end of this paper an interesting transition between the two phases of the south-west monsoon current is shown. (Chart B.)

On July 25 strong monsoon prevailed and the oceanic current ran east, as indicated on Chart A.

On July 28, 20 drift bottles were liberated just off Tallaivillu Point. These travelled on the head of the water north of the penetration of the oceanic current and were blown ashore at Mannar, where 18 were recovered.

This fact indicates that the water towards the head of the gulf during a strong monsoon is dead, and that the drains or outlets to this head of water at Paumben and Tallaivillu merely relieve the pressure without producing currents. The surface movement at such a time is merely due to the wind, as was shown by the bottles going ashore at Mannar.

A week later, as the lull in the monsoon continued, the head of water had had time to drain away, and a northerly set of the current was re-established. It was found that of 20 bottles liberated at the same station, 17 were recovered at Paumben. These facts are most instructive, and clearly corroborate the ideas regarding the currents during the south-west monsoon set forth in this paper.

During our investigations this year we found that the monsoon went through each phase twice and then died away. We attach no importance to these numbers at all, believing as we do that the phases named alternate with each other irregularly year by year.

Two things now become clear. On the pearl banks under lease, *i.e.*, those north of Tallaivillu Point, there are no true currents during this monsoon. There is a surface drift trending to the beach on inshore areas and due to the strong prevailing wind, but the banks are completely out of line with the direction of either phase of the surface south-west current. On the banks south of Tallaivillu Point, and still under Government control, the current runs south and in the teeth of the monsoon when the monsoon is strong; whilst when the monsoon is weak or moderate the current merely becomes a surface drift, due, as on the banks under lease, to the wind, and invariably running north towards the shore.

In our report to the Ceylon Government on the inspection of their banks, *i.e.*, those south of Tallaivillu Point (Part III., "Ceylon Marine Biological Reports"), we stated that the banks under lease owed their productivity to the fact that they were protected, and that owing to the deflected current above described being further acted upon by the south-west wind and sea, exotic spat drifted on to our banks, but never or seldom reached the southern paars. The statement is only partly true, but our investigations were at that time in their infancy, and the results of further investigations have enabled us to understand the situation better, even though the factors at work are still somewhat complicated.

It is to be remembered that pearl banks exist in the vicinity of Tuticorin, and it has been for a long time believed that spat from the oysters there drifted at times on to our own banks, *i.e.*, those under lease. This circumstance is by no means impossible, or even at times unlikely.

We must further note that oysters usually spat in July and August, and that their microscopic larvæ float about on the surface of the sea for about the first five to seven days. The exact period is somewhat uncertain. The larvæ are, therefore, liberated in one or other of the phases of the surface current during the south-west monsoon, and the whole interest attaching to surface currents lies in the distribution of these larvæ, which is effected by the surface current at the time of their liberation. The entire plateau on the West Ceylon coast is potential paar ground, and other and less productive tracts occur as noted near Tuticorin. It is evidently important to know what becomes of the spat shed by oysters living on the several areas. If the spat is retained on the area where it was liberated, the bank within limits continues to be productive. If the spat drifts away, the oysters tend to eventually become extinct. On the other hand, if well-defined currents exist, there is always the possibility of banks on one area being replenished with spat from other areas, which latter must of necessity be remotely distant. This phenomenon has been repeatedly witnessed on the pearl banks under lease. There have been periods when on this area scarcely a single oyster was to be found. Yet the banks recuperated and became stocked with countless millions of oysters. This rejuvenescence was certainly not due to their own recuperative powers. At present the banks are barren all along the coast, and no oysters are to be found. This circumstance has often been repeated during historical times. From where do the exotic spat come, and what brings them ?

With reference to the Tuticorin banks, it is easy to understand that should spat be liberated there when the south-west monsoon is light or moderate (when the current runs north), it is almost certain that the larvæ would be carried away through the Paumben Pass into Palk's Strait, or further north along the Indian coast.

If liberated during a strong monsoon, the possibilities are that the westerly wind would drift them out into the gulf, where they would become involved in the oceanic current and be carried towards Ceylon. Moreover, we have seen that during a strong monsoon the oceanic current actually sweeps the Tuticorin beds.

It follows from the nature of the currents that the Tuticorin banks receive no exotic spat, for, as far as we are aware, no other oyster beds exist round Cape Comorin. Moreover, their own resources are being continually drained, and it is not to be wondered at that they are unprofitable.

On the Ceylon side, and on the areas still under Government control, it is well known that they are markedly unproductive. Yet the bottom is very suitable, and a few scattered oysters have been found thereon from time to time. No living oysters occurred there when we inspected the area in March, 1909 (Part III., "Ceylon Marine Biological Reports"), and only three fisheries have been held south of Tallaivillu Point since 1800. They were all held on the Chilaw Paar, and took place in 1803, 1815, and 1884. We believe this sterility due also to the prevailing currents, which during the south-west monsoon either run south when the monsoon is strong, or north with the wind when moderate or weak. Local spat, whenever they occur, are swept away and lost. Moreover, the chances of this area being supplied with exotic spat are very remote indeed. It is only during an intensely strong and continued monsoon that the current penetrates far enough north into the gulf to sweep the Company's banks, and thus convey spat therefrom to the banks still under Government control, and even then it is highly probable that such spat would be driven ashore. Their chances of receiving spat from South India, whenever spat occurs there, is equally remote, for as we have seen, when the monsoon is only weak the currents on the Indian side run north and through the Paumben Pass. Even if a moderate monsoon persists, the easterly oceanic current which eventually reaches the banks still under Government control almost certainly does not sweep over the Tuticorin banks, or penetrates far enough north to allow of spat being drifted into it by the prevailing westerly wind.

It is only when a strong monsoon persists for some considerable time that the oceanic current penetrates far enough into the gulf to sweep the Tuticorin beds. In that case the easterly current stretching across the gulf reaches the Ceylon coast well north of Tallaivillu Point, carrying with it spat when present from the Indian side. Such spat appear to be deposited on the banks under lease, and to never reach the banks further south, as the distance in the latter case is too great (140 miles), and the larvæ mature and sink long before the current reaches so far south.

The pearl banks under lease which are situated in that beautifully protected *cul-de-sac* at the extreme north-east of the gulf now call for particular attention. Their productivity at times is marvellous, yet barren years intervene. Much of the barrenness is due to causes other than currents, but, on the other hand, it is quite certain that much of their productiveness is, and has been, due to the fact that they have been periodically stocked with exotic spat, which, added to their own inherent powers of production and recuperation, has more than amply satisfied the demands of rapacious men and predatory fish. They also owe much to their protected position, and a glance at the chart will serve to illustrate this fact.

The only surface movements on this part of the plateau are entirely dependent on the wind. Except in very strong and prolonged south-west monsoon no real current exists, and the tendency is for spat liberated in the vicinity to be retained thereon, and to be deposited near its source of origin. If strong monsoon persists, we have seen that the current penetrates further and further into the gulf until it sweeps the Tuticorin beds, and the possibilities are then present for spat being brought across and deposited on the banks under lease. The same current turning south and following the trend of the land would also carry away to the south the local spat from the banks under lease, but the likelihood is that such spat, instead of actually being deposited on the banks still under control, would merely drift ashore. On the more inshore areas, as on the Kondatchi Paar, succeeding spatfalls have gradually wandered closer inshore. The possibilities of the banks under lease receiving spat from the Indian side during a strong monsoon are very considerable, although as yet we only understand in merest outline a few of the factors which may conduce to bring about this result.

If the south-west monsoon is light or moderate, the spat from the Indian side runs with the northern current through the Paumben Pass. It is evident that under these conditions no spat could possibly drift on to the banks under lease. It is only when the south-west monsoon is very strong and prolonged that the oceanic current penetrates further and further into the gulf, until eventually it sweeps the Tuticorin banks. If oysters are present there, their spat is almost certainly brought across to the banks under lease by the current, which in strong monsoon most probably penetrates the gulf much further north than is indicated on the appended chart showing the results obtained during 1910, when the monsoon was not either very strong or continuous. The absence of an exotic spatfall this year, as in other years, has either been due to the moderate monsoon which prevailed, or to the absence of spatting oysters on the Tuticorin banks.

The larvæ of the oyster are pelagic, *i.e.*, they live on the surface of the ocean for about the first five to seven days of their existence. They then develop a shell, and dropping to the bottom become attached. There can be no doubt that many drop in deep water and are lost. The depth most suitable for oysters is 6 fathoms.

The distance from the Indian banks to the banks under lease is approximately 85 miles. Taking seven days as the maximum time occupied by the pelagic stage, a *continuous* surface drift to the east of 0·6 knot per hour for six successive days would place the spat on our banks. We believe that this does happen occasionally, but only during strong monsoon. Otherwise it would be impossible to explain the sudden transition from absolute barrenness to remarkable luxuriance which has characterized the area under lease through long periods of history.

Such in merest outline are the conditions of the surface current over the entire plateau. No doubt there are other factors at work, which subsequent research alone can elucidate, but we feel satisfied that the results and explanations given above have a very real significance, and that the broad general facts are as above stated. Although our results this year distinctly prove that the oceanic current reaches the Ceylon coast south of Tallaivillu Point during strong monsoon weather, the results of another year might show that the current struck either a little north or south of the point in question. This, however, would not in the least affect the main facts of its existence and general direction.

It is exceedingly unfortunate that in spite of all effects we have been unable to obtain any data regarding the oyster beds near Tuticorin. No systematic survey or inspection appears to be carried on round Southern India, and oysters are merely fished when present. Data concerning historical fisheries there (both recent and otherwise) would enable us to collect important data regarding spatfalls, for the monsoon conditions are recorded yearly, and on the Ceylon banks we have records of times when in all probability exotic spatfalls occurred on our own area.

In the investigation of these superficial currents we have relied almost wholly on sets or part sets of bottles which travelled quickly, or in bulk, as more likely to indicate the true nature and direction of the prevailing current and be free from extraneous and disturbing factors. Some bottles appeared to have had an erratic course, whilst others were, as expected, not recovered. However, the mass of the evidence was as given in the preceding pages.

It is remarkable how the productivities of the paar areas coincide with the evidence afforded by currents. Both the Tuticorin banks and those south of Tallaivillu Point are remarkably barren. This circumstance one would naturally expect to be the case on areas continually swept by currents at critical periods; whilst on the area under lease, not only are they protected and free from sweeping currents, but under certain circumstances they may even be replenished by spat derived from elsewhere.

Apart from the general trend and sweep of the oceanic current above named, there are, of course, innumerable minor and local eddies along the coast dependent entirely on the configuration of the land and the direction of the wind. They are in every case purely local, and in no way affect the general results just described. We, therefore, need not deal with them here, although we are cognizant of their existence.

We append a list of the stations where bottles were liberated during each monsoon, giving percentage returns, stations, &c., together with explanatory charts (A, B, and C).

We are strongly of opinion that drift bottles ought to be liberated in numbers every year over the Tuticorin banks during the spatting season. It is only by so doing, and by obtaining information regarding the condition of the Tuticorin beds at the time of liberation, that the question of exotic spat can be definitely settled and our results corroborated and enlarged upon. Even if the origin of exotic spat was fully and finally elucidated, the control of the elements in Nature producing the results would be beyond the power of man. As Steuart said in 1843 ("An Account of the Pearl Fisheries of Ceylon"), "the success of the pearl fisheries in the Gulf of Mannar depends primarily upon natural events beyond the control of man. Nevertheless, we may by the most vigilant attention and good management watch the progressive workings of Nature, and not fish up the oysters before they have reached maturity, nor, after they contain the pearl, suffer them to die on the banks and the pearl to be lost........ We may presume from past experience that unsuccessful intervals will continue to recur .... We cannot cause the spawn to settle down upon nourishing grounds. These are events beyond the control of man. The wind, the waves, and the uncertain currents of the ocean carry the embryo over unlimited space. It is only when in the infinite wisdom of the Creator of all things the oyster broods descend upon banks suited to nourish and support it that it comes within our limited power to watch its advancing age and to fish up the respective deposits in succession ...." A knowledge of the true facts is, however, essential to successful culture, as they enable us to lay and mature our plans accordingly.

III.—Bottom Currents.

Our knowledge concerning bottom currents over the plateau is confined entirely to the area under lease. Of the movements which the bottom layers of water may undergo on the ground still under Government control we have no information, and even on the northern area our knowledge is limited to the conditions existing during the north-east monsoon. These, however, give some indication of what the conditions must have been during the preceding south-west monsoon.

From what has been said in the foregoing pages on the surface drifts prevalent over the plateau under lease, it is evident that no serious disturbance at the bottom could accrue from the conditions existing at the surface. The loss of oysters through a bottom current implies a current sufficiently strong to actually tear oysters from their anchorage. Steuart, writing in 1843 ("Account of the Pearl

Fisheries of Ceylon "), stated that "there appeared to be no reason to believe that the oysters were subject to be covered with drifting sand." Any one who has endeavoured to remove a mussel or an oyster from its attachment will understand that considerable force is required to effect this. A *bottom* current of sufficient strength to sweep away and entirely annihilate whole beds of oysters must indeed be strong. It would appear that the disappearance of beds of spat or adult oysters has been curiously mixed up with surface currents, or rather with surface drift.

Whilst we attribute the disappearance to other causes, it is worthy of note that the distinction between surface current or drift and bottom current is most important. The oyster lives at the bottom, and the surface current or drift is only important in so far as it affects the bottom, or in that it is the agency whereby spat is brought or carried away. It is of course possible on a small scale for a bottom current to be independent of the surface current. Our investigations, however, even though limited in extent, have so far tended to prove that the water on the bottom of the area in question is calm and that currents do not exist. There *are* movements in the water, but these movements are vertical and not horizontal; they are gentle undulations, not currents; and we have been unable so far to collect any evidence to indicate that a bottom current exists either during the north-east or south-west monsoon. It would appear likely that if bottom currents exist which are strong enough to remove oysters from their anchorage, the evidence relating thereto would neither be scanty nor rare; but the dress-diving operations conducted by one of us over two seasons during the north-east monsoon has afforded no evidence of any current.

It is well known that from time to time beds of oysters or spat have entirely disappeared and left no trace behind. This disappearance has in every case been attributed to bottom currents. Yet in no single instance has any proof been adduced that such was really the case. The disappearance was merely attributed to currents because no other cause seemed apparent. In Part IV. Report of this series it was there shown that the annihilation of a bed of spat on the Periya Paar Karai, numbering 400,000,000, was due to predatory fish. The remains of the crushed shell on the area in question were only obtained when the dredge was lined with canvas, and the débris even escaped the notice of the divers. When these catastrophes occur on a rocky bottom, the clue to the situation remains obvious for a long time; but if it happens on sand, the broken shell *gradually* sinks into the sand and disappears. This circumstance is, however, not due to silting over by sand, but to the heavier shell débris gradually settling. It thus becomes clear how it may happen that a bed of oysters disappear and leave no trace behind them.

Whilst we are not prepared to state that every bed which has been lost has been devoured by fish, it appears very probable from the analogous case just quoted that such was the case, and that the apparently entire absence of any remains led to the conclusion that the bed had been swept away by a current.

It is impossible, however, with any degree of certainty to state why beds of oysters disappeared in the past. In this paper we shall deal with data collected during our own experience, and although our evidence is wholly negative, we recognize that bottom currents may have occurred spasmodically in the past, and may do so again, but during the last five years it is certain that none have existed or occurred.

It might be argued that on a shallow water plateau, such as the one under lease, any degree of surface current must of necessity produce a bottom current. This is most likely true, but, as we have already pointed out, no surface current exists on the banks under lease.

The almost regular appearance of spat on the Periya Paar, and its equally regular disappearance, presents an important question, which up to the present has not been sufficiently investigated. This bank is situated about 18 miles out at sea, towards the north of the plateau and due west of Tuticorin. The depth of water is from 8 to 10 fathoms, and within a cable's length there are the overfalls (200–300 fathoms). The spat so regularly found thereon are undoubtedly brought from the Tuticorin side by the oceanic current, which runs east during the south-west monsoon. These spat usually disappear before the end of the following January (or during the *north-east monsoon*). The oceanic surface current which at this time runs west from Tallaivillu Point no doubt produces some bottom current on the southern shallow water plateau over which it sweeps, but a reference to the chart will show that the Periya Paar is well north (30 miles) of the point from which the current takes a westerly direction. The disappearance of spat therefore from the Periya Paar is still very enigmatical, and the only conclusion one can arrive at in the present state of our knowledge is that in some way or other it is incident on the proximity of this paar to the overfalls. It is further to be noted (i.) a large portion of this paar is sand, where oysters could not possibly live ; (ii.) owing to the immense deposits, large numbers, even if occurring on rock, die from overcrowding ; and (iii.) that the bank is, *par excellence*, the home of large oyster-eating rays and teleosts, and is recognized as the best fishing ground on the entire plateau.

Finally, it is worthy of note that only one fishery has taken place on this paar (1879). The bank has been stocked with immense numbers of spat at least fifteen times during the last century, and in every case they have disappeared when about three to six months old. *The disappearance has always taken place during the north-east monsoon, and never during the south-west*, and that in the only case where the spat survived the first six months and thus acquired a firm foothold they lived to be adult and provided a good fishery. This latter point is of very considerable importance, for it shows to us that if *young* oysters occurring thereon *are* swept away by bottom currents, once they obtain a foothold they are safe. This fact lends an interesting side light on the impossibility of older oysters (one to five years) being swept away by currents on more protected areas.

In now dealing with bottom currents on the plateau in general, it is to be noted that our information has been derived principally from three sources, and, as previously noted, they refer only to the north-east monsoon and to the area under lease.

(1) Rough measurements of the bottom currents were made during two seasons by means of the following apparatus :—A tow net was sunk by means of a small iron ring round the mouth to within 3 feet from the bottom. The depth over which the observations were made varied from day to day between 5 and 10 fathoms. Assuming the depth to be 6½ fathoms, the tow net was suspended by 6 fathoms of rope to a flat bamboo float at the surface. This was placed just astern of the ship and allowed to drift for one hour. The direction of the drift was noted, and the distance at the end of the hour measured. This was done three times per day during two north-east monsoons. The average rate of the current over the entire period was approximately 0·15 knot per hour. This method is of course far from accurate, for it was found that the surface float was acted upon by the surface wind and drift, and thus tended to drag the bottom net, which was but lightly sunk. The results were further complicated by the fact that during parts of March and April dead calms prevailed. Only on one occasion was it found that the bottom current was running in an opposite direction to the surface current. The above results are of too crude a nature to count for anything, save that if a strong bottom current had existed the indication would certainly have been noted.

(2) During the last six seasons (1906–1911) native divers have been continually at work on the banks. It is exceedingly difficult to obtain precise information from divers, but only on very rare occasions they have stated that there was a "little current" at the bottom.

(3) The whole of the data on which we rely for our knowledge of the bottom currents has been obtained by one of us by means of the diving dress, and this work has been conducted over two seasons.

Although, as noted, dress diving has only been carried on during the north-east monsoon, the bulk of the work was done very early, before the south-west monsoon had fully subsided, and when one would naturally expect to find the accumulated and undisturbed results of the monsoon on the floor of the ocean. It is on this account that we place some reliance on our data, for although our observations were not made during the actual south-west monsoon, still, if a bottom current existed for several months, there would certainly be some indication of it at the bottom, particularly over the sandy areas which here and there alternate with rock.

This sand is divisible into two kinds : a loose, coarse-grained, angular kind, usually occurring on rock, and mixed with shell débris, and a fine-grained kind. Usually they do not co-exist at the same place, but if they do, one kind is predominant. The fine-grained sand is more or less consolidated, and is hard, and caked, and not yielding when trod upon. The coarse-grained angular sand may be considered as water-logged, for owing to its angular nature there are considerable interspaces between the grains filled with water, which do not exist in the fine-grained variety. Consequently it is found, and has been proved over and over again by means of the diving dress, that the coarse-grained sand is more susceptible to bottom movements than the fine-grained sand.

This fact is of some importance, for descents made over the banks on the heels of the south-west monsoon showed that here and there the coarse sand was thrown into ridges, usually—almost always—about 2 feet apart, 4 inches high, and facing south-west. These ridges could not be produced by a bottom current, for such a current would tend to drift the sand to the north-east and toward the land, the accumulated result of which over many centuries would ultimately sweep landward the whole of the sand and eventually leave a clean bottom. No such result has, however, taken place.

The counter effect of the north-east monsoon may be entirely neglected, for not only are the banks directly under the lee of the land, but they are further protected by a more or less continuous fringing coral reef.

The production of these ridges is obviously due to the surface agitation affecting the bottom layer of water. But the bottom movement is vertical and not horizontal; it is undulatory and not progressive. In other words, it is a wave and not a current.

It has been previously shown that on the area under lease the full force of the south-west monsoon is not felt owing to the penetration of the oceanic current, and consequently the bottom is almost calm.

To the south of the plateau (on the area still under Government control) and on the west coast of Ceylon south of Tallaivillu Point, where the plateau is narrow and swept by an oceanic current during both monsoons, and where the water is shallow, it is most likely that a bottom current is usual. In fact, our experience on these banks corroborates this idea, and a sandy bottom is rare on these southern banks.

Referring in particular to the area under lease, the banks to the south of the plateau, and including the Muttuvaratu Paars, are for the most part made up of dead coral, and sand only exists close to the shore.

In the vicinity of Karativu shoal bottom disturbance is naturally more evident than elsewhere, due to the swell breaking on the shoal. But this effect is purely local.

On the southern extremity of the West Cheval there is also evidence of bottom disturbance. Here the rock is covered in places by a few inches of coarse sand mixed with shell débris, and this sand is thrown into ridges averaging 2 feet in length and 6 inches in height, leaving the rock bare between the ridges. In all cases the coarse sand is composed of angular quartz, oxidized on its outer surface, slightly impregnated with iron, and of a yellow appearance. The ridges all face south-west, and their sides are steep, suggesting that they can only have been formed by vertical motion.

Apart from the vicinity of the Karativu shoal, there is little evidence of any disturbance. The rock is practically bare on the Mid-west, Mid-east, and North-west Cheval. The North-east Cheval is also very free from sand.

On other area, such as the Periya Paar Karai and Vankali Paar, where the rock is covered in places by only a few inches of coarse sand, the ridges are usually 2 feet apart and up to 6 inches high. On the Moderagam Paar the ridges are 3 feet apart and only 2 inches high.

On the real sandy wastes (in contradistinction to paar ground covered only by a few inches of sand) the sand, as we have seen, is fine-grained and very compact. The ridges over such areas are very slight indeed, and are never more than 1 or 2 inches high and about 2 feet apart.

Besides the evidence afforded by the ridging of the sand, which all over the plateau is on the small scale indicated, there exist numbers of crevices and holes on the floor of the ocean. In some cases these holes are caused by disintegrated coral having become dislodged, whilst in other cases they are natural configurations of the rock. Many of these holes are quite 3 feet deep, and one would naturally expect to find that if considerable movements in the sand took place, that these holes would eventually fill up. Yet they have often been examined, and never more than 4 inches of coarse sand found in them.

On the West Cheval Paar, in 9 fathoms of water, the rock has been observed to terminate abruptly in places on the west seaboard with a drop of 2 feet on to a sandy bottom. Here, too, one would expect to find that if the sand was carried about by a bottom current in a progressive motion, the sand would silt up against such an elevation of the rock, particularly during the south-west monsoon.

Further, during the drift bottle experiments carried out over many years on the plateau, many bottles sank on located positions. At least four such bottles were picked up several months afterwards lying on the sand in the position where liberated.

The fallen beacon and the tanks marking the shoal buoy position have been examined on several occasions by one of us in a diving dress for evidence of bottom movement. The tanks have remained exposed to successive monsoons at least during the last twenty years, and there has been no segregation or piling up of sand. The three remaining tanks are as empty as when first examined two years ago, and stand on the bottom with no piling up of sand or evidence of scour such as might be expected. But the sand is heavily ridged.

The shoal rises very abruptly on the west from 9 to 4 fathoms, giving rise to a confused sea during the south-west monsoon, which breaks at times. So that here, if anywhere, one would expect evidence of bottom movement. The tanks, however, remain empty as when first examined, and stand on the bottom free from segregating sand. So that it appears that the ridging of the sand is due to vertical and not horizontal disturbance.

The preceding facts indicate some of the reasons which lead us to the conclusion that bottom currents do not exist on the pearl banks under lease, neither during the north-east or the south-west monsoon.

Inspection work is often commenced late in October, before the south-west monsoon has subsided. At such a time the bottom layer of water is invariably turbid. The cause of this turbidity has been microscopically examined, and has been repeatedly proved to be due to the disintegrated remains of sea-weed and Caulerpas. The turbidity renders it almost impossible for divers to see, but it subsides gradually as the north-east monsoon begins. This condition of the bottom water is by no means an entirely unhealthy condition, for it provides extensive organic material for oysters to feed upon.

It has been suggested using a Nanson's currentometer for observations on the bottom currents during the south-west monsoon. Such a meter however would, we believe, in any case only give the *rate* of the current, and not the direction, or the varying directions. The utter impossibility of mooring such a meter on the banks during the south-west monsoon will, however, be apparent to any one who is familiar with the conditions in the gulf during this monsoon.

In addition to the preceding data, a further 927 bottles in all were liberated during 1907, 1908, and 1910. The results therefrom have, however, been discarded. In the majority of cases the place where they were liberated is not known. In other instances they were liberated between the monsoons, when no definite result can be expected; whilst the balance includes bottles liberated at unsuitable places, or under unsuitable conditions.

The returns quoted in Part III., "Ceylon Marine Biological Reports," are not included in this report.

The following table gives topographical returns and percentages :—

South-west Monsoon.

Bottles liberated north of Tallaivillu Point (inshore), 1908 and 1909.—Bottles liberated went ashore and form part of the 927 discarded.

Bottles liberated south of Tallaivillu Point, 1910.—Liberated, 60; recovered, 49; percentage, 81·6 per cent.

Bottles liberated between Colombo and Tuticorin, 1910.—Liberated, 505; recovered, 242; percentage, 48 per cent. (practically).

Total number of bottles liberated on the above positions, 1908 and 1910.—Liberated, 565; recovered, 291; percentage, 51·5 per cent.

North-east Monsoon.

Bottles liberated north of Tallaivillu Point, 1907, 1908, 1909, and 1910.—Liberated, 284; recovered, 48; percentage, 17 per cent. (practically).

Bottles liberated between Colombo and Tuticorin, 1909.—Liberated, 74; recovered, 12; percentage, 16·2 per cent.

Total number of bottles liberated on the above positions, 1907, 1908, 1909, and 1910.—Liberated, 358; recovered, 60; percentage, 17 per cent. (practically).

Abstract.

Total number of bottles liberated	1,853
Total number of bottles discarded	927
Total number of bottles liberated at all stations during both monsoons ..	923
Total number of bottles returned during both monsoons.. ..	351
Percentage returned over both monsoons	38·1

Table I.—Drift Bottles liberated during the South-west Monsoon of 1910.

Date of Liberation.	Position of Liberation.	Station.	Bottles liberated.	Bottles recovered.	Average Velocity of Current.	Remarks on Place of Recovery, Monsoon Conditions, &c.
1910.		No.	Nos.	Nos.	Knots.	*Unsettled Monsoon Conditions.*
June 28 ..	Off Cape Comorin ..	1	20	13	0·36	All recovered on the Ceylon coast, at Tallaivillu Point, near Chilaw, and at Negombo.
June 29 ..	Manapad ..	2	5	2	0·25	Recovered in the vicinity of Jaffna.
July 2 ..	Cape Comorin ..	1	20	8	0·13	One recovered at Paumben, the others near Mannar and as far north as Jaffna.
						Strong Monsoon ; Current to the East.
July 9 ..	Off Cape Comorin ..	1	20	9	0·6	All recovered on the Ceylon coast, in the vicinity of Barberyn and Galle.
July 10 ..	Do. ..	1	15	11	0·5	All recovered on the Ceylon coast, between Chilaw, Colombo, and Galle.
July 11 ..	Do. ..	1	5	5	0·5	All recovered on the Ceylon coast, between Mannar and Negombo.
July 16 ..	Do. ..	1	20	1	1·0	Recovered at sea off Galle.
July 19 ..	Do. ..	1	20	—	—	—
July 24 ..	Colombo ..	4	20	13	0·3	Recovered to the south of Colombo, as far as Kalutara.
July 25 ..	Tuticorin Pearl Banks	3	20	7	0·2	Recovered on the Ceylon coast, between Tallaivillu Point and south of Chilaw.
						Moderate Monsoon ; Current to the North.
July 28 ..	Off Tallaivillu Point ..	6	20	18	0·33	All recovered at Mannar.
July 30 ..	Manapad ..	2	20	8	0·2	Six recovered at Paumben and 2 at Mannar.
August 1 ..	Cape Comorin ..	1	20	9	0·13	All to the north, 8 at Paumben, 1 at Jaffna.
August 3 ..	Tuticorin Pearl Banks ..	3	20	10	0·15	Recovered 1 at Kilakarai, the rest at Mannar and Vankali.
August 3 ..	Manapad ..	2	20	9	0·13	Recovered to the north, in the vicinity of Kilakarai and Paumben.
August 4 ..	Chilaw ..	5	20	14	0·24	Recovered on the Ceylon coast north of station, 13 near Puttalam and 1 at Mannar.
August 5 ..	Tallaivillu Point ..	6	20	17	0·19	All recovered at Paumben.
						Strong Monsoon ; Current to the East.
August 15 ..	Off Tuticorin Pearl Banks ..	3	20	9	0·7	Recovered on the Ceylon coast south of Colombo, in the vicinity of Kalutara and Barberyn.
August 15 ..	Manapad ..	2	20	12	0·15	Recovered to the north, in the vicinity of Paumben.
August 15 ..	Cape Comerin ..	1	40	22	0·7	Recovered to the south of Colombo, near Mt. Lavinia, and also between Barberyn and Galle.
August 18 ..	Do. ..	1	20	7	0·4	Recovered on the Ceylon coast, south of Colombo.
August 18 ..	Manapad ..	2	40	21	0·25	Recovered on the Ceylon coast, south of Tallaivillu Point to Colombo and as far as Galle.
August 18 ..	Tuticorin Pearl Banks ..	3	20	9	0·4	Recovered on the Ceylon coast, at Negombo, beyond Barberyn, and as far as Kosgoda.
August 26 ..	Manapad ..	2	·20	14	0·25	Recovered on the Ceylon coast, from Chilaw South to Colombo.
						Moderate Monsoon ; Current to the North.
September 1 ..	Off Cape Comorin ..	1	20	11	0·4	Recovered north, in the vicinity of Paumben and Jaffna.
September 3 ..	Do. ..	1	20	18	0·4	Recovered north, in the vicinity of Paumben and Jaffna.
September 4 ..	Tuticorin Pearl Banks ..	3	20	7	0·4	Recovered north, in the vicinity of Jaffna.
September 4 ..	Capo Comorin ..	1	20	7	0·4	Recovered north, near Paumben and Jaffna.
		Total ..	565	291		

Percentage return, 51·5 per cent. Total average surface drift, 0·38 knot per hour.

Note.—The current ran steady north during the rest of the month (September).

Table II.—Drift Bottles liberated during the North-east Monsoons, 1907–08, 1908–09, 1909–10.

Date of Liberation.	Position of Liberation.	Station.	Bottles liberated.	Bottles recovered.	Highest Velocity of Current.	Where recovered, Weather Conditions, &c.
		No.	Nos.	Nos.	Knots.	*Typical North-east Conditions.*
November 20, 1907 ..	Off North-east Cheval Paar ..	2	14	1	0·3	At Alleppe, Travancore.
November 21, 1907 ..	Do.	2	13	—	—	—
November 23, 1907 ..	South-east Cheval Paar ..	2	16	10	0·4	All in the vicinity of Tuticorin
November 24, 1907 ..	Krusadai Paar	3	19	—	—	—
November 26, 1907 ..	Karativu Paar	3	12	1	Not traced.	Rajakumangalam Thura, Nagercoil, India.
November 28, 1907 ..	Periya Paar (south end) ..	2	16	2	0·3	One at Calicut and the other near Cochin, India.
November 28, 1907 ..	West Cheval Paar	2	12	1	0·3	Near Cochin.
November 29, 1907 ..	Moderagam Paar	2	14	—	—	—
December 12, 1907 ..	St. Anna's Church, 4 miles south of Tallaivillu Point ..	4	8	—	—	—
December 18, 1907 ..	Periya Paar (south end) ..	2	14	—	—	—
December 25, 1907 ..	Periya Paar	2	9	—	—	—
January 29, 1908 ..	Tuticorin Pearl Banks ..	6	10	2	0·46	Both at Kottar, Travancore.
January 29, 1908 ..	St. Anna's Church, 4 miles south of Tallaivillu Point ..	4	12	—	—	—
February 4, 1908 ..	North-east Cheval Paar ..	2	13	1	—	At Penang, 2 years and 8 months after date of release.
February 6, 1908 ..	West Cheval Paar	2	7	—	—	—
February 12, 1908 ..	Muttuvaratu Paar	3	8	—	—	—
February 14 & 15, 1908	Krusadai Paar	3	50	30	0·26	All in the vicinity of Tuticorin..
February 15, 1908 ..	Do.	3	10	1	1·3	Near Tuticorin.
						Typical North-east Conditions.
November 4, 1908 ..	Off Mannar or Nadukkudu Paar ..	1	16	5	1·0	All recovered near Colochel, beyond Cape Comorin.
January 27, 1909 ..	Muttuvaratu Paar	3	9	1	0·34	Milande Atoll, Maldive Islands.
February 16, 1909 ..	South Cheval Paar	2	10	—	—	—
March 10, 1909 ..	Cheval Paar	5	4	—	—	—
March 13, 1909 ..	Maraville Paar	5	8	5	0·10	All at Udappu.
						Typical North-east Conditions.
November 10, 1910 ..	Off Tuticorin Pearl Banks ..	6	20	—	—	—
January 4, 1910 ..	North Cheval Paar ..	2	18	—	—	—
January 13, 1910 ..	Alanturai Paar	3	16	—	—	—
		Total ..	358	60		

Percentage returned, 16·76 per cent. Average velocity of current, ·476 knot per hour.

Since the preceding report on the currents prevalent in the gulf was written, 900 more drift bottles have been liberated at the same stations during the south-west monsoon of 1911.

The results are similar to those obtained in previous years, which they fully corroborate. This year (1911), however, the monsoon was extraordinarily light, and the consequence was that the oceanic current from the west was feeble, and never penetrated into the gulf at all. Consequently there was no "head" of water in that region. The currents, therefore, ran to the north and through Paumben Pass. On one occasion, when the monsoon was a little stronger than the year's average, this oceanic current, sweeping past Cape Comorin, caught a set of bottles liberated there. Passing in a south-easterly direction, it reached the Ceylon coast a little to the north of Colombo, where it caught and swept southward a set of bottles liberated near Colombo. The interest of this fact is that bottles liberated off Tallaivillu and Chilaw about the same time were drifted to the *north*. This interesting result shows that the oceanic current just reached Ceylon between Negombo and Colombo, and *that* only on one occasion.

The monsoon during July was very light and the current on both sides of the gulf, that is, off Manapad and Tuticorin on the Indian side, and off Colombo, Chilaw, and Tallaivillu on the Ceylon side. During the early part of August the monsoon freshened a little, and on this occasion bottles released off Cape Comorin were swept easterly by the monsoon ocean current, and were recovered on the south coast of Ceylon between Colombo and Galle. During the second week in August the monsoon fell light again, and the current off Cape Comorin and off Ceylon ran steadily north, until the monsoon finally died away in September.

Strictly speaking, there was practically no south-west monsoon during 1911. Consequently the bottles ran generally north and were lost. Only 23 per cent. were recovered, as against 51·5 per cent. last year. Theoretically, during a perfect south-west monsoon, bottles liberated on the stations shown on the charts appended ought *all* to be recovered on the Ceylon coast. The strength of any south-west monsoon may be measured by the percentage of bottles recovered. The weaker the monsoon, the greater the percentage of bottles lost, and so with exotic larvæ.

Through the kindness of Captain Fysh, R.N.R., of the R.M.S. "Palitana," and Captain Dickinson of the R.M.S. "Putiala," we were enabled to collect plankton twice daily (5 A.M. and 7 P.M.) over the vicinity of the Tuticorin pearl banks. A net was devised to take the collections whilst the ships were under full way. The net consisted of a conical brass wire framework having a $\frac{1}{4}$-inch mesh. It was made of woven brass wire, and was suitably weighted with a brass ring round the top. This framework was intended to support the tow net when the ship was under way. Inside this net was fixed and fitted a net of jute hessian to prevent the tow net proper from chafing against the brass. The tow net itself was fitted and fixed inside the jute hessian. Splendid collections were made. The tow net had to be renewed almost every day, but the jute hessian net usually lasted for three or four days. We recommend this form of apparatus for collections of plankton under similar circumstances.

A few oyster larvæ were noticed in the plankton on July 28 and 29 only, and these were scanty. The experiment shows, however, that it is possible to obtain good plankton catches in this way, and thus to know whether the oyster larvæ which give rise to exotic spatfalls on our banks are present in the vicinity of Southern India.

The outstanding feature is however that, although oyster larvæ may be present in enormous numbers round Southern India, no exotic spat can possibly reach our banks unless the south-west monsoon continues *strong* during the critical period. The experiment during 1911 conclusively showed that, even if larvæ had been abundant, they would have drifted through Paumben Pass and been lost. When oysters *are* present on the Tuticorin side, their larvæ drift through Paumben Pass, or drop into the abyss on their way to the pearl banks, or successfully reach the plateau, depending absolutely on the strength of the monsoon.

As Steuart remarked, the factors controlling these natural events are at present beyond our control, but now that the facts are understood, we recognize that the intermittency of fisheries is dependent on the strength of the successive monsoons. We have often suspected that there were meteorological rhythm concerned in these periods of blankness, and we should not be surprised to find when the data comes to be carefully examined that this is so. The data already to hand appears to point to this conclusion.

To Ceylon the interest of the Tuticorin pearl banks lies in their being the area potentially supplying spat to the Ceylon pearl banks. As such they merit attention, and it is to be hoped that succeeding workers will have means of investigating these banks. With that information, and a knowledge of the nature of the south-west monsoon for any particular year, it will be possible to predict with a considerable degree of certainty whether an exotic spatfall has occurred on the Ceylon banks before the inspection has commenced.

In conclusion, we would tender the grateful thanks of the Company to all who have helped in this investigation by liberating drift bottles, and our special thanks are due to Captain Fysh and Captain Dickinson for the interest, care, and trouble they took in the collection of the plankton over a period of two and a half months.

Current Chart for South West Monsoon - A

Current Chart

Showing the easterly set when the South West Monsoon was strong from 9th to 25th July and again from 15th to 26th August 1910

Jas C. Kerkham
12. 10. 11.

Lith: S G O No. 60 Nov 1911.

Current Chart for South West Monsoon - B.

Showing a northerly current during a lull in the monsoon from the 28th July to 5th August and again when the monsoon commenced to subside from the 1st September 1910 after which date the current ran steadily to the north during the month

Jas. G Kerkham

12 10 11.

Lith S G O No 61. Nov 911.

Current Chart for North East Monsoon - C.

Jas C Kerkham

12 10 11.

Lith. S G O. No 62 Nov 1911.

No. 21.

NAUTICAL NOTES AND OBSERVATIONS ON THE CEYLON PEARL BANKS UNDER LEASE.

By Lieut. J. C. KERKHAM, R.N.R.,
Superintendent of Fisheries.

1.—Introductory Remarks.

It has been my privilege since taking up duties as Superintendent of Fisheries to the Ceylon Company of Pearl Fishers, Limited, to participate in the carrying on of a work which has been intensely interesting, very unique, and wholly novel to me, and which promises to continue to be very fascinating; for although at present there is no promise of a fishery, still one has only to turn to the past history of the banks to see that Nature, though heavily taxed by rapacious men, has always made good such ravages, and also those of the oyster's natural enemies, by huge deposits of spat from outside sources. One may therefore look forward hopefully to the near future for a plenteous supply of spat in such quantities as to defeat all the efforts of predatory fish and other enemies of the pearl oyster, and which will remain in such numbers on the banks as to ensure future fisheries.

My duties, other than the actual inspection work carried on by skin and dress divers and general supervision, has been to co-ordinate all the nautical data up to date, to add what I have been able to collect during the last two seasons, and incorporate same in a new chart. A preliminary chart was drawn up at the end of the last season, *i.e.*, April, 1909. Another chart with further data is now completed; a good deal of fresh data has been obtained. Some considerable inaccuracies have been found referring to the positions and contours of the coral reefs, particularly those outside Dutch Bay.

2.—Notes on Anchorages, &c.

Dutch Bay.—The survey of Dutch Bay was carried out during October, 1908. It is the only land-locked anchorage on the area leased by the Company. The bay, if such it can be called, is one of the entrances to the extensive backwater which extends as far south as Oodoopekeret, 10 miles north of Chilaw, and affords small native craft safe and navigable waters sheltered from both monsoons, and is the natural highway for a considerable coastal trade. The only anchorage available in Dutch Bay for even light draught sea-going vessels lays immediately east of a sandy extension of Mutwal island called Dutch Bay Land, on which there are two conspicuous coconut topes, which form useful landmarks as far north as Karativu beacon and south to Tallaivillu Point. A beacon has been erected by the Company on Dutch Bay Land 1 mile north of the northern tope, which forms an additional landmark. and marks the southern extremity of the Company's area.

The Company's attention was drawn to Dutch Bay, as it is the only protected area which appeared available for forming nurseries for oyster culture. Consequently, with that object in view, the bay was surveyed and an area selected, which, although far from offering what was desirable, was the best to be found there, having regard to depth of water, nature of bottom, and protection from the south-west monsoon. The area was marked off and cultched. On examination six months later the cultch was found to be silting over. A recent examination showed that the whole area was covered with a layer of coarse sand, with mud, and a sandy shoal which existed (stretching in an east-north-easterly direction into the bay from near the beacon) has extended out to, and partly over, the cultched area. This sand shoal is not shown on the original chart. It has formed on a small rocky patch, and of late has grown out into the bay and threatens to almost close the entrance. The shoal is a dangerous one, having only 3 feet on it at low water. It rises out of 3 fathoms of water, and is very abrupt on the north side. There are other striking changes taking place in Dutch Bay. Several very interesting characteristics were noted in Part III., "Ceylon Marine Biological Reports," June, 1909.

The severance of Ipantivu island from Karativu has taken place of late years. A shoal now marks the subsidence, and a sheet of water 2 miles in breadth separates the islands. Another remarkable change, concurrent probably with the subsidence, is that at the south-west extremity of Karativu full-grown trees of 3 feet circumference now stand in 9 feet of water at a distance of a cable and a half from the shore. As these trees do not appear to be more than twenty years old, it is evident that the subsidence is recent, and probably still going on, for when Dutch Bay was visited last it was found that a new channel had formed north of the present southern extremity of Karativu, so that the island is again divided.

The other striking change noted in the above Report was the formation of a channel, now a mile broad, cutting off Dutch Bay Land from Mutwal Island. The channel is still broadening, much to the sorrow of an enterprising Sinhalese fisherman, who has planted a coconut tope, which is slowly and surely being washed away by each succeeding monsoon. This new channel on the south probably accounts for the segregation of sand on ground hitherto kept clean by the velocity of the ebb and flow of tide, as doubtless a smaller volume of water passes through the main entrance now than formerly, when only one channel existed.

In the face of such rapid and striking changes Dutch Bay cannot be recommended as a safe anchorage, and should be entered with great caution. It is only available for vessels of very light draught—not over 12 feet. The entrance to the bay must be approached from the south of the Bar reef, the passage between the reef and Karativu not being safe, as sandy shoals form there.

Native craft frequently water from Ipantivu Island, where wells have been sunk at the north-west extremity, off which a depth of 12 feet is found at a distance of four cables. The water is good.

Portugal Bay affords anchorage sheltered from the south-west monsoon in 4 fathoms of water, with good holding ground, the bottom being stiff mud. This bay has no hidden danger, and the soundings are very even. It is only useful as an anchorage.

Marichchukaddi, 4 miles further north-east—the fishery headquarters—affords good anchorage for light draught vessels in 3 fathoms of water, and is sheltered from the full force of the south-west monsoon, although there is a very steep sea and considerable surf on the beach during the height of the south-west monsoon.

A good leading mark when approaching Marichchukaddi is the northern bungalow of the three built on a cliff, in line with a large conspicuous tree bearing east. This gives a leading line over Karativu shoal in 3 fathoms of water. The bungalows are very conspicuous, more so than Dixon's tower, which latter stands three cables north. The top of the tower is 95 feet above low water. Both form conspicuous marks over the East and West Cheval Paar.

At Marichchukaddi there is a good supply of fresh water from two reservoirs, one a quarter and the other three-quarters of a mile from the beach, but the water is not so good as that found at Silavatarai, which is obtained from concrete wells sunk close to the beach, and from which water can be readily pumped into a water boat.

Silavatarai Anchorage lays three cables south of an iron beacon erected lately on the Silavatarai coral reef, and is only used when calling for water. Of late a nursery—formed of expanded metal—has been erected under the shelter of this reef. The ground is flat rock covered with a little sand, and is not a safe anchorage.

Mannar South Bar Anchorage lays in from 2 to 3 fathoms of water; the latter depth is found 3 miles from the shore. The bottom is very shelving: the 2-fathom line is fairly close in, about seven cables from the beach.

The only mark in making South Bar is one recently erected by Mr. Stevenson, the late Assistant Government Agent of Mannar.

There are no port marks visible at South Bar. One has only the mark referred to above, which is a post 30 feet high painted alternate black and white. It is situated at the sea end of the South Bar road. Vankali lighthouse makes a good cross bearing with this mark.

The anchorage is only available for small craft, which unload where the South Bar road ends at the beach. Dhoneys alone are able to across the bar. When making Mannar anchorage from the south. Talaimannar Point (which is very conspicuous) bearing north leads clear of the north-west extremity of the Vankali reef. The black and white post described above may be steered for when bearing east.

3.—Reefs and Shoals.

Bar Reef is fittingly so called, as it lies at right angles to the coast line immediately outside Dutch Bay, and at the southern extremity of the area under lease.

The reef is exposed to the full force of the south-west monsoon, and doubtless accounts for the segregation of sand and the sandy elevation on Karativu north of the Bar reef, which it shelters. The elevation occurs north of where the new channel has formed referred to under "Anchorages, Dutch Bay," and has an approximate elevation of 12 feet. The reef protects a considerable sea area north as well as Karativu Island, north of the sandy elevation mentioned. The passage between the reef and Karativu is not safe for other than small craft, as sandy shoals form, and the bottom is very uneven.

The reef is formed of three coral patches, the south-west patch being the most extensive, and lying east and west. The other coral patches occur one on the north and one on the east. The three patches (all of which dry at low water) form a triangle, the base being to the south. The intervening space has patches of living coral in deep water, the coral nearly reaching the surface in places.

A striking feature about this reef is that, although it forms a natural barrier and breakwater, the sea, however rough, never breaks on it. In the height of the monsoon it is invisible, except at low water, when the coral can be seen, but there is no breaking sea. This particular characteristic is shared by the Vankali reef, and is accounted for by the coral extending out into deep water. A breaking sea only occurs where the coral grows and terminates in shallow water. The Bar reef in rough as in fine weather is invisible, except at low tide; consequently, as it lies in deep water, it is dangerous to approach. To obviate this two iron beacons have been erected, one on the south-west extremity, the other on the south-east.

The reef covers an area of about 1 square mile, and is formed principally of *Turbinaria crater*, which grows in dense masses, and which makes it all the more surprising that such a solid barrier does not cause a broken sea. The position of the reef has been found to be slightly different to that on the original chart. The reef has been re-charted, and the position of the beacons on it are now shown on the new chart. Dutch Bay beacon bearing east leads clear of the southern end of the Bar reef.

Karativu Shoal is a sandy shoal running north from the northern extremity of Karativu island. It narrows as it goes north, and deepens (which depression marks the channel across the shoal for vessels to Marichchukaddi drawing less than 18 feet). It then shoals again and broadens, terminating abruptly 10 miles north, where it deepens suddenly from 3 to 6 fathoms. The northern extremity is called the Shoal Buoy Position, and was marked at one time by an iron beacon, which, however, owing to the sandy nature of the bottom, did not withstand the strength of the south-west monsoon, and now lays at the bottom. The fallen beacon is buoyed when inspection work is going on, as the position affords a good southern mark. Deep draught vessels would need to round north of this position when approaching Marichchukaddi.

The shoal is clearly visible in fine and clear weather, as the white nature of the sandy bottom makes the water a light green. At such times the fallen beacon shows up as a dark shadow, as do several tanks sunk on the same spot. Karativu tope and beacon can just be seen, which, together with Kutrimalle tower and Kellar obelisk, form good marks to locate the position.

The sunken beacon mentioned above has been recently examined with a view to raising it, but it was found in a very bad condition. Such a beacon, with an iron tray between the legs at the base and heavily ballasted with a hundred tons or more of stone ballast, might perhaps stand the monsoon, but the position is very exposed, and the sand very coarse and loose. A station buoy meets all present requirements, and is removed at the end of the fishing season.

Aripu Reef lies due west of Aripu tope, at a distance of 4 miles, and occurs on the edge of the inshore overfalls of a shallow water plateau of from 2 to 3 fathoms, which extends out from the shore, and starting at Kutrimalle Point sweeps gradually in a curve to the north-west, and finally west-north-west. The coral reefs commence off Silavatarai, and are named Silavatarai, Aripu, and Vankali reefs. Silavatarai reef forms the southern extremity. These coral reefs, which extend in a north-westerly direction for a distance of 5 miles, cover an area of about 4 square miles, and terminate on the west in from 4 to 5 fathoms of water. On the north a deep arm of the sea runs in towards Vankali, and divides Aripu from Vankali reef.

The area on the inshore side of Aripu reef has been examined with a view to finding a suitable area protected by the reef, for another nursery like the one under the lee of the Silavatarai reef, where unfortunately there is only 12 feet of water; but although deep water was found on the northern extremity of the Aripu reef, it is not protected sufficiently.

The reef is made up of three groups of coral, including the Silavatarai patch, which dry at low water. *Madrepore* predominates, and occurs in great variety. On this reef the sea breaks in places, which is accounted for by shallow water, there being a depth of under 6 feet in parts.

Vankali Reef lays off the port of that name and north of the deep arm of the sea mentioned as dividing this from the Aripu reef. It occurs on the edge of the overfall of the shallow inshore plateau, which here extends in a more westerly direction, and is at the northern extremity, 9 miles from the shore. The plateau inside is shallow, *i.e.*, 2 to 2½ fathoms. The coral grows in dense solid masses on the overfalls, and terminates on the west face in from 5 to 6 fathoms. The most massive growths occur in from 1 to 2 fathoms. The reef covers an area roughly of 6 square miles, and is 6 miles long. It terminates north, where the shallow plateau ends, and soundings deepen to 5 fathoms.

The characteristic of the coral growth here is *Turbinaria cincerens* in huge masses, rising abruptly, and growing in separate dense growths with deep chasms between, which make walking over the reef (of which an extensive area dries at low water) a dangerous business, unless one is attended by a boat and companions, for one might get badly hurt by a sudden fall into the deep abysses, and as the coral overlaps, it would be an easy matter to find oneself fast under the overhanging edge. On this reef, as on the Bar reef, the sea does not break, due to the fact that the coral grows out into deep water.

An iron beacon has recently been erected on this reef, which has been placed on the highest and densest part of the reef, and in a position where it is hoped it will stand. The structure is of railway iron, and is surmounted by a black ball 6 feet in diameter over an inverted triangle, which can be clearly seen 8 miles. A beacon on this reef was necessary, as the only bearing available on the northern paars is Aripu tope, and a second landmark was much needed.

4.—Beacons and other Landmarks.

Since the Company took up the lease of the pearl banks considerable additions have been made to the landmarks, in order to facilitate the location of the various paars and rocky areas. The positions of the conspicuous natural landmarks have been fixed, and the positions of the original marks verified and corrected where necessary.

The beacons which the Company have erected are Kutrimalle, Karativu, and Dutch Bay beacons; and of late the two on the Bar reef, one on the Vankali reef, and another on Aripu reef.

Other small iron beacons have been put up, one on the Silavatarai reef and three others in Dutch Bay. Two of the latter have fallen owing to erosion and the loose nature of the sandy bottom where they were erected.

Besides the erection and maintenance of the above beacons, the Company have cleared Arunakalu tower of encroaching forest growth and cleaned and whitewashed it, as also Kutrimalle tower and Kellar obelisk—all original landmarks. Kutrimalle and Arunakalu towers, both trigonometrical stations, have furnished a base for fixing all landmarks as far north as Aripu tope. These two marks are masonry towers, and are to be seen a considerable distance owing to their high elevation. Kutrimalle tower is 230 feet and Arunakalu 280 feet above sea level.

Starting from the south, Dutch Bay Beacon marks the southern extremity of the Company's area. It is situated on Dutch Bay Land, 1 mile north of the northern of the two conspicuous coconut topes mentioned under "Anchorages, Dutch Bay." It is, like Kutrimalle and Karativu beacons, built of palmyra trees stepped in cement, and is 37 feet high from the base, which base is about 4 feet above low water level. The beacon is painted white.

Karativu Beacon is situated at the north end of Karativu island, and forms, together with Karativu tope, a useful mark to locate the Shoal Buoy Position. As previously mentioned, it can be seen clearly as far south as Bar reef. The beacon is 40 feet high and is coloured black.

Kutrimalle Beacon is situated on Kutrimalle Point, and has an elevation of 145 feet above sea level. It is painted black and white, one-third black from the top, the lower two-thirds white. The beacon, with Kutrimalle tower, makes a useful magnetic transit bearing for compass adjustment, as also does Karativu beacon with Kutrimalle tower.

The two beacons erected on Bar Reef mark the south-west and south-east extremities. The south-west beacon has a black ball 5 feet in diameter, the top of which is 18 feet above low water mark. The south-east beacon has a cask on top with a cross below. The top of the beacon is 12 feet above low water mark. The south-west beacon can be seen as far north as Karativu or Kutrimalle tope.

Aripu Reef Beacon is situated on the north-west extremity of Aripu reef, and marks the deep water channel which lays between the Aripu and Vankali reefs. It is built of railway iron topped with angle iron, and is triangular in form, having three uprights, which are bolted together at the top; the south and west sides are battered in and whitewashed. The beacon is surmounted by a staff and cross yard; the staff supports a conical cask, and a conical cask hangs from each yardarm, the whole being coloured black. The beacon stands in 3 feet of water at low water, and has a height of 30 feet above low water mark; it is clearly visible at a distance of 9 miles.

The Silavatarai Reef Beacon marks the southern extremity of this reef. It is a small beacon, and only serves as a guide when anchoring to the south of it, which position forms the most convenient anchorage for watering.

The Vankali Reef Beacon is built of railway iron bolted together. It is situated on the highest and most compact part of the reef, on a spot where the depth is only 5 feet. The rails have been driven through the coral well into the mud and securely bolted together. The beacon is surmounted with a 6-feet black ball, the top of which is 28 feet above low water; below the ball is an inverted black triangle. The beacon is clearly visible to the naked eye at a distance of 8 miles, and forms a useful and much-needed mark on the northern paars.

Kellar and Doric Towers—or more correctly obelisks—are both original marks, erected by Government on well-selected sites between Marichchukaddi and Aripu. They are visible all over the Cheval Paar. Aripu tope also forms a useful mark, and can be seen as far west as the Periya Paar, distant 16 miles.

The Vankali Light Beacon, which is an iron structure, has been boarded up by the Company on the west and south side and whitewashed; this was necessary, as owing to the nature of the structure it could not be seen by day from the banks, although the light at night is visible 11 miles. The beacon is now clearly seen a distance of 12 miles, and is, in conjunction with the Vankali reef beacon and the beacon erected on the Aripu reef, a most useful landmark for the northern paars, *i.e.*, Periya Paar Karai and the true Vankali. It is also a valuable mark when making Mannar anchorage. The height of the beacon is 46 feet from the base.

The next landmark north of Vankali is Talaimannar Point, on which the trees grow thickly and end abruptly, giving a well-defined landmark and a useful guide for clearing the north-west extremity of Vankali reef, where the point is clearly visible, although distant 12 miles. Talaimannar Point is also a useful bearing, coupled with the southern extremity of Mannar island, which latter from this point forms a good mark, distinguishable by the abrupt ending of the trees, to fix positions on Anaivilundun and Nadukadu Paars.

It is proposed to replace the palmyra beacons, *i.e.*, Kutrimalle, Karativu, and Dutch Bay, by masonry obelisks, as the palmyra beacons require frequent attention owing to the attack of white ants, and are therefore expensive in upkeep. Masonry obelisks require little attention, and are more conspicuous than beacons built of palmyra trees.

5.—Paars and other Rocky Areas.

The Cheval Paar, noted as being an area on which more oysters have been fished than the whole of the remaining paar ground, has always been carefully watched and examined, as here, if nowhere else, oysters may be looked for. Since the last fishery this ground has been most searchingly examined, in the hope that some portion of the late rich harvest of fishable oysters might still remain. These hopes, as is well known, were not realized.

During the course of this close examination of the rocky area, it became apparent that, although the paar ground was charted fairly correctly, several rocky areas shown as separate paars were extensions of the main paar. We had also reason to believe that the paar ground on the north of the Cheval was more extensive than shown. Consequently, a rectangular form of inspection was adopted in place of the old circular method. The latter form left intervening unexamined spaces between the circles, and was open to great distortion owing to the difficulty the boats had of making a true circular course.

The rectangular method of inspection means that the whole ground is examined, as each square abuts against the next. A greater area is covered daily, and the prevailing north wind can be utilized to assist the boats, which work across the wind east and west, starting from the windward or north side, where they are towed by the steam tender, which also picks them up on occasions, when the inspection is finished, to leeward of the ship's position and tows them back.

This rectangular method of examining the ground (which, as is well known, is done by skin divers) combines inspection work with survey, for it shows the exact lay of the rock and the contour very closely, and has revealed considerable differences in the configuration of the Cheval Paar.

The Periya Paar, and also the true Vankali, reveal similar differences, the latter being a much greater area than is shown on the old chart.

The Cheval Paar is formed of two large areas of rock. The one on the west, known as the West Cheval, is a compact, well-defined, oblong stretch of flat rock, only connected with the East Cheval by a narrow run of rocky ground on the north. A narrow stretch of sand runs north of the Shoal Buoy Position (mentioned before as being the northern extremity of the Karativu shoal). This stretch of sand carries the same depth of water as the paar ground on each side, and is in no way a shoal. The old horseshoe configuration is consequently not correct. The flat rock carries on it heavy calcrete in the centre, living coral on the north, and coral débris to the south.

The East Cheval has been found to have three extensions, which have been named northern extension, north-east extension, and south-east extension of the East Cheval. The East Cheval is also largely formed of flat rock, calcrete, and coral débris, the latter predominating, as shown on the chart furnished.

The northern extension is formed of heavy calcrete on flat rock, and it thins out north to cora débris, then sand. This extension appears to have been known as the old Aripu Paar, although it does not quite coincide with the original charted position of this paar, which position was found to be all sand.

The north-east extension is of coral débris alone with sand, and was formerly charted as a separate paar known as Kallatidel Paar. The south-east extension of the Cheval is of flat rock, heavy calcrete, and coral débris, and was known as the true Kondatchi Paar, and charted as a separate paar.

The entire area of the West and East Cheval, with extensions, is approximately 21 square miles. The depth of water over the West Cheval is from 7 to 8 fathoms, and on the East Cheval 6 fathoms. The extensions average a depth of 5 to 5½ fathoms of water. The most productive part of the Cheval has been the south part of the East Cheval.

The Moderagam Paar.—What has been known as the North and South Moderagam Paars, and charted as separate areas of rock, are practically a southern extension of the East Cheval, although separated from the latter. This area is nearly all sand with scattered coral débris, so scattered in fact as to hardly admit of being described as paar ground. A long narrow run of coral débris which extends due west from the East Cheval alone lends itself to configuration as paar ground, although scattered coral débris lies to the east and west. The rocky area lies in a deep water *cul-de-sac*, which probably accounts for oysters maturing here. A bed of 6,000,000 oysters matured on the Moderagam and was fished in 1904. The depth of water here, as on the East Cheval, is 6 fathoms.

The Periya Paar Karai.—This paar is a compact solid stretch of flat rock which lies due north of the Cheval at a distance of 2 miles, the intervening area being sand. A peculiarity of this paar is the prevalence of large potholes, varying from 12 to 15 feet across and from 3 to 4 feet in depth, with overhanging edges. These holes are the resorts of numbers of fish.

The existence of these holes is a striking proof of the absence of bottom currents and silting, for it is evident that the holes would be full of sand, and would appear as sand patches if there was any drift of sand. The prevalence of these potholes makes dredging difficult. The area of the paar is roughly 2 square miles, and the average depth 8 fathoms.

Calcrete and coral débris occur on the flat rock, and a great variety of weed. The Periya Paar Karai figures largely in the history of the banks as being a paar on which oysters have frequently matured. It was on this paar that a bed of spat was found in November, 1908, which unfortunately was demolished by predatory fish, as was amply proved by the quantities of broken shell and shell fragments dredged up by the "Violet," and also brought up by divers. The next paar of importance is—

The true Vankali Paar, which lays 2½ miles north-west of the Periya Paar Karai; it is separated from the latter by a narrow neck of sand. A bed of spat also occurred on this paar in November, 1908, which was considerably larger than the one which was found on the Periya Paar Karai, but shared the same fate. The area of this paar has been found to be much more extensive than shown on the original chart.

The paar lays roughly east and west. It is 3 miles long, and covers an area of about 6 square miles. The depth of water is 7 fathoms on the east; it deepens to 8 and 8½ in the centre, and to 10 fathoms on the west, where it approaches to within 2 miles of the northern extremity of the Periya Paar. Two-thirds of the paar has a depth of under 9 fathoms.

The paar is roughly made up of flat rock, with calcrete and coral débris. There is an extension to the north of coral débris, which thins out, and is too scattered to chart as true paar ground.

The whole of this paar is excellent ground for oysters. It is difficult to understand why it has not a better record, but it seems likely, as it is so closely adjacent to the Periya Paar Karai, that some of the fisheries attributed to the latter may have occurred on the true Vankali.

The general characteristics of the West Cheval, the Periya Paar Karai, and the true Vankali closely approximate each other, the nature of the bottom and the average depth of water being the same.

A northern landmark was much needed here. The beacons recently erected on the Vankali and Aripu reefs have met this want.

The Kondatchi Paar occurs on an area—now known as the Kondatchi area—east of the Cheval, extending to the 3-fathom line, and reaching as far north as the Silavatarai reef, and south to the Kellar obelisk. Scattered coral débris is found over a considerable portion of this area, but it is too scattered to be charted as paar ground. This scattered coral débris, together with the occurrence of beds of *Pinnas*, forms cultch on which oyster beds have frequently occurred and matured; but the oysters, although large, are known to be very poor pearl producers, incident on the shallow water on which they occur, *i.e.*, 4, 3½, and 3 fathoms, and the absence of infecting parasites.

The Muttuvaratu Paar comes next to the Cheval in productiveness. The Muttuvaratu Paar starts north of the northern extremity of Karativu island, on the edge of the overfalls, and extends south as far as Bar reef. Starting at the north, where the paar narrows to a point on the edge of the overfalls, it broadens south, and approaches Karativu island to within a mile of the beach. It then runs roughly south-south-west until the Bar reef is reached. The west is bounded by the overfalls. This extensive rocky area includes—starting from the north—Karativu, Alanturai, and Krusadai Paars, also Hamilton's Muttuvaratu and Donnan's Muttuvaratu, the whole being one continuous rocky area covering approximately 28 square miles. This vast stretch of rocky area represents about 25 square miles of potential paar ground, the paars above named being those on which oysters have matured and been fished.

The bottom is flat rock, on which quantities of massive *Porites* grow, the ruins of which lie scattered over the whole area, forming excellent cultch. Isolated growths of *Turbinaria crater* and brain coral also occur in great quantities, but the *Madrepore* ground is practically useless for oyster culture, and represents 3 square miles.

To the south, just north of, and in the vicinity of the Bar reef, beds of *Madrepore* occur, which cover considerable areas. The feature of the paar north of the Bar reef is the absence of *Madrepore* and the large size and massive growth of *Porites*, which occur in groups and rise on their own ruins to 3 and 4 feet above the bottom, and is described by native divers as "peaky rock." These massive growths of *Porites* make dredging and trawling operations impossible over this area.

With the *Porites* and other massive coral growths, such as brain coral, *Galaxia*, and *Mussa*, quantities of *Foraminifera* and *Halimeda* occur, together with a great variety of weed other than the latter.

The depth of water on the inshore or east side of the paar averages 5 fathoms, which deepens gradually as the overfalls are reached to 9 fathoms, which is found on the edge of the overfalls, which here are very precipitate. The Muttuvaratu Paar ends the list of the historically productive paars. We now come to the great—

Periya Paar.—This paar is situated on the edge of the overfalls from the 9-fathom plateau to the 14- to 20-fathom plateau, distant 18 miles from the land. A succession of plateaus occur off the coast at this point, *i.e.*, due west and north of Kellar obelisk, starting with a 2-fathom plateau, with a fall to the 4- and 5-fathom plateau, on which the Kondatchi Paar occurs, then again to 6 and 7 fathoms, on which the Cheval Paar is situated. After this we get a slight depression to 9 and 10 fathoms, which decreases to 8 and 9 fathoms respectively as the Periya Paar is reached. The Periya Paar lies on the edge of the fall from what may be termed the Cheval plateau, which gradually deepens from 6 and 7 to 8 and 9 fathoms until the overfall is reached to the 14- and 20-fathom plateau, which latter finally ends at the overfalls proper, where we get a precipitate fall to 100 fathoms or more.

The slight depression noted between the Cheval and the Periya Paar resembles the depression or valley noted on the plateau off the south coast by Captain Somerville, R.N., in "Spolia Zeylanica," Vol. V., Part III., April, 1908.

The average depth of water over the paar is 9 fathoms, deepening rapidly on the west to 14 fathoms. The paar on the south is about 2 miles broad, 11 miles in length, and tapers on the north to a fine point. The paar takes the trend of the overfalls on which it occurs, which here run in a north-west by north direction. The northern extremity of the paar approaches, as is noted elsewhere, to within 2 miles of the true Vankali Paar.

The paar is represented by a rocky edge, on which living coral occurs on the north, but which has died out on the south, where there is a little less depth of water, *i.e.*, 7½ to 8 fathoms. It was on the southern part that a bed of oysters matured which were fished in 1879, and this is the only fishery recorded on this paar. The importance of the paar is solely due to the frequent and almost seasonal occurrences of large spatfalls; but only on the above occasion have oysters matured here.

Anaivilundun and Nadukadu Paars are the most northern, and represent one continuous stretch of rocky ground with living coral, coral débris, and weed. The paar is situated on the edge of an overfall, from a 5-fathom plateau to a 7 to 8 fathoms, which is a continuation of the overfall on which the Vankali reef occurs, although the reef ends where the 2-fathom plateau between the reef and the coast terminates.

The above 5-fathom plateau extends out in a southerly direction from Adam's Bridge, and is formed of mud and fine sand, with patches of living coral and quantities of prawns and shells. The paar itself is formed almost wholly of *Turbinaria crater*. Massive stony coral is rarely found here. The area of the paar is considerable, being approximately 6 square miles. The average depth is 5 fathoms. There appears no record of oysters maturing or of fisheries on this paar, although the rock where the coral occurs is clean and appears suitable for oysters.

The paar is about 6 miles long and 1 mile broad, and runs in a west-north-westerly direction from Vankali reef, from which it is separated by a 3-mile stretch of sandy bottom, on which the depth of water increases as the Vankali reef is left and the paar is approached.

6.—Method of Inspection by Divers.

The examination and inspection of the pearl banks is carried out by native divers under the superintendence of the Superintendent of Fisheries, who also checks and verifies the native divers' reports as to the nature of the bottom by personal inspection in the diving dress.

The present method of inspection is an improvement on the circular method inaugurated by Capt. Donnan, which latter necessarily left intervening spaces between the circles, to obviate which the present rectangular method has been adopted. The circular method was convenient for prospecting, but for systematic survey and accuracy the rectangular method adopted has many advantages, such being continuity, greater accuracy, and the avoidance of distortion, equalized labour, and a greater area covered daily ; the courses are straight, and full advantage can be taken of the prevailing north wind, and finally four areas can be inspected from one central position, which means that the inspecting vessel need only move to a new position every third or fourth day. The latter advantage is a great saving of wear and tear to the Company's vessels. Another advantage of the rectangular method is alinement, which means that lines of positions can be extended to the outside positions with great accuracy ; and a further advantage is that beds of oysters can be, as the paar is, accurately figured and the numbers estimated more nearly.

The four inspection boats, six-oared whalers, start from the windward side of the area to be inspected, and work across the wind east and west, between the buoys (which are laid down north and south, east and west), in such a manner as to direct the boats on their east and west course and prevent their getting out of position. Each coxswain is provided with a chart on which the result of each dive is recorded with the soundings.

The inspection chart is divided into six sections ; the top or north one is known as No. 1 section. Starting, we will say, from the north-west buoy, the four boats take up their positions and proceed to take a line of dives as they go east. The north boat steers for the north-east buoy, and the south boat for the intermediate north buoy of the centre line of buoys. The centre intermediate line of buoys are laid as a guide to prevent the boats getting set to leeward. No. 1 boat (No. 1 coxswain) takes the windward position and No. 2 (No. 2 coxswain) the lee, and these coxswains are responsible for keeping position. Fourteen dives are made from each boat, and as they go across the area six times a total of 336 dives are made over the entire area. An area covers $2\frac{1}{4}$ square miles, and represents a 9-mile course from each boat, although with turning and getting into position for each section the actual distance is $10\frac{1}{2}$ miles. The boats are towed into position or back according to the ship's position. Each boat has a crew of six boatmen with three divers and two linemen, which, together with the coxswain, makes a crew of twelve. The inspection work starts at 7 A.M., and an area is inspected by 1 P.M., the inspection occupying six hours, and each section one. The same area inspected by dredge occupies four hours.

The smaller charts known as coxswain charts are filled in by each coxswain as each dive is made, and it is from these that the inspection chart is drawn up.

Such, in brief, is the present method of inspection, which has led to the moro accurate charting of the rocky areas known as paars, and, as pointed out above, also gives the correct configuration of oyster beds as well as the rock.

7.—General Observations and Remarks.

On visiting the pearl banks for the first time one is struck with the distance which the banks proper—such as the Cheval Paar—are from the land, and the featurelessness of the coast, which is here very low-lying.

The only conspicuous well-defined landmark is Kutrimalle Hill. The absence of other landmarks has been remedied by the erection of masonry towers, obelisks, and, of late, beacons, as described elsewhere. All landmarks are clearly seen after noon, but owing to the low elevation of the land, station or position buoys have had to be used to prolong lines of positions to the more northern paars in order to ensure accuracy. On such distant landmarks a slight error means perhaps half a mile out where an object is from 14 to 20 miles distant, as in the case on the Periya Paar Karai and the true Vankali Paar. Here a system of alinement and transit bearings has been adopted, together with masthead angles, ensuring accuracy where the landmarks are so distant; but we have the two new beacons, *i.e.*, Aripu and Vankali reef beacons, to work with.

On the southern paars, *i.e.*, those south of Kutrimalle Point, starting from the northern extremity of Karativu Island, this difficulty ceases, as the mainland has a good elevation. The paar ground, including the Karativu, Alanturai, Krusadai, and Muttuvaratu Paars, is bounded on the west by the overfall, which here approaches to within 6 miles of Karativu Island, so that all landmarks are clearly visible, both those on the mainland and on Karativu Island.

All nautical data accumulated during the last eight years, together with that obtained from the Admiralty chart of the Gulf of Mannar, the latest Government chart of the pearl banks, and other data obtained personally, has been co-ordinated within the last year, and are shown on a preliminary chart which has been drawn up of the whole area under lease. This chart embodies all nautical data collected up to date, and also shows the paar or rocky ground as revealed by the latest inspection, which, with the rectangular method of inspection as described, took the form of a survey. The chart also shows the fauna of the entire area, which has been determined by the Scientific Adviser to the Company; it is therefore a nautical and biological chart.

I may mention here that the positions of all landmarks have been fixed and verified from a base line between Arunakalu and Kutrimalle towers. The positions of these trigonometrical stations were furnished by the Government Survey Department on the latest chart of the pearl bank area. In addition to the above, a survey has been made of Dutch Bay, and a chart on a scale of 4 inches to one nautical mile drawn up.

Investigations on superficial currents in the Gulf of Mannar and immediate vicinity have been made and are being continued, which we have every reason to believe are of considerable importance, and will throw more light on the origin of exotic spat, which from time to time replenish the banks, the intermittency of which accounts for the failure of fisheries. These investigations are being made from independent data, together with information obtained from the liberation of drift bottles and the collection of planktonic forms over long periods of time.

An experimental nursery has been erected in the sea, under the lee of the Silavatarai reef. Unfortunately the depth of water is only 12 feet on this protected area. The nursery is built of expanded metal with railway iron uprights. It has withstood the south-west monsoons well, and answers all the purposes for which it was intended.

A masonry tank has been erected on the foreshore at Marichchukaddi, and is filled by a pump fitted with a filter. The pipe is carried well out clear of the foreshore into deep water. A second tank has been also fitted, and appliances—drain pipes, &c.—such as are necessary for the experimental scientific work carried on.

During recent trawling operations for certain fish required for scientific experimental work the small number of fish on the banks at present was apparent, and is incident doubtless on the absence of oysters and other shell fish.

No. 22.

A DESCRIPTION OF TEN NEW SPECIES OF CESTODE PARASITES FROM MARINE FISHES OF CEYLON, WITH NOTES ON OTHER CESTODES FROM THE SAME REGION.

By T. SOUTHWELL, A.R.C.Sc. (Lond.), F.L.S., F.Z.S.

With three Plates.

Trawling operations were continued, as usual, during the past year. The area under lease over which these operations were carried out cover the greater part of 700 square miles. At the present time fish are by no means abundant, a fact which is undoubtedly connected with the absence of suitable food. "Shell fish" are remarkably scanty. Five years ago, when both oysters and other shell fish were abundant, fish were much more plentiful.

All the fish caught have been carefully and systematically examined for cestode parasites, particularly the Elasmobranchs. No adult cestodes have been found in any Teleosts, but cysts are very numerous in most species, and a few are described in the present paper. The habitat and the larvæ of the adult cestodes described from the pearl banks are generally not known. Most probably this is because they have not been sufficiently carefully searched for.

It is almost certain that the larvæ of the adult forms described will be found later in the various crustacea and molluscs.

No parasites have been found in the *flesh* of any of the Teleosts examined. All the cysts obtained were found in the mesenteries, save in one case, where a few were discovered along with some *Trematode redia* (which measured about 20 mm. by 8 mm.) on the walls of the air bladder.

The position of the encysted forms found in Teleosts, with relation to the life-history of the parasite concerned, is very enigmatical. I am confident that in some cases these bony fish are merely parallel hosts, and that the life-history of the parasite is direct from the crustacean or molluscan host to the Elasmobranch. In some cases it may be found later that the infection of the Teleost is initial, and that the life-history is direct from the Teleost (particularly if this is a small form) to the Elasmobranch. The fact that no adult cestodes have ever been found in Teleosts lends favour to this theory.

With reference to the life-history of the pearl-inducing worm itself (*Tetrarhynchus unionifactor*) no further light has been adduced, but it seems practically certain that the life-history is direct from the oyster to the various Elasmobranchs which devour them, and that *Balistes*, *Serranus*, and possibly other genera of fish represent subsidiary or parallel hosts.

During an examination of Tamblegam Lake, which I recently made along with Dr. Pearson of the Colombo Museum, a few *Trygons* of various species were collected. In one species a few adult specimens of *Tetrarhynchus unionifactor* were obtained. There seems little doubt that the pearl-inducing larvæ of *Placuna placenta* is the same as in the pearl oyster, but the occurrence of the adult in a *Trygon* was surprising, as the adult form is so very rarely found.

A few of the genera, and many of the species, of cestodes described by Shipley and Hornell from the pearl banks have not been obtained by me.

I append to this paper a full list of the cestodes obtained by me from the pearl banks, and a comparison of this list with that of Shipley and Hornell (20) will show which genera and species I have not obtained.

I also append a list of parasitic Crustacea, Trematodes, Nematodes, &c. (mostly new species), collected during the last five years, which await description.

Owing to my leaving the services of the Company this paper has been prepared hurriedly. Few anatomical details have been dealt with, but it is hoped at some future time to fully describe the anatomical details of all the species dealt with, both in the present and in the preceding Reports.

In general, the classification adopted in this paper is that followed by Linton. According to this author, the pearl-inducing worm is a *Rhynchobothrium*.

The relations of the genera *Rhinebothrium* and *Echeneibothrium* require re-investigation, and our species *Rhinebothrium shipleyi*, n. sp., appears to require a new genus.

Larvæ of the genus *Otobothrium* are exceedingly abundant in the Teleosts found on the pearl banks, and it is very remarkable that only a few adult specimens have ever been collected, and these only recently.

In the present paper ten new species are described, and notes on seven other species are included. A note on a huge species of Trematode from *Diagramma crassispinum* is also added. The following is a list of the species described :—

Acanthobothrium herdmani, n. sp.
Platybothrium spinulifera, n. sp.
Anthobothrium floraformis, n. sp.
Anthobothrium ceylonicum, n. sp.
Orygmatobothrium tetraglobum, n. sp.
Rhinebothrium shipleyi, n. sp.
Spongiobothrium lintoni, n. sp.
Syndesmobothrium filicolle.
Tetrarhynchus gangeticus.
Otobothrium insigne.
Otobothrium linstowi, n. sp.
Rhynchobothrium, sp. I. Larvæ.
Rhynchobothrium, sp. II. Larvæ.
Rhynchobothrium, sp. III. Larvæ.
Rhynchobothrium, spp. A, B, and C. Larvæ.
Rhynchobothrium rossii, n. sp.
Paratænia elongatus, n. sp.
Trematode, sp.

I am indebted to my former Assistant, Mr. George Morrison Henry of the Colombo Museum, for all the drawings which illustrate this paper, and also for the descriptions of two or three species, and I tender my grateful thanks herewith. I would here correct an error made in Part V. of these Reports. The first cestode material from the pearl banks was collected principally by Mr. Hornell, and was described by Professor Shipley and Mr. Hornell, and not by Professor Herdman.

ACANTHOBOTHRIUM, Van Beneden.

Body articulate, tæniæform. Head separated from the body by a neck, quadrangular. Bothria four, opposite, attached to head by antero-dorsal side, neck with two transverse costæ on face and armed in front with two bifurcate hooks, and surmounted in front of hooks by a triangular pad bearing a supplemental disc which is capable of assuming diverse forms. Genital apertures marginal. (Linton 11.*)

Acanthobothrium herdmani, n. sp. (Plate I., Figs. 1, 2, and 3.)

Measurements.

Extreme length	63·0 mm.
Extreme breadth (at about ⅔ of the extreme length of the head) ..	2·5 mm.
Length of head	1·2 mm.
Breadth of head	1·7 mm.
Length of terminal proglottid	1·5 mm.
Breadth of terminal proglottid	2·0 mm.

* These numbers refer to the literature cited at the end of this paper.

Head.—The head is somewhat cubical in general shape. It is divided into four bothridia, which are sessile for the greater part of their length, only the terminal quarter or so being free. Each bothridium is divided into three loculi by two transverse septa. The loculi decrease regularly in size from the proximal one, which is the greatest. The loculi are rather shallow, and their lips and edges are broad in proportion to the area they enclose. A pair of bifurcated hooks overhang the proximal loculus of each bothridium. They are stout, brown, hollow structures, strongly curved. The two spines which compose a pair of hooks are united at their bases. The spines which are nearest to the longitudinal median line in each bothridium are very slightly larger than the outer ones. The degree of curvature appears to be the same in all the hooks. They are exactly like the hooks of *Acanthobothrium* (*Calliobothrium*) *crassicolle*, Wedl., figured by Zschokke (26, Plate 5, Figs. 93 and 94), but are much smaller. Above the four hooks each bothrium is provided with a small but well-marked accessory sucker, which is situated on a small knob-like projection. The neck is long and irregular in diameter. Its cuticle is very strongly wrinkled transversely, and it merges imperceptibly into the strobila.

The proglottides are remarkable, in that they are all broader than long. Over 200 proglottides were counted. Their sides are slightly convex, and their edges are salient. The greatest width of the strobila is anterior to its termination, the riper proglottides becoming slightly narrower. The worm is oval in transverse section. The cuticle is transversely wrinkled in the latter two-thirds of the posterior proglottides. Well-defined bands of longitudinal muscles can be seen to run through the worm.

The genital pores are lateral and irregularly alternate, the average being about four on the left side, then four on the right side.

The cirrhus is fairly long, bulbous at the base, but tapering towards the termination, and can be seen to be hollow. No internal structure can be observed without sectioning, owing to the extreme opacity of the worms. Several specimens when slightly pressed under a cover-slip extruded large masses of ova. These ova are very minute, being about 0·025 mm. in diameter. They consist of a clear spherical cell with a large granular nucleus. A number of calcospherules are irregularly dotted about on the periphery.

The diagnosis of *Acanthobothrium herdmani*, n. sp., is as follows :—

Stout opaque worm, 63 mm. long and 2 mm. broad. Oval in cross section. Head almost square, and comparatively small. The four bothridia are sessile for the greater part of their length. Each bothridium is divided by two transverse septa into three loculi, which regularly decrease in size from the proximal end, and is also surmounted by a pair of bifurcated hooks, proximal to which is a small sucker. Neck long and somewhat irregular in diameter. Proglottides always broader than long, their sides being slightly convex, and their edges not salient. Genital pores marginal and irregularly alternate, averaging four on the left side, then four on the right side.

Habitat.—The spiral valve of *Trygon kuhli*, Müll. and Henle. Fifteen specimens. Cheval Paar. November and December, 1910.

Following Linton, I have here adopted Van Beneden's classification in separating the genera *Calliobothrium* and *Acanthobothrium*, the latter genus being marked by the presence of bifurcated hooks, and the former genus by simple hooks. According to this classification *Calliobothrium farmeri*, Southwell (23), becomes *Acanthobothrium farmeri*. This classification, however, is not adopted by Zschokke.

Acanthobothrium herdmani, n. sp., closely resembles *Acanthobothrium crassicolle*, Wedl. The hooks are exactly similar, but are much smaller in *Acanthobothrium herdmani*, n. sp. Our specimens further differ from *Acanthobothrium crassicolle*, Wedl., in being four times larger, and in the size and shape of the scolex and areolas.

I have pleasure in naming our specimen in honour of Professor Herdman, whose kindly help and assistance I here gratefully acknowledge.

Professor Shipley (21, page 543) remarks that " A point of interest in the Helminthology of Elasmobranchs is the minuteness of the parasites. As Dr. Örly records, the tapeworms which infect the largest sharks, such as *Carcharias* and *Heptanchus*, never surpass 10 cms. in length. As a rule, the size of the Entozoon is inversely proportional to that of its Elasmobranch host. Both the small size and the comparative rarity of the parasites point to the fact that Elasmobranchs suffer little from the presence of cestodes, though doubtless the Teleosteans, in whose bodies for the most part the worms pass through the cystic stage, suffer considerably. When, however, they do occur in Elasmobranchs, they are often met with in great numbers, and this is especially the case with the genus *Calliobothrium*, which is sometimes found in enormous numbers on the spiral valve."

This hardly agrees with my experience on the Ceylon pearl banks. So far as I have observed, the cystic stages very often occur in various molluscs and crabs, and are by no means limited to smaller fish.

Cephalobothrium abruptum, Southwell, and *Cephalobothrium variable*, Southwell, measured respectively 12 and 13 cms. when preserved (23). *Rhinebothrium ceylonicum*, Shipley and Hornell, and *Prosthecobothrium trygonis*, Shipley and Hornell, measured 12 and 23 cms. (20). Cestodes of this length are, however, not very common. Ninety-nine per cent. of the Elasmobranchs I have examined, and they number many hundreds, were infected, and I have not noted that the parasites obtained therefrom were always smaller and more numerous than those obtained from smaller members of this family.

PLATYBOTHRIUM, Linton (11).

Body articulate, tæniæform. Head decidedly flattened, squarish, or trapezohedral. Bothria four, subtriangular, sessile, arranged in marginal pairs, armed with compound hooks, and each terminating posteriorly in a cup-like depression or loculus. A single indistinct circular depression (supplemental disc ?) on each bothrium in front of hooks. Genital pores marginal. (Linton.)

Platybothrium spinulifera, n. sp. (Plate I., Figs. 4, 5, 6, and 7.)

Average Measurements.

Extreme length	33 mm.
Length of head	·4 mm.
Breadth of head	·5 mm.
Length of terminal proglottid	·8 mm.
Breadth of terminal proglottid	·6 mm.

The head is provided with four sessile bothridia, which are arranged laterally. Thus the head in transverse section is oblong, with two bothridia on each of the larger sides of the rectangle. The bothridia are divided by a transverse septum into two loculi, and the proximal one is twice as large as the distal one. The edges of the bothridia are indented at the junction of the septa, and in the posterior loculus they are somewhat incurved, so that the loculus appears slightly pocket-shaped. Both loculi are deeply concave. On carefully examining each bothridium, it was found that in a few specimens there was a very faint indication of a second septum dividing the posterior loculus into two, and resulting in the bothridium appearing to have three loculi, whilst the rest of the three bothridia composing the head on the same individual bore no indication whatever of a second septum.

Each bothridium is surmounted by two hooks, each of which is strongly bifurcated and curved. The prongs or forks of the hooks are usually unequal in size. Where the prongs run into the basal part, there is often a blunt projection given off in another plane, which appears as a thick dwarf process, but it is not always present. The pair of hooks on each bothridium, which are situated on the middle line of the longer side of the scolex (when the latter is viewed in cross section), are slightly larger, and have a much longer subcutaneous basal trunk than those hooks which when viewed similarly are situated at the corners. The hooks on each bothridium are, therefore, not symmetrical. The basal parts of the two pairs of bifurcated hooks on each bothridium are widely separated from each other, and there is no intermediate bar or connecting piece which joins them, such as is figured by Linton (11) in *Platybothrium cervinum*. The hooks are all characteristically hollow.

Each bothridium is surmounted by a fairly large accessory sucker, the greatly thickened walls of which together form a squarish pad at the anterior extremity of the head. Linton refers to his specimen of *Platybothrium cervinum* as having "a single indistinct circular depression (supplemental disc ?) on each bothrium in front of the hooks," but in our specimens this accessory sucker is remarkably well defined.

The neck is long and covered with minute spinules, which are not apparently arranged in any definite pattern. The scolex is also covered with spinules. In some specimens this spinulation extends for some distance along the strobila, but it is a variable characteristic, and a few specimens show hardly any sign of it at all. It appears probable that this variation is due to the deciduous nature of the spinules, some of which have probably been abraded off during capture and preservation, because some of our specimens have large spineless patches in the midst of a spiny portion.

The proglottides, of which over 150 were counted, are broader than long, excepting the last three or four, which become slightly longer than broad. The sides are slightly convex, and more so in the last few segments. The edges are not salient. The genital pores are lateral and irregularly alternate. The internal anatomy was not investigated.

The diagnosis of *Platybothrium spinulifera*, n. sp., is as follows :—

Small worms, 3–4 cms. long. Head with four sessile bothridia disposed in pairs laterally. Each bothridium is divided into two loculi by a transverse septum, the proximal loculus being twice as large as the distal one. Incipient traces of a second septum were noticed in few isolated bothridia. Each bothridium is surmounted by two strongly-curved bifurcated hooks, which are not symmetrical, and the basal pieces of which are markedly unequally developed and are not connected with each other. In addition to the two forks of a single hook, there is usually present a third blunt and thick process which arises at the base of the fork. Each bothridium is further surmounted by a fairly large accessory sucker having thickened walls, the four accessory suckers together forming a squarish proximal pad. Neck long. Scolex, neck, and parts of the strobila covered with minute deciduous spinules. Segments broader than long, except the last three or four. Genital pores lateral, inconspicuous, and irregularly alternate.

Habitat.—The spiral valve of *Galeocerdo tigrinus*, Müll. and Henle. Forty-four specimens. Cheval Paar. December 14, 1910.

Linton established the genus *Platybothrium* on a single specimen, which he named *Platybothrium cervinum*, and, so far as I am aware, no other species of this genus has since been described. It seems fairly certain that the "single indistinct depression (supplemental disc ?) on each bothrium" of this specimen was an accessory sucker.

Linton's "objection to referring the specimen to the genus *Prosthecobothrium* is that the apparent homologue of the posterior bothrial appendage, which is characteristic of that genus, is in this (Linton's) specimen to be regarded as a loculus formed by a transverse costa near the posterior end of the bothrium" seems well founded, and the genera are not very similar, particularly since definite accessory suckers are now known to be present in the genus *Platybothrium* and absent in *Prosthecobothrium*.

The following list comprises a few of the distinct characters of the genera included in Bronn's family *Onchobothriidæ* (= *Phyllacanthiens*, V. Ben.), which may be useful :—

Genus.	Hooks.	Bothridium.	Accessory Suckers.
Onchobothrius ..	Rose thorn shaped, stout, four to each bothridium in two pairs ..	Each with two septa ..	Absent
Calliobothrium ..	Four to each bothridium in two pairs	Each with two septa ..	One to three
Acanthobothrium ..	Each with two bifurcated hooks ..	Each with two septa ..	One
Prosthecobothrium ..	Each with two bifurcated hooks ..	Septa absent ..	One posterior (not homologous ?)
Platybothrium ..	Each bothridium with two strongly bifurcated hooks ..	Each with one septa ..	One
Phoreiobothrium ..	Each bothridium with two hooks, each hook with three prongs ..	Septa absent ..	One
Ceratobothrium ..	Absent ? two curved simple hooks ..	Septa absent ..	One
Cylindrophorous ..	Each bothridium with two bifurcated or trifurcated hooks ..	Septa absent ..	Absent

Taking for granted (as appears likely) that Linton's specimen possessed accessory suckers, *Platybothrium spinulifera*, n. sp., then differs from *Platybothrium cervinum*, Linton, in being only half as large ; in possessing minute spinules on the head, neck, and parts of the strobila ; in the shape of the hooks ; and in the proglottides being broader than long (save in the last three or four).

Linton (13) describes a second species of *Platybothrium*, without naming it. It differed from *Platybothrium cervinum* in having two faint costæ on the posterior end of each bothrium, in only being half the size, and in being densely beset with conical spinules.

As only a single specimen was obtained, he did not venture to bestow a specific name, and pointed out that the differences named might be due to the second types of this genus being young strobila.

Platybothrium spinulifera, n. sp., corresponds exactly with Linton's description of his second type, save that there is no intermediate middle piece or connecting bar which unites the antler-like pairs of hooks which overhang the bothridia. As our specimens are all adult, they are obviously new species.

The indications of a second septum on a few isolated bothridia in our specimens shows how nearly related the genera *Acanthobothrium* and *Platybothrium* are, the principal difference being that in the former the bothridia are divided by two septa into three loculi, whilst in the latter genus the bothridia are divided by one septum into two loculi. The general shape of the head and hooks in two genera are, however, very different. The presence of minute cuticular spinules has been noted in certain members of the genera *Phorciobothrium* (*Phorciobothrium lasium*) (11) and *Cylindrophorous* (*Cylindrophorous typicus*, Dies) (1).

ANTHOBOTHRIUM, Van Beneden.

Body elongated, articulate, depressed. Supplemental discs (auxiliary acetabula) none. Head separated from the body by a neck. Bothria four, opposite or unilocular, cup-shaped or subglobose, affixed by a contractile pedicel, highly versatile, unarmed. Genital apertures marginal. (Diesing.)

Anthobothrium floraformis, n. sp. (Plate I., Figs. 8, 9, and 10.)

Measurements.

Extreme length	9·0 mm.
Breadth of head	0·7 mm.
Approximate length of neck	3·0 mm.
Length of terminal proglottid	1·4 mm.
Breadth of terminal proglottid	0·4 mm.

Head.—The head consists of four deeply concave bothridia, with very thick rims, borne on contractile pedicels. The bothridia are variable in outline, some being almost circular, whilst others are somewhat kidney-shaped. Their pedicels are capable of a considerable degree of contraction and elongation. In the majority of specimens the bothridia present a somewhat "Maltese cross" appearance, but one specimen has the bothridia borne on very distinct stalks. Other specimens have the pedicels so contracted that they cannot be seen, the bothridia being drawn up close together, and apparently sessile. The general appearance of the head is that of a four-petalled flower, hence the specific name. There is no trace of a myzorhynchus, there are no auxiliary suckers on the edges of the bothridia, and the latter are not divided into areolas.

The neck is long and very slender, and is almost the same diameter throughout. It is apparently cylindrical, and it merges rather suddenly into the broader strobila posteriorly. The cuticle of the neck is markedly wrinkled transversely.

The proglottides are not numerous, their number averaging about twelve or thirteen. The anterior ones are very indistinctly differentiated, and their sides are straight and practically parallel. They are almost square, being very slightly broader than long. The sides of the riper proglottides are slightly convex. The strobila is oval in transverse section. It shows considerable variation, however, in all the characteristics, some abnormal specimens having the ripe segments almost globular, and others having them somewhat attenuated.

The genital pores are situated laterally in the anterior third of each proglottid. In the majority of specimens they are all on one side, but a few had one or two pores on the alternate side. However, the pores are very indistinct, and it is not easy to detect them. No cirrhi were observed.

The anterior of the ripe proglottides show very little structure, except a large mass of somewhat large eggs on each side, with a dark space between the two masses and another on the sides, which latter is succeeded by a clear space which surrounds all the internal organs. A clear oblong space—the cirrhus pouch—can be seen to run from the genital pore into the centre of each proglottid. Another smaller clear patch is situated in the posterior extremity of the ripe proglottides, which probably represents the uterus. The parenchyma of the entire worm is very loose.

This specimen appears to be near to *Anthobothrium musteli*, Van Beneden, but the lack of accessory suckers, and the continuous thickening of the rims of the bothridia in our species, to say nothing about the great difference in size, warrants its separation.

The bothridia are almost similar in shape to those of *Anthobothrium rugosum*, figured by Shipley and Hornell (20), and *Anthobothrium laciniatum*, var. *brevicolle*, figured by Linton (11). Our species differ from the former in the bothridia being only one-sixth the size and in the general features. It differs from the latter in the absence of laciniæ on the posterior edges of the proglottides.

Diagnosis.—Head with four deeply concave, unilocular bothridia, with thickened rims, of varying form in the contracted state. Bothridia supported peltately by well-marked pedicels. No accessory suckers or myzorhynchus. Neck long, fine, and apparently cylindrical, with its cuticle transversely wrinkled, posteriorly merging suddenly into the strobila.

First proglottides almost square, posterior ones elongated. Ripe proglottides with sides slightly convex; anterior ones with straight, almost parallel sides. Proglottides few in number, averaging twelve or thirteen.

Genital pores lateral in the majority of specimens, and all on one side, some specimens having one or two alternate, situated in anterior third of each proglottid.

Ovaries large, occupying the greater part of the ripe proglottides. Uterus small, situated posteriorly. Cirrhus pouch visible as a clear space running from the genital pore into the centre of each proglottid.

Habitat.—A single specimen of this species was taken from a specimen of *Carcharias bleekeri*, Day, caught by line on November 15, 1910, and seventeen specimens were obtained from a small *Carcharias*, sp., trawled on the Periya Paar Karai on the 27th of the same month.

Anthobothrium ceylonicum, n. sp. (Plate II., Fig. 15.)

The head consists of four simple boat-shaped bothridia borne on short pedicels. The margins of the bothridia are thickened and crenulate, but there are neither marginal nor transverse loculi. In preserved specimens the breadth of the head is 1 mm. There is no myzorhynchus or accessory suckers. The neck is very short, and about equal in length to that of the head. The first segments are much broader than long, but they soon become square, and then much longer than broad. The terminal segment measures 1·8 mm. long and ·5 mm. broad. About sixty segments were counted in the mature worm. The entire worm measures 25 mm., and the anterior part is narrow and attenuated. The posterior extremity has a tendency to become curled. The genital apertures in the adult are enormous, and are lateral and irregularly alternate.

Habitat.—The spiral valve of *Trygon kuhli*. Eighty-six specimens. February 2, 1911.

According to Linton the genus *Anthobothrium* differs from the genus *Spongiobothrium* in having no marginal loculi round the bothridia. In our specimens the edges are merely frilled, but no loculi are present: they are accordingly referred to the genus *Anthobothrium*. Of this genus eight species are known, viz., *Anthobothrium cornucopia*, Van Ben., *Anthobothrium elegantissimum*, Lonnbg., *Anthobothrium giganteum*, Van Ben., *Anthobothrium musteli*, Linton, *Anthobothrium perfectum*, Van Ben., *Anthobothrium pulvinatum*, Linton, *Anthobothrium crispum*, Shipley and Hornell, and *Anthobothrium rugosum*, Shipley and Hornell. The present Report adds two new species, viz., *Anthobothrium floraformis* and *Anthobothrium ceylonicum*.

ORYGMATOBOTHRIUM, Diesing.

Body elongated, articulate, depressed. Head separated from body by a neck, with four opposite cup-shaped bothridia, attached by short, contractile pedicels highly versatile, each provided with a single supplemental disc on anterior end of border. Border of bothria entire, without loculi. Genital apertures marginal. (Linton, 11.)

Orygmatobothrium tetraglobum, n. sp. (Plate I., Figs. 11 and 11*a*.)

Measurements.

Extreme length	95 mm.
Length of a bothridium	1·6 mm.
Breadth of a bothrium	1·6 mm.
Breadth of head	4 to 6 mm.
Length of neck	10 mm.
Length of posterior proglottid	3 mm.
Breadth of posterior proglottid	·9 mm.

The head consists of four globular bothridia, which are attached by a broad and rather long stalk, which runs parallel to the long axis of the worm. Each bothridium is hollow, and opens both anteriorly and posteriorly to the exterior by a wide slit. Anteriorly each bothridium is surmounted by a single accessory sucker, which in our contracted specimens appears to have been drawn in towards the centre of the subglobular bothridium. This accessory sucker is circular, ·5 mm. in diameter, and is situated on that edge of the bothridium which is nearest to the centre of the head. Opposite to each sucker is a semicircular flap-like fold, which presents the appearance of a valve guarding the anterior entrance to the hollow bothridium. Its base is half the diameter of the bothridium. No trace of a second sucker could be found, in spite of frequent and continued search. The rim of the anterior aperture of each bothridium is only slightly thickened and muscular.

The diameter of each bothridium is 1·6 mm. The bothridia are quite separate from each other. They can be easily seen with the naked eye. Depending upon the state of contraction, the diameter of the head varies from 3·5 to 6·5 mm. There is no myzorhynchus.

The neck is roughly triangular in shape, tapering posteriorly, opaque, and 10 mm. long.

The first proglottides are almost square, with slightly convex sides. They become square and transparent at 2 mm. from the head. They gradually increase in length, until the posterior proglottides measure 3 mm. long and ·9 mm. broad. The sides are almost straight and parallel, and the strobila is almost transparent throughout. The edges are not salient, and the reproductive pores are lateral and irregularly alternate. Sixty-five proglottides were counted in one specimen.

Habitat.—The spiral valve of *Rhynchobatus djeddensis* (Forsk.). Three specimens. Ceylon pearl banks. February 3, 1911.

It is with considerable hesitancy that I have referred these specimens to the genus *Orygmatobothrium*, Diesing.

Diesing's original description of this genus was: "Body elongated, articulate, depressed. Head separated from body by a neck, with four opposite cup-shaped bothria attached by a contractile pedicel highly versatile, and each provided with two scrobiculiform supplementary discs (auxiliary acetabula). Genital pores marginal."

Linton (11), judging from Molin's figure of *Orygmatobothrium crispum*, concluded that a second sucker was not present, and re-defined the genus accordingly, including in it his species *Orygmatobothrium angustum*. There appears to be considerable variation in the form assumed by the bothridia. In *Orygmatobothrium angustum*, Linton, they are stated to be "hollowed out or boat-shaped" (11). In *Orygmatobothrium paulum*, Linton, they are said to be "from long to short oval, each with two pits" (12). In *Orygmatobothrium crenulatum*, Linton, they are stated to be "globular, each provided with an auxiliary acetabulum and an accessory disc of strong circular fibres" (12). The bothridia of our species closely resemble the figures given of the *Orygmatobothrium crenulatum*, Linton, but the "strong circular fibres" were not noted, and our worm is almost twelve times as large. There is evidently need for revision in the genus *Orygmatobothrium*, and my specimens are accordingly doubtfully referred here.

RHINEBOTHRIUM, Linton (11).

Body articulate. Head continuous with the body or separated by a neck. Neck merging into segmented body or separated by a constriction. Bothria four, opposite or in lateral or marginal pairs, faces divided into loculi by several or many transverse and one or few longitudinal muscular partitions, mounted on slender pedicels, very versatile, unarmed, myzorhynchus none. Genital apertures marginal.

Rhinebothrium shipleyi, n. sp. (Plate I., Figs. 12, 13, and 13*a*.)

The head consists of four bothridia borne on long, triangular, flattened, and very versatile stalks. The face of each bothridia is long and narrow, and is divided by transverse septæ only into ten unpaired areolas. There is no longitudinal septum. Each bothridium is 1 mm. long, and approximately ·3 mm. broad. The ends are rounded, and the whole bothridium is fringed with a delicate irregular membrane. In the contracted state the bothridia are often roughly semicircular in shape, with the areolas either on the concave or the convex surface. The breadth of the head varies with the state of contraction and with the disposition of the bothridia, but averages about 1·8 mm. There is no myzorhynchus. Immediately posterior to the head is a swollen bulbous portion, triangular in shape, with the apex passing into the proglottides. There is no neck, although the first few transverse divisions between the proglottides are faint and indistinct. The first segments are shallow, ·3 mm. in breadth, and much broader than long, and they continue so up to the last few (6–8) ripe segments, which latter are square, and then slightly longer (1·2 mm.) than broad (·9 mm.). The largest of our specimens was 60 mm. long, and the smallest 42 mm. Most specimens were whip-like in appearance, the maximum breadth being attained at a distance of about 20 mm. from the head, and they continued the same breadth to the end. This anterior part of the worm is apt to be of uneven breadth, which fact is doubtless due to irregular contraction. The posterior and ripe proglottides in our specimens are of varying shades of a dark brown colour. The genital pores are lateral and irregularly alternate. In some specimens the edges of the proglottides in the middle region of the worm were slightly salient.

Habitat.—The spiral valve of *Trygon kuhli* (Müll. and Henle). Seventy specimens. November and December, 1910.

The diagnosis of *Rhinebothrium shipleyi*, n. sp., is as follows :—

Worms about 60 mm. long. The head consists of four stalked, leaf-like bothridia, which are compressed in a plane at right angles to the axis of the worm. The free surfaces of the bothridia are of an elongated oval shape, and are divided by transverse costæ into ten unpaired areolas. This feature is distinctive of the species. The pedicels of the bothridia arise from a bulbous portion immediately anterior to the proglottides. There is no myzorhynchus and no neck. The proglottides are broader than long, except the terminal few, which are square, then slightly longer than broad. The genital apertures are lateral and irregularly alternate. About the middle length of the worm the proglottides tend to be slightly salient. The maximum breadth of 1 mm. is attained at a distance of about 20 mm. from the head.

I have pleasure in naming this species in honour of Professor Shipley, F.R.S., D.Sc., who described the first cestodes from the Ceylon pearl banks, and thus laid the foundations for future work.

The species described above are only provisionally placed in genus *Rhinebothrium*, Linton, pending an opportunity for further work on the Cestoda in general.

The genus *Echeneibothrium*, Van Beneden, was described by Diesing as follows : " Body elongated, articulate. Head continuous with the body or separated by a neck, with a terminal retractile myzorhynchus. Bothria four, opposite, transversely costato-plicate, sometimes provided with longitudinal partitions, attached by the posterior margin to the head by means of a contractile pedicel, versatile, unarmed. Os in apex of myzorhynchus. Genital apertures marginal."

It will thus be seen that our species are intermediate between the genera *Echeneibothrium* and *Rhinebothrium*. They cannot be included in the genus *Echeneibothrium* as described by Diesing on account of the absence of a myzorhynchus, nor can they be included in Linton's genus *Rhinebothrium* on account of the fact that the faces of the bothridia are not divided by " one or a few longitudinal muscular partitions."

It may be necessary later to refer these specimens to a new genus, in which the unpaired character of the areolas on each bothridium and the absence of a myzorhynchus are characteristic. Otherwise Diesing's description of the genus *Echeneibothrium* must be modified so as to include forms in which a myzorhynchus is absent, or else Linton's genus *Rhinebothrium* must be modified to include forms in which the bothridia may or may not be divided by "one or a few muscular partitions."

On the whole it would appear wiser and simpler to establish a new genus for the forms just described.

SPONGIOBOTHRIUM, Linton (11).

Characters amended (1891).

Body articulate, tæniæform. Head separated from body by a neck. Bothria four, in lateral pairs, pediceled, with crisp, folded, or auriculate edges, which are crenulate, and the auriculate flaps finely costate on account of a marginal row of loculi with muscular borders; unarmed, and without transverse costæ on face. No myzorhynchus, no supplemental discs. Genital apertures marginal.

Spongiobothrium lintoni, n. sp. (Plate II., Fig. 14.)

The head consists of four bothridia, with a row of tiny loculi round the edges. Each bothridium is roughly oval in shape, and is attached by a rather short stalk. Opposite the point of attachment each bothridium appears to be almost divided transversely into two halves, and their edges are indented. Placed centrally and opposite to the point of attachment is a minute flask-shaped depression on the face of each bothridium, which at first was mistaken for a sucker. Careful examination, however, showed that the two halves of a bothridium are capable of movement, simulating the movements of the parts of a hinge. When the faces of the two parts of the bothridium are apposed the central depression is noticeable, but when they are separated from each other and flattened, this structure is hardly visible under a low power. In shape the bothridia resemble those of *Rhinebothrium insignia*, Southwell (23), but the areolas are very differently distributed. The number of loculi round the margin vary greatly. In some specimens they are very pronounced, whilst in others they are only found with difficulty. There are no transverse or longitudinal septæ and no myzorhynchus. The average breadth of the head is 1 mm., and the length ·6 mm. The neck is very short, being about ·4 mm. long and about ·2 mm. broad. The anterior half of the neck is usually clear and transparent. The length of the worm is 20 mm. The average number of proglottides is twelve. The first segment is square, or nearly so. They elongate rapidly, however. The sixth segment is twice as long as broad, and the last segment is 4 mm. long and ·5 mm. broad. The sides of the proglottides are slightly convex. The genital apertures are lateral and irregularly alternate. Only the last two segments appear to be mature. The penis is ·6 mm. long, very narrow, with a bulbous base.

The diagnosis of *Spongiobothrium lintoni*, n. sp., is as follows: Small worms, 20 mm. long and ·5 mm. broad. Head with four leaf-like bothridia borne on short pedicels. Each bothridium has a marginal row of loculi, and is divided transversely at the centre. From this point the halves of each bothridium move like the parts of a hinge. When apposed a flask-like depression is to be seen, which is difficult to observe when the two halves are not apposed. Myzorhynchus absent. Neck very short. Usually twelve segments present. First segment square. Last segment 4 mm. long, and eight times as long as broad. Genital apertures lateral and irregularly alternate. Usually only the last two segments mature.

Habitat.—The spiral intestine of *Rhynchobatus djeddensis* (Forsk.) and *Urogymnus asperrimu* (Bl. Schn.). Eight hundred and fifty specimens. February, 1911.

So far as I am aware, only one species of this genus has been described, viz., *Spongiobothrium variable*, Linton. Our specimens answer perfectly to Linton's description of the genus, but differ from *Spongiobothrium variable*, Linton, in the nature of the bothridia and the segmentation, and in the presence of a flask-like depression on the face of the bothridia.

I have pleasure in naming this species in honour of Dr. Edwin Linton, whose work on American Marine Cestoda is so well known.

SYNDESMOBOTHRIUM, Diesing (11).

Body articulate, tæniæform. Neck tubular, rounded at base. Head tetragonal, with four terminal prominent bothria attached to the head by posterior margin, cruciformly disposed, oval, slightly convex, joined with each other at the base by a membrane, proboscides four, filiform armed, each one running through a bothrium (pedicel) excurrent at apex, long, retractile in the neck. Genital apertures marginal (?). In intestines of marine fishes of tropical America.

Syndesmobothrium filicolle, Linton. (Plate II., Figs. 16 and 17.)

I have no hesitation in referring to this species a number of larval forms obtained from the intestines of *Cybium guttatum* and *Chorinemus lysan.*

The head is squarish in front view, with a bothrium at each corner. The bothridia are oval or cup-shaped. The larvæ agree in every detail with Linton's figure of this species, save that in our types the exit of the proboscides was closed. The proboscis sacs were marked with fine criss-cross lines, only visible under a high power.

Habitat.—(i.) The mesenteries of *Chorinemus lysan.* February 25, 1911. Forty-five specimens. These larvæ were enclosed in tadpole-shaped cysts, the cysts measuring on an average 25 mm. by 2·5 mm. The larvæ was contained in the "head" part of the cysts, which in preserved specimens were of a yellow colour. The rest of the cyst was white, membraneous, and transparent. The larvæ measured 2 mm. by ·5 mm.

(ii.) The mesenteries of *Cybium guttatum.* November 27, 1910. Fifty-five specimens, same as preceding.

I believe these specimens to be the same as those described by Shipley and Hornell from *Cybium guttatum*, in Part V., "Ceylon Pearl Oyster Reports," Plate III., Fig. 43.

It is interesting to note that Linton states that he has "met with encysted forms similar to this (*Syndesmobothrium filicolle*) in various species of the *Teleostei*, such as *Pomatomus saltatrix*, *Cybium regale*, &c. One from Spanish mackerel (*Cybium regale*) was described by me in the 'American Naturalist' for February, 1887, under the name of larval *Tetrarhynchobothrium*."

The occurrence of this larva in these *Teleosts* raises the question as to the position of this stage in the life-history of the parasite. On the whole, I feel confident—and I have every reason to believe—that the larvæ normally inhabit the tissues of either crabs or molluscs, and have their adult stage in some Elasmobranch. The presence of the larvæ in these *Teleosts* is due to their feeding on crabs or molluscs, but the larvæ does not develop any further in them than in crabs or molluscs. But if either the fish containing these cysts derived from crabs and molluscs, or the crabs and molluscs themselves, be eaten by an Elasmobranch, then in every case the larva would attain the adult form in the Elasmobranch.

The stage found in these fish is probably not intermediate, but casual and accidental. These fish are not to be regarded as intermediate but as accidental hosts.

TETRARHYNCHUS, Rudolphi.

Body articulate, tæniæform. Neck tubular. Head with four bothria in two lateral pairs, parallel with the head. Proboscides four, terminal, filiform, armed, retractile in the neck, free, *i.e.*, not running through the bothria. Genital apertures marginal or lateral.

Tetrarhynchus gangeticus, Shipley and Hornell (20). (Plate II., Fig. 18.)

I refer with some hesitation four larval forms to the above species. They correspond with *T. gangeticus* in size, in the proboscis tubes being bent in and out and not spirally twisted, and in the size and shape of the bothridia. The hooks are also similar.

Habitat.—The mesenteries of *Sphyræna jello.* February 27, 1911. Four cysts, measurements as follows: (1) 32 mm. long, 6 mm. broad; (2) 30 mm. long, 5 mm. broad; (3) 26 mm. long, 5 mm. broad; (4) 14 mm. long, 4 mm. broad.

The larvæ themselves were large and fleshy, each measuring 7 mm. long and 3·5 mm. across the proboscides. Strobila absent.

Shipley and Hornell (Part V., "Ceylon Pearl Oyster Reports," page 70) describe cysts obtained from *Sphyræna commersoni* as follows :—

"The cysts are large forms varying in length between 8 mm. and 30 mm., with a breadth of about 3 mm. They belong to Vaullegeard's *Tetrarhynchus erinaceus* series, being enclosed in a vesicle as well as in a cyst, which latter is apparently formed by the tissues of the host. The teeth were very crowded and the excretory opening was visible, but little else could be made out."

Most probably these larval forms are similar to ours.

The adult *Tetrarhynchus gangeticus*, Shipley and Hornell, was obtained from *Carcharias gangeticus*, Müll. and Henle.

So far as I have been able to make out, these specimens fall naturally into the genus *Rhynchobothrium*, Rudolphi, which genus, according to Linton, is characterized as under :—

"Body tæniæform. Neck tubular. Head continuous with the neck, with two opposite bothria, parallel or converging at the apices, lateral or marginal, entire or undivided, or either bilocular with a longitudinal partition or bilobed or divided. Proboscides four, terminal, filiform, armed, retractile in the neck, for the most part longer than the head. Genital apertures, male marginal, female lateral, or male and female marginal approximate."

Otobothrium insigne, Linton (14 and 15). (Plate II., Figs. 19, 20, and 21.)

Except the species described in this Report, no adult forms of the genus *Otobothrium* have ever been recorded from the pearl banks, but the encysted larvæ of this species are the most common larvæ obtained from certain marine fishes in the gulf.

They occur in immense numbers encysted in the pharynx and in the mesenteries of all the species of *Balistes* and *Serranus* recorded from here. They are also common in *Diagramma*, spp., and *Stomateus niger*. The cysts measure on an average 30 mm. by 7 mm., but many forms are less. The cysts are roughly club-shaped, the narrow end being clear and transparent, whilst the broader end is gray black, due to the presence of a somewhat brittle layer of black pigment. Other cysts are perfectly transparent. Possibly these are younger forms.

Both these kinds of cysts occur together, and along with them there often occur numbers of what appear to be degenerate cysts. These are usually flattened, black, and have a powdery, limey consistency. No trace of a larva is to be found in them.

The larvæ in the healthy cysts measure 4 mm. in length. The breadth across the bothridia and the posterior end is 1·5 mm. The breadth is rather less behind the bothridia. No strobila are present. The larva can easily be seen as a milky-white object within the cyst. The specimens answer perfectly to Linton's description of *Otobothrium insigne* and to his figures. The bothridia are lateral and diverging, and there are four accessory bothridial organs. The hooks are of various shapes. Linton gives the length of the adult head and neck as 4·2 mm. Our larval forms measure 3 mm. The adult form was obtained from *Carcharhinus obscurus*.

The habitat of our larval forms was as follows :—

(1) *Diagramma crassispinum*. Twenty-five specimens. February 10, 1911.
(2) *Balistes*, spp. Twelve specimens. January 20, 1911.
(3) *Stomateus niger*. Eight specimens. February 10, 1911.
(4) *Serranus undulosus*. Over two hundred specimens. February 10, 1911.

Otobothrium linstowi, n. sp. (Plate II., Figs. 22, 23, and 24.)

The head consists of two undivided saucer-like bothridia, the edges of which are usually reflected back round the bothridium into an overhanging ledge. At the posterior margin of each bothridium are two very small sucker-like pits. The four proboscides are a little longer than the head and neck. The proboscis sacs are one-third the length of the head and neck, whilst the bothridia are two-ninths the length. The spines on the proboscides are of several kinds. Near one edge the spines have a wide base, and are short and strongly recurved. Over the rest of the proboscis the spines are much more slender. The length of the head and neck is 3 mm. The breadth of the head is 1 mm. Segmentation begins immediately behind the proboscis bulbs, which latter are much broader than the first proglottides. The first segments are much broader than long. The tenth segment is square. The last segment measures 3 mm. long and ·75 mm. broad. The genital pores are lateral and irregularly alternate.

The entire worm measures 19 mm. long.

Habitat.—The spiral valve of *Pristis cuspidatus.* Nine specimens. February 19, 1911.

This species differs from *Otobothrium crenecolle,* Linton, and *Otobothrium insigne,* Linton, in the disposition of the bothridia, in their relative proportions to the length of the head, in the shape and disposition of the spines, and in the general proportions of the head and neck.

I have been unable to obtain a description of the only other known species of this genus, viz., *Otobothrium dipsacum,* Linton, and it may be found later that my specimens are identical with *Otobothrium dipsacum.* They are referred to a new species only provisionally, and I have pleasure in naming them in honour of Dr. von Linstow.

Rhynchobothrium, sp. I. (Plate II., Figs. 25, 26, 27, and 28.)

Large numbers of cysts of an unknown species of *Rhynchobothrium* were obtained from the mesenteries of *Chorenemus lysan* and *Cybium guttatum.* The cysts measured 11 by 3 mm., and were milky-white in appearance. The larvæ measured 7 mm. by ·6 mm. The bothridia are two in number and are concave. Each bothridium appears to be divided by a faint longitudinal septum into two halves. At the posterior end each bothridium is indented. The bothridia and proboscis sacs are almost equal to half the entire length of the head and neck. The proboscides are coiled. The hooks are all similar, and are long and slender, and bent suddenly almost at right angles at their extremity.

Habitat.—(i.) The mesenteries of *Chorenemus lysan.* Eighty-six specimens. February 27, 1911.

(ii.) The mesenteries of *Cybium guttatum.* Nine specimens. February 25, 1911.

Rhynchobothrium, sp. II. (Plate II., Figs. 29 and 30.)

Large numbers of cysts containing larvæ of a second species of *Rhynchobothrium* were obtained from the mesenteries of various fishes caught during 1908 to 1911. The cysts when preserved are often globular, and measure 15 mm. in diameter. The outer part of the cyst is sometimes gelatinous in nature, and is usually absent. Inside the gelatinous covering is the cyst proper, which measures 5 mm. by 3 mm., and is either of a milky-white or golden-yellow colour.

The larva itself lies bent in two inside this cyst. It measures 5 mm. long and 1·5 mm. broad posteriorly. The posterior part is 3·5 times the breadth across the bothridia, and the sacs measure almost half the length of the head and neck. The proboscides are coiled, and are not protruded to the exterior, their external openings being closed. The spines are of various sizes and shapes, and do not appear to have any definite arrangement. There are two very small, undivided, saucer-like bothridia, having a diameter of barely ·5 mm. There are no strobila.

Habitat.—(i.) Walls of the air bladder of *Lutjanus argentimaculatus.* Twelve specimens. November, 1908.

(ii.) The mesenteries of *Drepane punctata.* Nine specimens. February 28, 1911.

(iii.) The mesenteries of *Diagramma,* sp. Twenty specimens. November, 1910.

(iv.) The mesenteries of *Serranus undulosus.* Over one hundred specimens. November, 1910.

Rhynchobothrium, sp. III. (Plate II., Figs. 31 and 32.)

Larvæ of a third species of *Rhynchobothrium* were obtained from cysts found on the mesenteries of *Balistes mitis.*

The cysts are long, cylindrical, firm, and opaque. They measure 14 mm. by 2 mm. The larvæ measure 2 mm. by ·6 mm. The bothridia are circular in outline, concave, with thickened overhanging rims, and are indented anteriorly and posteriorly, and each bothridium is divided into two halves by a shallow ridge running parallel to the body. They measure one-third the length of the head and neck. The proboscis sacs also measure about one-third the length of the head and neck. The proboscides are spirally coiled, and do not protrude to the exterior, the pores being closed. The spines are of various sizes and shapes. Some have narrow bases, and are long and slender, with the extremity bent at right angles. Others are short with a broad base, and are strongly recurved. The arrangement of the hooks could not be ascertained.

Habitat.—The mesenteries of *Balistes mitis*. Twenty-seven specimens. November, 1910.

Rhynchobothrium, spp.

I include here a note with figures of single specimens of larvæ obtained from cysts.

Species A. Plate III., Fig. 33. From oval cysts 9 mm. long and 3 mm. broad. Larva measuring 6 mm. by ·7 mm. A single specimen from the mesenteries of *Serranus undulosus*. February 27, 1910.

Species B. Plate III., Fig. 34. From oval cysts 7 mm. long and 2 mm. broad. Larva measuring 5 mm. long and ·4 mm. broad. A single specimen from the mesenteries of *Lutjanus gibbus*. December 8, 1910.

Species C. Plate III., Fig. 35. From oval cysts 4 mm. long and 1·2 mm. broad. Larva measuring 3 mm. long and ·3 mm. broad. A single specimen from *Psettodes erumei*. February 27, 1911. Possibly this is the same species as species B.

In none of these larvæ was the nature of the spines on the proboscides determined, as this could not be done without destroying the specimens.

Rhynchobothrium rossii, n. sp. (Plate III., Figs. 36, 37, 38, and 39.)

This worm, which measures 60 mm. long, consists of a very small head and a whip-like body, which broadens and thickens greatly posteriorly. Except the last 6–11 proglottides, which are pigmented brown, the rest of the worm is clear and very transparent. The head consists of two somewhat oblong, concave, undivided bothridia, with thickened rims, which are slightly indented both posteriorly and anteriorly, and measure approximately ·5 mm. long. They diverge slightly posteriorly. The head and neck, which are ·4 mm. broad and 2 mm. long, pass into the strobila without any alteration in breadth, and thus, except under a magnification of 30 diameters, the posterior termination of the proboscis sacs cannot be seen. The bothridia and proboscis sacs together measure half the length of the head and neck. The proboscides are loosely coiled spirally. The hooks are arranged spirally and have a broad base, and are short and strongly recurved. The whole surface of the head, neck, and first proglottides is marked by a series of straight lines crossing each other and giving a characteristic appearance. The head and neck together measure 2 mm. There is a short unsegmented portion between the proboscis sacs and the first proglottides. The first segments are very crowded, shallow, and much broader than long. They elongate very gradually. About one-third the length of the worm, from the posterior extremity, the segments thicken and become pigmented and opaque. The last segments measure 2·5 mm. long, breadth 2 mm. The proglottides are not salient. The genital apertures are lateral and irregularly alternate.

The diagnosis of *Rhynchobothrium rossii*, n. sp., is as follows :—

Long and fairly stout worms, 60 mm. long and a maximum breadth of 2 mm. The head is very small, and consists of two somewhat oblong, concave, undivided bothridia, with thickened rims, which are slightly indented both anteriorly and posteriorly. Each bothridium is ·4 mm. long. Neck not swollen where the proboscis sacs occur. Head and neck 2 mm. long. The hooks on the proboscides are arranged spirally, and are all alike. They are small, short, stout, with broad bases, and are strongly recurved. Head and neck covered with lines arranged in a criss-cross fashion. Short unsegmented portion between proboscis sacs and first proglottid. First segments crowded, much broader than long. They elongate gradually. Last one-third or one-fourth of the worm thick, and pigmented brown in preserved specimens. Last segment 2·5 mm. long, 2 mm. broad, and ·6 mm. thick. Genital apertures lateral and irregularly alternate.

Habitat.—The spiral valve of *Trygon kuhli*. Fourteen specimens. November 27, 1910.

Paratœnia elongatus, n. sp. II. (Plate III., Fig. 40.)

The head is exactly similar to that of the only other species of this genus, viz., *Paratœnia medusia*, Linton.

The head is globular. There are four small bothridia. From the terminal os at the anterior extremity about sixteen mobile tentacles may be protruded. Our species has a short neck, equal in length to the head. First segments shallow, and all the segments broader than long, the anterior ones being slightly salient. The worm is whip-like and very narrow until the ripe segments are reached.

The following are the measurements of our longest specimen :—

Length	50 mm.	Length of head ..	·5 mm.
Breadth of last segment ..	1 mm.	Breadth of head ..	·4 mm.
Length of last segment ..	·4 mm.	Length of neck ..	·5 mm.

The riper segments broaden suddenly.

Some specimens were strongly contracted, and these measured 39 mm. Our species thus differ from *Paratœnia medusia*, Linton, in being ten times longer, in possessing a neck, and in the ripe segments being broader than long.

The diagnosis of *Paratœnia elongatus* is as follows :—

Head globular or subglobular, with four small bothridia. From the terminal aperture there may protrude about sixteen tentacles, which are as long as the head. Neck short, as long as the head. First segments much broader than long. Anterior segments slightly salient. All segments broader than long. The posterior segments widen and thicken suddenly, and are quite opaque.

Habitat.—The spiral valve of *Trygon kuhli*. Forty-four specimens. 1910 and 1911.

TREMATODE (?), sp. (Plate III., Fig. 41.)

During the examination of a number of specimens of *Diagramma crassispinum*, three specimens were found to contain a most remarkable free living parasite in the cœlom.

Unfortunately I have not had the time to make a careful examination of this parasite, and I am at present uncertain of its strict zoological position. The worm is to all appearance a huge *Trematode*. In the living condition it measured 15 inches long and $1\frac{1}{8}$ inch broad. It was quite flat, and had a thickness of $\frac{1}{16}$ inch. The preserved specimens, of which I have three, measure $9\frac{1}{2}$ inches long, $\frac{3}{4}$ inch broad, and are about $\frac{1}{8}$ inch thick. The extremities are rounded, and terminate in a minute acute point. At one extremity there is a minute sucker-like aperture situated centrally, whilst at the other extremity there is a similar but slightly larger aperture situated laterally. This latter aperture appears to open to the interior of the worm. The edges of the worm are straight and parallel. A pair of narrow blackish tubes run along the lateral margins—one on each side. Down the centre of the worm, and stretching from one extremity to the other, is an opaque milky-white mass $\frac{1}{4}$ inch broad. On each side of this mass there are a series of black coiled tubes $\frac{1}{16}$ inch in diameter disposed in bunches, also running the entire length of the worm, but situated for the most part on one side. The rest of the worm is quite transparent.

No other apertures could be detected. In consistency the worm is that of a stiff jelly.

A full description of this enormous parasite, which is in all probability a *Trematode*, will be published as soon as the anatomical details have been worked out.

Habitat.—The body cavity of *Diagramma crassispinum*. Three specimens, only one in a fish. February, 1911.

I append herewith a list of parasitic material collected in Ceylon from various sources during the past few years. The list comprises all the cestodes I have up to the present collected from the marine fishes of Ceylon.

Many of the species described by Shipley and Hornell (20) I have not obtained. The other cestodes have been collected from the sources named. A few specimens were obtained from the Indian Museum, Calcutta.

Probably most of the parasitic Copepoda, Trematodes, and Nematodes collected are new species, and it is hoped that these as well as the other material named will be worked out and described at some later period.

General.

	From
Ticks	*Testudo elegans.*
Solitary corals, n. spp.	Ceylon pearl banks.
Halimeda gracilis in fructification	Ceylon pearl banks.
Dermal cysts	*Testudo elegans.*
Intra-uterine embryos, young	*Trygon kuhli.*
Do. slightly older	*do.*
Do.	*Rhynchobatus columnæ.*
Worms	Coral.
Sarcocystis tennella	Muscle of buffalo.
Echinorhynchus tenor	*Scops bakkuamun* (owl).
Do. n. sp., with cysts	Lungs of rat snake (*Zamenis mucosus*).
Do. n. sp.	*Aster badius.*

Parasitic crustacea.

Cymothoæ, n. sp.	*Serranus undulosus.*
Do. n. sp.	*do.*
Cilicicæa lattreilli (?)	White *Leptoclinid.*
Gnathia, n. sp.	Gills of *Trygon kuhli.*
Do. n. sp.	*Galeocerdo tigrinus.*
Do. sp.	*Urogymnus asperrimus.*
Ecto-parasitic Copepoda	*Trygon kuhli.*
Do.	*Tæniura melanospilos.*
Parasitic Copepoda	*Rhynchobatus columnæ.*
Do.	Root of mouth of *Lutjanus gibbus.*
Do.	*Serranus undulosus.*
Do.	*Lutjanus argentimaculatus.*
Do.	Gills of *Rhynchobatus djeddensis.*
Do.	*Tæniura melanospilos.*

Nematodes.

Filaria digitata (?), Von Linstow	*Bos indicus.*
Nematodes	*Tæniura melanospilos.*
Do.	*Chiloscyllium indicum.*
Do.	*Lethrinus miniatus.*
Do.	*Galeocerdo tigrinus.*
Do.	*Varanus*, sp.
Do.	Turtle (*Chelonia midas*).
Do.	do. (*do.*).
Do.	*Myliobatis nieuhofii.*
Do.	*Pristis cuspidatus.*
Do.	*Chorinemus lysan.*
Do.	*Urogymnus asperrimus.*
Do.	*Tetrodon stellatus.*
Nematode cysts	*Caranx*, sp.
Do.	*Caranx melanpygus.*

	From
Nematodes in large cysts	*Bos indicus.*
Nematodes	*Diagramma crassispinum.*

TREMATODES.

Anaporrhutum largum	*Chiloscyllium indicum.*
Amphistoma conicus	Bile duct of buffalo.
Paramphistomum bathycotyle	*Bos indicus.*
Schistorchis carneus	*Tetrodon stellatus.*
Trematodes	*Ætobatis narinari.*
Do. (Ecto-parasites)	*Chelonia viridis.*
Do.	*Pinna bullata.*
Trematodes with Redia	*Tetrodon stellatus.*
Trematode	*Diagramma crassispinum.*
Trematode, 3 specimens 15 in. long	do.
Redia and Trematode	*Diagramma*, sp.

CESTODES.

Solenophorus megalocephalus	*Felis tigris.*
Do.	*Python reticulatus.*
Tænia globipunctata	Sheep.
Tænia serrata	Wild jackal.
Do.	*Felis tigris.*
Do.	*Nesokia bengalensis.*
Tænia serialis	Dog.
Chittotænia bursaria	*Lepas ruficaudatus.*
Dutheria fimbricata	*Varanus exanthematicus.*
Plagiotænia gigantea	*Rhinoceros unicornis.*
Pterocercus, spp.	*Bentorphis pictus.*
Cysticercus pisiformis	*Mus rattus.*
Cysticercus fasciolaris	do.
Do.	Rat.
Cœnurus serialis	Goat.
Cysticercus polymorphus	*Bos indicus.*
Cysticercus cellulosæ	Human brain.
Echinococcus polymorphus	Goat.
A Cyst (*Echinococcus polymorphus*) (?)	*Bos indicus.*
Dipylidium caninum	Rat (Dog ?).
Hymenolepis, n. sp.	*Corvus macrorhynchus.*
Tænia marginata	*Bos indicus.*
Tænia, sp.	do.
Davania, n. sp.	*Centrococcyx rufipennis.*
Davania polyalcaria	*Corvus macrorhynchus.*
Davania, n. sp.	*Petragopeis gurial.*
Do. sp.	*Tockus gingalensis* (hornbill).
Do. sp.	*Corvus splendens.*
Oragmatobothrium tetraglobum, n. sp.	*Rhynchobatus djeddensis.*
Cyclobothrium typicum	*Ætobatis narinari.*
Adelobothrium ætobatidis	*Rhynchobatus djeddensis.*
Thysanobothrium uarnakense	*Trygon walga.*
Acanthobothrium herdmani, n. sp.	*Trygon kuhli.*
Platybothrium spinulifera, n. sp.	*Galeocerdo tigrinus.*
Prosthecobothrium trygonis	*Trygon kuhli.*

	From
Spongiobothrium lintoni, n. sp.	*Rhynchobatus djeddensis.*
Spongiobothrium variabile	*Trygon kuhli.*
Syndesmobothrium filicolle	*Cybium guttatum.*
Dibothrium hastatus	*Trygon kuhli.*
Dibothrium, sp.	*Sterna bergii.*
Otobothrium linstowi, n. sp.	*Pristis cuspidatus.*
Cysts containing *Otobothrium insigne*	*Diagramma crassispinum.*
Echinobothrium rhinoptera	*Trygon kuhli.*
Echinobothrium boisii	*Ætobatis narinari.*
Myzocephalus narinari	*Chiloscyllium indicum.*
Do.	*Galeocerdo tigrinus.*
Phyllobothroides hutsoni	*Ginglymostoma concolor.*
Phyllobothroides kerkhami	*Chiloscyllium indicum.*
Do.	*Ginglymostoma concolor.*
Rhinebothrium flexili	*Pristis cuspidatus.*
Rhinebothrium ceylonicum	*Chiloscyllium indicum.*
Do.	*Trygon kuhli.*
Rhinebothrium shipleyi, n. sp.	do.
Calliobothrium eschrichtii	do.
Do.	*Chiloscyllium indicum.*
Calliobothrium filicolle	*Pristis cuspidatus.*
Calliobothrium farmeri	*Trygon kuhli.*
Echeneibothrium simplex	do.
Echeneibothrium insignia	do.
Echeneibothrium walga	do.
Anthobothrium pulvinatum	*Ætobatis narinari.*
Anthobothrium ceylonicum, n. sp.	*Trygon kuhli.*
Anthobothrium floraformis, n. sp.	*Carcharias*, sp.
Anthobothrium crispum	*Trygon walga.*
Anthobothrium laciniatum	*Carcharias bleekeri.*
Tylocephalum uarnak	*Trygon kuhli.*
Do.	*Trygon*, sp.
Tylocephalum trygonis	*Trygon kuhli.*
Tylocephalum kuhli	do.
Tylocephalum dieruma	do.
Do.	*Pteroplatea micrura.*
Cephalobothrium variabilis	*Trygon kuhli.*
Do.	*Pristis cuspidatus.*
Cephalobothrium ætobatidis	do.
Do.	*Ætobatis narinari.*
Cephalobothrium abruptum	*Trygon kuhli.*
Do.	*Pteroplatea micrura.*
Phyllobothrium lactuca	*Galeocerdo tigrinus.*
Do.	*Trygon kuhli.*
Phyllobothrium blakei = *Anthobothrium pulvinatum* (?)	do.
Phyllobothrium foliatum, n. sp.	*Rhynchobatus djeddensis.*
Phyllobothrium pammicrum	*Urogymnus asperrimus.*
Larvæ of *Rhynchobothrium*, sp.	*Lutjanus argentimaculatus.*
Tetrarhynchus larvæ from cysts	*Trygon walga.*
Tetrarhynchus unionifactor	*Ginglymostoma concolor.*
Do.	*Urogymnus asperrimus.*

	From
Tetrarhynchus unionifactor	*Trygon*, sp. (Tamblegam).
Tetrarhynchus leucomelanus	*Trygon walga.*
Do.	*Trygon sephen.*
Do.	*Rhynchobatus djeddensis.*
Tetrarhynchus macrocephalus	*do.*
Do.	*Trygon walga.*
Tetrarhynchus ruficollis	*do.*
Do.	*Trygon kuhli.*
Tetrarhynchus rubromaculatus	*do.*
Tetrarhynchus spinulifera	*Rhynchobatus djeddensis.*
Paratœnia elongatus, n. sp.	*Trygon kuhli.*

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Explanation of Plates.

Plate I.

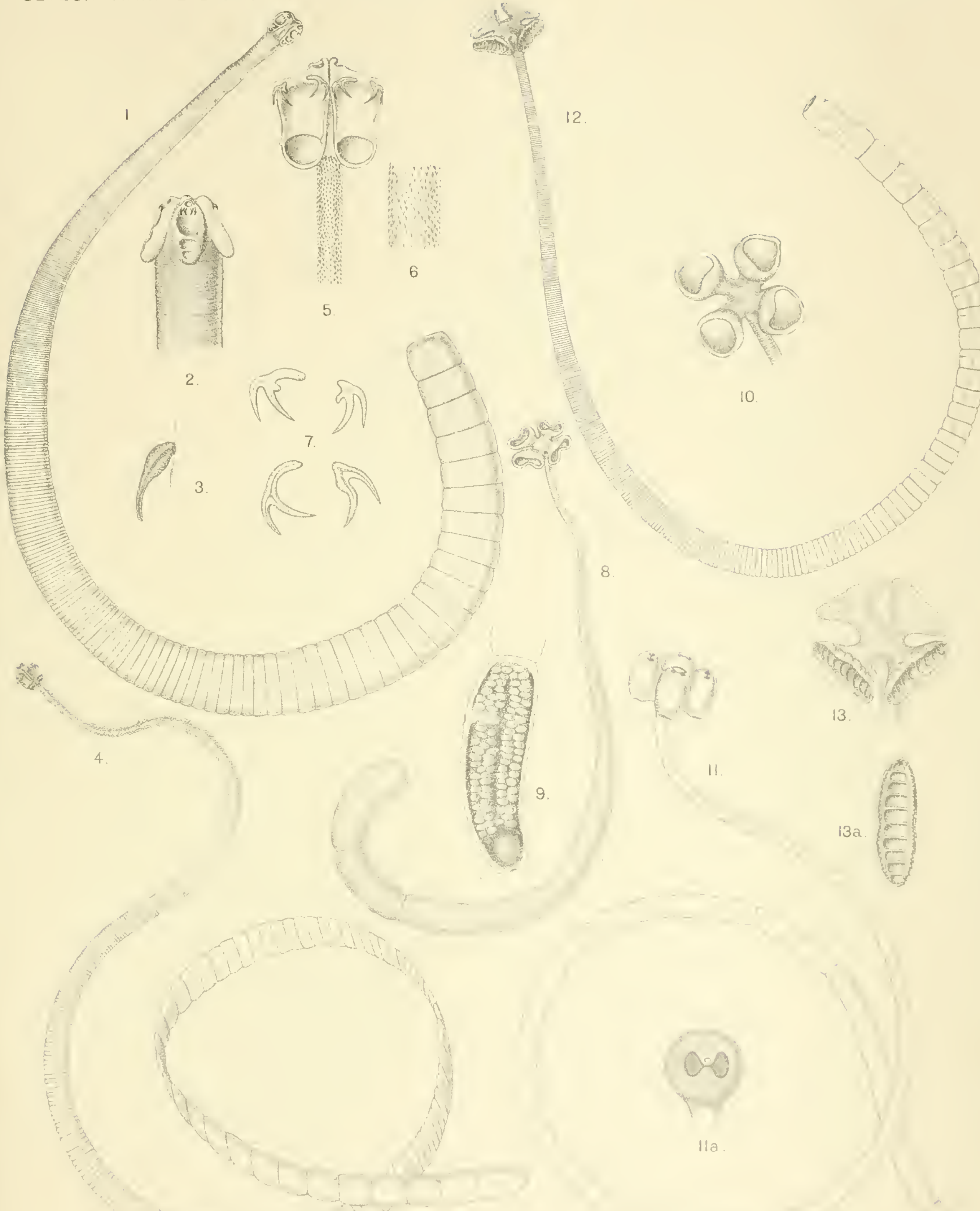
Fig. 1 .. *Acanthobothrium herdmani*, n. sp. Entire cestode. × 4.
Fig. 2 .. Head of same. × 10.
Fig. 3 .. Cirrhus of same. × about 40.
Fig. 4 .. *Platybothrium spinulifera*, n. sp. Entire cestode. × 11.
Fig. 5 .. Head of same. × 50.
Fig. 6 .. Portion of neck of same. × 90.
Fig. 7 .. Bothridial hooks of same. × about 100.
Fig. 8 .. *Anthobothrium floraformis*, n. sp. Entire cestode. × 20.
Fig. 9 .. Terminal proglottid of same. × 40.
Fig. 10 .. Head of same. × 40.
Fig. 11 .. *Oragmatobothrium tetraglobum*, n. sp. Entire cestode. × about 30.
Fig. 11*a* .. A single bothridium of same from above. × about 9.
Fig. 12 .. *Rhinebothrium shipleyi*, n. sp. Entire cestode. × $4\frac{1}{2}$.
Fig. 13 .. Head of same. × 10.
Fig. 13*a* .. One bothridium of same. × 16.

Plate II.

Fig. 14 .. *Spongiobothrium lintoni*, n. sp. Entire cestode. × 8.
Fig. 15 .. *Anthobothrium ceylonicum*, n. sp. Entire cestode. × 12.
Fig. 16 .. *Syndesmobothrium filicolle.* Cyst. × $1\frac{1}{3}$.
Fig. 17 .. Larva of same. × 24.
Fig. 18 .. *Tetrarhynchus gangeticus.* Larva. × 8.
Fig. 19 .. Cysts containing *Otobothrium insigne.* × 2.
Fig. 20 .. A second, with transparent cyst containing same. × 2.
Fig. 21 .. Larva of same. × 15.
Fig. 22 .. *Otobothrium linstowi*, n. sp. Entire cestode. × 10.
Fig. 23 .. Head of same. × 16.
Fig. 24 .. Part of proboscis of same. Highly magnified.
Fig. 25 .. *Rhynchobothrium*, sp. I. Larva. × 16.
Fig. 26 .. Cyst containing larva of same. × $2\frac{1}{2}$.
Fig. 27 .. A second larva of same. × 14.
Fig. 28 .. A hook from the proboscis of same. Highly magnified.
Fig. 29 .. *Rhynchobothrium*, sp. II. Cyst. × 4.
Fig. 30 .. Larva of same from cyst. × 13.
Fig. 31 .. *Rhynchobothrium*, sp. III. Cyst. × $2\frac{1}{2}$.
Fig. 32 .. Larva of same from cyst. × 25.

Plate III.

Fig. 33 .. *Rhynchobothrium*, sp. A. Larva from cyst. × 18.
Fig. 34 .. *Rhynchobothrium*, sp. B. Larva from cyst. × 20.
Fig. 35 .. *Rhynchobothrium*, sp. C. Larva from cyst. × about 25.
Fig. 36 .. *Rhynchobothrium rossii*, n. sp. Entire cestode. × 6.
Fig. 37 .. Head and neck of same. × 15.
Fig. 38 .. Termination of the proboscis of same. × 100.
Fig. 39 .. A hook from the proboscis of same. Highly magnified.
Fig. 40 .. *Paratænia elongatus*, n. sp. Entire cestode. × 10.
Fig. 41 .. *Trematode*, sp. × $\frac{2}{3}$.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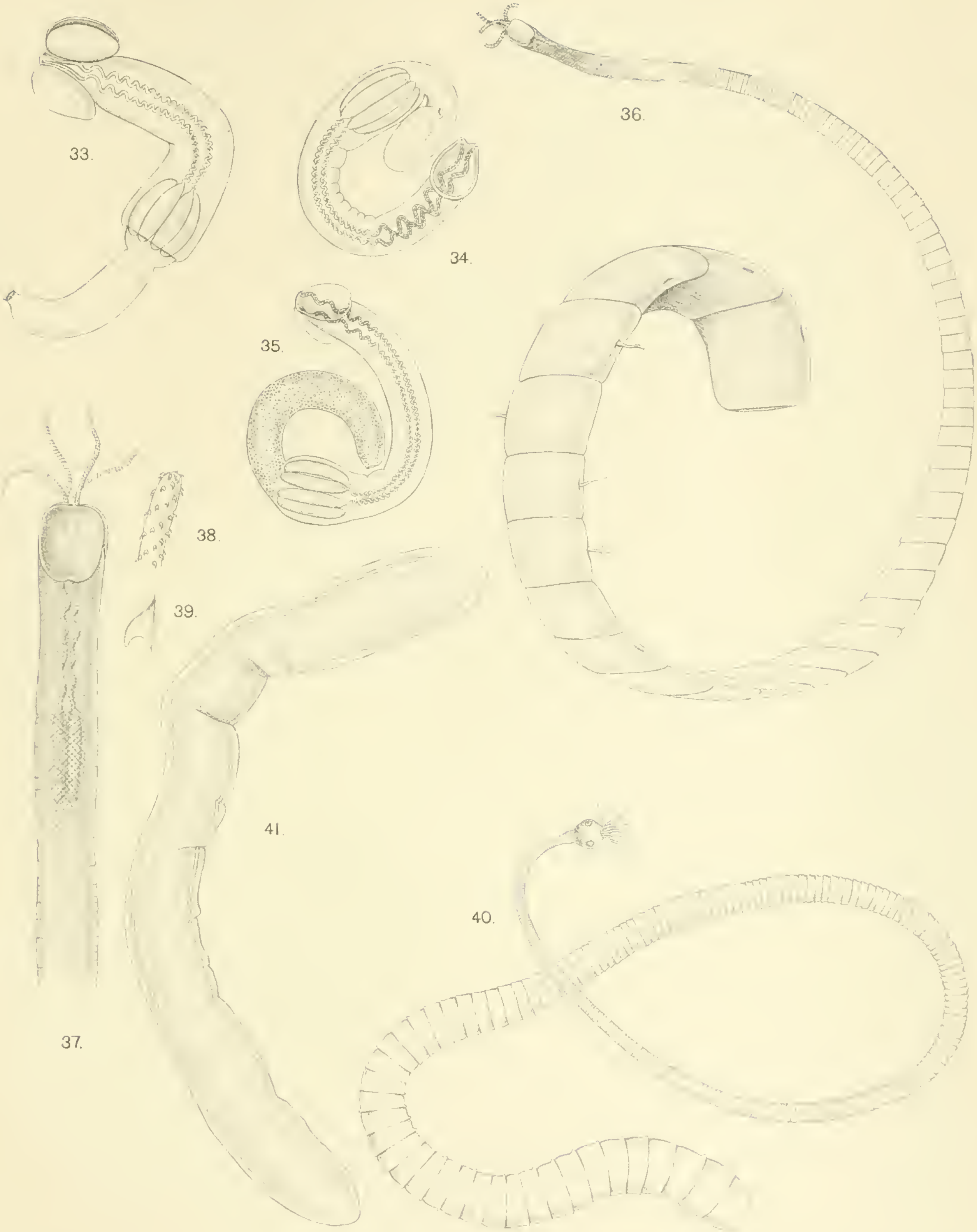
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